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Research Article

Access, Education, and Connectivity: Closing the Fourth Industrial Revolution Gap in Rural Regions

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Abstract

The Fourth Industrial Revolution has significantly reshaped global industries, yet rural communities continue to face critical gaps in access, education, and connectivity. This study explores the disparities in technology adoption, particularly in higher education, where artificial intelligence (AI) and emerging digital tools are transforming learning environments. Through an analysis of recent trends, challenges, and policy implications, this research highlights the barriers that rural populations encounter, including limited broadband access, slower AI adoption, and the need for targeted educational strategies. The findings emphasize the importance of inclusive technological integration and strategic policy reforms to bridge the digital divide. Empowering rural communities, and underserved populations with digital literacy may vastly improve education and employment opportunities for these individuals and families. This can, in turn, improve the economic output within each community, fill workforce gaps and provide an improved trajectory of prospects to society. By fostering equitable access to emerging technologies, institutions can better prepare students from rural backgrounds to participate fully in the evolving digital economy.

Keywords

Artificial Intelligence, Machine Learning, Underserved Populations, Rural Communities, Digital Literacy, Fourth Industrial Revolution, Technology Literacy, Learning Technology

1. Introduction

The emergence of artificial intelligence (AI) in the past decade has changed the trajectory and landscape of many arenas. One of these areas is education, and specifically higher education. AI tools have recently become more widely available and used within the higher education community both by faculty and students [11]. Crompton and Burke [11] determined in a meta-analysis that production of AI publications increased in triplicate from the years 2022 to 2023 as compared to the previous six years (2016-2022). As faculty and administrators of institutions endeavor to navigate the changing perspective of AI, one fact, as evidenced by the upsurge in literature regarding the topic; is that we must lean in to embrace this technology. One aspect of this includes involving all stakeholders in the education and responsible use of AI tools [3]. Students are among the largest impacted sector of all stakeholders, faced with not only navigating the innovative technology, but also implementing safe and responsible use [30]. Cowie et al. [10] highlighted some of the

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most at-risk populations of individuals as it relates to technology emergence and AI usage, which are rural communities. Traditionally, individuals from rural communities have slower than average connectivity rates, are comprised of a more aging population, and are gradually adopting emerging technologies [10]. This creates a particularly precarious gap for students from rural areas to keep up with the demands of AI and expectations of schools to either use or be informed of this technology. As higher education institutions push the boundaries of the traditional university models, the need, accessibility, and acceptance of technology (including AI, virtual reality, virtual classrooms, and intra-office online tools) remains a blind spot for many who are attempting to bridge this gap.

2. Digital Literacy in Rural Communities

The terms *technology literacy, digital literacy, or learning technology* are often used synonymously and are defined as the ability to understand and use information and forms of a variety of technologies or digital sources [29]. Li et al. [22] concluded that there has begun a smart divide in many areas, marked by the tremendous barriers between urban areas running on widely used broadband access and AI, and the decentralized counterparts of rural America. This paints a picture of disadvantaged communities, without the same resources that many of us access daily. Furthermore, the additional support offered by AI availability has been shown to positively impact individuals' lives from healthcare and medication access, to educational opportunities and beyond [25]. It has become evident we need to expand the reach of AI and technology access to our rural populations. Birhane et al. [4] suggested that participatory approaches to AI may be the new wave of buy-in for stakeholders. They go on to admit that this methodology is not always available to more rural regions [4]. Without these resources, our rural neighbors will continue to fall farther behind in an ever-evolving age of AI and technology, which may vastly improve the overall quality and quantity of life.

The divide between rural and urban communities is wide in many areas. This divide ranges from computer usage, internet usage, availability or even affordability to cell phone access, and other technology-related supplies [24]. The problem remains twofold, both a lack of awareness and a lack of access to sources. Lund et al. [23] conducted a quantitative study across the platform of ChatGPT, a popular AI chat bot narrative generator. This study included individuals from various demographic, geographic, age, and gender backgrounds. The authors concluded with the model presented that both data literacy as well as data literacy interest was highest in Urban young adults, while the lowest drive and literacy was noted in individuals over the age of 59, and from self-reported rural communities [23]. This validates the notion that our older generation, the ones most often the best recipients of increased technological advancements, are often the most unaware or enthusiastic about the prospects.

2.1. Fourth Industrial Revolution and Rural Communities

The development of this technology era, coined by many as the 4th Industrial Revolution (4IR) was initially proposed in 2016 by Klaus Schwab [32]. The 4IR is characterized by a rise in technological advances in nearly every facet of society across all spans of the globe [20]. From agriculture, to medicine, education, and even grocery lines, technology has inundated our communities. This paints a picture of 'when' versus 'if' for most individuals regardless of geographic location. In his book *The Fourth Industrial Revolution- What it Means and How to Respond*, Schwab [32] pressed the issue that only 30% of the world's population is tuned into social media. This is an alarming fact as educators not only forge onward with efforts to reach more rural communities, but also for those institutions looking to engage emerging technologies within the framework of service delivery. Mutambara and Bayaga [26] determined their algorithm for defining acceptance of mobile learning as a division of AI technology, was positively correlated with the engagement of all stakeholders within the community and surrounding area, specifically educational specialists. As both AI and machine learning gain popularity and awareness in educational arenas (among others), stakeholders must demonstrate both erudition and healthy skepticism.

The idea of AI in rural communities extends well beyond just the borders of the United States [1, 14, 16]. The possibilities as well as limitations encompass rural communities in nearly every other country across the globe. For the purposes of this article, rural communities within the US will be the focus. Wilkinson [34] defined rural communities in his book as communities with a vast territory of space, one in which community members must often travel long distances to complete daily functions and rarely tend to their daily needs amongst others. This is notable as it highlights the isolation often faced by members of rural areas within the United States, despite these communities being amongst urban centers. "A major problem of the rural community, therefore, is the lack of sufficient material density to support the level of moral or dynamic density needed for organic solidarity in modern times" [34]. Finally, Castillo-Vergara et al. [6] identified a technology acceptance model as part of a quantitative study of technology adaptation in rural communities. This study focused on objectives such as a lack of awareness and optimism as it relates to technology, AI and machine learning (ML) [6]. As these authors depict it, rural communities are, consequently, often void of modern technology; and even at times, not-so-modern technology.

2.2. Fundamental AI Opportunities in Rural Communities

One of the oldest, yet most remarkable agents for learning and technology is the library [15]. A library is a staple pillar

even in many rural communities. Libraries can provide vital resources as well as semi-structured or even informal learning whereby community members may develop life skills to better serve their daily needs. Without the knowledge or resources to leverage AI in daily life, rural communities are quickly falling behind the moving trajectory of education and many other fields of daily living in the US. Cowie et al. [10] prompted that we have woefully under-researched our rural communities and the opportunities available to them via technology and more specifically AI. One of these former literature pieces viewed accessibility in the UK within its rural communities [12]. Dwyer [12] cited an underdeveloped rural countryside within the UK marked by a lack of generalized awareness of changing policy and even planning and management in some areas secondary to digital deficit. Not only do they open opportunities for broadband in these spaces but also moving towards a collective lean-in to AI, digital learning and technology can keep these communities thriving in the twenty-first century. As Schwab [32] pointed out, the fourth industrial revolution will change the way humans live, work and even how economies are impacted and governed. Our rural communities are valuable stakeholders within each state, as well as our nation. Many underserved areas stem from rural spaces and are already faced with a lack of equitable services from gas stations and grocery stores to doctors and dentists [28]. Ziller and Coburn [36] emphasized that the Center for Disease Control and Prevention deaths in rural areas of the United States to include those which may have been prevented with improved access to healthcare. With the availability of telehealth opportunities and even the emergence of AI supported healthcare treatments, many rural communities are missing out due to the lack of recognition, perception or even appreciation for AI supported prospects [36].

In addition to health disparities, rural communities also often face educational inequity. In a training series by the Center for Public Education, one author pointed out that rural communities may be out of the pandemic but are also still out of the loop [7]. It was indicated the digital divide has become overwhelming for many rural students to keep up with access to the items they need to be successful in a public-school setting. This division is additionally exacerbated by the lack of awareness and educated healthcare professionals in some rural areas [28]. Faced with declining enrollment, declining funding for public schools, and a teacher shortage in rural regions, the use of AI teaching, learning and software could prove to be a step in the right direction for these rural communities.

3. Leveraging AI in Educational Organizations for Underserved Populations

Educational organizations at all levels are at a critical impasse for leveraging AI. The decision to leverage and embrace AI usage must be accompanied by educational training and policy to aid in the basic understanding of responsible use of this technology. From the elementary to higher education sectors, there must be training for the educators and students, and there must be supportive policy to guide and promote usage of AI [5]. Educational training and policies must be catered not only to the environment for implementation, but also the population in which they are intended for application. With the worldwide adoption of AI, new policies have been created at organizational levels to federal levels; however, it is understood that it cannot be a one-size-fits-all approach. The initial creation of any AI policy must include all stakeholders, and these stakeholders should maintain continuous involvement in the ongoing review and revision of standards or policies. Chan [8] identified the need for an AI policy that is created in educational organizations to create a space for the student to reference what is allowed under the concept of responsible use and what limits are in place to guide maximum use. Any consequences that could be instituted for irresponsible use must be determined and outlined clearly [8]. For AI to be leveraged in educational organizations for underserved populations, policy surrounding incorporation by the student should ultimately foster trust and openness about usage [5].

AI utilization by students in the educational setting requires initial training to ensure responsible use. Students need to understand the basic principles of how to create a prompt for generative AI and must be able to fact check and cite the information that is generated. These basic principles could be incorporated through an in-person or hybrid class that has been cited as the best method to support underserved learners [17]. The educational training should be tailored to the targeted student's needs and offer a level of support that allows the student to begin AI usage responsibly. Once the educator is certain the student has a basic proficiency, leveraging AI is possible through incorporating frequent usage in the curriculum and in student assignments. The student can gain practice by utilizing AI first to generate ideas for research and aiding in refining grammar and context [8]. In the higher educational settings, where learners come from diverse backgrounds and levels of education, educator support may be required outside of the classroom with tutors and specialists. Educational organizations that are leveraging AI usage must provide these additional support services to meet the needs of the students and promote responsible use of the technology. This need for additional support for students could lead to an increased need in the technology and support budgets for educational organizations. To support underserved populations by providing the resources needed to leverage AI, educational organizations must glean aid from local, state, and federal funds or grants to meet this need [17].

Leveraging of AI in educational organizations is reliant on the educators being able to encourage, support, and aid students to promote the responsible inclusion of the technology

[8]. To get to this point of full implementation into curriculums in all settings, there is a need to reduce the misconception that AI reduces student learning and is a cheating mechanism. Just as the need for student training has been identified as a primary focus, this must first start with educator training. Faculty development should begin with the basics. Educators can graduate from basic training and work towards completing micro credentials for advanced use. This can position the educators to promote a safe and productive environment for the use of AI in the classroom from elementary to higher education. A study conducted by Lee & Perret [21] focused on providing professional development for teachers in the K-12 setting, allowing participants to attend a 5-day workshop that provided education on how to incorporate AI in the classroom in each specific Science, Technology, Engineering, Mathematics (STEM) specialty area. The results of the workshop demonstrated that thorough education for teachers increases their basic knowledge, willingness to adopt, and eagerness to innovate to find ways to support the use for students. Furthermore, the results supported the concept that education needs to be an ongoing commitment for educators to be able to provide the best approaches for their specific classroom setting and learner population [21].

Perceptions of educators will be the driving factor on whether leveraging of AI in educational organizations will be successful. In a study conducted by Woodruff et al. [35], it was identified that educators in the age range of 45-64 with 20 years of experience or more would benefit most from increased education. Furthermore, it was identified that fear of the unknown and access to resources are the two largest barriers to classroom implementation into the curriculum [35]. Addressing these barriers could promote the adoption of AI usage in classrooms from K-12 to college. Allocating the training and ongoing support of leaders and mentors will continue the successful leveraging of AI and promote positive attitudes towards adoption. Starting with a pulse survey of perception could allow organizations to identify faculty leaders who could mentor their peers that require ongoing support, fostering collaboration and leadership. Helping educators to see that their role includes not only helping to use AI responsibly but to also incorporate it into their own practice for areas such as assessment, evaluation, performance prediction, learner support and tutoring [11].

4. Digital Literacy and Workforce Development Using AI

Adding to the gaps in equity for rural communities and stakeholders, is the continued dwindling pool of a developed workforce. As noted by the World Health Organization (WHO) [33], the organization put forth major efforts in a 2010 initiative related to creating and maintaining rural healthcare access and employees. One of two fundamental methods of acquiring a larger workforce is to educate those community members who already live in rural communities [33]. The challenge has become reaching these individuals and/or providing educational opportunities to these populations. With the bilateral deficit of incoming employees as well as the retirement of an aging workforce, rural communities are struggling to meet basic economic needs [31]. Even in pre-COVID climates, rural communities were much slower to recover from the 2008-2010 recession than urban areas, still not even seeing pre-recession employment rates before 2019 [31]. This speaks to the need for trained professionals, and workforce development in these more rural areas, now more than ever. Ayentimi [2] urged stakeholders from underdeveloped areas to create policies and processes which lend themselves to 4IR.

In 1984 at a Seminar on "Future Issues in Rural Development" Howard Newby presented data on rural development and participation in the technology revolution. He suggested that advancement of the personal computer and emerging internet access could lead to a reduction in peripherality [10]. As we can confirm forty years later, this was not the case, and rural areas still suffer from disparity and inequity related to AI and technology-driven services. Leveraging AI and machine learning to serve the underserved populations of the United States can lead to better educational outcomes for these residents [18]. This, however, will take the accountability of many stakeholders in the US including governmental authorities (local, state, and federal), AI and other digital technology organizations (such as Google, Amazon, and ChatGPT), and the urban area counterparts [10]. Opportunities exist beyond just bridging the gap in educational equity. Karako et al. [19] realized the potential of AI-driven real-time models for public healthcare access, diagnostic exams and even treatment in some rural communities. To incorporate these prospects, the technology must break the social and geographical barriers to our most rural areas.

5. Case Studies and Success Stories

AI can improve students' ability to communicate in the higher education setting, both in written and face-to-face venues. It can especially serve as a useful tool for English as a foreign language (EFL) students. Coady [9] illuminated a staggering 9.3 million students from rural communities who are identified as English language learning (ELL). This is not an insignificant number of students across the rural United States. In a quantitative case study conducted by Fathi et al. [13] a cohort of students were engaged in an experimental group that utilized the AI tool Andy English chatbot in various speaking activities. It was concluded that the use of the AI chatbot improved the learners' speaking skills and willingness to communicate, all the while promoting positive attitudes and perceptions of using the AI chatbot [13]. Furthermore, it was determined that those enrolled in the AI-driven Chatbot group experienced a 31% increase in language and grammar

skills beyond the scores of those of the control group. The results of this study support the idea that AI can serve to improve overall communication in both written and verbal formats, which can improve success in professional communication in higher education. This is one additional study that supports and encourages the use of exposure and engagement across communities who are immersed with ELL to expedite the facilitation of the English language as well as to improve overall morale and perception of the learning experience.

In a study by Nazari et al., [27] the authors conducted a randomized controlled single-blind study on the use of AI in non-native graduate students for academic writing. This study pooled 121 graduate students enrolled full time in a national university. The results of this study indicated multiple outcomes with the implementation of AI software (specifically Grammarly) to meet several objectives, including emotional intelligence about writing, engagement with the writing assignments, and self-efficacy with writing and writing skills. While this study highlights some of the value AI can bring nationally with graduate students, the implications of the findings can be extrapolated to rural areas for students enrolled in college, graduate or post-graduate programs. This highlights the importance of leveraging AI usage with underserved and underrepresented learners from a variety of backgrounds to drive engagement and self-efficacy.

Beyond Chat GPT, there are a variety of AI tools that can assist students in higher education. Students can be introduced to the AI technology early in their program of study to support their professional development in communication with faculty, peers, and potential employers. In a study aimed to analyze the effect of AI English writing features in post-graduate students, it was concluded that the use of AI improved overall scores, engagement, and emotions related to acceptance of AI technology [27]. According to Nazari et al. [27] exposure to platforms such as Grammarly, Hyperwrite, Co Pilot, and ChatGPT can improve the student's scores in the academic setting, along with grammar and professional tone in email communication, discussion posts, or written assignments. These platforms can be used to curate the whole email, assignment outlines, idea prompts for discussion posts, or simply to generate suggestions to improve the narrative or perception of written communication. Overall, if the use of AI technology is encouraged, it has the potential to promote ethical comportment and positive outcomes. Case studies such as these are numerous in volume, and illustrate the need for digital, ML and AI literacy in rural and underserved areas and communities.

6. Conclusion

As highlighted by this article, rural communities are falling farther behind in AI usage, digital literacy, and upkeep with the changing landscape of our daily lives. The literature here emphasized two aspects of the gap presented; the lagging use of technology in rural communities and how this impacts education and workforce, as well as how we can lean into technology and AI in higher education to support rural learners. As articulated by so much recent literature, digital literacy, AI and ML, and other emerging technologies are here to stay for the near future. Not only are our rural communities falling behind on the digital learning curve, the workforce in many of these areas is suffering as well. The domino-effect of insufficient educational infrastructure, limited opportunities for training and education, and a lack of awareness of the AI-driven methods of reaching higher potentials has been a catalyst for the gap in embracing the fourth industrial revolution. As professionals in a variety of disciplines band together, it is encouraged that data-driven decisions are used to bridge this gap for our rural communities. Opportunities presented can be the step the nation needs to improve economic stability, close the learning gap, and person-by-person combat generational poverty and underserved communities.

Abbreviations

4IR	4th Industrial Revolution
AI	Artificial Intelligence
ELL	English Language Learners
EFL	English Foreign Language
ML	Machine Learning
STEM	Science, Technology, Engineering, Mathematics
US	United States
WHO	World Health Organization

Conflicts of Interest

The authors declare no conflicts of interest.

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