

# **A cost-benefit analysis on the use of remote learning technologies: A systematic review and a synthesis of the literature**

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The outbreak of the Coronavirus (COVID-19) has had an impact on the educational programs of students around the globe. At the same time, it also opened a window of opportunity for them and for their educators. It encouraged instructors to embrace asynchronous as well as synchronous technologies to continue delivering their educational services, in real time. This research sheds light on the findings from a systematic review that evaluated academic publications on remote learning technologies. The authors relied on PRISMA's methodical protocol to capture and analyze high-impact articles through Scopus. This contribution identifies the costs and benefits of using digital media including learning management systems (LMS) and video conferencing software for educational purposes. It implies that the use of remote learning technologies will probably continue in the future as they may be utilized in blended learning approaches, in a post COVID-19 era.

CCS CONCEPTS • Human-centered computing • Human-centered computing – Accessibility - Accessibility systems and tools • Information systems - World Wide Web - Web applications - Internet communications tools - Web conferencing

**Additional Keywords and Phrases: remote learning, synchronous learning, asynchronous learning, conferencing technology, learning management systems.**

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## **1 INTRODUCTION**

After the outbreak of COVID-19 pandemic, educational institutions were expected to adapt to an unexpected crisis situation. In many cases, they had to follow their policy makers' preventative measures to mitigate the contagion of the pandemic [1, 2]. As a result, they introduced contingency plans, disseminated information on the virus, among students and employees. In many cases, educators were coerced to shift from the provision of traditional, face-to-face teaching and blended learning approaches, to a fully virtual remote course delivery [3, 4]. This transition resulted in a number of challenges to students and instructors [5]. In many cases, educators were pressurized to utilize digital technologies including learning management systems (LMS) as well as video conferencing programs [6]. Very often, they relied on their institutions' Moodle or virtual learning environment (VLE) software to share digital resources including videos, power point presentations and links to online notes [7]. During the pandemic educators also acquainted themselves with video-conferencing platforms [8].

Subsequently, when COVID-19 restrictions were eased, a number of educational institutions reopened their doors to students and employees [9]. They introduced social distancing policies and hygienic procedures in their premises [4, 10]. At the time of writing, a number of academic members of staff, in various contexts, are still utilizing learning technologies including LMS and video conferencing programs [6]. In many cases, student-centered educators are adopting hybrid/blended learning approaches, as they deliver face-to-face lectures in addition to online learning methodologies. Very often, they do so to support students who are not in a position to attend their lectures on campus.

This research presents the findings from a systematic review that is focused on "remote learning". It discusses about the costs and benefits of using online, asynchronous and synchronous technologies in education. The researchers utilized PRISMA's methodical protocol to search, screen, extract and synthesize articles indexed in Scopus between January 2020 to date.

Although, there are various academic contributions that explored the utilization of online educational technologies in different contexts [11-15], currently, just a few researchers have prepared a thorough review of the relevant literature on this topic [16, 17]. To the best of the authors knowledge, to date, there are no other systematic reviews on remote learning. Therefore, this research closes this gap in the academic literature.

## 2 BACKGROUND

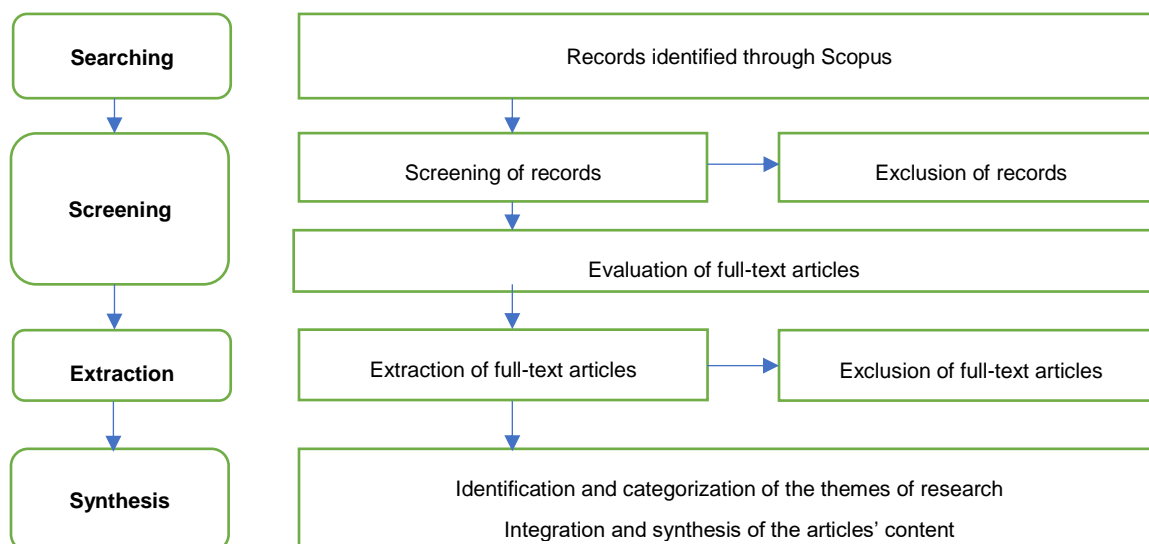
COVID-19 has accelerated the educators' as well as the students' dispositions to engage with online learning technologies. It triggered them to become acquainted with synchronous learning [18, 19], as they were expected to use conferencing software, to communicate in real time, through virtual meetings [6]. Of course, their migration to remote learning was not always easy and straightforward [20-25]. Individuals relied on their educational institutions' preparedness and on facilitating conditions, in terms of the provision of training and development, and ongoing support [26]. Notwithstanding, both students and course instructors had to have access to appropriate resources like personal computers, laptops, netbooks or tablets, at their institutions, as well as at home, to continue their learning journeys [18].

During the pandemic, course participants could access digital learning resources including recorded lectures, PowerPoint presentations, PDF and word documents, videos and podcasts, among others, through LMS like Moodle or VLE [6, 7]. Hence, they were availing themselves of video conferencing technologies including GoogleMeet, Microsoft Teams, Webex and Zoom, among others [9]. These online technologies facilitated virtual interactions, unless for some reason, the users decide to mute themselves and to leave their cameras off [1].

## 3 METHODOLOGY

The researchers relied on a grounded theory approach to capture and interpret the findings from secondary research. They adopted PRISMA's rigorous protocol to systematically search, screen, extract and synthesize content from academic articles that were indexed in Scopus. This thorough review methodology was considered as a rigorous and trustworthy approach to collect and analyze data from academic sources. PRISMA is based on a four-phase flow diagram as shown in Figure 1. Its protocol increases the legitimacy of the review and is intended to reduce the researchers' bias. Moreover, it enables other scholars to replicate the findings in different contexts. Therefore, it provides a clear account of the procedures that are required to scrutinize the literature from reliable sources.

Figure 1. A PRISMA protocol for systematic analysis



### **3.1 Searching**

The researchers inserted "remote learning" AND "education" AND "conferencing" OR "learning management systems" in the query that examined whether these keywords were featured in the publications' titles, abstracts and/or keywords. They narrowed down their search to journal articles and conference proceedings that were written in English, since 2020. Therefore, this review covered the last 27 months years (i.e. January 2020 – March 2022), since the emergence of COVID-19. Scopus results featured a complete list of contributing authors and identified their publications' subject areas and keywords. Moreover, it sorted them according to date, number of citations, relevance, authors' names or source titles. It distinguished between different subject areas, document types, publication stages, source titles, keywords, affiliations, funding sponsors, countries, source types and languages. The search query excluded publications that were featured in books, book series and trade publications from this review exercise.

### **3.2 Screening**

The findings revealed that there were thirty-one (31) documents that were indexed in Scopus on remote learning through conferencing technologies and/or learning management systems for educational purposes. All contributions that were yielded through the search query were examined, in their entirety, to ensure the accountability, integrity, and transparency of the results. The researchers did not exclude any articles or conference papers, from their systematic review.

### **3.3 Extraction**

The researchers organized the relevant content from the extracted articles, scrutinized it. They identified the authors who published articles on this topic, the research question(s), the methodologies that were used to capture the data and outlined their implications. Table 1 presents a list of articles and conference papers on remote learning via learning management systems and conferencing technologies. These publications are sorted in alphabetical order (as of 31st March 2022).

**Table 1. A list articles that are focused on remote learning through video conferencing and learning management systems**

Ref.	Authors	Year	Source title	Research question	Methodology	Implications	Document Type
[50]	Aloizou, V., Chasiotou, T., Retalis, S., Daviotis, T., Koulouvaris, P.	2021	Educational Media International	This research investigates the implementation of a gaming platform that was applied remotely to special education needs (SEN) students during the period of school closure due to COVID-19.	Case study / experimental	The researchers discuss about the positive effects of remote learning on autistic students.	Article
[21]	Backer, P.R., Chierichetti, M., Sullivan-Green, L.E., Rosenfeld, L.	2021	ASEE Annual Conference and Exposition, Conference Proceedings	This research explores the impact of COVID-19 on students and faculty employees in the San José State University (SJSU) College of Engineering.	Qualitative (interviews)	The researchers identified the challenges relating to the use of learning management systems (LMS), Canvas, as well as Zoom. They noted that faculty employees were not always recording their lectures or post them online for their students.	Conference Paper
[32]	Barger, M., Jayaram, L.	2021	ASEE Annual Conference and Exposition, Conference Proceedings	This research investigates advanced technology students' access to a learning management system. It sheds light on their online learning experiences.	Quantitative (survey)	The researchers found that the majority of students were worried about their academic progress. They recommended that students required assurances for pathways to completion, counseling, tutoring and mentoring to improve learning outcomes.	Conference Paper
[22]	Boye, T., Machet, T.	2021	Proceedings - SEFI 49th Annual Conference: Blended Learning in Engineering Education: Challenging, Enlightening - and Lasting?	This research sheds light on the transition to mixed-mode delivery (during COVID-19) for professional practice subjects at an Australian university.	Case study / experimental	The researchers posit that COVID-19 taught educators that there is scope to enhance future students' experience by improving inclusivity and accessibility.	Conference Paper
[16]	Butola, L.K.	2021	Indian Journal of Forensic Medicine and Toxicology	This research discusses about the effects of COVID-19 on educational institutions.	Review	The researchers suggest that educators became familiar with technology devices. They implied that these tools were very helpful to continue delivering education in a remote manner.	Article
[6]	Camilleri, M.A., Camilleri, A.C.	2022	Technology in Society	This research explores the facilitating conditions and the students' perceptions toward using interactive resources to continue their learning journey.	Quantitative (survey)	The researchers reported that the students adapted well to a new normal. They confirmed that students were willing to participate and engage in virtual meetings through video conferencing programs.	Article
[1]	Camilleri, M.A., Camilleri, A.C.	2021	Technology, Knowledge and Learning	This research investigates the students' perceptions on remote learning through asynchronous learning management systems (LMS) and via synchronous video conferencing technologies.	Quantitative (survey)	The researchers underline the importance of maintaining ongoing, interactive engagement with students, and of providing them with appropriate facilitating conditions, to continue improving their learning journey.	Article
[51]	Chaiko, Y., Kunicina, N., Patlins, A., Zhiravetska, A.	2020	2020 IEEE 61st Annual International Scientific Conference on Power and Electrical	This research analyzes educational applications, online conferencing platforms and resources. It compares the functionality of different platforms for the delivery of online classes.	Descriptive	The researchers argue that despite the shortcomings of certain online platforms (e.g. limiting the number of users), they suggested that their advantages outweigh their disadvantages.	Conference Paper

			Engineering of Riga Technical University, RTUCON 2020 - Proceedings				
[52]	Chatha, C.J., Bretz, S.L.	2020	Journal of Chemical Education	This research explored the provision of chemistry education research (CER) during the pandemic.	Qualitative (interviews)	The researchers contend that digital annotation tools and shared mouse control offer additional tools to better understand how students learn chemistry during remote instruction.	Article
[29]	Cotter, J.M., Guldiken, R.	2021	ASEE Annual Conference and Exposition, Conference Proceedings	This research investigates the transition from hybrid modality to remote format via website and YouTube.	Quantitative (survey)	The researchers noted that students appreciated the availability of recorded lectures that were available through YouTube - as opposed to the learning management system.	Conference Paper
[27]	Darr, A., Regan, J., Berrocal, Y.	2021	Medical Science Educator	This research compares summative exam performance data where examinations occurred in-person (2019) versus online methods (2020).	Quantitative (survey)	The researchers found that prolonged use of virtual platforms might negatively impact the efficacy of synchronous learning.	Article
[38]	Drake, A.E., Hy, J., MacDougall, G.A., Holmes, B., Icken, L., Schrock, J.W., Jones, R.A.	2021	Ultrasound Journal	This research explored remote teaching through video conferencing technology and real-time imaging (that can be viewed by the operator and educator simultaneously).	Quantitative (survey)	The researchers recommended the use of tele-ultrasound education.	Article
[43]	Gayah, V., Zappe, S.E., Cutler, S.	2021	ASEE Annual Conference and Exposition, Conference Proceedings	This research examines the students' perceptions of the learning environment as it relates to the development of their professional expertise.	Quantitative (survey)	The researchers noted that remote instruction approaches maintained the same supportive environment as normal, in-person instruction. They suggested that they even provided a more supportive environment in some respects.	Conference Paper
[23]	Giordano, A.N., Christopher, C.R.	2020	Journal of Chemical Education	This research provides a reflective account of the teaching insights gained from the implementation and assessment of a 'mini-unit' through remote oral examinations.	Reflective	The researchers identified the challenges of resorting to remote course delivery including student engagement and assessment.	Article
[24]	Honnurvali, M.S., El-Saleh, A.A., Sheikh, A.M., Goh, K., Gupta, N., Umar, T.	2022	Journal of Engineering Education Transformations	This research explores the challenges that were encountered by academics and their learners during COVID-19.	Quantitative (survey)	The researchers discuss about the challenges in terms of technological skills, teaching styles, time management, virtual labs infrastructure availability, and assessments skills. They elaborate on the difficulties that were encountered during remote course delivery.	Article
[17]	Hurst, W., Withington, A., Kolivand, H.	2022	Multimedia Tools and Applications	This research identifies the features and the barriers of virtual conferencing platforms; It explores the users' experiences with these technologies.	Review	The researchers argue that although Covid-19 disrupted the provision of education, it has also created opportunities for virtual conference creators to develop solutions to support remote working.	Article

[36]	Ilieva, G., Yankova, T.	2020	TEM Journal	This research investigates the role of internet of things (IoT) as a tool for the digitalization of remote learning in higher education.	Case study / experimental	The researchers put forward a new IoT framework. They suggest that it can be used to monitor and manage educational processes (including training and evaluation).	Article
[28]	Jung, J.-H., Shin, J.-I.	2021	Sustainability (Switzerland)	This research investigates online remote learning quality (system quality, information quality, and service quality), flow, and learner satisfaction during COVID-19.	Quantitative (survey)	The researchers reported that university students were valuing information quality, easy-to-understand educational content. They expected up-to-date information while participating in online remote learning sessions.	Article
[37]	Kinsky, E.S., Merle, P.F., Freberg, K.	2021	Howard Journal of Communications	This research explores the students' marketable skills that were acquired during COVID-19.	Quantitative (survey)	The researchers noted that there was a digital divide among students. They suggested that many students experienced connectivity issues and equipment problems during the pandemic.	Article
[53]	Legg, P., Higgs, T., Spruhan, P., White, J., Johnson, I.	2021	2021 International Conference on Cyber Situational Awareness, Data Analytics and Assessment, CyberSA 2021	This research discusses a new approach to teaching cyber security with a view of inspiring a new generation of learners to the subject.	Case study / experimental	The researchers contended that learners benefit from highly interactive and engaging experiences of remote working.	Conference Paper
[39]	Lei, M., Clemente, I.M., Liu, H., Bell, J.	2022	International Journal of Social Robotics	This research analyzes higher education students' perceived usefulness, ease of use, subjective norms and perceived risk from using telepresence robots on their intentions to continue using them in the future.	Quantitative (survey)	The researchers indicated that students felt that the telepresence robots were useful for their educational outcomes (they provided rich social interactions).	Article
[40]	Li, Y., Hicks, D., Lages, W.S., Won Lee, S., Sharma, A., Bowman, D.A.	2021	Proceedings - 2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops, VRW 2021	This research explores a mobile augmented reality application that allows users to 1) scan artifacts and share 3D models, 2) view the model simultaneously in a shared virtual environment from remote physical locations, and 3) point to and draw on the model to aid communication.	Case study / experimental	The researchers implied that there is great potential for to use augmented reality applications to support remote design education.	Conference Paper
[54]	Ross, J.M., Wright, L., Arikawa, A.Y.	2021	Online Learning Journal	This research presents a classroom simulation experience that features an online escape room, in nutrition education.	Case study / experimental	The researchers reported that students were pleasantly surprised on the effectiveness of their online assignment (involving escape rooms).	Article
[33]	Saldanha, K., Currin-McCulloch, J., Muskat, B., Simon, S.R., Bergart, A.M., Mesbur, E.S., Guy, D., Chilwalo, N.B., Seck, M.M., Tully, G., Lind, K., Lee, C.D., Hall, N., Kelly, D.	2021	Social Work with Groups	This research investigates a student group's perceptions on the essential components of effective online group work education.	Case study / experimental	The researchers recognize that online group work can be done effectively but requires additional planning and, ideally, peer and institutional support.	Article

[55]	Sangpratoom, J., Tharatipyakul, A., Ua-Arak, N., Thanasuan, K., Pongnumkul, S.	2021	Proceedings - 2021 International Conference on Information Systems and Advanced Technologies, ICISAT 2021	This research explores the use of interactive tutorials as an alternative to live online teaching (of Blockchain technologies).	Case study / experimental	The researchers found that students preferred learning through interactive tutorials than via live, online lectures. On the other hand, they noted that students could not interact with their tutors to ask questions.	Conference Paper
[41]	Subbiramaniyan, V., Apte, C., Mohammed, C.A.	2021	Advances in Physiology Education	This research investigates the utility of memes that could be used to promote engagement in the online environment.	Thematic analysis	The researchers reported that online interaction with students can help in creating a positive learning environment that fosters learning and retention.	Article
[26]	van Wyk, B., Mooney, G., Duma, M., Faloye, S.	2020	Proceedings of the European Conference on e-Learning, ECEL	This research explores emergency remote learning in a private higher educational institution during COVID-19.	Case study / experimental	The researchers contended that educational institutions ought to determine the 'preparedness' of their lecturers and eTutors to teach online and remotely.	Conference Paper
[25]	Wahid, R., Farooq, O., Aziz, A.	2021	Journal of E-Learning and Knowledge Society	This research examines the students' and teachers' experiences and opinions about virtual learning. It sheds light on the teaching, learning and assessments during the pandemic.	Quantitative (survey)	The researchers argue that blended learning might be the future of education. They identify the challenges to maintain a high quality of education.	Article
[56]	Wallace, S., Schuler, M.S., Kaulback, M., Hunt, K., Baker, M.	2021	Nursing Forum	This research explores prelicensure baccalaureate nursing students' experiences toward the transition to remote learning during the Spring 2020 semester.	Qualitative (interviews)	The researchers identified a number of challenges to the provision of remote learning including. Yet, they noted that students demonstrated a remarkable sense of resilience and perseverance.	Article
[10]	Welch, R.W., Rabb, R.J., Eggleston, A.G.	2021	ASEE Annual Conference and Exposition, Conference Proceedings	This research identifies selected effective approaches that are intended to respond to a hybrid/Hyflex learning delivery mode.	Case study / experimental	The researchers posit that faculty members (who are not experts in remote/online instruction) could require periodic developmental training to ensure the quality of their courses.	Conference Paper
[42]	Zavitz, J., Sarwal, A., Schoeneck, J., Glass, C., Hays, B., Shen, E., Bryant, C., Gupta, K.	2021	AEM Education and Training	This research explores a course's development, implementation, quality improvement processes, achievements, and limitations during COVID-19.	Quantitative (survey)	The researchers reported that they improved the students' knowledge and skills through the utilization of virtual technologies. They underlined the benefits of the provision of virtual training and of blended learning approaches.	Article

(Sorted according to the authors' surnames, in an alphabetical manner.)

### **3.4 Synthesis on the costs and benefits of remote learning technologies**

#### *3.4.1 The costs*

Many researchers noted that Covid-19 disrupted the provision of education. In the main, they reported that there were various challenges for the successful implementation of remote learning [17, 23-25]. For example, one of the contributions implied that the prolonged use of virtual platforms might negatively impact the efficacy of synchronous learning [27].

Various studies indicated that the research participants were not always pleased with the quality of education that was provided by their educators, during the pandemic [28]. Academic commentators indicated that faculty members were not experts in the delivery of remote/online instruction. They implied that instructors could require periodic developmental training to improve the service quality of their courses [4, 10].

While a few researchers noted that students appreciated the availability of recorded lectures [29], others reported that educators were not always recording their lectures and/or did not share learning resources with them [21]. This issue could have affected the students' learning outcomes [30, 31]. In fact, some students were worried about their academic progress during COVID-19 [32]. In many cases, they encountered a number of difficulties during remote course delivery. For instance, online group work involved additional planning as well as institutional support [33]. Previous literature suggests that students necessitate counseling, tutoring and mentoring as well as ongoing assurances to succeed [34, 35].

In many cases, the researchers discovered that course participants required adequate training and support to complete their assessments [23, 24, 36]. A few of them also hinted that a digital divide among students could have been evidenced among those who experienced connectivity and equipment problems, among other issues [5, 37]. Other authors argued about the individuals' challenges to focus on their screens for long periods of time [6]. Notwithstanding, educators and students may develop bad postures and other physical problems due to staying hunched in front of a screen. Therefore, students ought to be given regular breaks from the screen to refresh their minds and their bodies.

#### *3.4.2 The benefits*

Generally, a number of contributions shed light on the benefits of using remote learning technologies, including learning management systems [1, 21, 29, 32] and interactive conferencing programs [1, 6, 17, 33]. Such educational technologies can help in creating rich social interactions [38-40] as well as positive learning environments - that foster learning and retention [41, 42]. Previous research indicated that digital learning resources can enhance the students' knowledge and skills [43]. Remote instruction approaches can also provide supportive environments to students [39] and could even increase their chances of learning [30, 31]. Virtual lectures may be recorded or archived for future reference [29]. Hence, students or educators could access their learning materials at their convenience [44-46].

Several researchers underlined the importance of maintaining ongoing, two-way communications with students, and of providing them with appropriate facilitating conditions, to continue improving their learning journeys [6, 47-48]. Video conferencing technologies allow educators to follow up on their students' progress. They facilitate online interactions, in real time, and enable them to obtain immediate feedback from their students [1, 49]. Notwithstanding, there are fewer chances of students' absenteeism and on missing out on their lessons, as they can join online meetings from home or from other locations of their choice.

## **4 CONCLUSIONS**

This review implies that online technologies have opened a window of opportunity for educators. Indeed, learning management systems as well as conferencing programs are useful tools for educators to continue delivering education in a post covid-19 context. However, it is imperative that educational institutions invest in online learning infrastructures, resources and facilitating conditions, for the benefit of their students and faculty employees. They should determine



whether their instructors are (or are not) delivering high levels of service quality through the utilization of remote learning technologies to continue delivering student-centered education.

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