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Research Article

Higher Education during Lockdown: Literature Review and Implications on Technology Design

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Countries globally reacted to the COVID-19 pandemic by imposing lockdowns, and as a consequence, higher education institutions were forced to rapidly transition into distance learning. Here, technology played a paramount role as the enabler of remote learning and shaping teaching practices. The aim of this study is to understand the broad trends in higher education during the early lockdown transitions and the role of technology in this process through a literature review approach. After searching for literature and applying inclusion and exclusion criteria, 61 relevant publications were discovered, which were sorted into three clusters using co-word analysis: (1) teaching and learning; (2) policy and managerial issues; and (3) students' psychological well-being. Each theme was further divided into subthemes based on a thematic clustering approach. Based on this review, implications on learning technology design during the time of a pandemic were derived. First, due to the lack of social contacts resulting from isolation measures, emphasis is needed on interstudent interaction. Second, mobile distance learning technologies and teaching methods could be designed to enable students to move or exercise while learning. Third, diverse pedagogical approaches should be looked into to bring variety into students' lives.

1. Introduction

Governments issued restrictions on citizens' movement and social meetings globally starting from March 2020 onward to combat the spread of the new coronavirus disease (COVID-19) [1]. In this setting, universities and other higher education institutions (HEIs) were forced to rethink their existing modi operandi quickly. Changes concerned, for example, lectures, library services, school lunch, social meeting places, lab work, learning support groups, and extracurricular activities such as campus sports [2, 3]. As students and staff started working from home, HEIs turned to technology and the Internet to keep operating under the new circumstances [4–6]. This rapid transition from brick and mortar to completely online environment created challenges for the technological solutions and infrastructure, students, and the teaching and supporting staff.

Previous work has demonstrated that online learning has characteristics that make it different from contact teaching (e.g., [7]). Accordingly, the transition to work from home inadvertently required teachers to change their existing teaching practices. Students also faced new challenges, such as maintaining social relationships with their classmates and self-regulating their learning. From the perspective of HEI management, the restrictions on movement and social gatherings meant changes to the organization of staff meetings, examinations, and support services, among others. There is evidence that the pandemic caused students additional cognitive load due to the holistic changes to their lives and the looming pandemic threat [1, 8, 9], and to reduce any additional cognitive strain, top-down communication of how to operate needed to be clear. This situation pressured HEI management to quickly conceptualize what was going on and communicate decisions to students and the teaching

staff. As a consequence of all these changes, the role of learning technologies and education management systems was suddenly highlighted.

To select optimal learning technologies in this setting, policymakers and teachers need to understand the needs of the students, teachers, and HEI administration. As the major disruption during COVID-19 on HE was the transition into distance learning, the research question arises of whether and how distance learning technologies could also consider factors outside the immediate teaching and learning context. Therefore, the following research question (RQ) is investigated in this study.

RQ: Based on the academic literature, what challenges higher education institutions faced in the first half of 2020 when transitioning to distance learning, and what implications do these have on technology design?

To address the RQ, an examination of the research domain profile of HE during COVID-19 was conducted. First, a quantitative bibliometric analysis was performed to understand the main areas of focus in the extant literature. Second, a qualitative read-through and clustering of the articles were conducted to obtain more detailed insights into the literature. These processes led to identifying the main research trends and themes in the early literature on HEI during COVID-19. The analysis was then continued towards elucidating the areas of HE where the transition to distance education impacted and what is required from learning technologies during the new normal to facilitate students' learning and well-being.

2. Background

2.1. The Preparedness of Higher Education to Transition into Distance Learning. HEIs are constantly seeking ways to improve and optimize their existing teaching practices, both the content and pedagogy. One of the recent trends in HE has been the development and use of technological tools, sparking research into areas such as computer-assisted collaborative learning (e.g., [10, 11]), educational games (e.g., [12]), and asynchronous online learning [13]. Technological advances and the availability of learning tools have increased the popularity of some pedagogical approaches such as flipped learning or blended learning [14, 15] but also provided analytical tools for improving existing teaching [16, 17]. Before the COVID-19 pandemic, some universities already offered full online degrees [18], some offered a few online courses [19], and others still relied entirely on contact teaching [20].

While there are differences between individual HEIs and students, it remains unclear to what extent there were significant differences between HEIs in their ability to transition to working from home during the COVID-19 pandemic. Furthermore, as some courses in, e.g., physics, chemistry, and biology, might require presence due to lab work, there may have been differences between study disciplines within a university on adapting to the COVID-19 pandemic. An interesting aspect here is that while the technology existed to support fully online teaching, it may have been more difficult from an organizational perspective. Furthermore, distance learning brings many new variables for consideration regarding students' learning, such as the influence of students' and teachers' home conditions, self-regulation abilities, technical skills, and online social self-efficacy. Overall, the sudden change brought to HE by the COVID-19 pandemic introduced multiprong challenges that technology was increasingly expected to solve. Understanding these challenges is crucial for selecting and designing learning technologies that best suit HE students' and teachers' needs.

2.2. The Bibliometric Analysis Technique. Bibliometric analyses have been used extensively for studying novel, unclear, or obfuscated research areas, as they can provide an objective view of a specific research domain without involving researchers' subjective interpretation [21–23]. In recent years, the bibliometric review technique has been utilized for examining the evolution of research domains that include contributions from various disciplines. Examples of this include strategic management [24], corporate social responsibility [25], medicine [26], machine learning [27], the Internet of things [23], and information security [22]. Thus, unsurprisingly, scholars have also used bibliometric analysis to examine various research domains in the context of the COVID-19 pandemic. Table 1 shows five early bibliometric studies that have been conducted in the context of COVID-19.

The studies shown in Table 1 are related to a particular field or research domain, but there exists also broad bibliometric studies that are mostly aimed at identifying what is being studied across all disciplines (Hossain et al., [33]). In their recent bibliometric study, Verma and Gustafsson [28] identified 142 papers from Scopus and Web of Science relevant to the business and management field. They identified 18 clusters using coword analysis and referred to them as subthemes. They then put these subthemes into four main themes subjectively (overall impact of COVID-19 on business, COVID-19 and technology, COVID-19 and supply chain management, and COVID-19 and service industry). Zambrano et al. [30] analyzed bibliometric data of 223 papers collected from Scopus, using an R package. They found two themes: reporting of COVID-19 data and the psychological effects of COVID-19. Nasir et al. [31] reviewed publications from a broader timeline (2003 to 2020) and focused on social science in particular. Instead of explicitly looking for COVID-19-related literature, they also included studies on previous pandemics. With this approach, Nasir et al. [31] found four themes in the literature: social and economic effects of epidemic diseases, infectious disease calamities and control, the outbreak of COVID-19 and infectious diseases, and the role of international organizations. Tangriverdi et al. [32] conducted a review of the literature published in the Journal of Air Transport Management and provided suggestions for future directions in post-COVID-19 time for air transport management. Finally, Rodrigues et al. [29] examined the research activities in education, business, economics, and management using bibliometric mapping. They utilized Scopus and Web of Science and identified 93 relevant publications. This study utilized a broad set of keywords, which led to three research clusters:

TABLE 1: Five bibliometric studies in the COVID-19 context.

Title	Field/domain	Data source(s)	Reference
Investigating the emerging COVID-19 research trends in the field of business and management: a bibliometric analysis approach	Business and management	Scopus, Web of Science	Verma and Gustafsson [28]
COVID-19 and disruption in management and education academics: bibliometric mapping and analysis	Education, business, economics	Scopus, Web of Science	Rodrigues et al. [29]
Publications in psychology related to the COVID-19: a bibliometric analysis	Psychology	Scopus	Zambrano et al. [30]
A bibliometric analysis of corona pandemic in social sciences: a review of influential aspects and conceptual structure	Social science	Scopus, Web of Science, Google Scholar, Emerald	Nasir et al. [31]
What can we learn from the JATM literature for the future of aviation post Covid-19?-a bibliometric and visualization analysis	Transportation	Journal of Air Transport Management	Tanrıverdi et al. [32]

TABLE 2: Keywords and search terms for the literature search.

Keyword	Search terms
Coronavirus	"2019-nCoV", "COVID-19", "Coronavirus Disease 2019", "Novel Coronavirus Pneumonia", "NCP", "2019 novel coronavirus", "SARS-CoV-2", "2019 Novel Coronavirus Diseases", "novel coronavirus", "pneumonia"
Higher education	"higher education", "tertiary education", "university education"

COVID-19 and online education, COVID-19 from a management perspective, and COVID 19 in Canada. These works showcase how the bibliometric analysis technique has been used to profile research areas at the time of the COVID-19 pandemic and are evidence of the usefulness of the method for understanding emerging study domains.

3. Methodology

The goal of bibliometric reviews is generally to identify trends within a particular research field by year, country, publication venue, method, citations, or theoretical approach [34]. The approach is particularly suitable for fields with large amounts of studies or fields that otherwise lack clarity. The bibliometric analysis provides an objective view of the literature using publications' metadata [35]. This metadata consists typically of the title, abstracts, and keywords, and these can be regarded to represent the core content of the article.

One of the primary tools for conducting a bibliometric review is a process called coword analysis. Coword analysis applies a text-mining technique to identify keywords that occur together in articles and consequently enables the discovery of a concept network of research topics and trends in specific disciplines or research domains [27, 36]. While COVID-19 pandemic forced HEIs to adapt to distance education quickly, research on related phenomena was also produced rapidly. This means that a bibliometric review via coword analysis is a suitable methodological approach to identify and elucidate trends in the newly emerged field of research.

3.1. Data Sources. In the previously published bibliometric studies during COVID-19, various data sources have been utilized, with the most prominent ones being Scopus, Web of Science, and Google Scholar [28–32]. In terms of cita-tions, Scopus provides wider coverage than the Web of Science [37]. Although Google Scholar offers a better citation score as compared to Scopus and Web of Science, it has been previously criticized for inconsistency [37]. Web of Science has better coverage of journal citations [38]. Keeping all these in mind, Scopus was chosen as the data source for this study due to citation counts, coverage, and consistency [22]. The academic literature on COVID-19 is already large, consisting of journal articles, conference proceedings, editorials, books, and book chapters. As data source quality is paramount in bibliometric reviews, only studies published in journals indexed in Scopus were focused on.

3.2. Literature Search. Since this study is aimed at examining the current research in HE related to COVID-19, the first step was to identify the search terms that could be used for identifying relevant publications. For this purpose, a list of search terms related to COVID-19 was produced based on the studies listed in Table 1. As the aim was to look at literature related to higher education, a broad set of keywords was used, including "higher education", "tertiary education", and "university education", instead of more focused keywords such as "online education", "distance education", or "e-learning". In this way, a wide coverage of related studies with a focus on higher education (but not on school or primary education) could be obtained. Table 2 shows the keywords and corresponding search terms used for the data search in this study.

The Boolean operators, OR and AND, were used to conjugate the terms; OR was used between search terms of one keyword, and AND was used to concatenate synonyms of "coronavirus" and "higher education". On September 15, 2020, the title, abstract, and keywords of literature published during 2020 (January 1st-September 14th) were searched. Altogether 135 publications were identified. The full set of
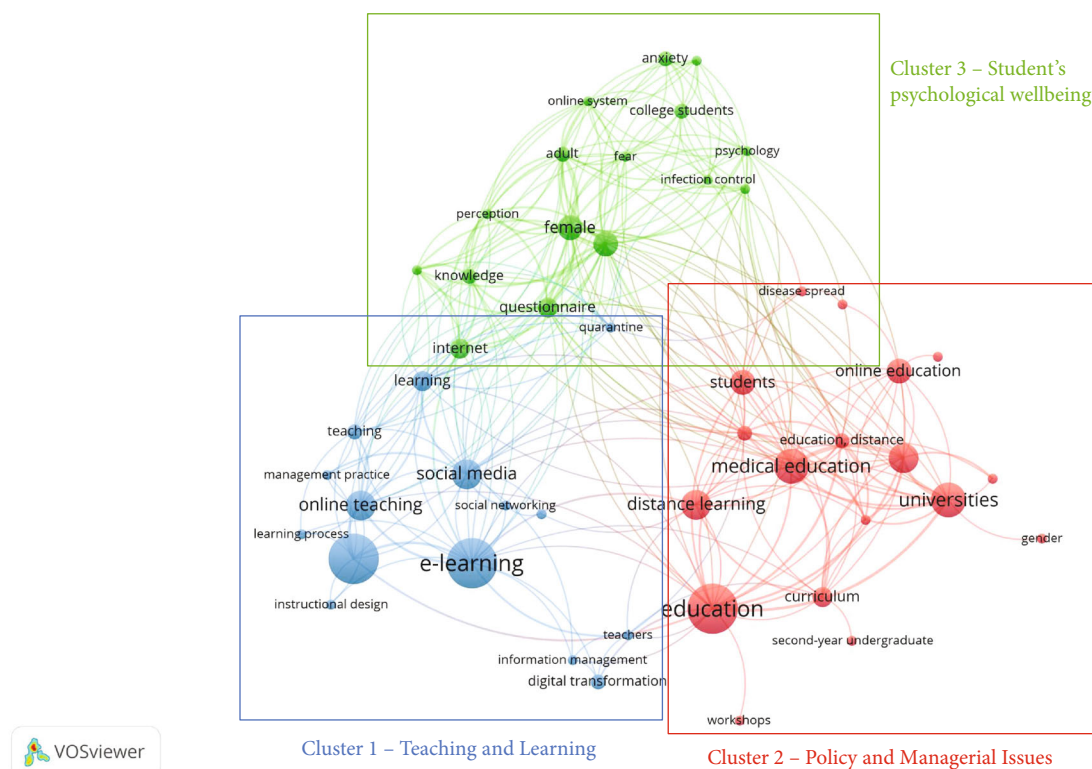
FIGURE 1: Clusters resulting from the bibliometric analysis.

bibliometric records, abstracts of the publications, and keywords were exported to a CSV file for further processing.

3.3. Data Analysis. Before proceeding with the coword analysis [36], two of the authors manually read the abstracts of each of the 135 studies. The following exclusion criteria were applied to remove irrelevant publications:

(1) Publications not written in English

(2) Publications where students were used as a convenience sample to understand a phenomenon completely unrelated to HE or which were otherwise unrelated to HE

Following the example of recent work [28], the exclusion criteria were kept voluntarily simple to minimize the number of false negatives and to avoid interauthor disagreement. This ensures the reproducibility of the research and supports the goal of objectivity in bibliometric coword analysis. In situations where it was not clear whether to include or exclude a study, it was included in the sample. After removing publications that matched the first two exclusion criteria, 61 publications remained. Next, the coword analysis was applied to the keywords of the publications to identify the research area profile using VOSviewer [36]. This allows the identification of the words (nouns) that cooccur in the target literature. The cooccurrence matrix words then cluster up the concepts that were studied together, which reveals visualization of the structure of the research domain [22, 39].

To obtain further insight into the research field, all studies in the final analysis ($n = 61$) were downloaded and read

in full by the authors. Using the coword analysis clusters as a starting point, the studies were further classified into subthemes based on full-text assessment. Two authors discussed the studies in each cluster and iteratively developed subthemes that best describe the data. After two authors agreed on the subthemes, the studies were placed in these themes. Building off these findings, design considerations were formulated for teaching in higher education during lockdown.

4. Results

The results of the bibliometric analysis are shown in Figure 1. Three clusters were identified, all interconnected with each other. The size of the circle depicts how often a specific term appeared in the papers, and the lines show the terms that they appeared together with. Based on the clustered terms, the corresponding sets of publications were looked at by the authors, and each cluster was given a title that the authors felt described the cluster. Table 3 shows the cluster number, cluster color, ten frequently occurring terms in the given cluster, and the proposed title of the theme.

4.1. Cluster 1: Teaching and Learning. The cluster visualized in blue and displayed on the left in Figure 1 relates to teaching and learning in higher education. Following full-text assessment and the identification of subthemes, this body of research was divided into four subthemes shown in Table 4. The cluster describing the changes in teaching arrangements due to the COVID-19 pandemic was the largest of the four. One reason for this is that the transition into

TABLE 3: Detail of clusters within higher education and COVID-19 research.

Cluster number	Cluster color	Top ten frequently occurring terms	Themes
1	Blue	Learning, teaching, social media, online teaching, social networking, instructional design, e-learning, learning processes, teachers	Teaching and learning
2	Red	Students, curriculum, distance learning, universities, online education, medical education, education, distance education, disease spread, gender	Policy and managerial issues
3	Green	Anxiety, psychology, fear, online system, adult, female, perception, knowledge, questionnaire, Internet	Student's psychological well-being

TABLE 4: Subthemes and studies of cluster 1, teaching and learning.

Subthemes	Studies
Teaching arrangements	[40]; [41]; [42]; [43]; [44]; [45]; [46]; [47]; [48]; [49]; [50]; Mahmood, 2020; Mhlanga, et al., [51]; [52]; [53]; [54]; [55]; [56]; [57]; Quintana, et al., [58]; [59]; [60]; Sankaranarayanan, [61]; Skulmowski et al., [62]; [63]; [64]
Staff perspective	[65]; [66]; [67]; [68]; [69]; [70]
Student perspective	[71]; Callo, et al., [72]; [73]; [74]; Rizun et al., [75]; [76]; [77]
Effectiveness and use of e-learning	[78]; [79]; [80]; [81]; Zalite, et al., [82]

distance education required rapid action from teachers and HEIs, and the early literature analyzed in this study likely reflects findings from what was done in response. Next, the research in each subtheme is discussed.

4.1.1. Teaching Arrangements due to COVID-19. The most prominent subtheme in cluster 1 was teaching arrangements and practical considerations in transforming bricks and mortar to remote teaching in the face of COVID-19. Three papers focused on the general advantages and disadvantages of online learning [49, 60, 63]. This work identified flexibility, comfortability, and the requirement of self-discipline as advantages and technical issues and lack of face-to-face interaction as examples of the disadvantages of online learning. More general studies included Edelheim [43], who discussed the nature and goals of higher education in these changing times; Murphy [53], who discussed securitization for HEIs; Skulmowski et al. [62], discussing the possibility for universities to rethink higher education from the perspective of the reasonable use of technology; and Fujita [44] who focused on the design of effective learning environments during the COVID-19 pandemic. The rest of the studies could be divided into further subcategories based on the level at which they described the teaching arrangements (institutional level, curriculum level, course level, and the level of tools).

(1) Institutional Level. Studies focused on the institutional level discussed the instructional strategies on the level of HEI management. Three studies dealt with the practical considerations and instructional strategies to facilitate online teaching (Mahmood, 2020; [52, 54]), while one looked at HEIs' readiness to support their teachers, students, and teaching assistants as they transitioned to online instruction [48]. Neuwirth et al. [54] and Nuere and de Miquel [55] provided HEI level case examples reflecting on the changes made to teaching arrangements, primarily related to the

forced transition to distance education, in specific HEIs. Based on the authors' experiences on institutional issues such as social justice, fairness, and students' needs, Neuwirth et al. [54] provide a framework for teaching virtual classes that interlinks synchronous teaching (lecturing) with asynchronous communication (text and chat). Mahmood (2020) discussed the need to reconsider how to assess students' learning, highlighting the need for flexibility. In practice, this could mean giving students extra time to finish their projects or providing alternative ways of demonstrating their learning. Along the same lines, Osores et al. [56] considered virtual assessment possibilities and stressed that learning assessment should not be set in stone but should reflect the vocational needs and desired skillsets of the changing society, which is particularly relevant during the COVID-19 pandemic and the following new normal.

(2) Curriculum Level. Studies focused on the curriculum level discussed changes made in teaching arrangements within certain degree programs. Most of these studies considered a transition to online teaching in programs, which traditionally require campus-based teachings, such as entrepreneurship education [59], chemistry [47], teacher education [57], physical therapy [45], anatomy [50], and social work [41]. These studies broadly described innovative solutions to transition practical and immersive training online via, e.g., augmented reality and scenario planning, videos, virtual experiments, and virtual learning platforms.

(3) Course Level. The course-level studies mostly focused on applying instructional strategies in the context of specific courses or certain types of courses such as organic chemistry [40], a course in ecology [46], and a course in counseling theories [42]. These studies looked at courses before COVID-19 taught in bricks and mortar, such as chemical experiments and clinical skills. A few studies focused on applying certain teaching methods, such as experiential

TABLE 5: Subthemes and studies of cluster 2, educational policy and economic impact.

Subthemes	Studies in cluster
Predicting the large-scale impact of COVID-19 on HEIs	[84]; Blakenberger and Williams, [85]; [86]
COVID-19 accelerating existing trends	[87]; Cai, [88]; [89]; Murphy and Shalley, [90]
Equality, diversity, and racial issues	[91]; [92]; [20]; [93]

education, guided online instruction [42], and online collaborative projects (Sankaranarayanan, [61]). In one study, the main emphasis was on engaging students in online course environments [46]. Here, the assessment was also studied, but instead of the curriculum level, it was studied in the context of a specific course (Quintana et al., [58]).

(4) Tools. The final cluster of studies in this subtheme was about using digital tools, e.g., a paper reviewing annotation tools and suggesting using social annotation in online teaching [64]. One study tracked the rate at which various HEIs used the fourth industrial revolution (4IR) tools during the COVID-19 pandemic (Mhlanga et al., [51]).

4.1.2. Staff Perspective. Studies in this subtheme dealt with either staff training and professional development or HEI staff's perceptions and experiences concerning the transition into online teaching.

(1) Staff Training and Professional Development. The COVID-19 pandemic put heavy pressure on human resource development, particularly on the training of teaching staff on how to use existing online tools for their courses [65]. This was viewed as a shared responsibility between the teaching staff, HEI management, and existing teacher support services. While open online resources on staff training existed (e.g., [83]), not all were aware of their existence. Furthermore, the rapid schedule in which HEI staff had to adapt to the work from home policy left little room for academic education, especially as teachers were busy transitioning their ongoing and upcoming courses to the online format [65, 69].

(2) Staff Perceptions and Experiences of Online Teaching. Despite the pressure HEI staff faced due to the transition into online education, one study, in particular, reported teaching staff to have had an overall positive experience of this process [67]. However, two studies were more critical. Watermeyer et al. [70] suggested that the migration to online environments caused significant dysfunctionality and disturbance to academics' pedagogical roles and their personal lives. Further, Sales et al. [68] reported that faculty members evaluated their students' information and digital competencies as inadequate, causing extra strain on the teaching staff.

4.1.3. Student Perspective. The third identified subtheme in the studies of the first cluster was students' perceptions and experiences of the online education transition. Shukri et al. [77] suggested that students perceive synchronous online learning as beneficial but not as effective as traditional classes. Online examinations were less challenging and pres-

suring for students than regular examinations [71]. The most common challenges among students are related to Internet connectivity and lack of interaction with the teacher and other students [71, 77]. Two studies in this cluster observed gender differences, with findings indicating that female students adapted to the transition into online education better [71, 76]. Other research directions included students' readiness to study online (Callo et al., [72]; Mohammed et al., [73]) and students' acceptance of online learning technologies (Rizun et al., [75]). Here, differences were found between students, for example, regarding what kind of study environment they had at home. One study also examined students' concerns regarding online teaching and whether the transition from brick and mortar to online impacted their anxiety levels [74].

4.1.4. Effectiveness and Use of e-Learning. The fourth subtheme was about the effectiveness and degree of online learning during the COVID-19 pandemic. From the global perspective, there seem to exist disparities in response to virtual learning across HEIs and national contexts [81]. A good technical readiness did not guarantee the development of good teaching practices. Both good technical tools and sufficient teachers' expertise in online teaching were required for efficient learning outcomes [80]. When measured in retention rates, students' success was reported to decline as the proportion of online courses in their studies increased [79]. One paper assessed the impact of the COVID-19 pandemic on HEIs in the European Union and their adaptability to the switch from brick and mortar to forms of distance education (Zalite et al., [82]).

4.2. Cluster 2: Educational Policy and Economic Impact. The cluster visualized with the red color and shown on the right of Figure 1 was characterized to focus on policy and managerial issues of HEIs during the COVID-19 pandemic. The cluster also contains aspects of online education similar to the first cluster, as evident by the keywords distance learning and online education belonging to the cluster. The subthemes of this cluster are displayed in Table 5.

4.2.1. Predicting the Large-Scale Impact of COVID-19 on HEIs. The complexity of the HEIs as organizations makes it difficult to make accurate analyses and predictions of the impact that the quarantine measures to combat COVID-19 have had on them [84, 85]. Starting from March 2020, HEIs had to iteratively adapt their response to the COVID-19 pandemic as the situation evolved [86]. For HEIs to react to crises such as the COVID-19 pandemic, flexibility, clarity, and agreed order of priorities are needed [86].

Universities in the UK estimated that the losses to UK-based universities in the first half of 2020 would be 790 million pounds and potentially in the next academic year (2020-2021) as much as 6.9 billion pounds [84]. This loss is primarily due to catering, accommodation, conference income, and students' appraisal of the worth of enrolling in a university for distance-only education [84]. However, the financial losses on HEIs due to the COVID-19 pandemic remain uncertain [84]. Given this situation, Blankenberger and Williams [85] argue that the role of HEIs during the uncertain time of the COVID-19 pandemic is to ensure that students receive a high-quality education and to create trust so that funding bodies keep supporting HEIs and students will keep applying and enrolling to study curricula.

4.2.2. COVID-19 Has Accelerated Existing Trends. HEIs were unique among businesses in that they globally transitioned into distance working in an extremely short time window [89]. This was made possible by the preexistence of the technical tools and infrastructure, meaning that the barriers to a transition into fully online education were primarily related to teachers' and students' needs, skills, and preferences [89]. Several studies discuss these changes as a new normal, indicating that there will be no coming back to the status quo before COVID-19 (Callo et al., [45, 72]). Al-Youbi et al. [87] point out that the COVID-19 pandemic permanently changed the needs of the labor market, meaning universities globally need to adjust their existing study curricula to meet these new demands. Cai [88] demonstrates that a trend to move away from standardized tests existed in the USA already before COVID-19, but the COVID-19 accelerated this shift. Societal change and the new normal were also visible in the argument that new educational measurements need to be devices to match the constantly changing requirements of the transforming society (Cai, [88]).

While the transition into online education may be cheaper for HEIs as, in the long run, costs related to office space and lecture rooms go down, the costs for students may continue climbing up. For example, Murphy and Shelley [90] demonstrated that low-income students struggled with the affordability of textbooks in the USA before COVID-19, and the switching to distance learning has further worsened the problem. While initially, course materials were offered online for free by some institutions, this solution was only temporary. Despite free educational resources existing online, universities require students to rely on paid materials (Murphy and Shalley, [90]). Besides educational resources, the work from home policy required students to have or purchase proper equipment for distance learning.

4.2.3. Addressing Equality, Diversity, and Racial Issues. While most HEIs in developed countries had the existing infrastructure to transition into distance education [89], developing countries did not necessarily have this capability [20]. Furthermore, in poor and developing countries, not all students have a quiet remote working place, a computer system, and a secure Internet connection [20]. In addition, universities lacked access to learning management systems that could support distance learning. As one solution, HE institutions in developing countries turned to available social media platforms for supporting offered courses [20].

Nash and Churchill [92] introduced the argument that academic women with children were disadvantaged during COVID-19. As schools closed, mothers had to look after their children while simultaneously doing remote work. Nash and Churchill [92] state universities did not adequately take this into account in their policy. Several equality issues are to be considered upon reopening universities after quarantines. Harper [91] lists 12, among which one is the potential risk of hatred towards Asian students due to racial stereotypes connected to the origins of the COVID-19 pandemic, and another is essential workers and other workers forced to work in crowded places being at an increased risk of contracting the disease. One study also expressed concerns that temporary changes made during COVID-19 may, in fact, last for prolonged periods, causing unequal treatment of the teaching workforce [93]. Furthermore, the pandemic response directed attention away from structural inequality within higher education institutions [93].

4.2.4. Students as a Resource for Propagating Trustworthy Knowledge about COVID-19. One study found students actively disseminate COVID-19 information to their friends and family predominantly through social media (Hashim et al., [94]). Viewing students as a resource for propagating trustworthy knowledge about COVID-19, HEIs need to ensure their students are taught sufficient knowledge about the disease and recommended health and social measures (Hashim et al., [94]).

4.3. Cluster 3: Students' Psychological Well-Being. The cluster on the top of Figure 1, visualized in green, is related to students' well-being, as evident from keywords such as psychology, anxiety, and fear. The subthemes of this cluster are displayed in Table 6.

4.3.1. Students Lost Access to Services and Social Meeting Places. The closing of HEI facilities meant not only the transition of lectures and workshops to the online format but also reduced access to services such as student support [2], school lunch cafeteria [84], and library services [3]. This accelerated the transition of these services to the online form where applicable, extending the reach of such services [2]. However, campus sports, school lunches, and conference dinners were not sufficiently replaced, and thus, these services were lost [84].

4.3.2. Studies on Students' Psychological Well-Being during Distance Education and Confinement. During the transition into distance learning in March 2020, students reported high levels of stress, anxiety, and depression [96]. The fear of personally contracting COVID-19 was one of the investigated antecedents of these negative outcomes. For this, the fear of the COVID-19 scale [95] was validated in the context of college students ($N = 237$) and found to have good validity and reliability [98]. Perz et al. [98] argue it is a good measure for student anxiety during the pandemic. In their study, age, gender, and income loss due to COVID-19 were not associated with fear of COVID-19, but personally knowing

TABLE 6: Subthemes and studies of cluster 3, students' psychological well-being.

Subthemes	Studies in cluster
Students lost access to services and social meeting places	[2]; [3]
Studies on students' psychological well-being during distance education and confinement	[95]; [96]; [97]; [98]

someone with COVID-19 symptoms was [98]. Another study found the opposite. Lan et al. [96] reported that females were significantly more likely to experience anxiety during COVID-19 than their male counterparts. Simultaneously, two other studies reported that females adapted better to distance education during the COVID-19 pandemic [71, 76]. While the fear of the COVID-19 scale measures the fear of personally contracting the disease, the economic and societal impacts of countermeasures against the spread may have also caused students' anxiety [99].

The only non-cross-sectional study on student anxiety during COVID-19 in our sample was the study of Li et al. [97]. They measured undergraduate students ($N = 550$) in December 2019 before confinement and again in February 2020, roughly 15 days after confinement. The confinement was associated with increased overall negative feelings, depression, and anxiety [97].

5. Discussion

The bibliometric review revealed three main research trends among the early literature on HEIs during the pandemic: (1) teaching and learning; (2) educational policy and economic impact; and (3) students' well-being. Out of the three clusters, the first one was the largest, which may be explained by the sudden changes to teaching arrangements that had to be made on a rapid schedule in early 2020 to align with government-issued social distancing rules. In this situation, the academic world reacted by sharing experiences and producing evidence-based information on best practices. The review revealed that educational policy, economic factors, and changes to students' well-being were studied, all influencing teaching arrangements. The research across the three clusters was primarily focused on the impact of social distancing and coping with the situation using technology. Accordingly, the observations have implications for learning technology design in the pandemic era.

5.1. Design Considerations for Learning Technologies in the Pandemic Era. Following the identification of the main research trends of higher education during COVID-19, the following design considerations for learning technologies in the pandemic era are proposed.

5.1.1. Design Consideration 1: Technology Should Provide Affordances for Collaborative Tasks to Scaffold Collaboration. Students' stress, anxiety, and depression levels increased during the COVID-19 quarantines [96], which a longitudinal study linked to time spent in social isolation [97]. As HEI students' social meetings were also restricted during COVID-19, the increased focus needs to be put on scaffolding interstudent communication and collaboration. Thus, designers could draw on the research tradition of computer-assisted collaborative learning [10, 11] to develop teaching strategies and technology design that enables students to have meaningful social interaction while engaging in distance learning. Strategies involving asynchronous messaging tools or chatting could be incorporated as part of the virtual classroom [54], or students could be directed to work on group projects and other collaborative endeavors. For example, teachers could allocate group homework tasks for students or reserve half of lecturing time for group discussions and student-teacher communication. Hence, the following concrete suggestions for teachers are provided:

(i) Reserve time for teacher-student communication during lectures and assign speaking turns for students to encourage participation

(ii) Assign group homework

(iii) Make use of collaborative learning tools and other social interaction opportunities during lectures, and outside them

5.1.2. Design Consideration 2: Audio-Only Lectures Could Be Utilized to Free Students to Exercise While Learning. With the social restrictions to combat the COVID-19 pandemic, several services were closed, including campus sports, gyms, and other sports facilities. Furthermore, as students were in a lockdown, they lacked the everyday exercise provided by commuting to campus and moving around during breaks. In this context, audio-only formats such as podcasts could be harnessed to allow students to move around while learning. This requires learning technologies to enable mobile listening of lectures, as well as mobile participation. The set of activities that can be done during lectures should be considered carefully, as some might hinder the students' ability to absorb knowledge. In practice, students listening to lectures should be encouraged towards activities that do not impose extraneous cognitive load on them, such as walking or weight lifting. Here, students should be made aware of what these activities could be for them personally. Potential examples include walking outdoors, gardening, cooking a familiar recipe, or knitting. Providing an audio-only lecture may require additional preparation and even a shift in pedagogical strategy from the teacher, but the outcome has the potential to increase the students' well-being. From here, the following suggestions for teachers for making audio-only lectures are derived:

(i) Specify to students which lecture is audio-only

(ii) Activate students with stories and other audio-based means during lecturing

(iii) Consider prerecording the lectures and enable students to relisten to them on demand

(iv) Facilitate follow-up discussion on group work

5.1.3. Design Consideration 3: Learning Technologies Should Support Various Pedagogical Approaches to Bring Variety to Distance Learning. To keep online education interesting for students, multiple pedagogical approaches and teaching strategies should be used. Instead of lecture-based teaching, various alternative forms of learning, from games [12] to project-based learning [100], could be utilized. This puts pressure on the teaching staff to design and organize different learning situations. Here, technology design can help by taking into account the need to utilize various pedagogical strategies. In practice, teachers should seek as complete existing solutions as possible to relieve pressure from them. For example, there are tools for 3D modeled virtual campuses such as Virbela, which have successfully been used during lockdown to provide students an alternative to real campuses [101]. For a more gamified approach, serious games designed to teach specific tasks are more relevant during lockdown than ever [102]. In summary, teachers could consider the use of, for example, the following technologies:

(i) 3D modeled virtual campuses and classrooms

(ii) Serious games

(iii) Interactive tools, quizzes, polls, and other activating technologies

5.2. Limitations and Future Work. This study has limitations in the way the bibliometric review was carried out. First, studies were fetched only from Scopus. While Scopus is the best-suited individual research database for this purpose, some important studies that do not appear in Scopus may have been left out. The search string also has limitations. While the terms for the COVID-19 pandemic and its synonyms could be considered robust, there were only three terms for looking up studies in HE. Arguably, terms such as "university" could have improved the search. However, the use of such broad terms would have increased the number of false positives, reducing the reliability of the bibliometric coword analysis. The search was directed at finding only journal articles, and the exclusion of book chapters and conference papers can be considered a limitation. Then again, including these might have lowered the quality of the sources, leading to a more distorted view of the research field. The search was conducted in September 2020, meaning that the literature reflects the early academic response on the impact of the COVID-19 pandemic on HEIs. Longer-term strategies and pedagogical innovations related to the later emerging new normal are thus likely missing. The design considerations presented in Discussion were derived from the authors' interpretation of the findings and should not be followed without criticism. Finally, the studies in the sample were conducted in 26 unique countries, with most done in the USA ($n = 18$) followed by the UK ($n = 6$) and Malaysia ($n = 4$). While there is diversity among the countries, the overrepresentation of USA-based studies means the findings should be generalized to the global population with care.

With regard to future work, students' lack of social contacts has already been explored in research concerning fully online degrees [103], but with COVID-19, there now exists large-scale real-world data on the situation. There is evidence of students' anxiety and depression levels rising [96], which can be attributed to quarantine measures and lack of social contact [97]. This imposes a challenge to both learning technologies and teachers. Learning technology designers need to think of how they can better scaffold collaboration, while teachers need to think about adopting teaching methods where students have more peer communication. This was also emphasized as a design consideration in the current study, and future work could look into this topic further. Also, the other two design considerations could be explored by intervention studies.

The reports that HEIs are losing money due to the COVID-19 pandemic [84, 85] have important implications for the future of HEIs. Research is needed on whether HEIs can pull back to become profitable without cuts. In the long run, a transition to online education may lead to a few HEIs dominating the education scene and smaller HEIs becoming obsolete. However, such scenarios are difficult to predict and require further study.

6. Conclusion

The aim of this study was to examine studies on HEI transition to online teaching due to the COVID-19 pandemic via a bibliometric approach and then to manually go through the studies to derive design implications for educational technologies in the pandemic era. This study can be understood as a look into the early reactions of the scientific community in terms of research output, and it shows three key areas of research that were produced: (1) teaching and learning; (2) policy and managerial issues; and (3) students' psychological well-being. As the pandemic situation normalises and HEIs enter the new normal of teaching and learning, this study can offer explanations and design ideas for the future of higher education.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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