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# COVID-19 as a prime driver of rapid technological experimentation in higher-education teaching and learning: An overview of reviews

## Abstract

The COVID-19 pandemic has given rise to a new era of rapid scholarly publications (e. g., peer-reviewed journal articles and non-peer-reviewed preprints). Included among such publications are reviews and reviews of reviews, both of which take longer to publish under normal circumstances. This is more so for overviews. Therefore, the current overview reviewed 18 review articles published between March 2020 and March 2021. It did so by investigating online technologies for teaching and learning used by higher education institutions (HEIs) during the COVID-19 pandemic, and by examining major themes, main findings, key conclusions, and other characteristics of these 18 reviews. One of its findings is that online pivoting tends to signal a necessary change and innovation embraced by HEIs during the COVID-19 pandemic. It is a pandemic technological change and innovation that underpins their SoTL.

## Keywords

overview, COVID-19, higher education, online technologies, characteristics

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# 1 Introduction

When the novel coronavirus disease 2019 (COVID-19) broke out in Wuhan, in China, in December 2019, and was subsequently declared a global pandemic by the World Health Organization (WHO) early in 2020 (CHAKA, 2020; ROMLI et al., 2020; SOHRABI et al., 2020; WHO, 2020), it became an overnight game-changer in many spheres of human life. Among these several spheres affected by COVID-19 is higher education (HE). Within the HE sector, teaching and learning, scholarly research, and administration were among the most affected areas. In respect of teaching and learning, the concomitant campus closures in response to physical distancing were followed by a rapid transition from in-person classes to online classes, or in some cases, to emergency remote classes. This move was intended to ensure academic business continuity by universities world-wide, and varied both across countries and across universities (TADESSE & MULUYE, 2020; TALIB, BETTAYEB & OMER, 2021).

As the paper focuses on technological experimentation in teaching and learning in the HE sector during the COVID-19 pandemic, both online and emergency teaching need briefly defining. Online teaching is a web-driven e-learning traditionally used for distance learning purposes. It is mostly deployed as an intentional and well-planned strategy embedded in and operationalized as part of institutional curriculum and pedagogy. In this context, emergency remote teaching (ERT) is a rapid form of teaching implemented with bare minimum resources, often resulting in poor outcomes (BATES, 2015, 2020; CHAKA, 2020; HODGES et al., 2020). Both online and emergency remote teaching as adopted by most higher education institutions (HEIs) during the COVID-19 pandemic serve as an instance of technological experimentation that took place during this period. They, then, temporarily became modes of teaching and learning with which most HEIs experimented so as to maintain their academic business continuity during this period.

In this regard, this paper sets out to investigate instances of technological experimentation related to online technologies for teaching and learning used by HEIs during the COVID-19 pandemic. It does so by providing an overview of 18 review articles published during the pandemic period, from March 2020 to March 2021. Primarily, it examines major themes, main findings, key conclusions, and other characteristics of these 18 review studies.

## 2 Situating issues

Overviews of reviews are conducted to investigate issues raised by or related to reviews of primary studies. In this case, they can examine reviews; literature reviews; scoping reviews; rapid reviews; narrative reviews; synthesis reviews; critical reviews; systematic reviews; systematic literature reviews; or meta-analyses. As overviews focus on second-order publications, publications that investigated primary studies, their primary units of analysis are aspects or characteristics of those secondary publications (KIM et al., 2018; PARÉ et al., 2015; ROMLI et al., 2020). However, PIEPER et al. (2012) maintain that there is no standard definition of overviews and that as a genre, overviews are often not definitively defined whenever they are employed.

Some of the benefits of conducting overviews include: formulating research problems of different reviews in broader terms; harnessing, integrating, or aggregating findings of several review studies; delineating trends emerging from multiple reviews; identifying gaps in current reviews; and broadening the knowledge base of existing reviews. Nevertheless, overviews have shortcomings. Among these shortcomings are a lack of methodological credibility, bias, out-datedness, and a lack of uniform reporting guidelines (PIEPER et al., 2012; POLANIN, MAYNARD & DELL, 2016).

## 3 Methods

As a relatively emerging genre for investigating characteristics of second-order studies, overviews do not yet have universally established guidelines undergirding them as is the case with established genres such as synthesis reviews, systematic reviews, systematic literature reviews, or meta-analyses. As such, they utilize the research protocols and some of the reporting guidelines applied by systematic reviews and systematic literature reviews (KIM et al., 2018; PARÉ et al., 2015; ROMLI et al., 2020). They also employ the search procedures recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (MOHER et al., 2009; ROMLI et al., 2020). One tool used to assess the quality of systematic reviews is A MeaSurement Tool to Assess systematic Reviews 2 (AMSTAR 2) tool (GATES et al., 2018; SHEA et al., 2017).

Based on the foregoing points, the current overview utilized PRISMA, and adapted and used some of the elements of AMSTAR 2. Additionally, it employed variations of search and identification strategies commonly used by systematic literature reviews. It, then, followed four phases in its data search and data collection process: planning; selection; extraction; and execution (OKOLI, 2015).

### 3.1 Planning

This phase consisted of three stages: establishing the purpose of the current overview, identifying the characteristics of the 18 review studies, and formulating research questions. The purpose of the present overview was: to identify online technologies for teaching and learning and the major themes (characteristics) related to HE in the 18 selected review articles; and to integrate and synthesize the main findings and the key conclusions of these reviews (see Table 1).

Table 1: Characteristics of the eighteen review studies

<b>Eleven key characteristics investigated in each review study</b>	
Author(s) and year of publication	Discipline(s)/Subject area(s)
Country	Online/digital technologies used for teaching and learning in HE during COVID-19
Review type	Major themes
Databases	Main findings
Research design	Key conclusions)
Sample size(s)	

The overview, then, formulated the following research questions (RQs).

- RQ 1: What are research designs and sample sizes employed by 18 review studies?
- RQ 2: What types of online technologies are used as part of technological experimentation for teaching and learning during COVID-19 in the HE sector as reported by these review studies?

- RQ 3: Do the major themes, main findings, and key conclusions of these review studies reflect any change and innovation for HE teaching and learning?

### 3.2 Selection

Four stages comprised this phase of the overview: identifying keywords; identifying databases; inclusion/exclusion criteria; and searching for and selecting studies. Search keywords were selected according to the title, the focus, and the purpose of the overview. To this end, strings of keywords were created and queried in keeping with the respective databases used as exemplified below:

- Google search engine: review AND Covid-19 AND higher education AND online technologies AND teaching and learning
- Microsoft Academic: (review) AND (Covid-19) AND (higher education) AND (online technologies) AND (teaching and learning)
- Scopus: “review” OR “Covid-19” OR “higher education” OR “online” OR “digital” OR “virtual” OR “e-Learning” OR “e-learning” OR “technologies”

These keyword strings were combined with the three Boolean search commands, AND, OR and NOT. Where applicable, keywords were enclosed in parentheses and double quotations marks. In addition, different iterations of these keywords were used, and in other instances, these keywords were replaced with their equivalents.

Fourteen databases, which comprised an online search engine and an academic social networking platform, were identified and used for purposes of searching for review articles. These were: Google; Google Scholar; Microsoft Academic; Semantic Scholar; ERIC; IEEE Xplore; JSTOR; ProQuest; ScienceDirect; Scopus; Springer-Link; Taylor & Francis Online; Wiley Online Library; and ResearchGate.

Table 2: Inclusion/Exclusion criteria

<b>Criteria</b>	<b>Inclusion</b>	<b>Exclusion</b>
Time period	Reviews published between 2020 and March 2021	Reviews not published between 2020 and March 2021
Types of articles	Reviews published in peer-reviewed journals	Reviews not published in peer-reviewed journals (e.g., preprints)
Databases	Use of at least one bibliographic database	No use of any bibliographic database
Content and focus of articles	Reviews whose focus is on the use of online/digital technologies for teaching and learning in HE as a result of COVID-19	Reviews focusing on the use of online/digital technologies for teaching and learning in HE, but which use has not been occasioned by COVID-19
Language of publication	Reviews published in English	Reviews not published in English

After the two stages mentioned above had been completed, inclusion/exclusion criteria were developed (see Table 2). Then, the search and selection of candidate articles was conducted. The search was conducted between 30 January 2021 and 31 March 2021. This search was informed by and based on the keyword strings mentioned above, and was carried out on the 14 aforesaid databases. Several queries run on these databases, together with bespoke ancestry searches, returned a total of 2,200 articles. In the end, 18 articles were judged as relevant and were retained after those not meeting the review criteria had been excluded (see Figure 1). Any ensuing disagreements were resolved through consensus.

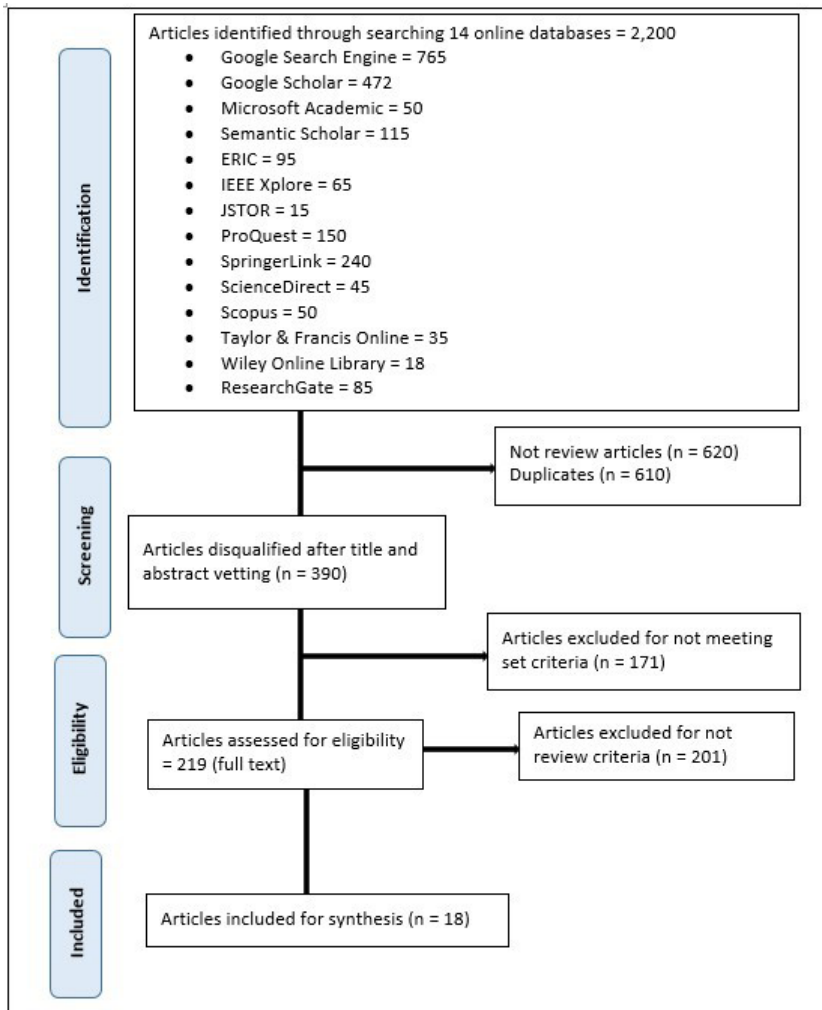


Figure 1: PRISMA flowchart for screening articles

### 3.3 Extraction

The extraction phase consisted of assessing the quality of the included studies and a data extraction strategy. All the extracted articles were assessed to ensure that they met a methodological quality applicable to review articles. They were assessed according to composite criteria drawn from elements of three quality assessment tools: the study quality assessment tools (NATIONAL HEART, LUNG, AND BLOOD INSTITUTE, n.d.); the A MeaSurement Tool to Assess systematic Reviews 2 (AMSTAR 2) (GATES et al., 2018; SHEA et al., 2009); and KITCHENHAM et al.'s (2009) quality assessment questions. The composite criteria were 12 in total (see Table 3).

The composite quality criteria, which were in the form of questions, were applied to the 18 review articles by three raters. Each article was allotted as a score rated as high (75% – 100%), medium (50% – 74%), or low (35% – 49%), depending on how fully, moderately, or partially it met the 12 composite quality criteria. An inter-rater agreement was calculated using Cohen's kappa ( $\kappa$ ) values (COHEN, 1960), which are grouped as follows:  $<0$  = poor; 0.00–0.20 = slight; 0.21–0.40 = fair; 0.41–0.60 = moderate; 0.61–0.80 = substantial; 0.81–1.00 = near perfect (MENGIST, SOROMESSA & LEGESE, 2020). An inter-rater agreement between the three raters was 0.82. Data were extracted from the 18 review articles according to the eleven characteristics depicted in Table 1.



Table 3: Quality assessment questions (GATES et al., 2018; KITCHENHAM et al., 2009; NATIONAL HEART, LUNG, AND BLOOD INSTITUTE, n.d.; SHEA et al., 2009)

<b>Quality assessment questions</b>	
1.	Is the review based on a focused question that is sufficiently formulated and described?
2.	Are eligibility criteria for included and excluded studies predefined and specified?
3.	Were three more electronic databases searched?
4.	Was a comprehensive literature search conducted?
5.	Is the sample size (e.g., the number of included publications) reported?
6.	Were titles, abstracts, and full-text articles collectively and independently reviewed for inclusion and exclusion to minimize bias?
7.	Are the review aims/purposes clearly stated?
8.	Was the status of publication (.e.g., peer-reviewed or grey literature) employed as an inclusion criterion?
9.	Was a list of reviewed publications (included and excluded) provided?
10.	Were the characteristics of the included publications provided?
11.	Was the quality of the included publications assessed and reported?
12.	Was the possibility of publication bias reported and assessed?

### **3.4 Execution**

The fourth and last phase involved analyzing and synthesizing data. The data extracted from the review articles were in the form of data sets. These data sets were extracted in keeping with the eleven review articles' characteristics depicted in Table 1. Thereafter, they were analyzed by employing qualitative content analysis (e. g., HISIEH & SHANNON, 2005; VAISMORADI & SNELGROVE, 2019). A coding scheme was developed to code the data sets. This coding scheme consisted of categories based on the eleven review articles' characteristics. Specific themes, which responded to the research questions (RQs), were derived from these categories.

## **4 Findings**

The findings presented in this section of the overview are based on the data sets extracted from the 18 review articles and are informed by the way in which the data sets were codified, categorized, and analyzed as highlighted above. Importantly, these findings have been framed to reflect the eleven articles' characteristics investigated by this overview.

### **4.1 Distribution of articles by authors' countries and years of publication**

As depicted in Appendix A, the 18 reviewed articles were written by authors from single, dual, triple, and quadruple countries. Eleven authors were from eleven single countries; five sets of authors were from five dual countries; and a set of three authors was from three countries, while a set of four authors was from four different countries. Twelve review articles were published in 2020, and six were published in 2021.

## **4.2 Review types, databases, research designs, and sample size(s)**

The 18 review articles, as illustrated in Appendix A, fall into seven review categories: rapid review (n = 1); scoping review (n = 1); review (n = 1); literature reviews (n = 2); systematic reviews (n = 7); systematic literature reviews (SLRs) (5); and bibliometric analysis review (n = 1). Many of these reviews were systematic reviews and systematic literature reviews, with the former outnumbering the latter by 2. All of these reviews were qualitative studies.

These review articles employed varying numbers of online databases in their search strategies. All together, these 18 reviews used 78 databases in their respective collective searches. The most used databases were Scopus (n = 11), WoS (n = 10), and Google Scholar (n = 9), respectively.

Sixteen of the 18 review articles reported the research designs they had used. Both the PRISMA approach (n = 7) and the SLR approach (n = 4) were the most used, respectively. All these reviews mentioned and specified the sample sizes of the articles or publications they had reviewed (see Appendix A). Collectively, the sample sizes of these 18 reviews amounted to 1,533 articles.

## **4.3 Disciplines and subject areas, and reported online technologies used**

Most of the academic disciplines on which some of the 18 review articles focused included: education; supply chain; medical and surgical education; dental education; business; economics; and management (see Appendix A). Eight reviews focused on education (e. g., e-learning, distance learning, open education, online education, augmented reality (AR) in education, and robotics education) as an overarching discipline. Four reviews concentrated on medical education (including surgical and dental education) as an all-encompassing discipline, while three reviews focused on management (e. g., education, business, and economics) as an all-embracing discipline. Among the reported academic disciplines and subject areas were: curriculum; engineering; science; physics; geography; biology; and early childhood education.

Nine reviews reported several technologies used by the articles they reviewed. Some of these technologies are:

- LMSs: e. g., Moodle, Blackboard, Canvas, and Edgenuity
- MOOC platforms: e. g., Coursera and EdX
- Video conferencing platforms: e. g., Zoom, D2L, Adobe Connect, Webex, Skype, Big Blue Button, EduMeet, Google Hangouts, GoToMeeting, Google Classroom, Microsoft Teams, Google Meet, Echo360, and FaceTime
- Social media platforms: e. g., Facebook, Twitter, YouTube, ILEARN, e-Case Live, and WhatsApp
- 4IR/Industry 4.0 technologies: e. g., virtual, augmented and mixed realities, 3-D models, robots, artificial intelligence, Internet of Things, and Google Cardboard
- Simulation platforms or 3-D models platforms: e. g., The Neurosurgical Atlas, and Touch Surgery;
- Specific robots: The NAO robot, AMiRo, GuiBot, and LEGO Mindstorms
- Podcasts, Kahoot!®, Mentimeter AB, and VoiceThread
- Online examination/test platforms: e. g., eProctor and ExamN.

Two reviews suggested robots to be used, while 7 reviews did not mention or report any technologies used by their reviewed articles.

#### **4.4 Major Themes**

As portrayed in Appendix A, the 18 review articles had multiple themes or purposes related to education, and medical, surgical and dental education in HE on the one hand ( $n = 10$ ), and to business, management, supply chain and bibliometrics in HE on the other hand ( $n = 3$ ). However, despite their multiplicity, most of these themes seem to converge and coalesce in terms of their foci. For example, 11 of these reviews had their themes explicitly foregrounding the COVID-19 pandemic and its impact in HE. This impact is in the form of opportunities/advantages and challenges/disadvantages in areas such as education, and medical, surgical and dental education; and medical student and resident training, and surgical training. It also relates to research in education, business, economics and management. Additionally,

the convergence of some of the themes of these reviews is in terms of learning, especially, either e-learning, distance learning, or online distance learning (n = 6). Moreover, it is in respect of teaching, particularly either online teaching (n = 1), virtual medical teaching (n = 1), effective or instructional strategies (n = 2), or continuing, or sustaining/sustainable teaching (n = 4).

## 4.5 Main findings and key conclusions

The main findings of the reviewed articles related primarily to the major themes or the purposes these articles had. Even though this is the case, nonetheless, there are common features that can be detected. These similarities fall into six categories:

- COVID-19
- Education (including medical, surgical, and dental education)
- Online teaching and learning
- Educational challenges (weaknesses) and educational opportunities (strengths)
- Educational continuity and educational recovery
- Educational technologies

The above-cited categories relate principally to how the COVID-19 pandemic has affected education in HEIs, especially mainstream education, and medical and surgical education, and how there has been a move to embrace online (virtual) teaching and learning, and online educational technologies (e. g., AI and AR) for educational continuity and recovery. They also have to do with educational challenges and opportunities brought about by the COVID-19 pandemic. Moreover, one review's main findings are about the impact of COVID-19 pandemic on academic research in education, business, economics and management in HE, while those of another review have to do with the impact of COVID-19 on the different facets of business and management (e. g., technologies, supply chain management, and the service industry).

The key conclusions of the reviewed articles can be summarized in two broad categories: COVID-19 as a trigger event, and its impact on HE; and the types of responses, reactions, or solutions of HEIs to and the recommendations made by HEIs in respect of this trigger event. Some of these factors are reflected below (see Appendix A):

- A forced migration to online instruction and virtual technologies (video conferencing, social media, and tele-medical tools) by HEIs. This migration varied across HEIs. This online migration helped maintain educational continuity or facilitated educational recovery.
- Virtual teaching is effective in HEIs
- There were challenges (e. g., faculty’s technological non-readiness, Internet connection problems, and transitioning content to online learning platforms)
- A need to improve the quality of online teaching and online content, and to pay attention to online teaching and learning infrastructure
- AR offers its own unique advantages for virtual learning
- A need to introduce educational staff and students to introductory courses and competitions related to the educational uses of robots.

These factors constitute transitional or adaptational responses, reactions, or solutions of HEIs to COVID-19 as a trigger event.

## 5 Discussion and conclusion

The current overview investigated instances of technological experimentation related to online technologies for teaching and learning used by HEIs during the current COVID-19 pandemic as reported by 18 review articles. It also examined major themes, main findings, key conclusions, and other characteristics of these 18 review studies. The discussion is confined to RQ2 and RQ3, and focuses on two of the special issue’s foci: how teaching and learning cultures in HE look like and how they have evolved as a result of recent changes in teaching and learning; and approaches to change and innovation that are relevant for HE teaching and learning.

With reference to RQ2, there are different sets of online technologies with which HEIs have experimented during the COVID-19 pandemic to maintain their academic continuity. These sets range from LMSs, MOOCs, and social media platforms to video conferencing platforms and 4IR technologies. Most of the academic disciplines in which this technological experimentation has taken are: education; supply chain; medical and surgical education; dental education; business; economics; and management. Educa-

tion, with its many permutations (e. g., distance learning, online education, etc.) is the academic discipline in which the most technological experimentation has occurred. It is followed by medical education. Some of the subject areas in which online technologies have been applied are curriculum and surgery. This means that the COVID-19 pandemic is a trigger event that has made HEIs pivot to online teaching and learning experimentation in the academic disciplines and in the subject areas reported by the 18 review articles. This online pivoting seems to be a new and emerging teaching and learning culture in the HEIs of the countries reported by these review articles (see Appendix A). Additionally, this online pivoting tends to signal a necessary change and innovation embraced by these HEIs during the COVID-19 pandemic. It is a pandemic technological change and innovation that underpins their SoTL.

Pertaining to RQ3, the six categories of the major themes of the review articles reflect the manner in which HEIs responded and reacted to the COVID-19 pandemic and the areas of HE to which these responses and reactions were directed. Even though six categories have been identified, all of them, bar one, have to do with education: its online teaching and learning version; its continuity and recovery; its challenges and opportunities; and technologies used during the COVID-19 pandemic. This scenario highlights the responsive or reactionary mode in which HEIs have operated during this period. Moreover, it emphasizes COVID-19 as a trigger event that has impacted HE and forced it to respond or react to it by embracing forced online instruction migration and virtual technologies in search of solutions for its teaching and learning enterprise. All of this collective approach has elements of transitional or adaptational responses, reactions, or solutions.

When viewed from a change and innovation perspective, the responses and solutions adopted by HEIs as reported by the 18 review articles reflect innovation in as far as the use of video conferencing platforms, 4IR technologies, simulation platforms, and online examination platforms is concerned. However, the use of LMSs, MOOCs, social media platforms, and podcasts is not innovative as these technologies have been employed for online teaching and learning by HEIs prior to the COVID-19 pandemic. In fact, the practice of online teaching and learning is not new nor is it innovative. Moreover, the fact that one of the key conclusions of the reviewed articles is that HEIs were forced to migrate to both online instruction and virtual technologies indicates how these institutions adopted emergency remote teaching (ERT) to maintain academic continuity during the COVID-19 pandemic.

## 5.1 Limitations and implications

This overview has some limitations. First, its search of review articles was restricted to the 14 online databases it employed, a factor which, despite numerous searches, could have limited possible candidate articles to these databases. Second, the keywords used and their attendant combinations, irrespective of their multiple iterations, may have had an impact on the types of resultant candidate articles yielded by the 14 online databases. Third, the focus on peer-reviewed journal articles excluded review articles that were in preprint forms, which could have shed additional insight into the topic investigated by the present overview. However, preprints were excluded as they are not peer-reviewed, something which is a bitter-sweet development as the COVID-19 pandemic has spawned the era of preprints in scholarly publications. Fourth, the 18 review articles are fewer, and yet they are too heterogeneous. Regarding heterogeneity, it is not uncommon for qualitative overviews to investigate diverse review articles and synthesize their characteristics. Fifth, review articles selected were confined to those published in English, a factor that excluded reviews published in other languages. However, despite these limitations, this overview is likely to serve as an anchor point or as a reference point for future similar overviews.

One implication of this overview is that the COVID-19 pandemic seems to have disrupted HE immensely, and the possibility of a return to the old normal appears to be slim at the moment. It is ironic that it has taken a pandemic of the magnitude of COVID-19 to be a technological disruptor for HEIs to embrace online educational technologies in the way that they have done. It is even a double irony that 4IR/Industry 4.0, long touted as a disruptor itself pre-COVID-19, has not led the way in this regard, and that it appears not to have had a high uptake among HEIs in the midst of this pandemic. However, all of the educational technologies reported in this study and the embracing of online teaching and learning are a valuable technological experimentation that can be transferred to the post-pandemic *new normal*.



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# Appendix A

Author(s) & publication year	Country	Review type	Database(s) searched	Research design	Sample sizes	Discipline(s)/ Subject area(s)	Reported Online/ Digital technologies used	Major themes	Main findings	Key conclusions
1. Butler-Henderson et al. (2020)	Australia, Singapore, USA & India	Systematic literature review	10 (Academic Search Ultimate; EBSCO; IEEE Xplore; Informa Online; Ovid; Proquest; ScienceDirect; Scopus; Web of Science; and Google Scholar)	Mixed-method (The PRISMA approach)	138 manuscripts published online between 01 Jan 2020 and 30 June 2020	Teaching, curriculum, education, students, and researchers in diverse disciplines	Not applicable	Documenting a method for creating the first version of the COVID-19 in Higher Education Literature Database (CHELD).	Not applicable	CHELD is the first database in HE that curates and openly shares the existing literature for HE practitioners and researchers.
2. Camilleri (2021)	UK	Systematic review	Scopus plus inter- and non-governmental policy documents and university ranking sites and league tables	Qualitative (Grounded theory-based inductive reasoning)	82 conference proceedings, 21 reviews, and 15 book chapters.	Not mentioned	Several technologies: LMSs (e.g., Moodle, Blackboard, Canvas); MOOC platforms (e.g., Coursera and EdX); video-conferencing platforms (e.g., Zoom, D2L, Adobe Connect, Webex, Skype, Big Blue Button & EdumMeet).	Presenting the latest opportunities and challenges that HEIs faced due to the COVID-19 pandemic.	HEIs can employ several performance metrics and indicators to assess service quality for students, research, and resources.	The COVID-19 pandemic has compelled HEIs to embrace virtual technologies to deliver instruction, to disseminate research, and to engage stakeholders.
3. Cavus et al. (2021)	Cyprus & Nigeria	Systematic review	4 (Web of Science, EBSCO, Scopus, and PsycINFO)	The PRISMA approach	31 peer-reviewed journal articles	Not mentioned	Facebook; Twitter; YouTube; ILEARN; and e-Case Live	Highlighting the prevailing e-learning challenges and providing effective strategies for a sustainable educational use of SNSs by institutions, teachers, and students during the COVID-19 pandemic.	Some of the main findings showed the viable use of SNSs for communication, collaboration, content creation, and resource sharing during the COVID-19 pandemic.	SNSs can support traditional LMSs for teaching and learning purposes, and can enhance student engagement during the COVID-19 pandemic.

4. Chowdhury et al. (2021)	Australia & Bangladesh	Systematic review	2 (Google Scholar and Web of Science)	A systematic literature review (SLR) approach	74 articles published on or before 28 Sep. 2020	Supply chain disciplines	Recommended technologies to use during and post-COVID-19 pandemic: mobile devices; personal protective equipment (PPE); ventilators; and Industry 4.0 technologies such as cloud computing, 3-D printing, digital supply chains, drones, the Internet of Things (IoT), artificial intelligence (AI), and big data analytics.	Describing main themes, methodologies, context, and theories employed in each article.	Four themes emerged in the reviewed articles: impacts of the COVID-19 pandemic; resilience strategies for handling impacts and recovery; the role played by technology in applying resilience strategies; and supply chain sustainability.	There is a dearth of empirically designed and theoretically grounded studies in supply chain.
5. Dedellia et al. (2020)	Greece, USA & UK	Systematic review	2 (MEDLINE and EMBASE)	Qualitative descriptive (The PRISMA approach)	61 manuscripts	Medical and surgical education	Google Hangouts; Skype; Zoom; GoToMeeting; Webex; The Neurosurgical Atlas; podcasts; Twitter; Facebook; simulation programmes; virtual reality; and 3D models.	Identifying challenges brought by the COVID-19 pandemic to medical and surgical education, and proposing innovations to enable the continuation of medical student and resident training.	Disruptions of medical and surgical education spawned by the COVID-19 pandemic have necessitated a prompt evaluation and discussion of the available methods that can be used globally to address these educational challenges.	Solutions such as virtual learning, videoconferencing, social media, and telemedicine can address COVID-19 related challenges in medical and surgical education.
6. Hope et al. (2020)	UK	Systematic review	4 (MEDLINE, EMBASE, PubMed, and the Cochrane Central Register)	The PRISMA approach	29 journal articles	Surgical training (education)	Not mentioned	Describing the global impact of COVID-19 on surgical training.	Most studies reported a move towards online educational	Owing to the COVID-19 pandemic, surgical training needs to shift from

7. Misieliu (2020)	South Africa	Literature review	16 (Google Scholar; EBSCOhost; ScienceDirect; Web of Science; Jstor; Science online; Sabinet; Scopus; Project MUSE; Proquest; Academic Search Complete; SAGE Journals; Social Science Research Network; Web of Science Core Collection; SpringerLink; and Social Sciences Citation Index (Web of Science))	An extensive literature search	85 peer-reviewed journal articles	Not mentioned	Not specified	Eliciting relevant evidence on e-learning and e-teaching challenges and opportunities in the era of the COVID-19 pandemic.	Most of the reviewed studies addressed HEIs' response to COVID-19 and challenges related to online teaching and learning. Few studies highlighted opportunities presented by the pandemic and academic outcomes.	Even though COVID-19 had a lot of challenges, it has also created opportunities for HEIs in terms of new approaches and tools for online learning, and in relation to capacity building.	tools; and all of the included studies reported a decrease in the number of operative cases available to trainees.	traditional models of learning to online learning (training).
8. Pregowska et al. (2021)	UK & Poland	Scoping review	6 (IEEE Xplore; Google Scholar; Elsevier; Directory of Open Access Journals (DOAJ); European Open Science Infrastructure (OpenAIRE);	A scoping review approach	Over 100 publications	Fields such as physics, geography, chemistry, biology, engineering, and medical studies	Virtual, augmented and mixed realities; Zoom; Google Classroom; Microsoft Teams; D2L; and Edgenuity	Providing an overview of the history of distance learning.	Online learning offers wide access to education—not only during a pandemic—but in specific geographical locations, and also for people with	The COVID-19 pandemic presented a litmus test for the e-learning formula, and different countries seem to have coped in well in varying degrees.		



9. Ramirez-Montoya (2020)	Mexico	Systematic literature review	NB: Plus websites. 2 (Web of Science and Scopus)	A systematic literature review method	245 articles	Transversal	Not specified	Analyzing the evidence published about open education in the period 2014–2019 to identify future challenges.	The challenges caused by global crises such as the COVID-19 pandemic; require all stakeholders to collaborate with a view to innovating open education for all.	During contingency times such as that of COVID-19, educators, students, educational administrators, parents, decision-makers, and society need to expand educational avenues.
10. Rodrigues et al. (2020).	Portugal	Systematic literature review	2 (Web of Science and Scopus)	A systematic literature review approach	93 peer-reviewed journal articles	Education, business, economics and management	Not mentioned	Mapping the scientific literature in education, business, economics and management in the context of COVID-19 and analyzing its content through bibliometrics.	Studies reviewed were of conceptual, empirical, exploratory and descriptive typologies. Two main sub-topics were identified: online education and COVID-19's relation with the research areas of education, business, economics and management.	Publications in health grew faster than in fields such education, business, economics and management. Scholars in management and education were faced with paradigmatic challenges.
11. Santos et al. (2020)	Brazil	Systematic review	10 (Google Scholar; ProQuest; Open Grey; Cochran; Embase; Lilacs; Livivo; PubMed; Scopus; and Web of Science)	The PRISMA approach	16 studies	Dental education	Several reported technologies: E.g.: Moodle; Zoom; Google Meet; Google Classroom; Kahoot <sup>®</sup> ; CAE Learning Space; Mentimeter AB; Dent:INJURY	Elucidating experiences, benefits, and challenges imposed on dental education by the COVID-19 pandemic, the learning technologies, and methods	All studies highlighted the use of learning technology to ensure education continuity; 15 studies described the pedagogical models applied; 8 studies	The results suggest that learning technologies can support continuity in dental education. Reported problems include poor knowledge of faculty members on how



12. Talib et al. (2021)	United Arab Emirates	Systematic literature review	3 (Google Scholar, Elsevier, and Scopus)	The PRISMA approach	47 articles	Not specified	APP ; Echo360; eProctor (e.g., ExamIN); Metrics platform; autonomous simulation equipment; micromotor;; touch surgery; and virtual reality	used to sustain education.	investigated knowledge gain, while 12 searched learners' satisfaction with online technologies.	to handle technology, internet connection, and content transition to online education..
13. Teymori & Fardin (2020)	Iran	Review	4 (PubMed, Medline, Elsevier, and Science Direct)	Not mentioned	9 articles	Not mentioned	Not mentioned	Investigating online education and summarizing specific instructional	Reviewed studies indicated the success of online education during the	The value of online education has become more urgent than ever before. So, it is necessary to pay special attention

14. Vargo et al. (2020).	USA	Rapid review	4 (Google Scholar, Web of Science, Scopus, and PubMed)	A rapid review method	281 empirical articles	Healthcare, (medical) education and workplace	<p>Several technologies:</p> <p><b>Healthcare</b></p> <p>Computerized tomography machines; robots; wearable devices; mobile devices' sensors; digital HIP AA. complaint tools; 3-D machines; Zoom; FaceTime; WhatsApp; Facebook messenger; thoracic VCAR software; YouTube; Twitter;</p> <p>artificial intelligence (AI); the internet of Things; virtual reality.</p> <p><b>(Medical) education</b></p>	<p>strategies for online teaching.</p> <p>Sketching an expansive, multilevel model of the current knowledge of how humans are using technology during the COVID-19 pandemic.</p>	<p>COVID-19 period. However, there were some problems in the transition from face-to-face teaching methods to online educational methods.</p> <p>Twenty eight various forms of technologies have been used, ranging from computers to artificial intelligence; eight different populations of users are using these technologies, primarily medical professionals.</p>	<p>to the appropriate infrastructure required for online learning in Iran's education and the higher education system.</p> <p>Digital technologies such as computerized tomography machines, video-based communication platforms, and AI have been broadly used in healthcare, education, work, and daily life domains during the COVID-19 pandemic.</p>
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15. Verma & Gustafsson (2020)	Denmark & Norway	Bibliometric analysis	2 (Scopus and Web of Science)	107 articles	Business and management	Web-enabled computers; mobile devices; Zoom; WebEx; Google Hangouts; GitHub; Blackboard; Coursera; VoiceThread; Cloud classrooms; Google Cardboard; AI; and virtual reality.	Suggested technologies to use: the internet of Things, AI, big data analytics, and drones.	Presenting the findings of a bibliometric study of COVID-19 literature in business and management so as to identify current areas of research, and proposing a way forward.	This study examined the impact of COVID-19 on different facets of business and management, and identified four major themes: impact of COVID-19 on overall business; technologies; supply chain management; and the service industry.	This bibliometric study revealed that, within a short space of time (4% months), 107 unique documents had been published in Scopus and WoS journals, 272 different institutes, and 61 different countries.
16. Vuță (2020)	Romania	Literature review	1 (Google Scholar)	30 research papers	Several reported fields: chemistry, medical studies, engineering studies, science, multiple fields of education (e.g., emotional growth, learning, and	Augmented reality (AR), virtual reality (VR),	Presenting a systematic review of literature on AR in education in the last 3 years.	In the context of COVID-19 pandemic, AR technology has the potential to aid students and support educators in the learning process.	The findings of the literature review validate the view that AR offers its own unique advantages for virtual learning.	

17. Wilcha (2020)	UK	Systematic review	2 (PubMed and Google Scholar)	The PRISMA approach	34 articles	early childhood education). Medical education	Zoom, virtual reality simulation, and WhatsApp	Reviewing the advantages and disadvantages of virtual medical teaching for medical students during the COVID-19 pandemic as informed by the current emerging literature.	The strengths of virtual teaching included several web-based resources available. Weaknesses of virtual teaching included technical challenges, confidentiality issues, reduced student engagement, and loss of assessments.	The evidence from the reviewed articles suggests that virtual teaching is effective, and institutions are working to further develop these resources to improve student engagement and interactivity. Special attention needs to be given to the mental impact of COVID-19 on students and to improving the security and technology of virtual platforms.
18. Younis et al. (2021)	Iraq & Malaysia	Survey/ Systematic literature review	5 (Scopus, Taylor & Francis, ScienceDirect, IEEE Xplore, and Web of Science)	Not mentioned	35 articles	Education	The MAO robot, AMIRO, GuiBot, LEGO mind storms, and EV3robotics	A need for e-learning and robotics education for students to continue their studies and to avoid the mingling between academics and students.	The results indicate that the application category carries 17.4%, the platform category 20%, and the education category 22.85%.	It is necessary to introduce educational staff and students to introductory courses and competitions related to the educational uses of robots.