

Review

Digital transformation of education, the limitations and prospects of introducing the fourth industrial revolution asynchronous online learning in emerging markets

David Mhlanga¹

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Abstract

This study aims to evaluate the opportunities and limitations of switching from conventional, face-to-face education to online, asynchronous education made possible by the Fourth Industrial Revolution's technology. This transition has been considerably expedited in several nations by the COVID-19 epidemic. Desktop analysis was used to conduct the research, along with non-intrusive approaches, including documentary analysis and conceptual analysis, and reliable sources were consulted. The research findings identified several barriers to the broad implementation of the Fourth Industrial Revolution asynchronous online education in emerging nations to address COVID-19's effects and keep the needs of the revolution. Among these challenges are poverty and inequality, power shortages, a lack of knowledge, restricted access to technology and the internet in rural areas, and a clear national policy. Despite these difficulties, institutions can increase access to top-notch education by establishing themselves as centres of excellence and innovation through online learning. Therefore, for the infrastructure required to enable the widespread use of asynchronous education, the education sector in emerging nations requires additional resources. Therefore, the study recommends that educational institutions in emerging markets prioritize investments in digital infrastructure and training. This will enable a smoother transition to asynchronous online education. Additionally, policymakers should develop comprehensive strategies that address the digital divide, ensuring equitable access to technology and the Internet, especially in rural and underserved areas. Collaboration between governments, educational institutions, and private sectors is essential for the effective implementation of 4IR technologies in education.

Keywords Asynchronous online learning · COVID-19 · Challenges · Education · Emerging markets

1 Introduction

Digital transformation has emerged as an issue that educational institutions must address in the twenty-first century. It is an essential step for organisations that want to maintain high levels of competitiveness and achieve leadership positions in their industries [1]. Several authorities in the field of business have attempted to provide definitions for "digital transformation." For instance, Hess et al. [2] define it as the alterations brought about by digital technologies in a company's business model, which could result in changes to products, organisational structures, or the automation of processes. This could reduce the need for employees to perform certain specific tasks. According to Gobble [3], digital transformation

✉ David Mhlanga, dmhlanga67@gmail.com; dmhlanga@uj.ac.za | ¹College of Business and Economics, The University of Johannesburg, PO Box 524, Auckland Park 2006, South Africa.



is defined as a comprehensive transformation of business operations, procedures, knowledge, skills, and designs. This transformation is carried out to maximise technology's impact on society and capitalise on the opportunities event and s in a strategic and prioritised manner. This makes a seamless transfer of the opportunities and influences technology has on society. These definitions were mainly focusing on business so in education digital transformation is defined as the integration of technology into various aspects of the education system, including teaching, learning, assessment, and administration [4–6]. This involves using digital tools and platforms to enhance the educational experience, improve learning outcomes, and increase the efficiency and effectiveness of educational institutions. Some examples of digital transformation in education include online learning platforms, digital tools, and platforms such as Learning Management Systems (LMS) and Massive Open Online Courses (MOOCs) which provide students with access to educational content and resources from anywhere in the world. Other examples include digital assessment tools such as online quizzes and automated grading systems that allow teachers to assess student performance and provide feedback, in virtual and augmented reality quickly and accurately. These technologies provide students with immersive learning experiences that can enhance their understanding of complex concepts.

On the other hand, Asynchronous online learning in emerging markets refers to the use of digital technologies to provide education and training to individuals in emerging economies without requiring them to be present at a specific time or location. Asynchronous online learning allows students to access course materials and complete assignments at their own pace, which can be particularly beneficial for individuals who are working or have other responsibilities [7, 8]. Emerging markets often face challenges in providing high-quality education due to limited resources, infrastructure, and a shortage of qualified teachers. Asynchronous online learning can help overcome some of these challenges by providing access to educational resources and training opportunities that might not be available otherwise. However, there are also challenges to implementing asynchronous online learning in emerging markets. These include limited access to technology and internet connectivity, language barriers, and the need for localized content and curriculum. To overcome these challenges, it is important to develop innovative solutions that address the unique needs of students in these regions.

According to the World Bank [9], around 262 million children do not go to school most of these children live in countries with low and intermediate incomes. The World Bank [9] continued by stating that many kids are not enrolling in schools due to several problems. Some of these challenges include a shortage of schools, an inability to go to schools due to violence or a disaster, and other similar circumstances. In certain instances, the issue can be traced back to an insufficient number of adequately educated educators. In the worst-case scenarios, the problem is only worsened by a scarcity of teachers. The very existence of COVID-19 has made an already dire situation much worse, and as a direct result, all schools around the world have been closed. On the other hand, because of the technological revolution, children, and teenagers in both the developed and developing worlds are experiencing profound shifts in their access to information, their capacity for communication, their educational experiences, and even how they choose to spend their leisure time. Jhurry and Rampersad [10] suggested that the development of the internet and information and communication technology in the 1990s was responsible for online education's rise in popularity and digital platforms' utilisation.

Jhurry and Rampersad [10] further argued that the evolution of the web from a repository of hypertext links to a fully functional medium of communication, along with a change in learning theory from behaviourism, which has long dominated educational theory, to constructivism and cognitivism, supported by tools and methods like online databases. This has made a significant contribution to the effectiveness of online learning, whose advantages are now undisputed. Implementing online learning requires adopting a strategy that is both well-structured and continuously adaptable to a dynamic environment, claim Jhurry and Rampersad [10]. Jhurry and Rampersad [10] further argued that academic institutions must now keep moving step by step by further adopting technological transition as a series of profound and synchronised cultural, working population, and technical advances for enhanced processes and strategic directions, as well as value propositions, in these early days of Industry 4.0. This is because colleges must embrace digital in these early stages of Industry 4.0 given the rapid advancements in artificial intelligence and data science.

The e-library is no longer the endpoint, as library staff should keep moving from the understanding of the collection to the understanding of the users, as Jhurry and Rampersad [10] discovered. Libraries have a crucial role in supporting universities during this transformation phase, and Jhurry and Rampersad [10] found that this is the case. Additionally, Azevedo and Azevedo [11] noted that educational institutions have engaged in digital transformation, which has brought about new opportunities and issues linked with this transition. According to Azevedo and Azevedo [11], the COVID-19 outbreak hastened this trend, highlighting online education's importance in the educational system. Azevedo and Azevedo [11] gave a presentation that outlined the difficulties and opportunities associated with the digital transformation of educational institutions and the requirements brought about by the COVID-19 epidemic. According to Azevedo

and Azevedo [11], digital transformation involves restructuring educational institutions, not only in the academic curriculum but also in both networking and social ways. This reorganisation must take place before the digital transformation can take place. According to Azevedo and Azevedo [11], efforts are required to integrate students and teachers in this digital age because both groups require training, supervision, and support in digital knowledge and digital security. Otherwise, there is a chance of disruptions and agony occurring during the shifting process, and only some of the progress that has been accomplished may be sustained. Again, Azevedo and Azevedo [11] emphasised that despite all of the recognised advantages of applying new technologies in learning, the digital divide raises issues about equity. This was said in the context of a study. It was also underlined by Azevedo and Azevedo [11] that a decent internet connection and equipment availability are crucial to making the educational process uniform and fair.

Additionally, Azevedo and Azevedo [11] found evidence that the Covid-19 pandemic put everyone. However, teachers have especially been put under a significant amount of stress due to the forced digital transition and the abrupt change in routines and procedures. However, Azevedo and Azevedo [11] believe that this massive change also brought strong points, such as additional investment in future technologies with various efforts and having to learn frameworks already in exercise and which are here to stay, as the teaching techniques will never be the same again after such an impactful experience. The study was guided by the following research questions. What are the primary challenges associated with implementing Fourth Industrial Revolution (4IR) technologies in the education sector of emerging economies? How do 4IR technologies create opportunities for innovation in educational practices, particularly in asynchronous online learning, in emerging economies? What are the socio-economic impacts of integrating 4IR technologies into the educational systems of emerging economies? What strategies and policy recommendations can be derived to facilitate the effective integration of 4IR technologies in education in emerging economies? Therefore, the objective of the study was to explore the transformative impact of the Fourth Industrial Revolution (4IR) on education in emerging economies, particularly focusing on the shift from traditional classrooms to online learning environments. We aim to critically analyze how 4IR technologies, through asynchronous online learning, present both challenges and opportunities in these settings. The study delves into the nuances of digital infrastructure, policy implications, and socio-economic factors, with an emphasis on creating inclusive and innovative educational methods. Our goal is to offer practical solutions and strategies for effectively integrating 4IR technologies into educational systems, thus fostering sustainable development in these economies. By examining the transition to online education, we will assess the resultant opportunities and obstacles, evaluating their impact on the educational framework from technological and socio-economic perspectives.

2 Digital transformation in education

Introducing pedagogical changes during the educational sector's digital revolution is crucial for improving student learning experiences. The improvements include implementing new technologies in classrooms, changing evaluation methods, and monitoring student progress. The primary objective of these adjustments is to enhance results for children, irrespective of the type of reforms [11]. Higher education has recently transformed digital technology into a sophisticated ecosystem that enables online teaching and learning, diverging significantly from conventional approaches [11]. The transition to digital platforms has led to a major movement towards virtual teaching and learning, facilitated by a range of digital educational tools. Examples comprise learning management systems like Moodle and Google Classroom, online collaboration tools such as Zoom and Teams, and gadgets like Google Chromebooks, MacBooks, iPads, and tablets. Since the onset of the COVID-19 pandemic in 2022, more than 1.5 billion students worldwide have transitioned to online education [12]. Educational institutions and governments are working together to create and execute digital transformation initiatives to streamline the learning experience for all students. Education has a large role in the GDP of numerous countries, with worldwide expenditure projected to hit \$404 billion by 2025, highlighting its significance as a key industry [12].

Digital transformation in education is thought to improve the quality of educational experiences for students, teachers, and all stakeholders. The enhancements aim to boost engagement and accessibility by utilizing interactive and individualized learning methods, ultimately lowering the expenses of online education and enhancing its comprehensiveness and availability. Micro-lessons, interactive videos, quizzes, and AI-based learning approaches improve student engagement and participation. They also provide accessibility for those with disabilities by offering features like colorblind-friendly visualizations and text-to-speech capabilities. Incorporating digital technology into education greatly improves and streamlines the learning process. This involves automating operations such as printing essays, grading tests, and computing grades. Mobile and tablet technologies have advanced, giving students

more flexibility and control in creating and sharing knowledge. Learners, educators, and researchers can create new ways that enhance student autonomy in the classroom due to these advancements. Technology-enhanced teaching methods help create novel teacher–student dynamics and expedite the exchange of pedagogical expertise. The main goal is to enable students to manage their education by participating in online assignments, generating new information, and applying their knowledge in actual situations.

3 Critical areas of digital transformation in the education industry

Figure 1 below outlines some critical areas where digitalisation of the learning process is possible.

The following is a list of the important sectors that are being transformed by digital technology in the educational sector: managing admissions, limiting risks, increasing learning outcomes, and measuring performance, amongst others. It is time-consuming and exhausting to manually upload the enrolment application to colleges or universities. It will be much simpler and more convenient to submit them through a unified online system. Applicants have the option of selecting all the institutions that are of interest to them and simultaneously sending the relevant documents. This time-efficient alternative would accept an applicant’s documents and process them more quickly. Again, online education can accommodate both scenarios, whether a child is ill, or the lessons are cancelled due to severe weather conditions.

Now, all an applicant must do to keep up their impressive attendance rates and ensure they do not miss an essential lesson is either click the “Join” option on the meeting tool or simply go through the content uploaded to the cloud. Increase students’ learning abilities by providing them with interactive classes and applying high-tech solutions. This will help pupils become more motivated to learn. They can take in more pertinent information at once if they pay greater attention to what is being placed. Using online technologies, students who are being evaluated based on their performance will have quicker access to their tests and grades. E-learning platforms enable students to submit papers, do quick checks for plagiarism, and keep track of their attendance; together, these components comprise students’ performance levels, which may be easily measured using a digital platform.

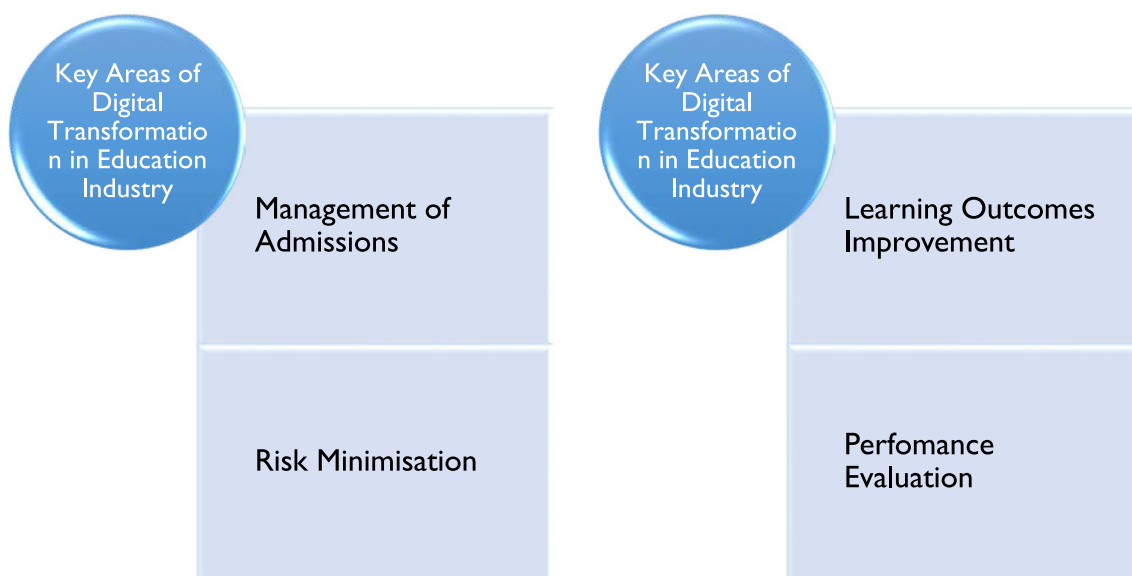


Fig. 1 Key areas of digital transformation in the education industry

4 Empirical literature on digital transformation of education

The digital transition has brought forth new experiences that have opened opportunities for research in all spheres of the economy, including education. For example, Bilyalova et al. [4] argued that digital technology in the world today is not only a tool but also a living environment that provides new possibilities for learning at any convenient time and continuing education. Various research studies were conducted to determine the effects of digital transformation on the education sector. The uniqueness of digital education, the state of its implementation now, the anticipated outcomes, and any related problems were all described by Bilyalova et al. [13]. According to Bilyalova et al. [13], the effectiveness of the teaching and learning process in which modern students are engaged must be considered when evaluating the benefits and hazards of digital education. In addition, Bogdandy et al. [14] suggested that COVID-19 made the gradual pace of digital transformation in education into a pressing issue in the spring of 2020.

The Hungarian government stopped the schools and universities in the middle of March, and lessons were then held online, which presented difficulties for both students and professors, according to Bogdandy et al. [14]. However, a poll by Bogdandy et al. [14] revealed that students studying computer science and information technology at Eszterhazy Karoly University valued their digital education, with half saying they would like to continue it in the future. Additionally, Bogdandy et al. [14] discovered that during tutorials that permit some adjustments in the labour environments, pupils would prefer to use their own devices. Unfortunately, Bogdandy et al. [14] report that some students experienced technical problems that the heterogeneous software environment might have brought on but could be resolved with the help of support materials. The digital transformation was successful, and the feedback will be incorporated into our online classes. According to Balyer [15], with the help of Industry 4.0 and globalisation, evolving information and communication technologies have impacted and even revolutionised practically every aspect of our current digital age.

According to Balyer [15], the structure of education and the learning environments are impacted by the world's rapid changes and transitions. According to Balyer [15] findings, managers must develop a vision to generate and manage the following for an effective learning environment during the digital transformation process. Another finding from Balyer [15] is that it may be possible for school shareholders to participate in this transformation process by providing them with access to suitable materials and infrastructure at the right time. Educational administrators and program specialists should be prepared for this shift and possess the skills necessary to handle it, according to Balyer [15]. According to Benavides et al. [16], the Industrial Revolution 4.0's technological growth has permeated higher education institutions (HEIs), forcing them to deal with a digital revolution in every aspect. Benavides et al. [16] claim that applying digital transformation methodologies to the HEI domain is a developing topic that has attracted interest recently because it enables us to define the intricate relationships between actors in an educational domain assisted by technology. The distinguishing features of the Kitchenham protocol-enabled digital transformation (DT) implementation process that took place in HEIs were outlined by Benavides et al. [1]. The major conclusions by Benavides et al. [1] demonstrate that this discipline is indeed in its infancy and that none of the DT in HEI projects that have been identified have been developed holistically. According to Qarkaxhja et al. [16], studies on mobile learning have grown in recent years, and more technological tools are being employed in education every day.

As a result, Qarkaxhja et al. [16] discovered that the opinions of teacher candidates on mobile learning were obtained by utilising qualitative research methods to determine their perspectives on mobile learning. Future teachers' thoughts on mobile learning are therefore highly essential. According to Schenk and Dolata [17], university curricula must be adjusted to adequately prepare graduates for managing digital transformation in public administration. This is especially true in business and engineering departments that offer practice-oriented university courses to address real-world digitalisation challenges. According to Schenk and Dolata [17], how to incorporate a modern, hands-on training strategy for digitisation with the subjects covered in public administration courses is still being determined. Schenk and Dolata [17] state that a public administration course taught in a German university follows a specific structure and incorporates a predetermined number of different teaching strategies. The preliminary findings of Schenk and Dolata's [17] research indicate that participants in the course, both students and practice partners, viewed it as beneficial. Schenk and Dolata [17] provided an example in their conclusion of how public administration universities could support digital transformation by collaborating with local governments and preparing students to lead and manage it in the public sector. Schenk and Dolata [17] provided this model. According to Abad-Segura et al. [18], the digital transformation of the education sector has compelled the participation of sustainable management to react to the changes brought on by new technologies. These changes were brought about due to the introduction

of new technologies. Abad-Segura et al. [18] analysed trends that were seen in international research on the topic of digital transformation in education from the years 1986 to 2019. The data that were reported by Abad-Segura et al. [18] provided information on the scientific production of authors, journals, establishments, and countries that encourage the expansion of this field of study. Again, the data by Abad-Segura et al. [18] demonstrate exponential growth, with a particular focus on the past 5 years, with the primary categories being social sciences and environmental science. The Journal of Sustainability has the highest rate of productivity. The author who has contributed to the most publications is Mulder, who teaches at The Hague University of Applied Sciences. The Delft University of Technology is the most fruitful institution in terms of research and development. The United States of America is the nation that has contributed the most to international panel discussions and scholarly publications.

5 Research methodology

This study aims to provide a comprehensive analysis of the challenges and opportunities associated with the adoption of asynchronous online learning in the educational systems of developing countries. To achieve this, we employed a mixed-methods approach, integrating both qualitative and quantitative analyses derived from an extensive review of secondary data sources. This included peer-reviewed journals, official publications, and reports from reputable local, national, and international organizations.

6 Systematic literature review process

Our systematic literature review was meticulously designed to ensure the inclusion of relevant, high-quality studies that directly contribute to understanding the impact of the Fourth Industrial Revolution (4IR) on asynchronous online learning in developing countries. The process involved several key stages which include the Initial Search and Preliminary Screening. Following the guidelines by Tawfik et al. [19], an initial search was conducted to identify publications relevant to our research question. This step aimed to validate the research idea, avoid duplication of existing studies, and ensure a sufficient volume of literature for review. The other stage was the Inclusion and Exclusion Criteria. With the Inclusion Criteria, studies included in the review were required to (a) focus on the integration of 4IR technologies within education, (b) specifically address asynchronous online learning, (c) be conducted within the context of emerging economies, and (d) be published in the last decade between 2010 and 2020 to ensure relevance to current technological advancements. We included empirical studies, theoretical analyses, policy reports, and case studies. Concerning the Exclusion Criteria, studies were excluded if they (a) did not focus on asynchronous online learning, (b) were not relevant to the context of developing nations, or (c) lacked methodological rigour or were not peer-reviewed. The term emerging economies is defined in this study as countries experiencing rapid industrialization and growth but facing significant challenges in education, infrastructure, and technological access, aligning with the classification provided by the World Bank. Figure 2 below shows the selection process of the studies included in the paper.

Figure 2 above gives the flow diagram of the screening process. The process also involved Data Checking and Validation. To mitigate the risk of human error and bias, a data-checking stage was incorporated. Each study selected for inclusion underwent a verification process, where its key details were compared against its corresponding entry in an extraction sheet, following a predefined template for consistency. Boolean Search Strategy was also utilised. To refine our search, we employed specific Boolean operators (AND, OR, NOT) across various databases (Scopus, Google Scholar, ResearchGate, and Web of Science) to define the relationship between our primary keywords shown in Fig. 3 below “4IR”, “asynchronous online learning”, and “emerging economies”. This strategy was consistently applied across all databases to ensure a comprehensive and replicable search process. For example, the search string might look like “4IR AND asynchronous online learning AND emerging economies” The search was conducted for publications released between January 2010 and December 2020, providing a clear and specific timeframe that aligns with the onset and development of the Fourth Industrial Revolution’s impact on education. The quality of the studies included in the review was assessed based on their relevance to the research topic, the credibility of the publication source, the methodological rigour, and the impact factor of the journals. This comprehensive appraisal ensured that our conclusions and recommendations were based on robust and reliable research.

Figure 3 depicts the search terms that were used in the analysis.

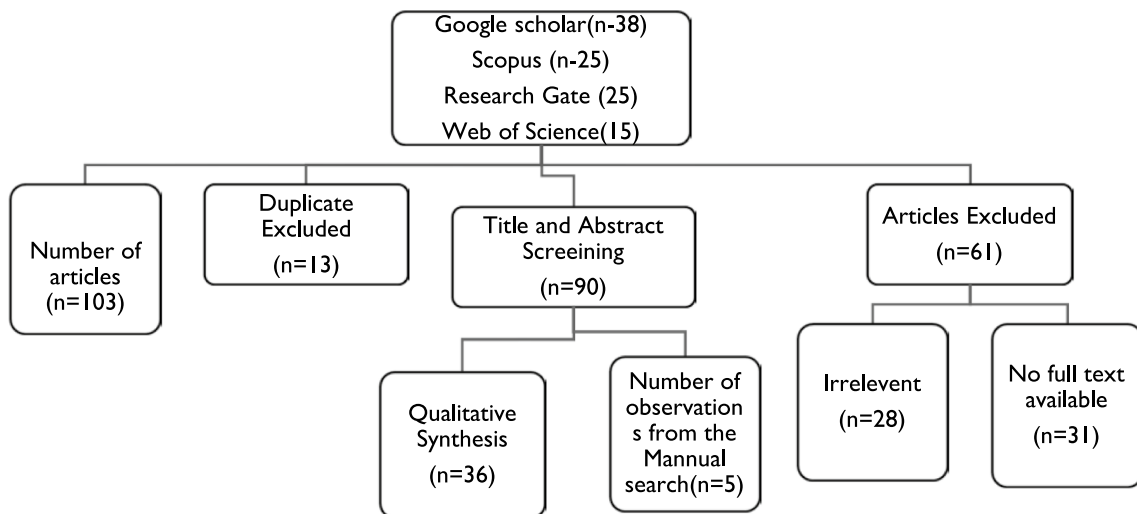
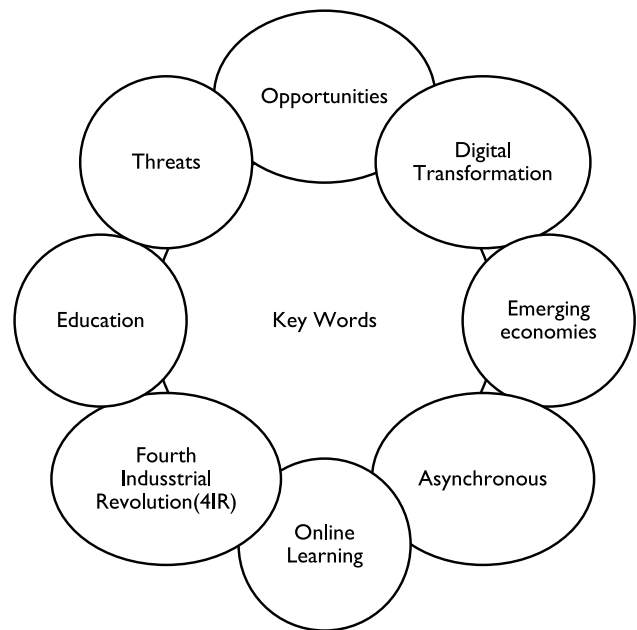


Fig. 2 Flow diagram of studies' screening and selection (Source: Author's Analysis)

Fig. 3 Key words utilized in the identification of sources



7 Data analysis and synthesis

Using the collected data, the study identified key challenges, such as limited access to technology, inadequate infrastructure, and insufficient educator training, which hinder the adoption of asynchronous online learning in developing countries. It also highlighted opportunities like enhanced educational accessibility, flexible learning environments, and the potential to bridge the educational divide between developed and developing nations.

The papers that were chosen to be included in the research are outlined in Table 1 above. The table is only a subset of the total number of publications that were considered for the study. For data analysis, we employed a thematic coding scheme. This involved categorizing the collected data into key themes such as “technological challenge”, “policy implication”, “socio-economic barrier”, and “innovative educational practice”. This systematic approach enabled us to distil the vast array of information into coherent, focused insights directly relevant to the integration of 4IR in educational contexts of emerging economies.

Table 1 Selected articles consulted in the study

Study	Focus	Year
Kayembe and Nel	Challenges and opportunities for education in the fourth industrial revolution. <i>African Journal of Public Affairs</i>	[20]
Mhlanga and Moloji	COVID-19 and the digital transformation of education: what we are learning in South Africa	[4]
Meyer and Gent	The status of ICT in education in South Africa and the way forward. <i>Centurion: the National Education Collaboration Trust (NECT)</i>	[21]
Schwab	The fourth industrial revolution	[22]
Kuali	Four key challenges of digital transformation for higher education	[23]
Starkey	A review of research exploring teacher preparation for the digital age	[5]
Ekstrand	Prerequisites for persistence in distance education	[24]
Mhlanga	The fourth industrial revolution and COVID-19 Pandemic in South Africa: the opportunities and challenges of introducing blended learning in education	[11]

8 The implementation of 4'R tool and digital transformation in e'ucation

COVID-19 has had a profound impact on the educational system in developing nations as well as the rest of the world. Learning through the traditional face-to-face interaction method was difficult in developing nations because of the pressure placed on social separation to prevent the virus from spreading ultimately. The declaration of the lockdown by many governments of made conditions even direr, which only served to exacerbate the situation. Because of this, the Departments of Education decided to form partnerships with various private institutions and non-governmental organisations to implement a remote learning system that uses a wide variety of digital tools. These tools include televisions, radios, internet services, social media applications, and mobile phone programs [4]. The following table provides an overview of the various 4IR technologies that were utilised during the lockdown in various nations. Mhlanga and Moloji [4] state that these technologies were implemented across several different platforms to mitigate the negative effects that COVID-19 had on education. Figure 4 below outlines the soft technologies applied in the education sector to facilitate teaching and learning.

Some of the soft technologies that were implemented in developing nations as a response to the disruptions caused by the COVID-19 epidemic are depicted in Fig. 4. According to the table, there was a significant amount of use of free programs and websites dedicated to education, as well as social networking platforms like Facebook, Twitter, and WhatsApp, as well as internet websites like YouTube, Microsoft Teams, Skype, Zoom, Blackboard, and Smart Notebook [11]. The hard technologies that are utilised to make online and remote learning possible in developing nations are displayed in Fig. 5.

Some of the hardware and software utilised in the educational system are depicted in Fig. 5, which may be found below. A significant amount of time was spent on electronic devices such as laptops, tablets, mobile phones, television, and even the radio. The application of these instruments was a significant contributor to the success of the academic year. Because of this, several researchers believe that the educational system in developing nations should adopt blended learning as a model for teaching and learning as a means of adapting to the requirements of the 4IR.

9 Asynchronous learning a requirement in the presence of COVID-19 and the age of technology the 4IR

According to Schwab [22], sixty-five per cent of youngsters who start elementary school today will end up working in entirely new occupations that still need to be created. This creates risks for the education industry regarding being prepared for 4IR. To make matters even more complicated, COVID-19 is, in effect, compelling governments worldwide to rethink their plans to transition from the in-person instruction of the third industrial revolution to the asynchronous educational model of the fourth industrial revolution. Synchronous learning is also appropriate in some cases, although this is very dependent on the resources that are available to the learners. In South Africa, COVID-19 took the country by surprise; hence, the asynchronous form of online learning will be the most suitable option in

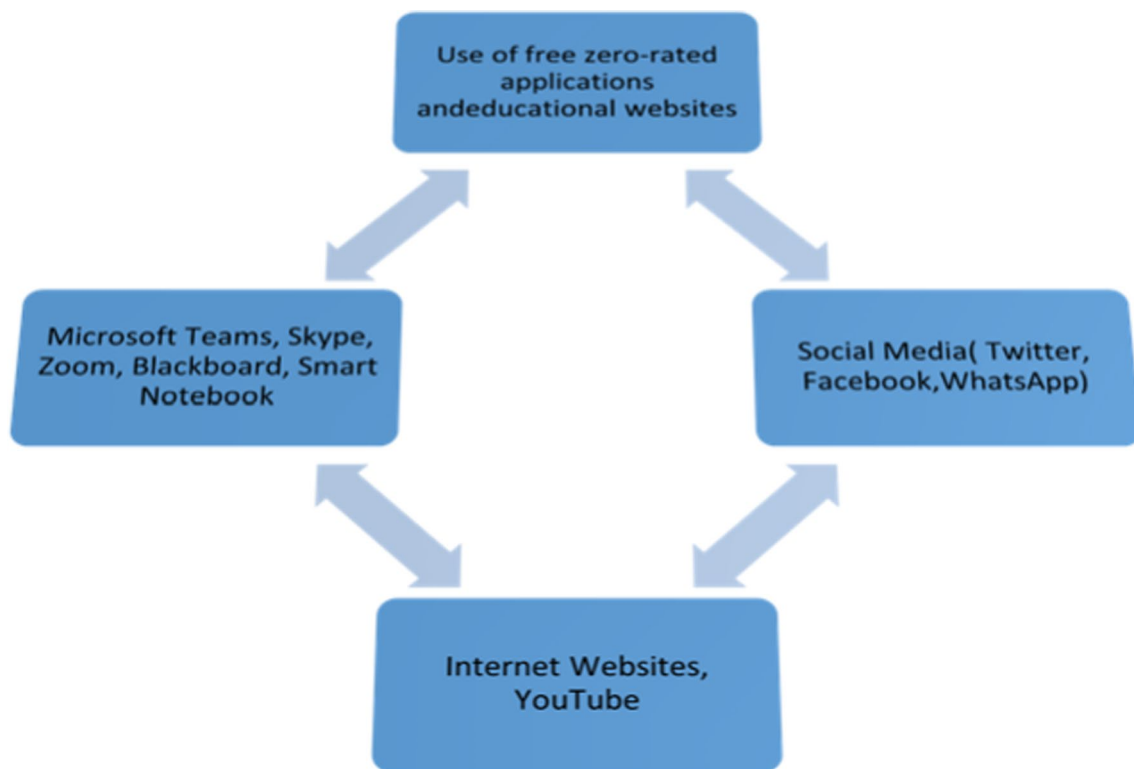
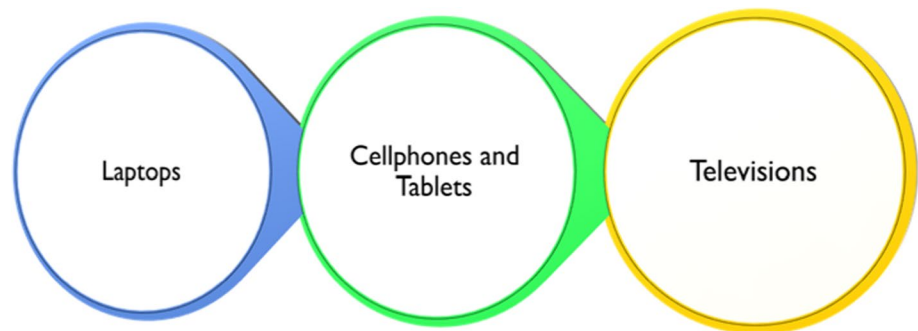


Fig. 4 Soft technologies used during the lockdown

Fig. 5 Hard technologies employed during the lockdowns



this scenario because the level of preparedness in the country is low. Even if some colleges can begin offering online courses, many others are not ready to do so, and what is worse is that many of the professors at these universities still need to be trained.

10 Asynchronous learning

According to the definition provided by Wegerif [25], asynchronous learning refers to the form of learning that takes place on the learner's timetable. In this scenario, the instructor is the one who supplies the reading materials, the assignments, the lectures that may be watched online, and the tests. Flexible learning is made available to the learners so that they can fulfil the criteria of the course within a schedule that is adaptable to their needs [25]. Asynchronous online learning can be accomplished through a variety of means, such as self-guided lesson modules, video content that can be streamed on-demand, virtual libraries, posted lecture notes, and online conversations that take place on discussion boards or social media platforms [25, 26].

11 Synchronous learning

According to Finkelstein [27], synchronous learning refers to the process of education that takes place in real time. In this scenario, the students and the teachers communicate with one another in an online environment using a variety of different platforms. Learning takes place at a predetermined time for students participating in synchronous online learning. Synchronous learning can be accomplished through several different approaches, including video conferencing, teleconferencing, live chatting, and live streaming of lectures. This kind of education is feasible in developing nations, mainly when it is necessary to maintain a social distance owing to the damaging impacts of COVID-19. The only obstacle is the financial burden that many students have when it comes to their internet data plans, which will be covered in the following section.

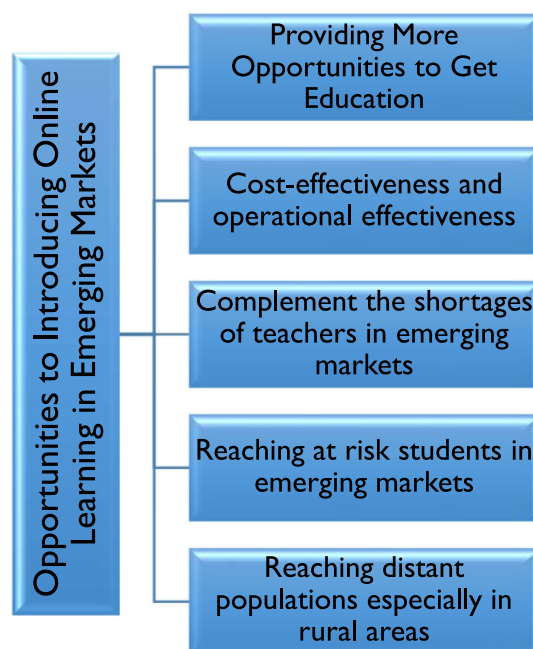
12 Opportunities to introducing online learning in emerging markets

Figure 6 above outlines the opportunities for moving to online learning in emerging economies. Some of the opportunities outlined include providing more opportunities to get an education, cost-effectiveness, and operational effectiveness, complementing the shortages of teachers in emerging markets, reaching at-risk students in emerging markets and reaching distant populations, especially in rural areas.

13 Providing more opportunities to get an education

It was previously impossible for developing countries to meet the growing demand for post-secondary education, but thanks to online education, these countries can now do so [28]. In underdeveloped countries, the availability of traditional on-campus education is frequently restricted due to a lack of infrastructure facilities and other constraints. However, knowledge received via the Internet can help close this gap. Access to higher education has been hampered in many developing countries due to a scarcity of resources, one of which is constrained space [11]. Because of this, many educational institutions have established limits on the number of new students they can accept each year due to the limited space available in their physical facilities [29]. For example, as of the year 2016, there were nine community and training colleges (CET), 26 public higher education institutions, 123 registered private higher education institutions, 50 colleges for technical and vocational education and training (TVET), 279 registered private colleges, and 50 public

Fig. 6 Opportunities to introducing online learning in emerging markets



colleges [30]. In 2016, enrollment in public institutions of higher education hit a record high of 1.1 million students, with 975,837 students enrolling in public institutions and 167,408 students enrolling in private institutes of higher education. The South African National Development Plan (NDP) has set a goal of 1.6 million student enrollments by 2030 [30, 31].

Learning using the internet, which can be done anywhere with an internet connection, is one strategy for accomplishing this objective. Access to technical and vocational education and training (TVET) colleges, whose enrollment reached 705,397 in 2016, but the NDP intends to reach 1 million by 2015 and 2.5 million by 2030, can also be increased with the use of online education (Department of Higher Education, 2018). Blended learning presents a similar opportunity for CET colleges to boost student enrollment. The Development Plan in South Africa has set enrollment goal of one million students, but as of 2016, the number stood at 273,431, which was down 3.6% (10,171) from the previous year's total [11, 30]. Most developing nations have seen the ongoing expansion of online education, despite lacklustre backing from their governments, limited access to necessary resources, and a need for more qualified teachers [11].

14 Cost-effectiveness and operational effectiveness

Online education allows educational institutions to grow revenue by making it easier for students from a broader range of demographics and geographic areas to access the institution's offerings. Students from low-income households can continue their education through online learning platforms, making this education provision particularly important in developing nations. Online education also can improve the overall quality and the expansion of universities in countries still developing. Students benefit from improved flexibility and convenience when participating in online learning since they can set their learning environment and engage in distant learning. In addition, it has been demonstrated that blended learning, which mixes traditional classroom instruction with online education, can enhance student knowledge of the material covered in a course and foster learning in a social setting [11]. Blended learning provides a variety of learning management systems and e-learning methods, such as webinars, which enhance student engagement and can reduce the costs associated with face-to-face training, such as travel and accommodation expenses. Blended learning can also reduce the costs associated with face-to-face training. Blended learning is not, despite its many advantages, a panacea for all of the problems that can arise in the classroom; instead, it is a method for enhancing more conventional instructional approaches through more modern technology. Therefore, blended learning has the potential to enhance traditional teaching methods by incorporating information and communication technologies that provide value.

15 Complement the shortages of teachers in emerging markets

Another issue that plagues educational institutions in emerging nations is the need for qualified teaching staff. The education system in many developing countries is in crisis, and the lack of trained teachers, unappealing working conditions, and inadequate budget all undermine the teaching profession. According to Unesco [32], educators are at the centre of the battle for the right to receive an inclusive and high-quality education. According to Unesco [32], it is estimated that 69 million teachers are required worldwide to achieve universal primary education by the year 2030, with the greatest need in sub-Saharan Africa. It is anticipated that an additional 24.4 million teachers will be required in primary education and approximately 44.4 million teachers in secondary education to realise the goal of universal basic education by 2030 [32]. Sub-Saharan Africa is home to some of the most overcrowded classrooms in the world. It also has some overworked teachers and the most underfunded educational systems. Ninety per cent of secondary schools in the region are dealing with major teacher shortages [32]. Again, suppose we are going to meet the goals outlined in the 2030 Agenda. In that case, sub-Saharan Africa will require 5.4 million teachers for the basic level and 11.1 million teachers for the secondary level, according to new statistics that were presented by Unesco on World Teacher Day in 2022. According to projections made by the United Nations Educational, Scientific, and Cultural Organization (Unesco), Southern Asia will require 1.7 million additional instructors at the primary level and 5.3 million at the secondary level. The overwhelming amount of work is the primary challenge faced by developing countries. According to recent data from Unesco, primary teachers in these nations have an average of 52 students in their classes, while the average number of students in a primary classroom worldwide is 26. The ratio is exceptionally high in sub-Saharan Africa, where there are 56 students for every teacher, while in Southern Asia, there are only 38 students. On average, there are only 15 students for every teacher in Europe and North America. In this study, we are making the point that developing countries are turning to the utilisation of streaming technology or virtual classrooms to ease the scarcity of teachers in general in

several different areas. Uruguay's government is employing the Internet to send English teachers from other countries into classrooms throughout the country.

16 Reaching at-risk students in emerging markets

A second advantage that will accrue to emerging markets because of asynchronous learning is the possibility of communicating with students who are at risk. Online classroom technologies can assist students who are in danger of dropping out of school or performing poorly in their academic endeavours. This is especially true when these technologies are paired with face-to-face engagement as part of a "blended approach" some pupils must travel great distances to school because they reside in dangerous places. Some of these students can participate in their education through online education because of the accessibility of resources such as internet connectivity. It is important to emphasise that this strategy can be successful in developing markets provided that the institutions involved, and the students have access to reliable internet connectivity, reliable power supplies, accessible technological devices, and the knowledge necessary to operate those devices.

17 Reaching distant populations especially in rural areas

The transition to online learning presents several important opportunities, one of which is the possibility that more children, particularly those living in rural areas, will be reached. However, this is only possible if the children have access to dependable internet connections and electronic devices. Learning that takes place online will help reach out to geographically dispersed communities in places where it is economically infeasible to construct schools or post teachers. It is essential to emphasise that this is only feasible if the locations in question have access to the internet, a reliable source of power, and possibly even electronic devices and people who are familiar with their operation.

18 The challenges of introducing asynchronous online learning in emerging economies

When it comes to mitigating the effects of COVID-19 in emerging nations, the usage of 4IR techniques presented several difficult issues. To overcome these obstacles, a concerted effort on a national scale and meticulous planning are required. It is also imperative to highlight that the new technologies made available through online learning can completely revolutionise the educational system and the lives of the general population. Nevertheless, it is imperative to recognise the difficulties connected to this change since they pose a significant threat to the efforts being made to promote the right of the people of many developing nations to get an education.

Figure 7 above outlines the Challenges of Introducing Asynchronous Online Learning in emerging economies. These challenges are well explained in the next sections.

19 The challenge of poverty and inequality in many emerging economies

When it comes to switching to online education, the problem of poverty and inequality in developing countries is the first challenge that needs to be surmounted. Approximately one million children in the United States are of school age and are now enrolled in school. These youngsters will likely need to acquire the fundamental competencies necessary to have healthy and productive lives. Further research reveals that if you are a poor girl currently attending school in a rural area, you have a much higher chance of not learning essential abilities, such as reading, writing, and mathematics. This is especially true if you are a child. Even though disparities in gender, income and regional learning remain in the majority of sub-Saharan African nations, in this situation, introducing online learning will only result in more complications, as the children, many of whom come from disadvantaged backgrounds, will not have access to the necessary technological devices for learning online. It is generally accepted that considerable educational achievement inequalities exist for children from poor socioeconomic backgrounds. It has been found that a family's income level significantly impacts the percentage of members who enroll in secondary and higher education. Figure 8 shows the Share of the population living in extreme poverty.

Fig. 7 The challenges of introducing asynchronous online learning in emerging economies

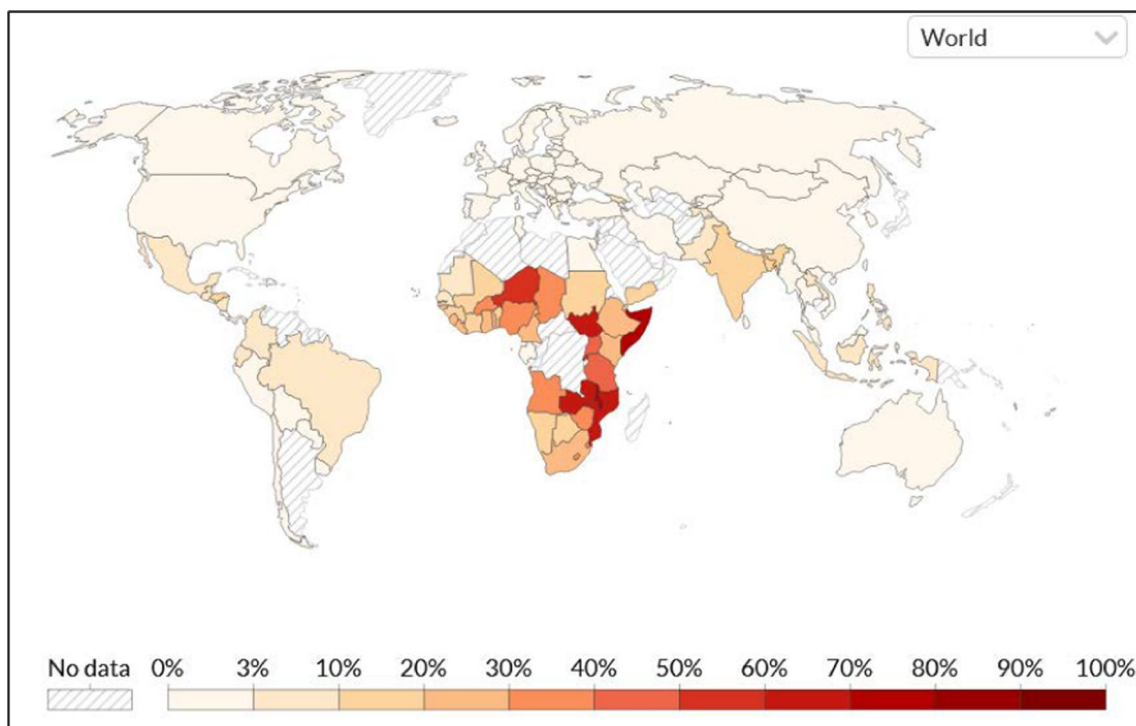


Fig. 8 Share of population living in extreme poverty (Source: Our World in Data [33])

Living below the International Poverty Line, which is currently set at \$2.15 per day, is the definition of extreme poverty as shown in Fig. 8 above. This data has been modified to account for inflation and variances in the cost of living from country to country. Compared to the rest of the globe, rising markets such as Africa and India, as well as many other parts of the world, still have a significant number of people living in poverty. Implementing a program of online education might provide a significant challenge.

20 Difficulties in technological access especially in rural areas

The purpose of emphasising the digital gap is, first and foremost, to draw attention to concerns regarding equity in terms of opportunity and access. In the excitement to open new horizons in learning and teaching through technology to those who are most ready to embrace them, students, teachers, institutions, and communities, it is easy to overlook these considerations. These individuals and groups are typically, but only sometimes, already relatively advantaged. Access to technology, particularly connectivity to the Internet, is sometimes unequally distributed and severely limited in developing countries [20, 21]. There will be a marginalisation of specific populations if asynchronous online education is implemented, particularly schools located in more rural regions that have limited access to the internet and, in some circumstances, do not have access to electricity. This will be especially true if asynchronous online education is implemented. Students in metropolitan regions, for instance, are acquiring knowledge through a wide array of mediums. Some pupils are trying to access learning through the websites of the departments of education; others are learning through Worksheet Cloud Online Lessons; and still, others are accessing learning through zero-rated mobile apps, among many other options. These platforms include virtual classes provided by SABC in partnership with the government in South Africa, for example.

All of these different measures were taken to mitigate the potentially harmful impacts that COVID-19 could have. Children who live in rural areas and do not have access to radios and televisions, electricity, or internet connections will not be able to use these services despite being provided free of charge. Moreover, these children will not be able to use these services even though they are available. These people are, in a sense, being denied access to education, which is a fundamental violation of their human rights. These persons have their human rights violated. This will make an already difficult situation in countries like South Africa, where African children of colour and mixed race have difficulty enrolling in conventional schools, even more difficult. Kayembe and Nel [20] state that the gross participation rate of Black South Africans and people with a mixed ethnic background in South Africa is noticeably lower than that of White South Africans. This is the case in comparison to the rate of White South Africans. If the appropriate measures are not taken, online learning in schools will make it much more difficult for children of colour and African descent to acquire an education. Children from disadvantaged families should be given more opportunities to participate fully in their community's lives if we avoid the further marginalisation of the groups to which they belong.

21 Problems of capacity and inadequacy in the public sector concerning skills

The possession of the required abilities is one of the prerequisites for the effective implementation of online learning in the field of education. According to Butler-Adam [34], having the relevant abilities is necessary to fully deploy and effectively handle the technologies connected with online learning. Appropriate abilities must be possessed for the education industry to realise its objective of maximising the benefits derived from newly developed technologies [11]. Also, teaching calls for unified principles to be implemented across the whole education sector to provide a theoretical basis for digital pedagogy [11]. Learners need to have substantial digital abilities in addition to the skills that are required of the instructors for them to be able to benefit completely from the materials that are supplied by instructors online. This is because the instructors deliver these resources online. Many children, particularly those living in townships, face difficulties in terms of their digital knowledge; consequently, for them to derive a more significant benefit from the programs, they should be provided with extensive education and training to be able to participate fully. As noted by Ostlund [35], Ekstrand [24], Meyer and Gent [21], and Kayembe and Nel [20]. The following should be taken into consideration for a successful deployment of online learning. Teachers must understand ways to integrate technology, and they also need to learn how to serve kids who have a variety of requirements. Educators need to understand the role that information and communications technology plays in educational policy, pedagogy, and evaluation, as well as in the organisation and management of educational institutions. There should be methods for collaborative work, and teachers need to have a way to share information since this gives them more control over the technology they use in the classroom.

Instruction and awareness are necessary to guarantee that information and communication technologies will be phased while receiving pedagogical backing. Learners and teachers must be provided with a clear set of goals to follow when using ICTs to support teaching and learning. There should be a significant pool of e-skilled educator personnel

available to raise the standard of educational provision. In addition to a need for more expertise, inadequate financing is another significant obstacle that stands in the way of the effective implementation of 4IR in educational settings in emerging economies. Although there has been an upward trend in funding for the education sector over the years, there still needs to be more money in the budget to cover online instruction fully. The amount of money necessary to fund the program, including paying for internet subscriptions and purchasing computers for students and teachers, is substantial, particularly for some of the smaller educational institutions. The training of professors should have a greater priority at educational institutions, along with increased investments in new technology advancements, a diversity of technical infrastructure, and other related areas. According to Brown-Martin [36], one of the most significant expenses associated with the transition to a more digital form of education is the provision of training to educators and the investment in technology infrastructure. The following forms of funding need should be accessible, according to Ekstrand [24], Meyer and Gent [21], and their respective sources. An information and communications technology (ICT) school environment that is well-funded and well-managed as the basis to provide support for teaching and learning with technology. There must be a pool of skilled on-site support colleagues available to offer instructional staff and students specialised guidance in a variety of subject areas. A high level of security is essential and sufficient funds to enable the provision of time for instructors to participate in ongoing professional development to guarantee consistency.

22 Connectivity issues as well as difficulties gaining access to the power source

Other concerns that can arise whenever schools in emerging nations switch to online learning include connectivity problems and the availability of reliable power sources. Digital transformation is a genuine phenomenon typically understood to be the process of using digital technology to create new or modify existing business practices, cultural norms, and consumer experiences. In the modern day, business is being reinvented through digital transformation. Digital transformation refers to a company's embrace of digital technologies. Increasing efficiency, value, or innovation are the three most typical reasons for putting it into practice. Different facets of society and the economy are affected by the digital revolution. It opens new opportunities for networking and teamwork amongst various parties, who can then share data and start new processes [37]. Infrastructure is essential in this concept of digital transformation for it to provide outcomes, including new and contemporary infrastructure that is referred to in the definition of digital technology. Kuali [23] asserts that many higher education institutions in developing countries employ outdated, ineffective technology that is challenging to integrate with new information technology infrastructures, to the point where those in charge of the digital transformation may lack the resources to update out-of-date systems, which can be costly and time-consuming. Access to electricity significantly impacts, particularly in developing countries where many schools are implementing online education. The threshold for what it means to "have access to power" is set relatively low by the definition used in international statistics. It is characterised as having a source of electricity that can run a radio for 4 h a day, charge a phone, and provide highly rudimentary illumination. Figure 9 shows the Global Access to Electricity.

Over the past few decades, there has been a consistent rise in the number of individuals across the globe who have access to electric power as shown in Fig. 9. Around 71% of the world's population had internet access in 1990; in 2016, that number had climbed to 87% [38]. On the other hand, there is still a significant problem with connectivity across Africa, which presents a significant obstacle, particularly concerning the implementation of online education.

23 Conclusion and policy recommendations

The COVID-19 pandemic has propelled many nations to explore the shift towards remote, asynchronous learning, leveraging technologies from the Fourth Industrial Revolution (4IR). This study examines both the advantages and challenges of this shift. Utilizing desktop research methods, such as documentary and conceptual analysis, the research seeks to understand the implications of 4IR and COVID-19 on education. The findings indicate significant barriers to widespread implementation of 4IR-driven asynchronous online education in developing countries, aimed at addressing the challenges posed by the pandemic and adapting to 4IR demands. These barriers include socio-economic disparities, energy shortages, limited access to technology and internet especially in remote areas, knowledge gaps, and the lack of a cohesive national strategy. Despite these obstacles, the study highlights the potential of

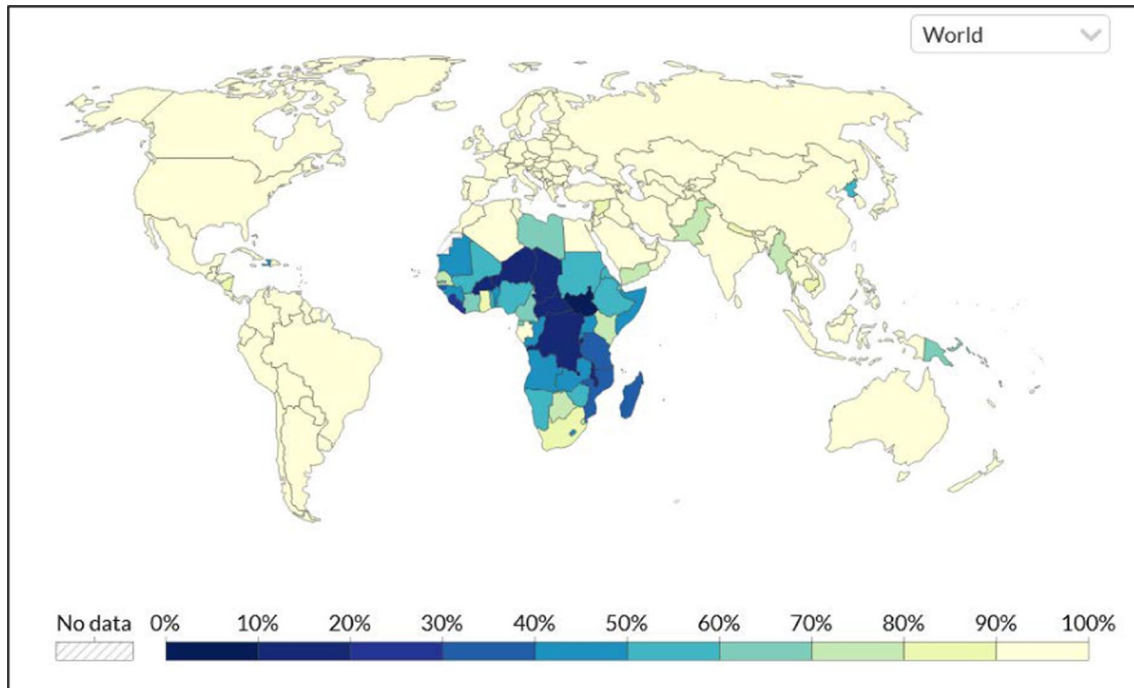


Fig. 9 Global access to electricity (Source: Our World in Data [38])

online education to transform schools into centers of innovation and broaden access to quality education. It calls for enhanced investment in infrastructure to support asynchronous learning in the developing world.

The research emphasizes the critical need for policy reforms and increased investment in digital infrastructure to maximize the educational benefits of 4IR technologies in emerging economies. Key policy recommendations include prioritizing the allocation of resources towards improving internet access, making digital tools more affordable, and ensuring a stable electricity supply, with a focus on reaching marginalized communities. Furthermore, it suggests that addressing the financial aspects of these upgrades requires collaborative efforts from both government and private sectors. The study also advocates for future research to develop online education models that are both scalable and sensitive to the socioeconomic conditions of these areas. Overcoming these infrastructural hurdles is crucial not only for improving educational outcomes but also for fostering socioeconomic growth in emerging economies, preparing them for a digitized future. The study proposes a strategic approach to close the digital divide, highlighting the necessity for, increased investment in digital infrastructure, emphasizing the need for accessible internet, affordable technology, and reliable energy sources in underserved areas through innovative funding strategies and public–private partnerships. The creation of inclusive policies that promote equal access to online education, addressing issues of cost, accessibility, and quality to ensure the widespread adoption of 4IR technologies. Enhanced support for research and innovation to develop online education frameworks that reflect the unique socioeconomic landscapes of developing countries, encouraging educational innovation and the creation of relevant content and teaching methods.

Author contributions David Mhlanga—conceptualisation and combining the article.

Data Availability No data was used in this study.

Declarations

Competing interests The authors declare no competing interests.

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