The Potential of Artificial Intelligence and Emerging Technologies for Digital Accessibility in Childhood Literacies: A Critical Review of the Literature

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Abstract: This review examines how AI and emerging technologies can increase digital accessibility in childhood education, focusing on ethics, communication, tutoring, and health. Findings are presented with consideration for accessibility and inclusion, and implications for stakeholders are explored. Concerns center around data protection and children-centered AI development. Opportunities and threats are highlighted based on current guidelines and frameworks. Despite the potential of AI to bridge social gaps in childhood education, a local approach that prioritizes contextual needs is crucial.

1 INTRODUCTION

The XXI century is marked by rapid technological advancements that are transforming almost every aspect of human life and society. Artificial Intelligence (AI) is one technology that challenges the foundations of human intelligence, free will, and cognition. The increasing sophistication of data processors has enabled the development of technologies that can emulate human abilities, ranging from robots that move like humans to software that simulates the human mind.

This review explores AI's potential to increase digital accessibility and literacy development in childhood education. The authors bring together a diverse range of disciplinary and cultural backgrounds, with interests ranging from the impact of the digital divide on education and health to eHealth literacy and its influence on health decision-making. The authors' shared interest in the topic is the basis for a transdisciplinary dialogue (Shahamiri & Thabtah, 2020).

The definition of AI adopted in this review is from UNICEF's policy guidelines (UNICEF & Ministry for foreign affairs of Finland, 2021), which defines AI as machine-based systems that can predict, recommend, or decide to influence real or virtual environments. These systems interact with humans and adapt their behavior through learning from their context. According to Wikipedia (Wikipedia Collaborators, 2021), the field of AI is the study of "intelligent agents" that perceive their environment and take actions that maximize their chances of achieving their goals.

This review focuses on AI's impact on formal education and literacy development, which refers to acquiring literacy skills inside and outside educational institutions. Accessibility encompasses cultural, linguistic, gender, race, and disability-based and social-based conditions.

This paper discusses the impact of AI on early childhood education in four sections. The first provides an overview of research methods and findings. The second analyzes AI's ethics in childhood education, communication, language acquisition, tutoring, and health literacy. The third examines global trends in policy guidelines. The fourth explores AI's impact on childhood education,

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health outcomes, and stakeholder groups. Conclusions provide final insights, while we expose our challenges and restrictions in Limitations.

2 STATE OF THE ART

Reviewing two kinds of literature ecosystems was necessary to achieve the goal of this document. First, the scientific and academic literature, and second, the regulatory and normative literature produced by governments, multilateral and supranational structures (UN, UNICEF, UNESCO, among others), and expert concept notes from the private sector or non-governmental organizations (NGOs).

2.1 Methods

We used the critical literature review approach, but due to limited time and resources, there are some variations from the PRISMA Statement, particularly in the double-blind process.

2.1.1 Literature Review

Scientific and Academic Literature
Three scientific databases were selected to cover a range of disciplines: Scopus, ERIC, and PsycInfo, along with grey literature on Google Scholar and Google from 2016 to 2021. Guidelines from each database were followed to create queries (see Table 1).

Table 1: Elements of the critical literature review approach.

Element	Description
Databases	Scopus, PsycInfo, ERIC
Grey literature	Google schoolar
Languages	English
Period	Five years (2016-2021)
Document type	Original papers, reviews, reports, guidelines

We formulated a question using the PICO model to generate relevant keywords and incorporate a broad range of knowledge fields (Table 2).

What is **artificial intelligence and emergent technologies**' potential in digital accessibility on **childhood education** and literacies development?

Table 2: Literature review question structure.

P	Childhood
I	Artificial intelligence technologies
C	Traditional interventions for childhood education
O	Accessibility and Digital Accessibility in education and literacies development

We used the following keywords to build queries for databases and search engines based on this question: Childhood, artificial intelligence, accessibility, and education (Table 3).

The data-collected documents were analyzed using the Qatar Computing Research Institute web-based application Rayyan.ai designed for screening and analysis purposes in literature reviews (Ouzzani et al., 2016).

All documents that did not address AI or emerging technology interventions related to childhood education or literacy development and theoretical or position documents were excluded.

Table 3: Queries.

S	***Query / Queries***
PSYCinfo	((Artificial intelligence OR emergent technologies) AND digital accessibility)
ERIC	"Artificial intelligence" AI digital accessibility childhood
SCOPUS 1	((("Artificial Intelligence" OR "AI") OR ("emergent technologies")) AND ("Digital accessibility" OR "accessibility") AND literacy AND child*) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese"))
SCOPUS 2	TITLE-ABS-KEY(((("artificial intelligence" OR technolog*) AND "health"AND litera* AND child* AND accessibility)) AND (LIMIT-TO (PUBYEAR,2021) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2017)) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re") OR LIMIT-TO (DOCTYPE,"ch") OR LIMIT-TO (DOCTYPE,"bk"))

Grey Literature
AI and emergent technologies are critical topics for decision/policymakers, with multiple stakeholder groups involved in shaping their impact on society. These stakeholders can be categorized as public

(including multilateral and regional organizations, as well as local governments), private (including global technology conglomerates), and third-sector (including civil society organizations and academia). We used Google Search Engine to gather relevant documents, focusing on keyword combinations with geographic specifications by continent.

2.2 Findings

2.2.1 State of the Art

In this systematic review, we analyzed 20 full-text papers on AI applications in childhood education, following an SLR approach to summarize trends and notable advances in each topic to get a broad view of the available literature. The recent research focuses on four main areas: ethics of AI in education and childhood, tutoring systems, language translation systems, and intelligent virtual assistants. Among the analyzed papers, 32% related to the ethical implications of AI in education, followed by 32% on developing tutoring systems and intelligent virtual assistants. Around 28% of the papers were on practical applications of AI in human language processing, and 8% were on AI applications for health conditions impacting children's education.

2.3 Analysis

We analyzed research and policy documents from 2015 to 2022 to identify trends in the potential of AI for digital accessibility in childhood literacy development. The documents reviewed highlight four main thematic paths.

2.3.1 Ethics Analysis of AI in Childhood Education

The use of AI in childhood education raises concerns about the potential and risks of deepening inequality. Veinot et al. (2018) pointed out that there is a risk of intervention-generated inequalities, where privileged individuals and communities may benefit more from using AI in education than others who are less privileged. (Veinot et al., 2018). Saltman (2020) analyzes the development of for-profit AI educational technologies in the current economic and ideological structure and its impact on public education privatization (Saltman, 2020). Park et al. (2021) argue that the lack of critical thinking development increases the risks of AI technologies that support students in their self-directed learning process, transforming the traditional view of the student as a passive agent. Educators need to foster critical thinking development as AI technologies already support students in their self-directed learning process, transforming the traditional view of the student as a passive agent in the teacher-student relationship (Park et al., 2021). AI research in childhood education focuses on language acquisition, speech, hearing, writing, and reading. Natural Language Processing (NLP) has a broad range of applications, including text lexical adaptation, making written texts more accessible to low-literacy adults, children, and those with cognitive disabilities. The research in this area can be classified into two branches: text simplification and text production (Hartmann & Aluisio, 2021). Deaf children's vocabulary acquisition through sign language is being made easier with the development of AI-based systems like SiLearn (Joy et al., 2019). Additionally, the production of educational materials for vision-impaired and blind children is being studied with the help of AI systems that can scan images and convert them into 3D-printed braille-tagged versions (See & Advincula, 2021).

2.3.2 Human Communication: Language Acquisition, Translation & Processing

AI research in childhood education focuses on language acquisition, speech, hearing, writing, and reading. Natural Language Processing (NLP) has a broad range of applications, including text lexical adaptation, making written texts more accessible to low-literacy adults, children, and those with cognitive disabilities. The research in this area can be classified into two branches: text simplification and text production (Hartmann & Aluisio, 2021). Deaf children's vocabulary acquisition through sign language is being made easier with the development of AI-based systems like SiLearn (Joy et al., 2019). Additionally, the production of educational materials for vision-impaired and blind children is being studied with the help of AI systems that can scan images and convert them into 3D-printed braille-tagged versions (See & Advincula, 2021).

2.3.3 Tutoring: AI-Based Virtual Intelligent Assistants Applications

The use of AI systems in teaching and tutoring has become a significant area of research in childhood education. While the ideal learning environment would have a team of professionals to support students with specific learning needs, such an environment is rare in most schools worldwide.

Therefore, AI-based systems have been studied to accompany students with special needs or disabilities.

IBM's Watson Tutor (WT) system is a recognized AI-based platform designed to improve educational outcomes by promoting student engagement with content through a dialog strategy in a one-on-one interaction. Afzal et al. (2019) note that the WT has been trained based on best tutoring practices for each student age group, though it remains challenging to train the system to perform high-level soft human skills required in tutoring.

While an AI-based tutor system cannot replace human tutors' soft skills, it has the potential to considerably impact children and young people worldwide, particularly those with learning difficulties or disabilities. The affordability and availability of tutoring services for less privileged students can be drastically improved with the possibility of an AI-based tutoring system, leading to better educational and social outcomes (idem, 2019).

2.3.4 Health Literacy and Health Outcomes

Some applications of AI systems are transversal to health outcomes (including health literacy) and educational outcomes (including media and information literacies development). Recently, AI-based algorithms have demonstrated the potential to diagnose pediatric ophthalmological diseases early, preventing blindness development. That is the case of retinopathy of prematurity (ROP), which causes retinal detachment, resulting in complete vision loss. More than 30.000 children lose their vision from ROP worldwide yearly (Li et al., 2021). AI algorithms have been recently integrated into a telemedicine system for ROP. They have demonstrated high accuracy in the early detection more accurate than human experimented examiners (2021). The ROP's early diagnostic impact is vital because it allows early treatment, preventing, retarding, or reducing total vision loss. Developing these AI-based systems prevents physiological damage and protects the well-being of children at risk of ROP. Again, the cost of access to this kind of technology will determine the actual benefit it can have. We have not found research that directly studies AI-based technologies on health literacy development during childhood.

3 LEGAL & REGULATORY FRAMEWORK

Due to AI technologies' vast social, economic, and ethical implications, governments and many organizations are setting guidelines for its development and implementation. Through the documental review, we found that legal and regulatory frameworks are being built by multilateral organizations, regional instances, the private sector, and regional and government (Figure 1).

3.1 Trends

UNICEF Innovation created a Memorandum on AI and the Rights of the Child, which provides policy guidance for centered-child AI development. The policy guidance includes nine requirements that governments, policymakers, and businesses should meet when developing technologies. However, the regulatory framework and policies show inequalities among regions. In Africa, there is a notable disparity in access to the knowledge, data, education, training, and human resources necessary to develop and utilize AI. Latin American countries face challenges in policymaking, capacity, and adequate resources but recognize the potential to impact social well-being positively. Developed countries focus their regulatory framework and policies on the ethical use of AI, digital safety, child protection, and data preservation. (Barakina et al., 2021; Sibal & Neupane, 2020; Cabrol et al., 2020; UNICEF Innovation, 2020; see Table 4).

Table 4: Guiding UNICEF criteria for governments, policymakers, and businesses in child-centered AI development.

Support children's development and well-being	Ensure inclusion of and for children
Let AI help develop their full potential	Include them and those around them

Prioritize fairness and non-discriminatory for children	Protect children's data and privacy
AI must be for all children	Ensure their privacy in an AI world

Ensure safety for children	Provide transparency, explainability, and accountability for children
Children need to be safe in an AI world	Children need to know how AI impacts them. Actors need to be accountable for that

Empower governments and businesses with knowledge of AI and children's rights	Prepare children for present and future developments in AI.
Actors must know what children's rights are and uphold them	If children are well prepared now, they can contribute to responsible Ai in the future

Create an enabling environment
Make it possible for all to contribute to child-centered AI

4 IMPLICATIONS FOR SOCIETY

For better or worse, the disruptive effects of AI will transform children's lives in ways we cannot yet understand. Therefore, our collective actions on AI today are critical for shaping an inclusive future that children deserve.

Although AI holds great potential for advancing education, health, and well-being, its widespread implementation also presents significant challenges and risks that must be addressed with equal dedication and responsibility to ensure AI's safe and ethical application in these fields. In the various spheres of society today, Artificial Intelligence and emerging technologies are already a reality, especially in developed countries. The education sector could not ignore the tools and technologies available to improve educational processes.

The modern scientific literature presents optimistic research results that validate these technologies in specific population segments, promoting accessibility in education (teaching and learning) or health (diagnosis and follow-up). However, unlike other technologies we have mastered, the potential and applicability of AI and emerging technologies raise some reservations among the various stakeholders.

4.1 Childhood Education and Literacies

Research shows that AI technologies in education have been implemented in three main directions: training, research, and qualifying specialists to work with AI (Tuomi, 2018). However, according to UNICEF, there are risks of increasing inequalities due to uneven access to technology, limited digital skills, and inability to leverage its benefits, which can exacerbate the gap in socio-economic and technological spheres between low-income and high-income countries (UNICEF, 2021b). Most studies on the applicability of AI in childhood education occur in countries with more robust economies, leaving low-income countries at risk of being left behind.

To mitigate the risks of inequality, it is crucial to ensure equitable access to technology and develop AI systems that consider the characteristics and requirements of the context in which they are being applied (OECD, 2021). The development approach should be cyclical to continuously evaluate technologies' impacts and promote updates or modifications to the strategies, system, and algorithms (UNICEF, 2021b).

The digital divide is a significant problem, and AI in education can either close or exacerbate the gap. In developing countries, less internet connectivity and digital literacy may limit the potential of AI solutions. According to UNICEF, North America, and China are predicted to gain the most from AI, while developing countries in Africa, Latin America, and Asia may experience more modest gains (UNICEF, 2021b).

To ensure the success of AI solutions in less developed countries, tech companies and other stakeholders must design solutions tailored to each region's specific contexts and needs. Rather than simply transferring solutions from technology-intensive countries, solutions should be developed based on a deep understanding of the region or culture to increase the likelihood of adoption and success (Vinuesa et al., 2020).

In developed countries, AI-enabled learning tools can help children learn how to collaborate and develop critical thinking and problem-solving skills (UNICEF, 2021b). Customized learning experiences provided by robust learning platforms can address individual user needs. However, children growing up in underprivileged environments may fail to seize the opportunities they require to thrive in a world increasingly reliant on artificial intelligence without access to AI-enabled services. This may undermine their capacity to exercise their citizenship in politics or civic affairs, restrict their prospects of becoming active "prosumers," and render them inadequately prepared for future challenges in the job market.

Teachers can also benefit from AI-enabled tools that help them quickly develop educational programs, freeing time to focus on other classroom requirements or individual student needs (UNICEF, 2021b). However, the absence of such tools may compromise the quality of teaching and content made available to children.

Algorithm bias is a risk associated with AI in education. Such bias may lead to predictions, instructions, and analysis of patterns that neglect certain data or present results that respond only to a specific context. Algorithm bias can also compromise the expected outcome for children with special learning needs. In a non-regulated environment, development bias may promote exclusion and discrimination.

4.2 Childhood Health Outcomes

AI-based developments in childhood healthcare services for children with dyslexia, autism, and motor, visual, or speech limitations show remarkable potential. AI technologies have a wide range of health-related applications, from early diagnosis and gap-closing in mental healthcare to increasing health

and eHealth literacy. Multimodal learning analytics, interactive learning environments, and new research instruments enable researchers to track and evaluate emerging conceptual capacity and generate a new form of student-teacher-knowledge interaction (Abrahamson et al., 2020).

However, concerns about disorders related to blending education models, such as screen fatigue and stress adaptation, and falling behind those ill-equipped for digital learning still exist (OECD, 2021). Any approach to education must consider the gains and implications for learning and children's health, as AI applications are dynamic systems that learn and adapt to their environment and will continue to be part of various aspects of our lives.

4.3 Implications for Parents and Caregivers

AI is increasingly affecting the lives of children directly and indirectly, making it necessary for parents and caregivers to play a more active role in monitoring and guiding their use of technology. The UNICEF AI Parenting Guide encourages caregivers to consider the potential impacts of AI systems on their children's privacy and data and advocate for the responsible use of AI in schools and other settings (UNICEF, 2021a). Parents and caregivers can help children better understand the pros and cons of AI, as well as control their exposure to AI systems and personal data collection.

AI technologies offer opportunities for children with physical or cognitive conditions to receive personalized education and support, but they also present risks and challenges that must be addressed. Multimodal learning analytics, for example, enable researchers to track and evaluate students' emerging conceptual capacity while formalizing their gestures and actions in disciplinary formats and language (Abrahamson et al., 2020). However, parents and educators must be aware of potential issues such as screen fatigue, stress adaptation, and falling behind for those unprepared for digital learning (OECD, 2021). As AI systems evolve and become more prevalent in all aspects of life, it is essential to balance the potential gains with the implications for children's health and learning.

4.4 Implications for Teachers and Schools

The Covid-19 pandemic led to the sudden adoption of digital learning, with schools closed and education moving online (OECD, 2021). This acceleration of the digital transformation of education has brought about innovative approaches to learning, design, and analysis instruments and technologies in education (Abrahamson et al., 2020; Barakina et al., 2021; OECD, 2021). However, it is essential to note that technology is only a tool to improve the quality of the educational process, not a replacement for the teacher or school. The use of AI and emerging technologies in the educational system should focus on improving the interaction between various stakeholders and not limit the ability of children to "think for themselves" (Barakina et al., 2021).

The main issue with digitalization and AI in education is how education responds adequately to emerging societal and labor-market needs. Therefore, it is necessary to ensure that the performance of algorithms is not biased and that the data and information entered do not exclude individualities (OECD, 2021). In addition, the increasing importance of skills that are more difficult to automate, such as creativity, critical thinking, communication, and collaboration, should be considered in using AI in education (Vincent-Lancrin et al., 2019 in OECD, 2021). It is essential to consider that emerging technologies are still new tools not yet sufficiently mastered by teachers, students, and parents and that their safety and reliability must be precisely confirmed before their successful use (Barakina et al., 2021).

4.5 Implications for Tech Companies and AI Developers

AI systems rely on data as their primary commodity and can make decisions and predictions without human involvement (UNICEF, 2021b). While AI has contributed to improving education, there are concerns about how data is obtained, and patterns are identified, especially when decisions are made about people (UNICEF, 2021b). The design of AI solutions should involve all stakeholders, consider affordability, and adapt to the evolving needs of children and the education system (OECD, 2021).

Furthermore, the purpose and motivation for the development of AI in education must consider its impact on children directly and indirectly and its contribution to preparing children for the future. The literature highlights the importance of considering the context in which AI is applied, including national AI strategies and regional AI infrastructures. To promote updates or modifications to strategies, systems, and algorithms, the development approach of tech companies must be cyclical, continuously evaluating technologies and their impacts (OECD, 2021).

4.6 Implications for Multilateral and Supranational Instances

AI systems are mostly embedded within digital systems and hardware. For this reason, AI systems-related discussions must also approach ethical, legal, and digital ecosystem issues. While beneficial, explicability and accountability are robust principles specific to AI systems, protecting user privacy, fairness, and inclusion are relevant for the whole digital ecosystem. The absence of a guiding matrix or multilateral guidance policies leads to unmeasured actions by business groups in motivating, developing, and implementing some technologies in education and data appropriation.

The existing initiatives of transnational entities are still very marked by a specific generalization, and discourse is still very focused on the realities of technologically advanced countries that are also the ones that contribute the most and collaborate in carrying out studies on AI and emerging technologies.

AI applications in education and health care can improve learning outcomes, health, and well-being. However, we need regulations and safeguards that ensure that AI systems are reliable, safe, and trustworthy (UNICEF, 2021b). Society needs legal frameworks that ensure that misappropriation of data and violation of children's rights, guarantees, and freedoms effectively fall within the legal framework of each country, such as money laundering, tax evasion, and other social issues.

4.7 Sustainable Development Goals (SDGs) 2030

To date, there is a lack of published studies that assess the extent to which AI might impact all aspects of the 17 Sustainable Development Goals (SDGs). Although AI-enabled technology can act as a catalyst to achieve the 2030 Agenda, it may also trigger inequalities that may act as barriers ones (Vinuesa et al., 2020).

Although the positive impacts outweigh the large-scale negative, reported potential impacts of AI report positive and negative repercussions on SDGs. A recent report on the role of AI in achieving the SDGs states that "AI can help achieve 134 targets across all the goals" (2020). We focus on the implications of AI on SDG 4 quality education for this document.

Linking AI policies and strategies with the SDGs can prioritize equity and inclusion and advance children's development and well-being (Pedro et al., 2016). However, regulatory oversight is essential to enable the positive impacts of AI. Currently, there is little or no oversight of global AI systems that contribute more than those presented in this work. The duality of AI impact is related to identifying different needs and addressing appropriate responses. However, it may also lead to additional qualification requirements that do not exist, especially in developing countries where cultural values often provide the answers to such needs.

5 CONCLUSIONS

Artificial intelligence can revolutionize childhood education and make it more accessible for children of all backgrounds and abilities. However, it is crucial to approach this technology cautiously and consider its ethical implications.

AI-powered tutoring systems could be a powerful tool for improving educational outcomes for children, particularly in subjects like math and science. However, it is imperative to ensure that these systems are appropriately designed and monitored to avoid reinforcing existing biases or perpetuating inequalities.

Health literacy is a critical component of childhood education, and AI has the potential to improve health outcomes by providing personalized recommendations and guidance. However, ensuring that these systems are transparent and based on accurate and reliable data is critical.

The legal and regulatory framework around AI in childhood education is still evolving, and policymakers must consider this technology's potential risks and benefits. There is a need for clear guidelines and standards to ensure that AI is used ethically and responsibly.

While certain limitations and challenges are associated with using AI in childhood education, overall, the potential benefits of this technology are significant. As we continue to explore the possibilities of AI, it is vital to prioritize the needs and well-being of children and ensure that this technology is used to promote equity and inclusion.

6 LIMITATIONS

The objective of studying AI in childhood education and legal and regulatory frameworks was too ambitious, given time, resources, and thematic literacy constraints. Combining the two topics limited the exploration of AI's implications for society.

Nevertheless, the review provided a preliminary understanding of the implications of AI for childhood education and accessibility from a scientific and regulatory perspective. This review was conducted before the release of GPTChat, a language model developed by OpenAI, which could be a critical tool for further research in this area.

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