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RESEARCH ARTICLE

Towards Inclusive Higher Education: Challenges and Opportunities of Artificial Intelligence in Addressing the Digital Divide

Pedro Antonio Cedeño-Salazar[1], Laila Milena Vera-Carrasco[2], Susy Grey Morales-Cobos[3], Juan Carlos Briones-Macías[4]

[1] Universidad César Vallejo, Piura, Peru
[2,3,4] Universidad de Guayaquil, Guayas, Ecuador

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***Corresponding Author:**

Pedro.cedenosa@ug.edu.ec

ABSTRACT

The crisis brought about by the COVID-19 pandemic has exacerbated existing inequalities in access to education and technology, directly affecting vulnerable social groups and rural areas. Over 190 countries closed their educational institutions, revealing significant disparities in educational quality and access to technological resources. The lack of digital infrastructure and skills in using technology has limited the continuity of the teaching-learning process for many educators and students, highlighting the need for inclusive public policies that ensure equitable access. Artificial Intelligence (AI) emerged as a highly potential tool to improve educational access, but its implementation must consider existing inequalities. Despite technological advancements in various countries, digital divides continue to widen, particularly in Latin America, where wealth concentration and dependence on foreign technology significantly hinder local development. Strengthening connectivity and promoting digital literacy are essential to ensure that all students have equitable opportunities in an increasingly digitalized environment driven by globalization. The objective of this review article is to analyze the challenges and opportunities that artificial intelligence offers in higher education, focusing on its potential to address and reduce the digital divide exacerbated by the COVID-19 pandemic. It seeks to explore how AI can be implemented as a tool to enhance access to education and ensure a quality teaching-learning process.

INTRODUCTION

The educational crisis caused by the COVID-19 pandemic marked a turning point in the recent history of humanity. In the first quarter of 2020, more than 190 countries were forced to close the doors of schools, colleges, and universities to mitigate the spread of the virus. This necessary action exacerbated existing issues in the educational context, such as social inequalities, poverty, and extreme poverty, leaving a profound impact on millions of learners and their families around the world (Naciones Unidas, 2020).

In the new global landscape that emerged as a result of the coronavirus pandemic, a profound inequality in educational achievements became evident, particularly in rural areas and regions with limited resources, where the distribution of qualified teachers is particularly scarce. According to the United Nations Children's Fund UNICEF (2022), the measures adopted to address the health crisis included the suspension of in-person classes and the implementation of distance learning modalities through various platforms and technological resources. However, these strategic policies highlighted serious disparities in access to education, especially regarding access to technology, which hindered the continuity of the teaching-learning process for a significant portion of students worldwide.

The COVID-19 pandemic has exposed one of the greatest barriers in the global educational landscape: the inequality in access to essential technological resources for online learning. Although education is recognized as a fundamental right that should ensure equity, the gaps in access to these digital tools have highlighted marked differences among various social groups, particularly affecting the

most vulnerable communities and individuals with special educational needs (Pérez Valles & Reeves Huapaya, 2023).

According to Chávez (2020), the growing dependence on artificial intelligence (AI) alongside robotics in this digital era not only affects the productive sector but also redefines areas in the economic, commercial, political, and especially educational fields, laying the groundwork for a digital society. However, the latent fear that robots may replace humans in various job functions presents complex challenges that could compromise the quality of life for different social groups.

The internet, as a central axis in this transformation, has evolved from the late decades of the 20th century to become a key tool for communication and global knowledge transfer through information retrieval. This progress has required digital environments to be accessible to both inexperienced users and those with advanced skills, ensuring the efficiency and effectiveness of various communication strategies. In this context, David López (2022) argues that while Industry 4.0 promises significant advancements, it also underscores the need to critically address its social and economic impact. It is essential to balance the benefits of this digital revolution with actions that minimize its risks, thus ensuring sustainable and inclusive development for all regions, especially in Latin America and the Caribbean.

Despite various technological advances in some countries, these may obscure the increasing digital divides. The rapid adoption of technologies, while projecting an image of efficiency and progress in citizens' quality of life, lacks sustainable impact if not supported by a solid legal framework complemented by inclusive public policies that guarantee the full exercise of fundamental rights. It is important to emphasize that without these guarantees, technological development runs a severe risk of deepening precariousness and undermining the fundamental rights of society (Salazar Gómez, 2023).

Latin America faces significant challenges in its digitalization process due to deep economic and social inequalities. The concentration of wealth in a small elite limit the necessary investment to reduce digital divides, while dependence on foreign technology corporations to drive the development of public, private, and social sectors creates structural vulnerabilities. According to CEPAL (2022), the massive importation of technology, coupled with the absence of robust legislation to protect consumers, exposes the region to potential abuses and complicates the defense of basic human rights in this new century.

Currently, this problem is exacerbated in various state contracts, where public policies aimed at closing the digital gap often favor technological monopolies without prioritizing local needs or ensuring appropriate auditing processes. Additionally, the scant investment in research and development (I+D) limits Latin American countries' capacity to actively contribute to the advancement of emerging technologies like artificial intelligence, relegating them to the role of mere consumers of foreign innovations. Without a strategic approach that promotes local innovation and effectively utilizes public data, Latin America and the Caribbean risk being excluded from global technological development (Rivera Polo, 2023).

The connection between Artificial Intelligence (AI) and the Sustainable Development Goals (ODS) lies in the promotion of innovation and technological advancement. According to Pernas (2022), in an effort to address inequalities, three pillars of public policies are proposed that relate to the ODS: improving digital infrastructure in developing countries; promoting technology transfer from wealthy nations; and developing competencies in AI through education.

Considering the latter point, “developing competencies in AI through education,” it is essential to state that the objective of this systematic review article is to analyze the challenges and opportunities that artificial intelligence offers in higher education, focusing on its potential to address and reduce the digital divide.

Objectives

The general objective of this review article is to analyze the challenges and opportunities that Artificial Intelligence (AI) offers in higher education, with a particular focus on its potential to specifically address the digital divide. In the context of public health where the COVID-19 pandemic has exacerbated educational inequalities, it is essential to explore how AI can be implemented as a

tool to improve access to education and ensure a quality teaching-learning process. This exploratory-documentary analysis aims to identify relevant strategies that can be adopted to integrate AI into educational systems, strengthening opportunities for all students regardless of their socioeconomic status to benefit from current technological innovations.

METHODS

The present research was conducted through a systematic literature review on the educational crisis exacerbated by the COVID-19 pandemic, focusing exclusively on the digital divide and the impact of Artificial Intelligence (AI) in higher education. The PRISMA methodology was utilized to ensure a rigorous and replicable process in selecting relevant studies. Inclusion criteria were established that prioritized various articles from the last six years (2018-2024), both high-impact and regionally reviewed by blind peers, sourced from diverse reliable databases. Out of an initial pool of 150 articles, 20 were selected after a screening process that excluded irrelevant studies lacking clear empirical evidence. These articles were organized into a comparative matrix to facilitate a detailed analysis, allowing for the evaluation of current trends and challenges facing the educational system in the post-pandemic digital context. This review article concludes that it is essential to implement inclusive public policies that strengthen technological infrastructure and promote the development of digital competencies to significantly reduce inequalities in access to education.

RESULTS

Challenges of Artificial Intelligence in Addressing the Digital Divide Post-Pandemic

Based on the National Survey on the Availability and Use of Information Technology in Households (ENDUTIH) 2019, in Latin American countries like Mexico, it was found that prior to the COVID-19 pandemic, approximately half of the households nationwide had internet access. However, as shown in Figure 1, only 19% of households in rural areas of the country were connected, compared to around 62% in urban areas. This digital divide worsened following the COVID-19 pandemic, highlighting the challenges faced by the rural sector in receiving telecommunications services, which are related to their geography, low population density, irregular topography, and isolation of various localities (Martínez Domínguez, 2020).

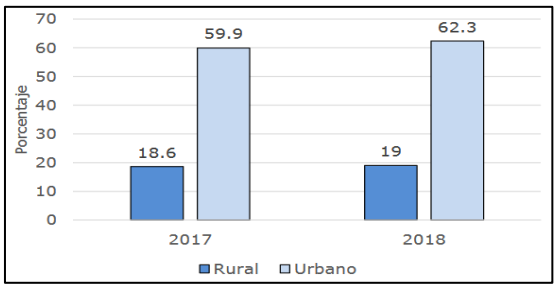

Figure 1.Internet Access in Rural and Urban Households

It is essential to identify the underlying causes of limited internet access. According to the national survey conducted by ENDUTIH (2019), which included a total sample of 40,931 individuals in Mexico, distributed between rural and urban areas, table 1 shows the main barriers preventing internet connection in households. The most significant barrier is the lack of financial resources, followed by a lack of interest, a lack of knowledge in digital skills, and finally, a lack of technological infrastructure

Table 1.*Internet Access in Rural and Urban Households*

Rubro	Rural (%)	Urbano (%)
Lack of Financial Resources	60.82	64.98
Lack of Interest	13.36	26.29
Lack of Digital Skills	7.11	4.55

Lack of Infrastructure	18.71	4.19
Total	**100**	**100**

Source**:** (ENDUTIH , 2019)

Table 2.*Main Reasons for Not Using the Internet in Urban and Rural Areas of Mexico*

Rubro	**Rural (%)**	**Urbana (%)**
Lack of Infrastructure	25.55	20.67
Lack of Interest	12.45	23.11
Lack of Digital Skills	62.00	56.22
Total	**100**	**100**

Source: (ENDUTIH , 2019)

The results obtained from the survey conducted by ENDUTIH (2019) involving 24,347 individuals reflect the barriers that limit internet usage in Mexico, particularly highlighting the importance of digital skills in both urban and rural areas. It is worth mentioning that the survey did not consider the cost of internet access; however, the findings indicate that in rural areas, the primary reasons for not accessing the internet are the lack of digital skills and insufficient technological infrastructure for telecommunications. The latter is mainly due to rural areas being less profitable for telecommunications companies because of their low population density and distance from urban centers.

In South America, considering Ecuador as a developing country, it has historically faced an unequal distribution of wealth, which has had a catastrophic impact on vulnerable social sectors. However, in the last decade, the country has made notable progress thanks to the reorientation of public policies and a more equitable allocation of resources to address historically marginalized sectors. Based on this context, after successfully incorporating computers into the educational system for two decades, the transformative impact of Information and Communication Technologies (TICs) is recognized (Pita et al., 2021).

Achieving various advancements focused on education is beneficial for the country; however, Ecuador faces a fundamental challenge in digitally literate approximately 80% of the economically active population. This requires the continuity of effective public policies that promote gradual learning in the management and mastery of various technological resources, along with sustained efforts in updating, training, and developing the teaching staff in the educational system. It is essential to establish innovative methodologies that facilitate learning mediated by ICTs, recognizing that teachers should not be reduced to mere executors of mechanical activities and tasks during extensive work hours. In fact, the excessive workload faced by educators can negatively impact the excellence and quality of the teaching-learning process (Arellano Sarasti, 2024).

To reduce these negative indicators and overcome these barriers, it is crucial to prioritize the strengthening of connectivity and the technological platforms necessary to achieve quality education. From the educators' perspective, it is essential to take advantage of the various resources available on the web, many of which are free, for both enriching students' learning and for their own professional development. It is important to emphasize that the use of the internet, along with different social networks, can become a powerful tool for establishing connections with other teachers, students, and the educational community in general, promoting collaboration and the ongoing exchange of new knowledge.(López Gaibor , 2018).

In its early stages, the digital divide was directly associated with underdeveloped countries and was considered a temporary problem that would disappear with the global expansion of technology. However, this inequality in access to technology persists even with the proliferation of electronic devices with internet access. In this context, Villalta, Machuca & Palma (2023) refer to the access gap as the differences in opportunities to access technology. This aspect is influenced by factors such as socioeconomic inequalities between individuals and countries. Additionally, digitalization requires

significant investments and the ongoing development of costly infrastructures, especially in less developed regions and rural areas.

According to Reyes et al. (2021), individuals may possess various skills and competencies in digital literacy to navigate the internet but lack the necessary knowledge to make good use of the web and achieve optimal results. This refers to the gap concerning the quality of its use, particularly in accessing quality information.

Technological discrimination represents a form of social exclusion and poverty, as it limits certain groups' access to essential resources for their development and wealth generation. This was clearly evidenced during the COVID-19 pandemic when many students and workers faced various obstacles to telecommuting or continuing online education. As a consequence, according to Coronel (2021), the following aspects emerged:

- Communication breakdown and isolation.
- Barrier to study and the acquisition of new knowledge.
- Progressive increase in social disparities.

The digital divide in Ecuador has a significant impact on the educational sector, especially in the context of the COVID-19 pandemic. According to the National Institute of Statistics and Census (INEC) (2021), approximately 50% of the population lacks internet access, with the situation becoming more severe in rural areas, where nearly 85% of households do not have this service, in contrast to urban areas where internet access reaches only 37.2% of households.

The arrival of the pandemic exposed multiple deficiencies in the educational system regarding the digital divide in Ecuador. One of the most affected groups was students from public schools, who mostly come from less privileged social backgrounds and face greater limitations in accessing digital tools. This lack of connectivity restricted access to knowledge, an unexpected situation that was not adequately considered in the policies adopted by educational authorities (López , Herrera, & Apolo , 2021).

Before the onset of the COVID-19 pandemic, it was revealed that only 46% of urban households in Ecuador had internet connectivity, while in rural areas, this access reached just 16.1%. Although there has been a reduction in the digital divide in recent years in Ecuador, it remains a significant limitation. Nationally, only 37.2% of households have internet access, and merely 11% own a desktop or laptop computer (Cóndor et al. 2020).

These data are highly relevant as they highlight not only the inequalities between urban and rural areas but also the disparities among the major cities of Ecuador, where the lack of access to various technological resources continues to be an obstacle for the development of new forms of learning, especially those that depend on the simultaneous use of computers and stable internet access (Pulles Aldaz, 2023) .

Many educators lack the proper training to effectively integrate Artificial Intelligence into their pedagogical practices, which limits their ability to harness its potential for improving educational outcomes. Additionally, the inequality in access to technology and inadequate digital infrastructure contribute to the challenges of implementing AI in the context of the digital divide post-pandemic.

Opportunities of Artificial Intelligence in Addressing the Digital Divide Post-Pandemic

Artificial Intelligence (AI) offers innovative and transformative approaches to address digital literacy and its various implications in the contemporary world through advanced algorithms in machine learning and natural language processing. AI has the capability to optimize the acquisition of digital competencies, adapting to the individual needs of users. Primarily, AI-based platforms can design personalized learning modules tailored to each person's preferences and learning styles, allowing individuals to progress at their own pace and effectively acquire fundamental technological skills (Hernández Fuentes, 2022).

It is essential to establish and understand that AI is not limited to personalizing learning; it also expands access to information and various technological resources. User interfaces based on voice commands and chatbots make technology more inclusive, especially for those with limited technological skills. These tools overcome the barriers imposed by traditional interfaces and enable

more people to interact with digital platforms in a more accessible manner. AI-focused recommendation systems analyze individual preferences, offering personalized educational content and resources that cater to the specific needs of each person, thereby promoting greater technological equity and significantly reducing the digital divide in disadvantaged communities (Rodríguez Pedró, 2024).

Smart tutoring systems that utilize real-time analytics adjust pedagogical strategies according to each student's strengths and weaknesses, enhancing knowledge retention and fostering greater engagement through the use of AI. Additionally, the integration of tools based on virtual reality and augmented reality opens up new possibilities for interactive experiential learning, promoting a deeper and more analytical understanding of the concepts addressed (Arellano Morales, 2019).

When various AI tools are effectively implemented to reduce the digital divide, a virtuous cycle of empowerment is created that benefits both individuals and communities. As more people acquire digital competencies, access resources, and engage in personalized learning environments, their self-sufficiency and resilience increase. This gradual process drives greater socioeconomic mobility and contributes to the development of digitally prepared and more inclusive societies (Corzo & Alvarez Aros, 2020).

It is essential to ensure that AI technologies are implemented and developed equitably, avoiding the perpetuation of inequalities that have existed for decades. Algorithms must be designed inclusively to prevent biases and ensure that AI-driven initiatives are accessible to historically marginalized groups. Therefore, it is necessary to provide ongoing support to those facing technological access limitations, ensuring that advanced tools and methodologies genuinely contribute to closing social and digital gaps (Libaque-Saenz , 2023).

According to Ortega G., Acosta, Ortega C., & Díaz (2021), the flexibility of artificial intelligence to update and adapt to technological advancements in real-time ensures that individuals receive highly relevant and up-to-date training, allowing them to remain competitive in a constantly evolving digital environment. This approach not only promotes digital literacy but also lays the groundwork for an educational transformation that benefits people across all contexts and socioeconomic levels.

Table 3 details ten digital educational programs implemented in vulnerable contexts worldwide, providing relevant information and significant conclusions about the potential of technology, with an emphasis on artificial intelligence aimed at countering the digital divide in higher education. The described programs reflect how technology can serve as a bridge to educational and digital inclusion. Initiatives like eSchool 360 in Zambia and Ubongo in Tanzania demonstrate how technology can transform teaching in historically marginalized regions through interactive tools, accessible content, and mobile devices.

It is important to emphasize that the projects described in Table 3 highlight the need for basic infrastructure, such as internet connectivity, relevant devices, and teacher training, without which the impact of artificial intelligence and other technologies can be limited. Although the programs listed in Table 3 do not directly mention the use of AI, many of the strategies presented could benefit from its integration. For example:

- The personalization of learning in the "Accelerated Learning Program" in Kenya could be enhanced with AI systems that automatically adjust content to meet each learner's needs.
- Tools like Otsimo already implement digital technologies that could evolve into AI-based solutions for special education and personalized therapies.
- Foundational programs like Teach 2030 could utilize AI to monitor teachers' progress and optimize training resources based on specific outcomes.

. Tabla 3. Ten digital education programs to reduce the digital divide

Program	Country	Description
Comunidad Atenea	Argentina	Social network for teachers that promotes collaboration, professional development, access to MOOCs, and meaningful use of various digital tools.

Programa Acelerado de Aprendizaje	Kenia	The program trains teachers to assess and level the learning of children. In just 30 days, it significantly improves literacy and mathematics skills in vulnerable children.
Proyecto CITPPST	Nigeria	In-person and online training for educators that enhances competencies for 21st-century teaching, with digital monitoring of their performance.
Habaybna.net	Jordania	An Arabic platform featuring videos, courses, and guidance for parents of children with special needs, helping to develop specific skills and improve their environment and quality of life.
eSchool 360	Zambia	An integrated model that equips teachers with technology (tablets, projectors) and provides intensive training and weekly monitoring to improve outcomes within the educational process.
Otsimo	Turquía	A learning platform based on playful activities that provides virtual therapy and special education for children with special needs, used in 67 countries.
Teach 2030	Gran Bretaña	Digital professional development courses designed for teachers in challenging contexts, featuring accessible materials for various devices.
Thaki	Holanda	A program that provides laptops with preloaded educational content to children in refugee status, promoting digital inclusion and utilizing a circular economy.
La lección más grande del mundo	Reino Unido	Creative and free educational resources supporting the Sustainable Development Goals, impacting millions of children in over 70 countries worldwide.
Ubongo	Tanzania	A massive classroom that utilizes various traditional media and mobile devices to teach cognitive and socio-emotional skills to over 17 million children through engaging educational programs.

Source: Extracted of (Profuturo, 2021)

Table 3 demonstrates that digital innovations are fundamental elements for artificial intelligence to expand its reach in higher education. The integration of AI can strengthen educational systems by personalizing learning, optimizing resources, and ensuring that historically marginalized communities have access to dignified and quality education. It is noteworthy that this analysis directly aligns with the objective of this review article, which explores how AI can address the inequalities exacerbated by the COVID-19 pandemic.

It is essential for governments and international donors to direct their efforts toward closing the digital divide globally, especially in middle- and low-income countries. Investment in digital infrastructure must become a priority to ensure equitable access to technology, which includes improving connectivity, digital literacy, and affordability. To achieve this primary objective, it is crucial that investments align with national needs, promoting collaborative efforts among civil society, the public sector, and private entities. Without effective coordination, there is a high risk of duplication and fragmentation of efforts, which would hinder the progress of digital transformation (Labrique, 2022).

According to Labrique (2022), it is essential to implement inclusive national strategies that improve access to technology and address gaps in training and the use of digital tools. This involves creating strong regulatory frameworks and implementing effective public policies that ensure equitable access to technology across all sectors of society, especially in historically marginalized sectors. Only through coordinated strategies involving all key stakeholders, both direct and indirect, and with adequate funding, will it be possible to reduce the digital inequality, allowing a greater number of people to benefit from technological advancements.

The educational crisis was significantly impacted by the global coronavirus pandemic declared in 2020, leaving deep negative marks on the educational system, exacerbating pre-existing inequalities, and revealing shortcomings such as the lack of essential technological resources for remote

education. During the first quarter of 2020, over 190 countries closed various educational institutions, worsening problems like poverty and social inequalities, affecting millions of learners along with their families.

The COVID-19 pandemic highlighted a significant inequality in educational achievements, particularly in rural areas and regions with limited resources. The measures adopted in various countries to address the health crisis, such as the suspension of in-person classes and online learning, have shown severe disparities in access to education and technology. This evidently disrupted the continuity of the educational process for many students globally.

The 4.0 technological revolution and the growing dependence on artificial intelligence (AI) alongside robotics pose complex challenges that may compromise the quality of life for various social groups. Limited access to the internet and technological resources has become a significant barrier. In Mexico, for example, it was evident that before the COVID-19 pandemic, only 50% of households had internet access, a figure that drastically decreases in rural areas. A study revealed the main barriers to accessing the internet in Mexico:

- Lack of economic resources
- Lack of digital skills
- Lack of technological infrastructure

These factors are crucial for identifying the reasons that lead to a progressive increase in the digital divide, further affecting the most vulnerable areas such as rural regions.

As a final point, it is essential to determine various strategies to improve educational opportunities, such as:

- ✓ Development of digital infrastructure
- ✓ Ongoing training in digital skills
- ✓ Promotion of local innovation
- ✓ Inclusive policies
- ✓ Integration of AI in education
- ✓ Promotion of collaborative Learning

These strategies not only aim to combat the existing digital divide but also aspire to ensure equitable access to educational opportunities that allow all students to fully develop in an increasingly digital world. The implementation of these initiatives can open up new avenues for research in future studies based on this review article.

CONCLUSION

The health crisis caused by COVID-19, declared a global pandemic in 2020, has highlighted the deep disparities in access to technological and educational resources, significantly affecting vulnerable social groups, especially those located in rural areas. This underscores the immediate need to implement public policies that ensure equitable access to technology alongside education.

The integration of AI in the educational context presents various significant opportunities to personalize learning and improve access to education; however, its implementation must be accompanied by a critical approach that considers existing inequalities and seeks inclusive solutions that benefit all students, regardless of their socioeconomic reality.

It is essential to develop legal frameworks and public policies that not only promote access to technology but also protect citizens' rights. This includes encouraging investment in digital infrastructure and ensuring that educational initiatives prioritize local needs, thereby avoiding an increasing dependence on technological monopolies.

Overcoming the digital divide, along with ensuring inclusive education, requires a collective commitment among governments, educational institutions, communities, and technology companies. Only through this coordinated effort can we build an educational system that not only meets current needs but also prepares learners to face future challenges in an increasingly digitalized environment driven by globalization.

CONFLICT OF INTEREST. The authors declare that there is no conflict of interest.

AUTORSHIP CONTRIBUTION

Conceptualization: Pedro Antonio Cedeño-Salazar

Research: Laila Milena Vera Carrasco – Susy Grey Morales Cobos – Juan Carlos Briones Macías

Methodology: Pedro Antonio Cedeño-Salazar

Data analysis: Pedro Antonio Cedeño-Salazar

Writing: Laila Milena Vera Carrasco – Susy Grey Morales Cobos – Juan Carlos Briones Macías

Writing-revision and editing: Pedro Antonio Cedeño-Salazar

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