



Analytical study on the impact of technology in higher education during the age of COVID-19: Systematic literature review

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Abstract

With the advent of COVID-19 arose the need for social distancing measures, including the imposition of far-reaching lockdowns in many countries. The lockdown has wreaked havoc on many aspects of daily life, but education has been particularly hard hit by this unprecedented situation. The closure of educational institutions brought along many changes, including the transition to more technology-based education. This is a systematic literature review that seeks to explore the transition, in the context of the pandemic, from traditional education that involves face-to-face interaction in physical classrooms to online distance education. It examines the ways in which this transition has impacted academia and students and looks at the potential long-term consequences it may have caused. It also presents some of the suggestions made by the studies included in the paper, which may help alleviate the negative impact of lockdown on education and promote a smoother transition to online learning.

Keywords COVID-19 · Education · Technology · Online learning · Students · Performance

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1 Introduction

Severe acute respiratory syndrome, also known as COVID-19, is a contagious respiratory disease caused by the SARS-CoV-2 virus, which was first identified in a seafood market in Wuhan in late December 2019 (Huang, 2020).

The disease is airborne and mainly spreads through physical proximity with infected people. Clinical analysis results of the virus showed person-to-person transmission (Li et al., 2020). Broadly speaking, there are two modes of transmission—direct and indirect. The direct mode involves droplet and air transmission, while indirect transmission may occur via contaminated surfaces (Karia, 2020).

Due to its highly contagious nature, the COVID-19 virus swept the globe in the matter of weeks. Between December 2019 and October 2020, more than 45 million cases of COVID-19 were reported, including over a million deaths. (European Centre for Disease Prevention and Control, 2020). By March 2020, the epidemic was declared a pandemic by the World Health Organization (WHO, 2020).

The call for social distancing and limiting face-to-face contact outside the immediate family has never been louder. Social distancing is a deliberate increase in the physical gap between individuals to minimize the spread of disease (Red Cross, 2020).

Many facets of everyday life have been devastated by the pandemic. It prompted countries around the world to adopt a sequence of emergency response systems (Zhang et al., 2020). Authorities worldwide issued stay-at-home orders, imposing prolonged periods of lockdown, which led to a disruption in educational activities globally. This was done to curb infection rates and flatten the incidence curve in an effort to prevent healthcare systems from being overwhelmed.

In many parts of the world, this meant a temporary shutdown of educational institutions. These nationwide closures impacted millions of students and their families, particularly those from underprivileged communities (UNESCO, 2020).

Some of the educational institutions that faced closure progressively re-opened and started operating under online learning models in order to continue the academic progress of students, while simultaneously observing measures to reduce the impact of the current health crisis.

Previous outbreaks of infectious diseases such as swine flu have prompted significant school closures worldwide, with varying degrees of effectiveness (Barnum, 2020). If school closures happen late during a pandemic, they are less effective and may have little impact at all (Zumla et al., 2010). Educational institutions have been compelled to make an immediate transition to remote methods of learning that rely heavily on technology. The immediate transition to online learning has not made it possible for many to be adequately prepared for the challenges ahead (Hodges et al., 2020). This migration to remote learning had to be implemented as quickly as possible, and for many learning institutions, it happened several months into the academic year, leaving both staff and students with little time to plan, adjust and adapt.

This shed the light on various underlying economic and social issues. According to UNESCO, more than a billion learners worldwide have been affected at some

point by the school closures that were initiated in response to the COVID-19 pandemic. As of November 2020, over 300 million learners spread across over 30 countries, which constitute approximately 18% of total enrolled learners, have been kept out of schools due to lockdown (UNESCO, 2020).

While the disruption in learning caused by COVID-19 is unprecedented, important insights can be gained about its far-reaching implications through an examination of relevant existing studies and data.

This paper is a systematic literature review that looks at the existing literature and discusses the crisis-response migration methods to technology-based online learning done by mainly higher learning institutions in terms of their impact on instructional delivery, students and faculty, and education as a whole. Firstly, it categorizes the studies in terms of which facet of education the impact of COVID-19 in was explored. Then, it performs a SWOT analysis on the digital transformation to online learning. In other words, it looks at the strengths, weaknesses, opportunities and threats. Lastly, it attempts to collect and summarize student and faculty feedback on online education and then outlines some of the recommendations made by either the students and faculty or the authors of the selected studies for improving the system.

The rest of the paper is divided into six sections. Section 2 discusses some of the related works, while Section 3 presents the methodology used in this study, including the selected research questions, search strategy, study selection process, quality assessment rules and data extraction strategy. It also presents some statistics about the selected papers. Section 4 presents the findings of the study and discusses them in detail, while Section 5 concludes with a summary of the research outcomes and possible future work. Section 6 constitutes an acknowledgement of various contributions to the creation of this paper.

2 Related work

In response to COVID-19, a lot of countries were faced with pressure to contain the spread of this highly contagious disease. To many educational institutions, this meant either partial or complete closure. Others transitioned to technology-based distance learning.

A systematic review was conducted by Viner et al. (2020) examines existing knowledge to identify the effects of school closures and other social distancing measures during outbreaks on infection rates and virus transmission. It suggested that school closures play a relatively small role in the control of disease transmission, and that the insignificant benefits such closures bring to transmission reduction could be easily outweighed by their profound negative economic and social consequences (Viner et al., 2020).

There is no strong evidence to support the effectiveness of full closure in controlling the pandemic. If anything, there are significant economic downfalls to such a response, not to mention the academic delay incurred by students. That is why a lot of academic institutions opted for the less drastic measure of transitioning to online distance education (ODE).

ODE is the use of the internet and certain other significant technology for the production of educational content, instructional delivery and program management (Fry, 2001). ODE can be delivered in two main formats: synchronous and asynchronous. As the name suggests, synchronous distance education (SDE) involves live, real-time interaction between teachers and students. It aims to simulate the communication model of a traditional classroom. Examples of SDE would include live webinars or virtual classrooms. Asynchronous education, on the other hand, introduces temporal flexibility. It does not require real-time interaction; instead, the educational material is available online for students to access at their own convenience. Examples of asynchronous education would be video recordings and emails (The Florida Center for Instructional Technology, n.d.).

A systematic review and meta-analysis provided on randomized controlled trials (RCTs) conducted by papers released between January 2000 and March 2020 on the effectiveness and acceptance of SDE in health sciences as compared to more traditional educational methods measured the knowledge of students, their skills (using objective assessments) and their overall satisfaction (using subjective evaluations). It found there to be no significant difference between traditional education and synchronous distance education in terms of effectiveness and objective assessments. However, in subjective evaluations, SDE resulted in a higher satisfaction rating, indicating that it was preferred to some extent by students, despite being neither better nor worse in the earlier two measures (He et al., 2020).

Additionally, Carrillo & Flores (2020) conducted a review of the literature between January 2000 and April 2020 on online teaching and learning practices in teacher education to explore how and why online teaching and learning in teacher education occur, and also discussing its implications in the context of the pandemic. The review highlighted the complex nature of the model, discussing such factors as social, cognitive and teaching issues and the need for a comprehensive view of the pedagogy of online technology-based education used to support teaching and learning (Carrillo & Flores, 2020).

Daoud et al. (2020) conducted a systematic review focused on the issue of equity regarding home internet access by evaluating the educational value of having internet at home for school-aged children. It found a range of correlations that were mostly positive between access to home internet and educational value across three functions: qualification (academic knowledge and skills), subjectification (strengthening individuality) and socialization (of future citizens). However, the correlation was not straightforward, nor did it imply causation. The educational value in home internet use is influenced by variables regarding the nature of online activities such as how the technology is being used and socio-economic status (Daoud et al., 2020).

Di Pietro et al. (2020) produced a paper that attempts to explore the direct and indirect ways in which the COVID-19 pandemic may impact education. Based on the existing literature and pre-COVID-19 data, it made predictions about the impact on and future of education. The paper drew four main conclusions: 1) learning is expected to suffer a setback on average; 2) the effect on academic performance is likely to vary with socio-economic status; 3) inequality in socio-economic status may manifest in an emotional response, as those from less

privileged backgrounds may be under more environmental stress; 4) the widening social gap may persist and have long-term implications (Di Pietro et al., 2020).

Some online emergency learning approaches are criticized for not adhering to sound pedagogical norms, best practices and prior studies (Hodges et al., 2020). Some have noted the potential negative effects of educational technology fixes being implemented quickly without balancing their effect (Selwyn et al., 2020; St. Amour, 2020). In addition, leaping into online education and online learning platforms has also raised concerns regarding surveillance and privacy and its impact on the lives of students (Harwell, 2020).

A study that aims to map the scientific literature in the areas of education and management in the context of the COVID-19 pandemic suggests the existence of three distinct groups or research flows in the published literature. These main themes were identified as: 1) education based on online constructs and distance learning; 2) the impact of COVID-19 from a management perspective; and 3) studies with a particular focus on Canada. The studies chosen for the analysis were found to be of various typologies, the most relevant of which was qualitative. The analysis revealed that research on the disruption in education and scientific production caused by the pandemic is rather scarce, which might be the result of the lack of empirical data (Rodrigues et al., 2020).

Since this phenomenon is still relatively recent, there is a lack of research that discusses the direct effect of the digital transformation in higher education caused by the pandemic, its pros, cons and future implications. This systematic literature review is different from those described above, as it provides an extensive review on the research done on the impact of the COVID-19 pandemic on formal education. Specifically, this study explores the ways in which the transition from traditional in-person educational models that involve face-to-face interaction and classroom teaching to ODE has impacted academia and students, and the consequences it might have had on student performance and the well-being of all involved.

The pandemic might have set in motion changes that are to last millennia in the way education is conducted across the globe. It is therefore imperative to study the direct impact of the pandemic on the education sector and understand the role it played in revolutionizing the way we think about education in order to make informed pedagogical choices in the future and ensure a smooth transition into more flexible but effective online teaching methods. As a result, our research paper has the following important contributions:

- Explore the kind of changes the shift to online education has caused
- Discuss the impact of these changes on students and teachers
- Provide an insight into the current state of education and how the pandemic could affect its future

Table 1 summarizes the literature reviews discussed in this section as well as this study's objective.

Table 1 Literature review summary

Paper Title	Summary
School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review	Attempts to identify the effects on infection rates and virus transmission by examining what is known about the use and effectiveness of school closures and other social distancing measures during pandemics.
Synchronous distance education vs traditional education for health science students: A systematic review and meta-analysis	Explores the effectiveness and acceptance of SDE in health sciences as compared to more traditional educational methods. Measures the knowledge of students, their skill and overall satisfaction.
COVID-19 and teacher education: a literature review of online teaching and learning practices	Explores how and why online teaching and learning in teacher education occur, and discusses its implications, particularly in the current emergency remote learning scenario. Seeks to address recurrent topics explored in the studies on online teaching and learning in teacher education.
The educational value of internet use in the home for school children: A systematic review of literature	Brings focus to the issue of equity regarding home internet access by evaluating the educational value of having internet at home for school-aged children.
The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets	Attempts to explore the direct and indirect ways in which the COVID-19 pandemic may impact education, based on the existing literature and using pre-COVID-19 data to make predictions about the impact on and future of education.
COVID-19 and Disruption in Management and Education Academics: Bibliometric Mapping and Analysis	Aims to map scientific literature in the areas of education and management in the context of the COVID-19 pandemic.
This Paper	Looks at the existing literature and discusses the crisis-response migration methods to technology-based online learning done by higher learning institutions in terms of their impact on instructional delivery, on students and faculty, and on education as a whole. Includes summaries of the advantages and disadvantages of distance education, student and teacher feedback, and recommendations made in the papers.

3 Methodology

This study is a Systematic Literature Review (SLR) based on the guidelines for performing such reviews laid out in the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (Moher et al., 2015), which are comprised of three main stages: search, eligibility and data collection and extraction. For example:

1. Search defines the search strategy in terms of what keywords and search engines or libraries will be used.

2. Eligibility is concerned with setting up inclusion and exclusion criteria aligned with the research objectives to specify the study and reporting standards, and then applying them to the collected papers.
3. Data collection and extraction is the process of obtaining eligible reports and extracting data from them in order to investigate the posed research questions.

This study tackles the topic of education during the COVID-19 pandemic and the accompanying shift to remote learning. The review process is composed of six stages. The first stage was coming up with research questions that reflect the aim of the study. The second involved collecting papers relevant to the topic. In the third stage, exclusion and inclusion criteria were defined and applied to the collected papers. The fourth stage involved extracting answers to the research questions from papers that made it through the final round of exclusion. The fifth and final stage was the synthesis of data obtained through this information extraction process to reach meaningful conclusions.

Figure 1 below illustrates this process.

3.1 Research questions

This systematic literature review aims to examine and summarize the impact COVID-19 had on education through the shift to online learning it caused in early 2020. The following five research questions were posed:

RQ1: What are the aspects and impacts of COVID-19 on education?

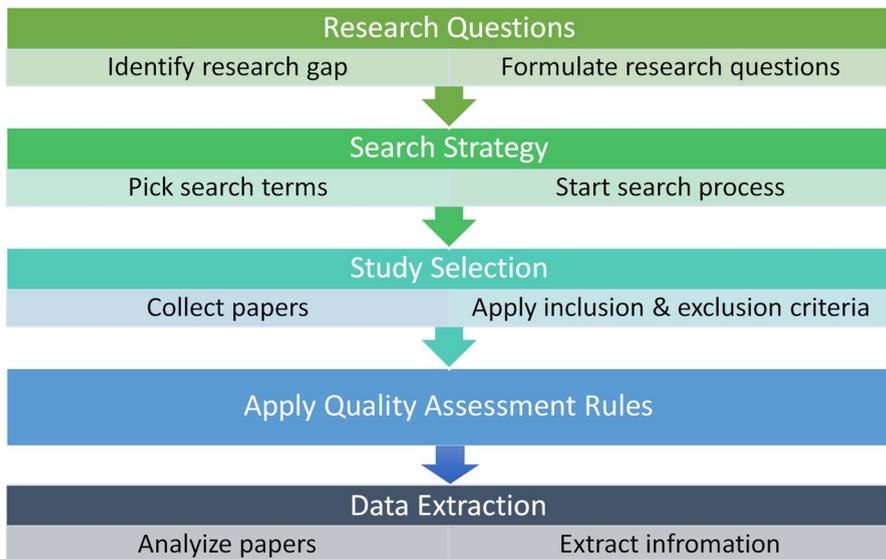


Fig. 1 Research methodology

RQ1 aims to identify the underlying theme or lens through which the impact of COVID-19 on education was explored in the papers. In other words, on what aspect of education or the educational system is the paper attempting to shed light on the impact of COVID-19?

RQ2: What are the limitations of online education?

RQ2 examines the implemented online teaching models critically and identifies their flaws as defined in the research papers. This is the first phase of a SWOT analysis, which stands for strengths, weaknesses, opportunities, and threats. It considers the weakness and threats of online education.

RQ3: What are the advantages & opportunities laid out by this digital transformation in higher education?

The aim of RQ3 is to recognize the benefits and opportunities presented by this unprecedented move toward digital-based learning in higher education institutions. This is the second phase of the SWOT analysis and it focuses on the digital transformation's strengths and opportunities.

RQ4: What was the feedback of students and teachers?

RQ4 collects and summarizes the responses of students and teachers to this transformation and how it impacted their experience.

RQ5: What recommendations were made?

RQ5 attempts to summarize the recommendations put forward by either the authors of the studies or the people who participated in them.

3.2 Search strategy

The research questions were used as a guideline to roughly identify the main search keywords. Terms synonymous or highly related to the main search keywords were included in the search. Google Scholar was used for the search, which employed variations of the following search keywords: “COVID-19” “effects” “impact” “education” “higher education” “academia” “university” “online learning” “students” “teaching” “e-learning”.

The number of results varied by combination of keywords, but on average between 200 and 300 results showed up per search, a number increasing by the day given the current relevance of the topics at hand. The majority of papers came from journals.

3.3 Study selection

All papers based on the search keywords mentioned above that seemed, if only tenuously, relevant to the topic of education during COVID-19 were collected. Only papers that were published later than 2019 were retained. Papers that did not belong to high-quality, prestigious journals were excluded.

To ensure the quality of the selected papers and they do not belong to predatory journals, we first checked them against Elsevier's abstract and citation database, Scopus. We also made sure they belonged to either the first quartile (Q1) or second quartile (Q2) according to the SCImago Journal Rank (SJR). SJR indicates the scientific influence of scholarly journals. Moreover, the journals were reviewed against Beall's List, which is a list of predatory open-access publishers that did not perform proper peer review and they publish any article as long as the authors paid the open-access fee. This brought the number of papers selected for the purpose of this study down dramatically to 47—less than half of all papers collected initially.

As mentioned earlier, the search based on the selected keywords yielded somewhere between 100 and 300 results. Over 100 papers seemed relevant and were downloaded to serve as a starting point. Moving on, we filtered the papers based on their compliance with our inclusion criteria. The process can be summarized as follows:

- Step 1: download papers that showed up in the search results
- Step 2: delete any duplicates
- Step 3: apply the inclusion and exclusion criteria to get rid of any irrelevant papers
- Step 4: set aside survey and review papers
- Step 5: extract answers to the research questions from the selected papers while applying the quality assessment rules stated in section 3.4 that were designed to include only qualified papers.

Table 2 summarizes the applied inclusion and exclusion criteria of study papers.

Table 2 Inclusion & exclusion criteria

Inclusion criteria	Exclusion criteria
Include only journal and conference papers	Articles and opinion pieces
Include papers belonging to reputable publishers or journals. In other words, papers that show up on Elsevier's abstract and citation database, Scopus, and belong to either the first quartile (Q1) or second quartile (Q2) according to the SCImago Journal Rank (SJR)	Preprints and papers that either do not show up on Scopus or belong to Q3 or Q4 Journals according to the SJR
Include papers that answer at least 2 of the research questions	Papers that do not sufficiently address our research questions Papers not related to education during the COVID-19 pandemic

3.4 Quality assessment rules (QARs)

This final step is to determine the quality of the collected research papers. To measure the quality of the papers included in the study and confirm their pertinence to our research objectives, ten Quality Assessment Rules (QARs) were set. Marks out of 10 were given to each paper based on its compliance with the established QARs. The QARs were formulated based on our understanding of the current state of research in this field and the research gap this paper is attempting to fill. The papers were scored for their ability to meet high research standards while adequately addressing our research question. For each of the ten questions, a paper is given a score as follows: “fully answered” = 1, “above average” = 0.75, “average” = 0.5, “below average” = 0.25, “not answered” = 0. The summation of the marks achieved for the 10 QARs is the paper’s ranking. Papers that score 5 or higher are accepted, while the remaining are excluded.

- QAR1: Are the study objectives clearly defined?
- QAR2: Is the impact of COVID-19 on education well-defined?
- QAR3: Is the specific context and usage (themes) clearly defined?
- QAR4: Is the study method well-designed and justifiable?
- QAR5: Is the scope of the study large enough?
- QAR6: Are the advantages and opportunities of the proposed teaching/technology methods well-explained?
- QAR7: Are the weaknesses and limitations of the proposed teaching/technology methods well-explained?
- QAR8: Are student/teacher evaluations reported?
- QAR9: Are the recommendations of the proposed methods suitable?
- QAR10: Overall, does the study enrich the academic community or industry?

3.5 Data extraction strategy

In this step, the final list of papers was analyzed to answer the research questions and extract any pertinent information.

The following information was extracted from each paper: Paper title, Publisher, Journal, month of publication, description of the paper’s objective, the answers to RQ1, RQ2, RQ3, RQ4 and RQ5.

Due to the indistinct terminology used within some papers and the relative narrowness of our research questions in comparison to the questions posed by the collected papers, there were gaps in the answer extraction as reflected in Fig. 4.

In some cases, the authors had to infer answers that weren’t explicitly expressed in the papers. This meant that some of the answers extracted were personal interpretations of the findings done by the authors.

3.6 Statistics about the selected papers

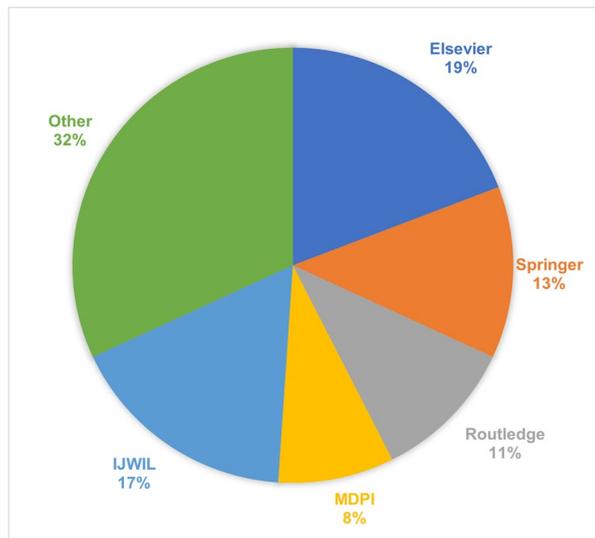
As can be seen from Fig. 2, Elsevier & IJWIL journals held the 2nd and 3rd positions, coming in at 19% and 17% respectively. Other publishers, including Springer, Routledge & MDPI, contributed similar amounts of papers and came at 13% of the total paper count or less.

However, 32% of the papers were put out by miscellaneous publishers. These publishers include: The BMJ, ACS Publication, Science Press, Wiley, Taylor and Francis Ltd., Primrose Hall Publishing Group, Scientific Research Publishing, Academy of Science of South Africa, Association for Learning Technology, Association for Social Studies Educators, Modestum and Kathmandu University.

Figure 3 shows the months of publication of the selected papers. It is noteworthy that the largest number of papers relevant to this review were produced in July, three to four months after many lockdowns were implemented and distance learning was put in effect. The number of papers selected for this review subsequently declined. For 13 of the selected papers, the month of publication was either not explicitly specified or couldn't be identified by the authors.

As can be seen from Fig. 4, all research questions were answered by more than 70% of the papers, which speaks to their broadness and generality. The only exception was RQ5, which had a 61.70% answer rate, mostly from papers discussing the topic of “student experience”, as will be shown in the following section.

Fig. 2 Publishers of the selected papers by frequency



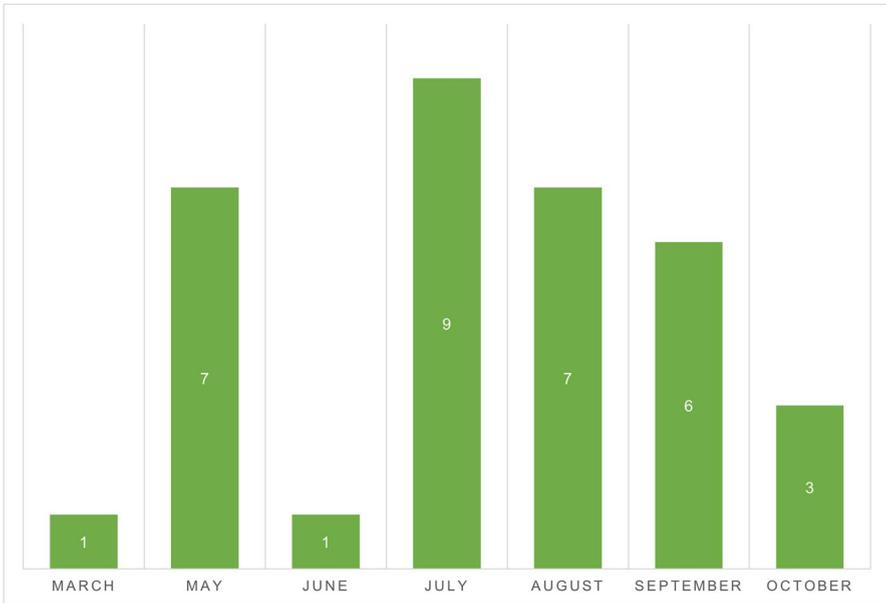
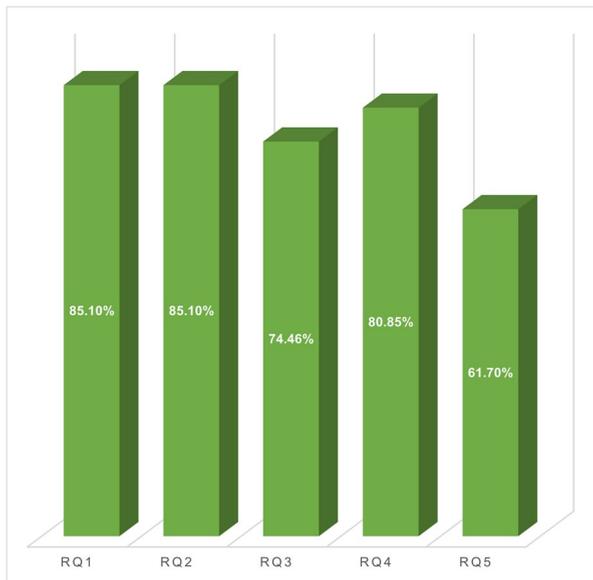


Fig. 3 Frequency of selected papers by month

4 Results and discussion

The majority of educational institutions in the chosen studies migrated to distance learning. While not all papers specified the particular methods or platforms

Fig. 4 Frequency of answers for each research question



employed, video conferencing, E-portals, webinars, websites, video recordings, simulations and online quizzes were frequently listed as the primary means of conducting classes and evaluating student performance.

A total of 47 studies were compiled using the quality criteria mentioned in section 3.4. A list of these studies is included in Table 7 in Appendix A. Here in section 4, we present the findings of this literature review. The outcomes of each research question are explored in detail in each of the following five sections.

4.1 Area of focus

In this section, the first research question (RQ1) is addressed, which aims to identify the underlying theme or lens through which the impact of COVID-19 on education was explored in the papers. There were four main identifiable themes:

- a. **Impact on Education:** explores the transition from traditional classroom teaching methods to more technology-based learning, and the impact of that transition.
- b. **Student Experience:** explores the impact the lockdown had on students either academically or personally and their experience with ODE as well as their academic performance using remote learning methods.
- c. **Proposal:** proposes and/or experiments with a remote teaching method or platform.
- d. **Policy:** explores the responses to the pandemic and the role of policymaking in leveling the playfield in education.
- e. **Equality:** discusses the disparity observed between different social groups during the pandemic and the impact it had on accessibility and equity.

In this review, 25 papers discussed the impact of COVID-19 on education, namely the digital transformation driven by it, its advantages and disadvantages, and what this could mean going forward.

Eighteen papers included discussions about the experience of students and staff with ODE, as well as the participants' views on its potential upsides and downsides. Most of the answers given for RQ5 came from this group.

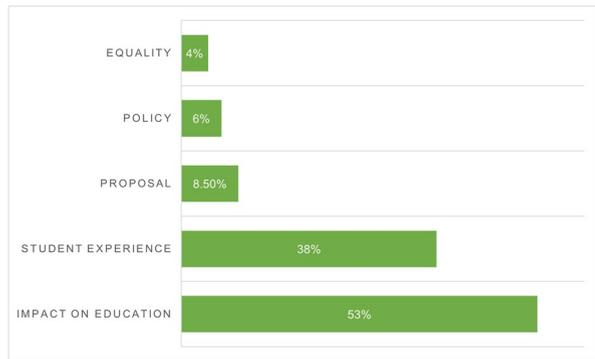
Four papers proposed solutions for remote learning or experimented with a particular platform to analyze its efficacy.

Three papers looked at the current academic situation through a political lens, discussing education-related policy in light of the pandemic.

Two papers discussed how the lockdown and the accompanying transition to technology-based learning further exacerbated differences in educational progress between the children of lower income families with limited access to Wi-Fi and digital devices or services and those of higher income families that do not share the same struggles.

Figure 5 highlights the differences in the frequency of the discussed areas. It is worth noting that these percentages add up to more than 100% because there is overlap between the papers in terms of the areas chosen for discussion.

Fig. 5 Topics discussed in selected papers



4.2 Disadvantages & limitations

This section addresses research question 2 (RQ2), which takes a critical view of the implemented teaching models and identifies their shortcomings as described in the papers that studied or mentioned them.

The key disadvantages can be summarized in the following points:

- **Inequality & inaccessibility:** there is a gap in student access to this type of education, which is usually related to family income.. Transitioning to online learning exacerbated differences between privileged and underprivileged students. Students from less prosperous regions have limited or no access to digital devices and Wi-Fi. They also have lower technical abilities., granting more privileged students an unfair academic advantage. This disparity extends to educational institutions in rural areas or deprived parts of the world that may be less well-equipped than those in urban areas.
- **Inadequacy:** while technology can be a great aid to the learning experience, it cannot act as a complete substitute, particularly for STEM fields that require hands-on training in laboratories or operation rooms. This is especially true for health care sciences. 34% of the chosen studies focused on medical education specifically, looking at nursing or residency programs in particular. These papers tended to emphasize the value of practical training and how indirect knowledge gained from simulations or demonstration videos alone cannot act as a substitute.
- **Communication quality:** building and sustaining relationships and developing rapport between students, their peers, and their teachers became more difficult due to the devaluation or lack of face-to-face contact, as well as the inherent ambiguity of written interactions.. Clarifying instructions and gauging student response, engagement and participation, or lack thereof, becomes more difficult for teachers and instructors in the absence of direct contact and the ability to monitor students face-to-face.
- **Technical difficulties:** poor internet reception or Wi-Fi, connection stability, glitches and other technical failures can interfere with the flow of communication.

- **Stress, workload and morale:** the forced and rapid transition to online learning affected mental health among students. Many experienced lockdown-related anxieties about financial stability and socializing that indirectly affected their performance. Academic staff had to deal with an increased or even doubled workload. Also, lack of face-to-face social interaction for extended periods of time can have a detrimental effect on mental health.
- **Technological literacy:** due to the sudden and forced nature of this digital transition, a lot of educational institutions were caught off-guard, allowing them little to no time to prepare their academic staff. This left non-tech savvy teachers and instructors underprepared and/or underequipped to handle sophisticated computer and internet related tasks. Instructors' lack of technological competence and previous training in or familiarity with utilizing online tools posed an obstacle. The inability of academic staff to use technology negatively impacted the success of ODE in many cases.
- **Student engagement, participation and motivation:** student engagement was sometimes lacking due to factors such as reliance on recorded lectures, a lack of motivation or interest, stress and boredom, as well as the distraction caused by using electronic devices. Added to this was fatigue induced by prolonged staring at screens and feelings of isolation and depression from lack of personal contact.
- **Student performance assessment:** due to the difficulties associated with bringing students to campus to administer tests, academic staff were faced with the challenge of redesigning evaluations in a way that fairly and reliably captured student performance. This was particularly challenging in practical courses.
- **Work-life balance:** ODE allows great flexibility in time and location. While this flexibility may be convenient, it's a double-edged sword that could also blur the boundaries between academic and personal life. Whereas in conventional educational models lectures are strictly bound by fixed times and physical locations.
- **Privacy concerns:** concerns about breach of privacy, data protection and anonymous misconduct.

Table 3 lists the research articles that mentioned disadvantages and limitations of distance education based on the aforementioned points.

4.3 Advantages & opportunities

This section addresses research question 3 (RQ3), which aims to identify the advantages and opportunities laid by this digital transformation in education.

There are several main identifiable key advantages and opportunities. They can be summarized as follows:

- **Remote learning:** ODE transcends the borders of time and geographical location. It allows students the flexibility to tune in into their lectures from the comfort of their own homes or any other location. It also allows students to self-regulate their learning and proceed at their own pace thanks to the temporal

Table 3 Disadvantages & limitations discussed among articles

Disadvantages & Limitations	Reference	Frequency	Percentage
Inequality & inaccessibility	A2, A8, A10, A11, A12, A15, A16, A17, A18, A19, A20, A21, A22, A23, A24, A27, A28, A29, A31, A33, A37, A41	22	47%
Inadequacy	A1, A2, A10, A12, A15, A17, A19, A20, A22, A26, A28, A32, A40, A41, A43, A44, A45, A46	18	38%
Communication quality or lack thereof	A2, A6, A10, A15, A18, A20, A22, A30, A31, A33, A35, A36, A40, A41, A45	15	32%
Technical difficulties (connectivity)	A2, A6, A15, A21, A24, A30, A31, A32, A33, A34, A35, A41, A44, A45	14	30%
Stress, workload and morale	A12, A15, A17, A19, A20, A28, A30, A33, A37, A45	10	21%
Technological literacy	A2, A10, A15, A17, A20, A22, A23, A24	8	17%
Student engagement, participation and motivation	A1, A6, A29, A31, A32, A35	6	13%
Student performance assessment	A15, A17, A22, A33, A34, A35	6	13%
Work-life balance	A8, A19, A39, A40	4	9%
Privacy	A8, A29, A31	3	6%

flexibility of online learning, which is made possible by features such as lecture recording.

- **Discussion & Communication:** online learning facilitates a modern and convenient mode of communication. Important discussions can be raised during lectures and participating students can benefit from these discussions by listening or by engaging through chat. It is also an effective means of communication as participants do not have to meet in person or face the discomfort that can accompany speaking in front of a live audience, thereby further encouraging discussion. Online learning also helps parents of young children to be more involved in their children's education.
- **Impetus for change:** this forced digital transformation in education exposed problems within the system and pushed educators to contemplate and review current and previous models of education, providing a window into what a technology-based education and work environment might be like, thereby stimulating pedagogical innovations and accelerating change. It is hastening progress and can be viewed as an impetus for the reform of curriculum and teaching approaches.
- **Equally effective:** the implementation of online learning and the use of simulations and other methods for didactic purposes were perceived as useful and adequate, if not complete, substitutes for traditional learning. It accomplished its goal of continuing the delivery of education amidst the pandemic, while also helping students meet the requirements expected from them.
- **Efficient:** contributed to or improved knowledge dissemination, with cost-effectiveness, flexibility and overall efficiency as added benefits.
- **Exposure to tech:** incorporating technology into education exposes students to modern and relevant technologies. This helps both students and academic staff close the technological literacy gap while also fostering expertise in online and digital media, thereby preparing students for the job market in an increasingly technology-reliant world of digitization and automation.
- **Decreased costs:** the shift to online education can be credited for the decrease in educational costs. It provides students with a comparable learning experience without the need for expensive infrastructure, not to mention a reduction in other hidden costs such as travel expenses.

Table 4 lists the research articles that mentioned advantages and opportunities of distance education based on the aforementioned points.

4.4 Student and teacher feedback

This section addresses the fourth research question (RQ4), which aims to gauge the response of students and teachers to this transformation and how it impacted their experience.

The papers that explored the topic of student experience provided the main insights to this question, which can be summarized as follows:

Table 4 Advantages & Opportunities discussed among Articles

Advantages & Opportunities	Reference	Frequency	Percentage
Remote learning	A6, A10, A13, A16, A17, A18, A20, A26, A29, A30, A35, A43, A44, A45, A47	15	32%
Discussion & Communication	A5, A6, A10, A18, A20, A22, A29, A35, A44, A46	10	21%
Impetus for change	A8, A12, A15, A16, A19, A28, A31	7	15%
Equally effective	A26, A32, A40, A41, A43, A44, A45	7	15%
Efficient	A2, A10, A16, A19, A46	5	11%
Exposure to tech	A13, A15, A21, A22, A35	5	11%
Decreased costs	A1, A9, A10, A26	4	9%

- **Satisfactory or beneficial:** ODE was regarded as a good learning experience and helpful in the sense that it assisted in cultivating knowledge in a unique and efficient manner.
- **Adequate and effective:** ODE was deemed satisfactory in achieving its objective of continuing education. In some cases, it was thought to have had no significant impact on studies. And in other cases it was thought to boost productivity.
- **Expressed doubts or concern:** participants expressed doubts about the efficacy of ODE, uncertainty about the future, and concern over the long-term consequences of the digital transformation on health, security and equity..
- **Overwhelming:** some staff had difficulty adjusting given how abrupt the transition was. Many had to devise new student performance assessment methods to compensate for the inability to directly monitor students in exams and quizzes. In some cases, the transition led to an increase in workload.
- **Potential:** some participants thought ODE could support their teaching or studies, recommended it for future use or viewed it as a catalyst for revision of existing norms.
- **Appreciation for staff or peers:** participants expressed appreciation and gratitude towards others within the institution for their efforts in coping with the situation, providing assistance and being responsive.
- **Improvement in performance:** ODE was thought to enhance efficiency, performance and attention, as well as help in the learning process.
- **Preferred to traditional:** although students expressed sentiments of missing peer-to-peer interaction, the majority were open to and some even favoured ODE to conventional learning that requires physical attendance and is restricted to classrooms. This may be due to the flexibility, convenience and low cost of online learning.
- **Anxiety inducing:** some participants reported feelings of stress or anxiety in trying to grapple with the current pandemic situation while adapting to the new learning scheme.

Table 5 lists the research articles that described feedback received on distance education based on the aforementioned points.

Table 5 Received feedback discussed among articles

Received Feedback	Reference	Frequency	Percentage
Satisfactory or beneficial	A25, A30, A33, A34, A38, A40, A42, A44, A45	9	19%
Adequate and effective	A22, A23, A25, A30, A31, A45	6	13%
Expressed doubts or concern	A15, A19, A31, A44	4	9%
Overwhelming	A3, A15, A20, A21	4	9%
Potential	A19, A23, A30, A41	4	9%
Appreciation for staff or peers	A15, A25, A38	3	6%
Improvement in performance	A1, A10, A23	3	6%
Preferred to traditional	A2, A6, A29	3	6%
Anxiety inducing	A33, A37	2	4%

4.5 Study recommendations

This section addresses research question 5 (RQ5), which attempts to summarize the recommendations put forward by either the authors of the selected studies or the people who participated in them.

The following are the key recommendations made:

- **Support for students:** boosting and maintaining motivation of students to improve morale and help combat any lockdown-induced stress or anxiety.
- **High-quality tools:** providing accessible, user-friendly, error-free and high-quality E-learning portals and other types of online platforms.
- **Providing & receiving feedback:** providing and receiving feedback to and from students to improve the quality of online education.
- **Investigating efficacy:** exploring the outcomes of ODE and reflecting on the differences between it and traditional education in order to ascertain which aspects of it are viable and meet the demands sets by the pandemic situation. This is also to assist teachers in employing effective teaching techniques and to enable researchers and institutions to continue the development of online educational tools.
- **Stating objectives:** students need to feel the relevance of the study material to the real world, as well as understand the course requirements. To that end, teachers must spell out expectations and clarify course objectives as well as the importance of the syllabus. They also need to delineate their roles and responsibilities as lecturers and mentors early on in the academic year.
- **Policymaking:** policymakers should seek to understand and mitigate any risks or inequalities created by this rapid transition to online learning, which may be caused by income or workload disparities.
- **Redesign:** the revisiting and rethinking of pedagogical strategies and the development of orienting principles to guide the transition to online education, as well as making the necessary adjustments to infrastructure.
- **Training of staff & students:** providing students and teachers with adaptability training to familiarize them with technology, increase their competence and

prepare them to deal with technical issues that can occur during online lectures. This will also help in the smart application of technology to realize its potential in the realm of online education.

- **Diversifying:** maximizing efficiency by avoiding reliance on a single method or platform and instead using a variety of online learning resources. For example, a course could use both video conferencing and text messaging.
- **Broadening accessibility:** this could mean providing underequipped students with the equipment necessary to partake in online activities, such as electronic devices and stable internet connection.

Table 6 lists the research articles that made recommendations based on the points listed above.

5 Conclusion and future work

It goes with without saying that the COVID-19 pandemic has had profound impacts on society and on the way humans organize themselves in the real world. It has exposed systematic issues within institutions and brought about long overdue changes. The educational system was no exception to this.

This review aimed to look at and evaluate the impact these changes have had on education, with a particular focus on the digital transformation and the shift to online learning caused by the pandemic. To do so, we took a look at more than 40 papers from high impact journals that touched on the topic of education during the times of COVID-19.

Many institutions and governments were underprepared for this abrupt migration to technology-based working and learning. This resulted in issues of inequality, lack of access and lack of skills to facilitate this type of learning. There are limitations inherent to ODE that prevent it from acting as a full substitute to traditional education. This is particularly true in fields where hands-on training is an absolute necessity to meet learning requirements.

Table 6 Recommendations discussed among articles

Recommendations	Reference	Frequency	Percentage
Support for students	A8, A12, A13, A15, A16, A18, A20, A21, A29, A30, A31, A33, A42	13	28%
High-quality tools	A6, A9, A22, A26, A32, A33, A35, A38, A42, A43	10	21%
Providing & receiving feedback	A8, A9, A12, A31, A32, A38	6	13%
Investigating efficacy	A19, A22, A24, A33, A40, A43	6	13%
Stating objectives	A8, A12, A15, A29, A31, A46	6	13%
Policymaking	A8, A18, A24, A28, A29, A38	6	13%
Redesign	A13, A17, A18, A33, A41	5	11%
Training of staff & students	A16, A25, A30, A35, A46	5	11%
Diversifying	A5, A13, A40, A44	4	9%
Broadening accessibility	A2, A9, A24, A38	4	9%

On the plus side, the new forced dependence on technology in education may hasten some already underway changes. On the negative side, requiring children to continue their studies at home may worsen educational disparities caused by inequalities.

From the viewpoint of learners and educators, there are a range of difficulties in switching from offline to online learning modes. Another stumbling block in the acceptance of online teaching is involving students and indulging them in teaching-learning progression. It takes an hour to create content that not only covers the curriculum, but also inspires learners.

We found that some of the key disadvantages of ODE that were cited in the collected papers were inequality of access, inadequacy of online teaching, poor communication quality, technical difficulties, increased workload and stress, low technological literacy, difficulty in assessment of student engagement and performance, bad work-life balance and some privacy concerns.

Whereas the main advantages of ODE according to the papers were flexibility and convenience, discussion & communication, effectiveness as a didactic tool, efficiency, decreased costs, increased exposure to technology and that it was seen as an impetus for change.

The papers that explored the topic of student experience aimed to gauge the response of students and teachers to this transformation and how it impacted their experience and we found that the main feedback point given was that online education was satisfactory, beneficial and effective. However, some expressed doubts over the efficacy of remote learning, uncertainty about the future, and concern over the long-term consequences on health, security and access due to this digital transformation. Others found it to be overwhelming or anxiety inducing. However, some observed an improvement in performance and expressed more appreciation towards their peers and faculty members.

Although the adoption of online teaching during COVID-19 is commendable, the quality of teaching and courses offered online must also be developed and strengthened. Some of the advice that has been put forward to help in that regard includes supporting students by improving morale, providing high-quality e-learning tools, giving and receiving feedback from students, investigating the outcomes of ODE, clarifying course objectives and expectations to students, providing training for students and teachers to familiarize them with technology, diversifying instructional delivery methods, broadening accessibility to online learning, soliciting policymakers to make necessary changes and the revisiting and redesigning of pedagogical strategies.

The flexibility and convenience ODE offers and the much-needed push for change it has inspired cannot be denied. However, its efficiency in terms of student outcome as compared to traditional education is still a point of dispute. It is therefore imperative to continue investigating online education. Policymakers should take the findings of research on education seriously in order to bridge whatever gaps may be present.

Future research could draw from a broader diversity of sources to reach wider conclusions.

Appendix

Table 7 Selected research articles

ID	Title	Publisher	Reference
A1	Radiology Education in the Time of COVID-19 - A Novel Distance Learning Workstation Experience for Residents	Elsevier	(McRoy et al., 2020)
A2	Using Technology to Maintain the Education of Residents During the COVID-19 Pandemic	Elsevier	(Chick et al., 2020)
A3	Distance education as a response to pandemics: Coronavirus and Arab culture	Elsevier	(Al Lily et al., 2020)
A4	Virtual Learning During the COVID-19 Pandemic: A Disruptive Technology in Graduate Medical Education	Elsevier	(Almarzooq et al., 2020)
A5	Creating Bioethics Distance Learning Through Virtual Reality	Elsevier	(Harfouche & Nakhle, 2020)
A6	Utility of a webinar to educate trainees on UK core surgical training (CST) selection – A cross sectional study and future implications amidst the COVID-19 pandemic	Elsevier	(Patel et al., 2020)
A7	Undergraduate Radiology Education During the COVID-19 Pandemic: A Review of Teaching and Learning Strategies	Elsevier	(Darras et al., 2020)
A8	Education, the science of learning, and the COVID-19 crisis	Springer	(Thomas & Rogers, 2020)
A9	Effects of COVID-19 in E-learning on higher education institution students: the group comparison between male and female	Springer	(Shahzad et al., 2020)
A10	Learning and Teaching Online During Covid-19: Experiences of Student Teachers in an Early Childhood Education Practicum	Springer	(Kim, 2020)
A11	Learning in times of lockdown: how Covid-19 is affecting education and food security in India	Springer	(Alvi & Gupta, 2020)
A12	Inclusive Teaching in Isolating Situations: Impact of COVID-19 on Efforts Toward Increasing Diversity in BME	Springer	(Matters et al., 2020)
A13	We Asked the Experts: Virtual Learning in Surgical Education During the COVID-19 Pandemic—Shaping the Future of Surgical Education and Training	Springer	(Ehrlich et al., 2020)
A14	Transforming ophthalmic education into virtual learning during COVID-19 pandemic: a global perspective	Springer Nature	(Chatziralli et al., 2020)
A15	Forced Disruption of Anatomy Education in Australia and New Zealand: An Acute Response to the Covid-19 Pandemic	Wiley	(Pather et al., 2020)
A16	Multidisciplinary academic perspectives during the COVID-19 pandemic	Wiley	(Al-Taweel et al., 2020)

Table 7 (continued)

ID	Title	Publisher	Reference
A17	Covid-19 pandemic and online learning: the challenges and opportunities	Routledge	(Adedoyin & Soykan, 2020)
A18	Reconceptualising relatedness in education in 'Distanced' Times	Routledge	(Murray et al., 2020)
A19	The Covid-19 pandemic and its effects on teacher education in England: how teacher educators moved practicum learning online	Routledge	(Kidd & Murray, 2020)
A20	Serving up food studies online: teaching about "food from somewhere" from nowhere	Routledge	(Levkoe et al., 2020)
A21	The use of digital technology at home during the COVID-19 outbreak: views of social work students in Greece	Routledge	(Papouli et al., 2020)
A22	Experiences of Nursing Students during the Abrupt Change from Face-to-Face to e-Learning Education during the First Month of Confinement Due to COVID-19 in Spain	MDPI	(Jes et al., 2020)
A23	Students' Acceptance of the COVID-19 Impact on Shifting Higher Education to Distance Learning in Poland	MDPI	(Rizun & Strzelecki, 2020)
A24	Suspending Classes Without Stopping Learning: China's Education Emergency Management Policy in the COVID-19 Outbreak	MDPI	(Zhang et al., 2020)
A25	Teaching Challenges in COVID-19 Scenery: Teams Platform-Based Student Satisfaction Approach	MDPI	(Rodriguez-segura et al., 2020)
A26	Covid-19: using simulation and technology-enhanced learning to negotiate and adapt to the ongoing challenges in UK healthcare education	The BMJ	(Wyres & Taylor, 2020)
A27	Experimentation Skills Away from the Chemistry Laboratory: Emergency Remote Teaching of Multimodal Laboratories	ACS Publications	(Sandi-Urena, 2020)
A28	COVID-19 and the academe in South Africa: Not business as usual	Academy of Science of South Africa	(Hedding et al., 2020)
A29	Using social media to support teaching and learning in higher education: an analysis of personal narratives	Association for Learning Technology	(Kara et al., 2020)
A30	Successes and Challenges: Online Teaching and Learning of Chemistry in Higher Education in China in the Time of COVID-19	ACS Publications	(Huang, 2020)
A31	An Analysis of the Effectiveness of Online Learning in Colleges of Uttar Pradesh during the COVID 19 Lockdown	Science Press	(Agarwal & Dewan, 2020)
A32	University Education in KSA in COVID Times: Status, Challenges and Prospects	Primrose Hall Publishing Group	(Ibraheem et al., 2020)
A33	Impacts of Online Remote Education on the Learning Process among Nursing Students	Scientific Research Publishing	(Ali et al., 2020)

Table 7 (continued)

ID	Title	Publisher	Reference
A34	Introducing a comprehensive high-stake online exam to final-year dental students during the COVID-19 pandemic and evaluation of its effectiveness	Taylor and Francis Ltd.	(Khalaf et al., 2020)
A35	Impact of COVID-19 Emergency Transition to On-line learning on International Students' Perceptions of Educational Process at Russian University	Association for Social Studies Educators (ASSE)	(Novikov, 2020)
A36	Prospective Teachers' Online Learning Mathematics Activities in The Age of COVID-19: A Cluster Analysis Approach	Modestum	(Mulenga & Marbán, 2020)
A37	Impact of "e-Learning crack-up" perception on psychological distress among college students during COVID-19 pandemic: A mediating role of "fear of academic year loss"	Elsevier	(Hasan & Bao, 2020)
A38	Online Learning in the Face of COVID-19 Pandemic: Assessment of Students' Satisfaction at Chitwan Medical College of Nepal	Kathmandu University	(Sharma et al., 2020)
A39	Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life	Elsevier	(Dwivedi et al., 2020)
A40	Responding to an international crisis: The adaptability of the practice of work-integrated learning	IJWIL	(Zegwaard & Rowe, 2020)
A41	Using simulations to improve skills needed for work-integrated learning before and during COVID-19 in Namibia	IJWIL	(Batholmeus, n.d.)
A42	Preparing for work-integrated learning during COVID-19: How a new virtual orientation tool facilitated access for all	IJWIL	(Carmody et al., 2020)
A43	The potential of a simulated workplace environment for emergency remote teaching	IJWIL	(Hudson et al., 2020)
A44	Virtual WIL clinics in medicine: Overcoming the COVID-19 challenge	IJWIL	(Rasalam, 2020)
A45	Working remotely: Innovative allied health placements in response to COVID-19	IJWIL	(Salter, 2019)
A46	Preservice teachers use of WhatsApp to explain subject content to school children during the COVID-19 pandemic	IJWIL	(Practicum, 2020)
A47	Reimagining internships through online experiences: Multi-disciplinary engagement for creative industries students	IJWIL	(Briant, 2020)

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