Environment and Social Psychology (2025) Volume 10 Issue 7 ISSN: 2424-8975 (O)
doi: 10.59429/esp.v10i7.3671 2424-7979 (P)

RESEARCH ARTICLE

Bridging the digital divide in education: Strategies for equitable access to technology in Low-Income communities

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ABSTRACT

The digital divide continues to hinder educational opportunities for low-income students, limiting access to technology and digital resources. This study examines socioeconomic disparities in access to educational technology, identifies key barriers, and assesses strategies to bridge the gap. This article synthesizes effective interventions by systematically analyzing literature, policy frameworks, and case studies, including infrastructure expansion, affordable technology programs, digital literacy training, and community-based initiatives. It also examines government policies and private-sector contributions to promoting digital equity. The findings offer a comprehensive understanding of current efforts, highlighting financial constraints and implementation hurdles. This study provides actionable insights for educators, policymakers, and stakeholders seeking to ensure equitable access to educational technology, thereby fostering inclusive and sustainable digital learning environments.

Keywords: digital divide; educational technology; socioeconomic disparities; equity in education; access interventions; marginalized communities

1. Introduction

The digital divide refers to the gap between individuals without access to modern information and communication technology. This divide manifests in unequal access to digital resources in educational contexts, exacerbating learning disparities among students from different socioeconomic backgrounds[1]. Addressing this issue is crucial to fostering inclusive and equitable education.

Over the past few decades, technological advancements have transformed educational practices, enabling remote learning, personalized instruction, and global collaboration. However, for many students in low-income communities, these advancements remain out of reach due to financial barriers, lack of infrastructure, and limited digital literacy[2]. The digital divide is not merely about the presence or absence of technology; it encompasses broader issues related to affordability, accessibility, and digital competency. One of the primary challenges in addressing the digital divide is ensuring access to essential digital tools such as computers, tablets, and internet connectivity[3]. While some schools and communities have implemented programs to provide these

ARTICLE INFO
Received: 29 April 2025 | Accepted: 31 June 2025 | Available online:15 July 2025

CITATION
Adako OP, Ekundayo TF. Bridging the digital divide in education: Strategies for equitable access to technology in Low-Income communities. *Environment and Social Psychology* 2025; 10(7): 3671. doi:10.59429/esp.v10i7.3671

resources, many students still struggle to obtain consistent and reliable access. Additionally, disparities in digital literacy among students, teachers, and parents further compound the issue, as effective utilization of technology requires a foundational understanding of its applications[4].

The impact of the digital divide extends beyond academic performance. Limited access to technology can hinder students' development of critical digital skills necessary for future employment and civic participation. As the global economy increasingly relies on digital proficiency, students from underserved communities face long-term disadvantages if the digital divide is not addressed[5]. Therefore, bridging this gap is crucial for achieving academic equity, social mobility, and economic growth. Governments, educational institutions, and private sector organizations have recognized the need to address the digital divide. Various initiatives, including broadband expansion projects, device distribution programs, and digital literacy training, have been implemented to support students in underserved communities [2]. However, these efforts often face challenges related to funding, infrastructure limitations, and policy implementation[6, 7].

To effectively bridge the digital divide, a multifaceted approach is required. This involves investing in technological infrastructure, providing affordable digital devices, implementing digital literacy programs, and fostering collaboration between public and private entities[8, 9]. Furthermore, policies that promote equitable technology access must be continuously evaluated and refined to address emerging challenges[10].

This study article aims to provide a comprehensive analysis of the digital divide in education, examining its root causes, evaluating existing interventions, and identifying effective strategies for promoting digital equity. By synthesizing research findings, case studies, and policy frameworks, this article offers practical recommendations for educators, policymakers, and stakeholders dedicated to ensuring that all students, regardless of socioeconomic background, can thrive in the digital age.

2. Socioeconomic disparities in technology access

Socioeconomic disparities play a significant role in determining access to educational technology. These disparities are shaped by factors such as income levels, geographic location, infrastructure availability, and government policies, all of which influence students' ability to acquire and effectively use digital resources[11].

2.1. Income and financial constraints

The financial burden of acquiring and maintaining digital technology is a major contributor to the digital divide. Families in low-income communities often struggle to afford essential tools such as laptops, tablets, and reliable internet access[3]. This issue is especially pronounced in households with multiple school-aged children, where the need for several devices intensifies the financial strain. As a result, many students rely on outdated or shared devices, which limits their ability to engage effectively in digital learning[12]. Beyond hardware, recurring expenses such as data plans, software subscriptions, and technical support create additional barriers. These costs often prevent students from accessing key educational resources, participating in online classes, or developing necessary digital skills[13]. The lack of personal internet-enabled devices and high-speed connectivity directly impacts students' academic performance, engagement, and digital literacy[14,15].

The financial gap also limits parental support, as many caregivers in low-income households may lack the resources or training to assist their children with online learning[16]. This compounds the challenges faced by students who are already at a disadvantage. Addressing these financial barriers through subsidies, low-cost device initiatives, and community-based support programs is essential for ensuring equitable access to educational technology in underserved communities.

2.2. Geographic disparities and infrastructure limitations

Geographic location is critical in shaping access to digital resources, with rural and underserved urban areas facing significant infrastructure challenges. In many rural communities, the absence of high-speed internet infrastructure makes consistent online access nearly impossible[17]. Sparse population density often leads to limited commercial incentives for internet service providers to expand their broadband networks, leaving these areas with slow, unreliable, or unavailable connections[18].

Urban centres, while generally better connected, are not exempt from digital inequities. Low-income neighbourhoods in cities often suffer from outdated infrastructure and inadequate broadband coverage due to long-standing underinvestment. These structural deficits mean that even students living near wealthier, well-connected districts may struggle with unstable internet and reduced access to digital tools.

Without reliable connectivity, students face difficulties participating in online classes, downloading educational materials, or engaging with interactive learning platforms. This digital exclusion affects academic performance and limits opportunities for digital literacy development and lifelong learning[19]. Bridging this geographic digital divide requires targeted infrastructure investment, community Wi-Fi initiatives, and policy support to ensure equitable access to technology regardless of where students live[20].

2.3. Educational institutions and resource allocation

The digital divide is further intensified by disparities in funding and resource allocation among educational institutions. Schools in affluent communities often benefit from higher property taxes, greater private investment, and stronger institutional support, enabling them to provide modern computer labs, one-to-one device programs, high-speed internet, and access to advanced digital learning platforms[21,22]. These schools also tend to employ educators with specialized training in technology integration, creating a more enriched and future-ready learning environment.

Conversely, schools in low-income or marginalized communities frequently operate with constrained budgets and outdated infrastructure. Limited funding translates into insufficient devices, minimal IT support, and a lack of comprehensive digital literacy instruction[23,24]. In many cases, students must share devices, use outdated software, or attend schools without consistent internet access, putting them at a distinct disadvantage compared to their peers in well-funded districts[25]. These inequities hinder students' ability to build essential digital competencies that are increasingly vital for academic success, workforce readiness, and participation in a technology-driven society[5,26]. Bridging this institutional divide requires equitable funding policies, targeted investments, and support programs prioritizing digital inclusion in under-resourced schools.

2.4. Parental and teacher digital literacy

The successful integration of technology in education hinges on student access and the digital literacy of parents and educators. Parents and teachers in many low-income communities often lack formal training in digital tools, which limits their ability to guide and support students in a tech-driven learning environment[27]. This digital skills gap becomes especially problematic during remote or blended learning, where adult assistance is often crucial for navigating platforms, troubleshooting issues, and ensuring student engagement[28]. Parents with limited digital knowledge may struggle to help children complete assignments, communicate with teachers, or access online educational resources. Similarly, educators without adequate training may underutilize digital tools or fail to integrate technology effectively into the curriculum, hindering the learning experience[29]. This reinforces educational inequalities and widens the digital divide.

Addressing this challenge requires targeted interventions, including professional development programs for teachers and community-based workshops for parents. Schools, nonprofits, and local governments must collaborate to provide accessible digital literacy training tailored to the needs of these groups[30,31].

Empowering educators and caregivers with essential digital skills is critical to building a more inclusive and supportive educational ecosystem for all learners[5].

2.5. Government policies and digital equity initiatives

Government policies play a crucial role in shaping the landscape of digital access and reducing socioeconomic disparities in educational technology. Across the globe, many governments have introduced initiatives such as subsidized internet access for low-income families, grants for schools to purchase digital devices, and nationwide digital literacy campaigns[32]. These efforts aim to create a more inclusive digital environment, especially for marginalized and underserved communities.

Despite these positive strides, several challenges hinder the full realization of digital equity goals. Funding limitations, bureaucratic delays, and uneven implementation across regions often reduce the effectiveness of these initiatives[33]. Programs are usually rolled out in areas without proper infrastructure or support systems, resulting in limited uptake or poor outcomes. Moreover, the lack of community engagement and feedback can result in misaligned policies that fail to address the specific needs of local populations[34]. For digital equity initiatives to be successful, policies must be designed with a long-term vision, backed by sustained financial investment, and executed with transparency and accountability[5]. Active involvement from local stakeholders including educators, parents, and community leaders is essential to ensure that programs are tailored, inclusive, and impactful. A collaborative and consistent policy approach is key to closing the digital divide.

2.6. The impact on student learning and future opportunities

Limited access to technology significantly hinders students' academic performance and long-term success. Without reliable internet and digital devices, students in low-income communities often struggle to complete assignments, engage with interactive learning tools, or participate in virtual classrooms[35]. This disconnect leads to lower academic achievement and widens the educational gap between socioeconomic groups.

In today's digital economy, foundational tech skills are essential for higher education, vocational training, and virtually all career paths[36]. Students who lack exposure to digital tools and platforms risk falling behind their peers, which reduces their competitiveness in the job market and limits their upward mobility. Moreover, the absence of digital access contributes to a cycle of inequality, where students from disadvantaged backgrounds face systemic barriers that extend well beyond the classroom[5]. Bridging this divide requires more than just distributing devices it demands a coordinated effort involving infrastructure development, sustained financial support, inclusive policy reform, and community engagement[37]. By addressing these disparities, educators and policymakers can create a more equitable educational landscape where every student can thrive in a technology-driven world.

3. Strategies for bridging the dgital divide

Bridging the digital divide in education necessitates a comprehensive, multifaceted approach that includes technological, financial, educational, and policy-driven interventions. Addressing the digital gap requires improving access to digital devices and reliable internet, and ensuring that students and educators are equipped with the necessary skills to use these tools effectively[5]. Financial support mechanisms, such as subsidies for technology purchases and partnerships with non-governmental organizations (NGOs), can make devices and internet services more affordable for low-income families. Education systems must invest in digital literacy programs for students and teachers, integrating these skills into the early stages of the school curriculum. Policy interventions, including the development of national digital equity frameworks, can guide and sustain long-term efforts for equitable digital access[38]. These strategies reduce barriers to digital education, enabling students in underserved communities to achieve better learning outcomes.

3.1. Infrastructure development and broadband expansion

One of the foundational steps in closing the digital divide is expanding broadband internet access. Reliable internet connectivity is essential for online learning, digital collaboration, and accessing educational resources[39]. Governments and private organizations have implemented various initiatives to extend broadband infrastructure to underserved areas. For example, public-private partnerships have been critical in subsidizing broadband expansion projects, ensuring that rural and low-income urban communities receive high-speed internet access[9].

In addition to expanding broadband networks, mobile internet solutions and community Wi-Fi hotspots offer alternative connectivity solutions. Local governments and school districts have increasingly invested in providing free public Wi-Fi access in libraries, community centres, and even school buses to support students without home internet access[40].

3.2. Affordable technology and device distribution

Access to digital devices, such as laptops and tablets, is another significant barrier for students in low-income households. Many regions have implemented device donation programs, low-cost technology initiatives, and one-to-one device distribution policies to address this issue. Programs like the U.S. Federal Communications Commission's (FCC) Emergency Connectivity Fund and initiatives by tech giants such as Microsoft, Google, and Apple have provided affordable devices and software solutions to schools and families in need. Emergency Connectivity Fund is a $7.17 billion program to provide schools and libraries with connected devices and broadband services to support remote learning[41].

Recycling and refurbishing old electronic devices also offer sustainable ways to provide affordable technology. Nonprofit organizations have partnered with corporations and educational institutions to refurbish and distribute used laptops and tablets to needy students, reducing e-waste while increasing accessibility[42,43].

3.3. Digital literacy and skills training

Access to technology alone is insufficient if students, teachers, and parents lack digital skills. Digital literacy training programs ensure that users can effectively navigate and utilize technology for educational purposes. Many school districts have incorporated digital literacy into their curricula, 42 teaching students skills such as online research[44], cybersecurity awareness[45], and software proficiency [38].

Community-based digital literacy workshops further enhance the capacity of parents and guardians to support their children's education. Initiatives such as Google's 'Be Internet Awesome' and local digital training hubs have empowered families by providing free educational resources and skill-building opportunities[46].

3.4. Government policies and educational reforms

Government policies play a pivotal role in shaping digital equity initiatives. Policymakers have introduced legislation to fund digital inclusion programs, improve broadband accessibility, and integrate technology into national education strategies. Notable examples include the European Union's Digital Education Action Plan (2021–2027)[47] and the U.S. Infrastructure Investment and Jobs Act. This act allocated $65 billion for broadband expansion, including programs such as the Broadband Equity, Access, and Deployment (BEAD) initiative, the Tribal Broadband Connectivity Program, and the Affordable Connectivity Program, to improve internet access and affordability[48].

Educational reforms must also ensure that technology integration in schools is inclusive and effective. Schools should adopt blended learning models that combine traditional teaching methods with digital tools to accommodate students with varying levels of access to technology.

3.5. Public-private partnerships and community engagement

Collaborations between governments, private enterprises, and nonprofit organizations have proven instrumental in addressing the digital divide. Companies like Google, Facebook, and Amazon have launched initiatives to improve internet access in underserved communities. Nonprofit organizations [49,50], such as One Laptop per Child[51] and the National Digital Inclusion Alliance[52], have also contributed to providing devices, internet services, and educational resources to disadvantaged students.

Community engagement is another essential aspect of digital inclusion. Local leaders, educators, and parents must actively participate in identifying barriers to technology access and developing targeted interventions to address these issues. Programs that involve community-driven solutions, such as neighbourhood internet cooperatives and school-led technology lending libraries[53], have shown promising results in closing digital gaps.

3.6. Inclusive technology and accessibility considerations

Equity in educational technology access also ensures that digital tools are designed to accommodate diverse learning needs. Students with disabilities require assistive technologies, such as screen readers, speech-to-text software, and adaptive learning platforms[54]. Schools must invest in accessible digital learning resources and provide educators with training to effectively integrate these tools into their classrooms. Multilingual digital content is another critical factor in inclusive technology adoption. Many low-income communities include non-native speakers who may struggle with English-based online resources[55]. Expanding language accessibility in educational platforms helps ensure that all students benefit from digital learning opportunities.

3.7. Financial aid and subsidies for low-income families

Affordability remains a major barrier to digital access. Governments and private organizations have introduced financial aid programs, such as internet subsidies and discounted technology services, to support low-income families[56]. The Affordable Connectivity Program (ACP) by the U.S. Federal Communications Commission (FCC) provides discounts of up to $30 per month for broadband services to eligible households and up to $75 per month for households on qualifying Tribal lands. It also offers a one-time discount of up to $100 for connected devices[57]. Organizations like the International Telecommunication Union (ITU) and the Alliance for Affordable Internet (A4AI) work globally to improve broadband affordability. Their studies highlight efforts to reduce costs and address affordability gaps in low- and middle-income economies[58].

Schools and community organizations have also implemented technology loan programs that allow students to borrow laptops and mobile hotspots for educational use[40]. These programs ensure students can complete assignments, participate in remote learning, and access essential digital resources without financial strain.

3.8. Evaluating the effectiveness of digital equity initiatives

Continuous monitoring and evaluation are necessary to ensure the long-term success of digital inclusion efforts. Researchers and policymakers must assess the impact of digital access programs by analyzing data on student performance, technology adoption rates, and socioeconomic outcomes[39]. Periodic reviews help refine existing strategies and identify areas requiring additional intervention.

For instance, Finland's education system emphasizes equity and inclusivity, leveraging digital tools to bridge educational gaps. For example, Finland has invested in digital infrastructure to ensure all students can access the internet and devices, as highlighted in this case study. Additionally, Finland's national distance learning programs during the COVID-19 pandemic showcased their commitment to accessible education[59].

South Korea has integrated technology into education through initiatives like e-Hakseupteo[60], a public education platform that supported uninterrupted learning during the pandemic. As detailed in this UNESCO report, the country has also developed AI-driven digital textbooks and smart classrooms to enhance personalized learning[61].

3.9. Future directions and innovations in bridging the digital divide

Emerging technologies offer new possibilities for addressing digital disparities. Innovations such as low-earth orbit (LEO) satellite internet services, 5G network expansion, and AI-driven personalized learning platforms have the potential to revolutionize digital accessibility. Companies like SpaceX's Starlink and Amazon's Project Kuiper are developing satellite-based internet solutions to bring high-speed connectivity to remote and underserved areas[62].

Artificial intelligence and adaptive learning technologies can further bridge educational gaps by providing customized learning experiences tailored to students' individual needs. AI-driven platforms can assist teachers in identifying learning challenges and tailoring instructional approaches to improve student engagement and comprehension[63]

4. Case studies of successful interventions

Bridging the digital divide requires a combination of strategic interventions, policy support, and community engagement. To gain deeper insights into what works, this section examines multiple case studies of successful initiatives from different regions. These case studies highlight best practices, challenges, and outcomes, providing a blueprint for future interventions.

4.1. One laptop per Child (OLPC) Initiative

The One Laptop per Child (OLPC) initiative was launched in 2005 and operated till 2014 as a nonprofit effort to provide low-cost, durable laptops to children in low-income countries. The initiative aimed to enhance digital literacy and learning opportunities for students with limited access to educational resources[64,65].

Implementation:

OLPC distributed laptops with educational software, providing students with interactive learning experiences. The initiative collaborated with governments, NGOs, and private sector partners to fund and distribute the devices.

Outcomes:

- Increased digital literacy among students in participating countries such as Peru, Rwanda, and Uruguay.
- Enhanced student engagement in STEM subjects.
- Challenges included a lack of teacher training, limited internet access in remote areas, and sustainability issues.

Key Takeaways:

- While device distribution is crucial, ensuring infrastructure support (internet connectivity, teacher training) is equally essential.
- Government buy-in and local adaptation of digital content improve long-term success.

4.2. The National Digital Inclusion Alliance (NDIA), USA

The NDIA is a U.S.-based coalition of organizations working to provide broadband access, digital literacy training, and technology support to low-income communities [52].

Implementation:

- NDIA partners with local governments, libraries, and community organizations to implement digital inclusion programs.
- Programs include free Wi-Fi zones, subsidized broadband services, and digital literacy workshops.

Outcomes:

- Improved internet access for low-income families in urban and rural areas.
- Enhanced job opportunities and educational attainment through digital literacy training.
- Policy advocacy led to state and federal initiatives supporting digital equity.

Key Takeaways:

- Collaboration between stakeholders, including government agencies and grassroots organizations, fosters effective digital inclusion.
- Policy advocacy is essential for securing long-term support and funding.

4.3. Kenya's Digital Learning Program

In 2016, the Kenyan government launched the Digital Literacy Program (DLP) to integrate technology into the country's primary education system[66,67].

Implementation:

- Distribution of tablets to students in public schools.
- Training for teachers on digital pedagogy.
- Establishment of digital infrastructure, including solar-powered computer labs in rural areas.

Outcomes:

- Increased student engagement and interactive learning.
- Digital skills development among both students and teachers.
- Challenges included device maintenance, occasional internet connectivity issues, and initial teacher resistance.

Key Takeaways:

- Government commitment plays a crucial role in scaling digital education initiatives.
- Infrastructure investments (e.g., solar power solutions) ensure accessibility in remote areas.

4.4. India's PMGDISHA (Pradhan Mantri Gramin Digital Saksharta Abhiyan)

The PMGDISHA initiative, launched by the Indian government, aims to make at least one person per household digitally literate in rural areas [68,69].

Implementation:

- Free digital literacy training for millions of rural residents.
- Partnerships with local training centres to provide hands-on computer training.

- Use of mobile-based learning to reach remote communities.

Outcomes:

- Over 40 million individuals are trained in digital literacy.
- Increased use of e-governance services, digital banking, and online education.
- Challenges include language barriers and sustaining long-term digital engagement.

Key Takeaways:

- Community-based training centres are effective in reaching rural populations.
- Government backing ensures large-scale impact and sustainability.

4.5. Brazil's connected schools program

Brazil's Connected Schools Program focuses on providing broadband internet access to public schools, particularly in underprivileged areas[70].

Implementation:

- Installation of fibre-optic networks and satellite connections in remote schools.
- Partnerships with private telecom companies to ensure cost-effective solutions.
- Development of digital learning resources in Portuguese.

Outcomes:

- Over 70% of public schools gained broadband access.
- Increased student engagement in digital learning activities.
- Teachers reported improved confidence in integrating technology into their teaching.

Key Takeaways:

- Public-private partnerships can enhance digital infrastructure development.
- Localized digital content improves student learning experiences.

4.6. South Africa's vodacom e-School initiative

Vodacom e-School is an online learning platform that provides free educational content to South African students[71].

Implementation:

- Partnership with the Department of Education to provide zero-rated mobile access to the platform.
- Content aligned with the national curriculum in various subjects.
- Outcomes:Over 1 million students have accessed digital learning resources.
- Increased performance in subjects such as Mathematics and Science.
- Challenges include digital literacy gaps among students and teachers.

Key Takeaways:

- Mobile-based learning platforms can be highly effective in regions with high mobile penetration rates.
- Collaboration with telecom providers helps reduce connectivity costs.

4.7. Canada's computers for schools program

Canada's Computers for Schools (CFS) initiative refurbishes donated computers and distributes them to schools, libraries, and community centres[72].

Implementation:

- Partnerships with government agencies and private companies for hardware donations.
- Training programs for students and teachers on digital skills and device maintenance.

Outcomes:

- Over 1.5 million refurbished computers are distributed across the country.
- Reduced e-waste while enhancing technology access for students.
- Challenges include ensuring continuous hardware upgrades and sustainability of refurbished devices.

Key Takeaways:

- Repurposing old technology is a cost-effective way to bridge the digital divide.
- Sustainability planning is necessary to ensure the long-term viability of refurbished devices.

4.8. Lessons learned from case studies

Examining these diverse interventions highlights key elements of successful digital inclusion programs[73]:

- Government and Policy Support – Programs with strong government backing, such as Kenya's DLP and India's PMGDISHA, achieved large-scale impact.
- Public-Private Partnerships – Collaborations, as seen in Brazil's Connected Schools and Vodacom e-School, helped provide cost-effective solutions.
- Localized Solutions – Tailoring programs to local needs, such as language-specific content and mobile-based access, enhances engagement.
- Infrastructure Development – Investments in broadband expansion and digital learning hubs remain crucial for sustainable digital inclusion.
- Digital Literacy Training – Equipping teachers and students with the necessary skills ensures long-term adoption of digital tools.

These case studies underscore the importance of holistic approaches that combine infrastructure, training, and policy interventions to bridge the digital divide effectively. Future initiatives should address persistent challenges such as affordability, sustainability, and digital literacy to ensure equitable access to technology in education.

5. Challenges and future directions

Significant challenges persist despite numerous efforts to bridge the digital divide in education. These challenges stem from financial constraints, infrastructural deficits, socioeconomic disparities, digital literacy gaps, and policy enforcement issues. Addressing these barriers requires multi-stakeholder involvement, long-term policy planning, and sustainable intervention strategies[74]. This section explores the major obstacles to digital inclusion, critically examines their implications, and presents future directions for achieving equitable access to educational technology.

5.1. Persistent financial constraints

Financial limitations remain among the most formidable barriers to achieving digital equity in education. For many low-income families, the cost of purchasing digital devices, such as laptops, tablets, or smartphones alongside monthly internet fees significantly strains already limited household budgets[75]. In homes with multiple school-aged children, the need for more than one device further compounds the financial burden, often leading to shared usage or a complete lack of access[76]. Educational institutions serving underprivileged communities also grapple with tight budgets, making providing sufficient technological resources, digital infrastructure, or teacher training programs difficult. These budgetary constraints limit the scope of support schools offer, widening the gap between students in well-funded districts and those in under-resourced ones[77]. Government-led initiatives to subsidize technology access often fall short due to inconsistent funding, bureaucratic delays, or lack of scalability[78]. Consequently, many families rely on outdated or inadequate technology, preventing students from fully participating in modern, digitally integrated education[39].

Addressing these persistent financial challenges requires sustained public investment, innovative funding models, and increased involvement from the private and nonprofit sectors.

5.1.1. Cost of infrastructure development

Developing and expanding broadband infrastructure in remote and underserved communities poses significant financial challenges. The high costs of laying fibre-optic cables, establishing network towers, and maintaining connectivity in low-density or geographically complex areas often deter investment[79]. For many governments, especially in low- and middle-income countries, allocating sufficient funding to large-scale infrastructure projects is difficult amidst competing national priorities. Even in high-income nations, broadband expansion efforts tend to favour more profitable urban and suburban regions, leaving rural and low-income urban neighbourhoods with limited or no access to high-speed internet[80]. This uneven distribution of infrastructure contributes to long-standing geographic disparities in digital connectivity.

Public-private partnerships have emerged as a potential solution to share the financial burden and accelerate deployment. However, these collaborations often prioritize areas with greater commercial viability, which may not align with the needs of the most marginalized communities[81]. As a result, market-driven approaches risk deepening digital inequality rather than resolving it. To ensure equitable access, infrastructure development must be guided by inclusive policy frameworks, equitable funding mechanisms, and regulatory incentives that prioritize underserved areas[82].

5.1.2. Device affordability and maintenance

Providing students with free or low-cost digital devices is a positive step toward inclusive education, but long-term sustainability poses significant challenges. Maintenance, repairs, software updates, and device upgrades require continuous financial investment[82]. Many educational institutions, especially those in low-income or rural areas, struggle with limited budgets and often lack the necessary infrastructure and technical staff to support ongoing device management[84]. As a result, students are often left with malfunctioning or outdated equipment that hinders their learning experience and reduces engagement. Furthermore, when devices are not regularly maintained, the effectiveness of digital learning programs diminishes over time, widening the digital divide rather than closing it[85].

5.2. Digital literacy gaps

Digital literacy is a critical factor in the successful integration of technology in education. However, many students, educators, and parents lack the skills to engage with digital tools and platforms effectively[86]. This gap limits the benefits of technology-enhanced learning and reinforces existing educational inequalities. Students may struggle with basic tasks such as navigating online classrooms, using productivity tools, or

evaluating digital information critically[87]. Similarly, educators without adequate digital training may struggle to integrate technology into their teaching practices, reducing instructional effectiveness. Parents, who often support learning at home, may also struggle to assist their children in digital environments[88].

5.2.1. Teacher training deficiencies

Teachers are central to the successful integration of technology in education, yet many lack the necessary training in digital pedagogy. Without a strong foundation in how to use technology to enhance instruction, educators may underutilize or misuse digital tools in the classroom[89]. The limited availability of high-quality, ongoing professional development programs focused on educational technology often worsens this gap. As a result, teachers may feel overwhelmed or resistant to adopting new technologies, leading to inconsistent or ineffective implementation[90].

5.2.2. Student digital competency gaps

Students from low-income communities frequently face limited exposure to digital tools, leading to significant gaps in digital competency. These students may lack basic skills in using learning management systems, word processing software, or online research tools, essential components of modern education[136]. As a result, they are often at a disadvantage when engaging with online learning platforms, completing digital assignments, or participating in technology-driven classrooms. In contrast, their peers with consistent access to technology tend to develop these skills earlier and more effectively, widening the educational divide[39].

5.2.3. Parental involvement and digital skills

Parental support is crucial to a child's academic success, especially in digital learning environments. However, in many low-income households, parents often lack the digital literacy necessary to assist their children with online education[92]. This gap limits their ability to help with assignments, navigate learning platforms, or communicate with teachers via digital channels. As schools increasingly rely on technology for instruction, the digital divide affects students and their families. When parents are unfamiliar with basic digital tools such as email, educational apps, or virtual meeting platforms, they are less likely to engage with their children's learning progress[93]. This disconnect can hinder academic performance and reinforce educational inequality. Community-based digital training programs can serve as a valuable solution, equipping parents with foundational digital skills[94].

5.3. Infrastructure limitations

Reliable internet access and stable electricity are critical foundations for effective digital education. Unfortunately, many low-income communities—especially those in rural or underserved regions face significant infrastructure challenges[95]. In such areas, frequent power outages, poor network coverage, and slow internet speeds severely limit students' ability to participate in online learning or access digital resources. Without consistent connectivity, students miss out on real-time instruction, virtual collaboration, and timely submission of assignments[96], widening the educational gap between them and their peers in better-connected environments. Additionally, teachers struggle to deliver engaging lessons when technological tools are hindered by unreliable infrastructure[97]. These limitations also impact school operations, as institutions struggle to fully implement and sustain digital learning programs. Bridging this gap requires coordinated efforts from governments, telecom providers, and educational stakeholders to invest in broadband expansion, power supply improvements, and long-term infrastructure development that ensures equitable access to digital learning for all students[98].

5.3.1. Limited broadband penetration

In many remote and low-income regions, the lack of robust broadband infrastructure leads to slow, unstable, or completely unavailable internet access. This limited connectivity severely hampers students' ability to engage in digital learning, access educational content, and participate in virtual classrooms[99]. Teachers in these areas also struggle to adopt online teaching tools, reducing the overall effectiveness of educational delivery. The lack of broadband access affects formal education, preventing learners from acquiring essential digital skills necessary for future employment. Bridging the digital divide requires a multi-stakeholder approach that involves governments, telecommunications companies, and NGOs[74]. Public-private partnerships can drive infrastructure development, incentivize broadband expansion, and subsidize access for underserved populations. Additionally, implementing policies that prioritize digital inclusion and investing in innovative solutions, such as satellite internet or community Wi-Fi hubs, can play a transformative role in ensuring that every learner, regardless of location, has equitable access to digital education[100].

5.3.2. Unstable electricity supply

In many low-income and rural areas, an unreliable electricity supply poses a significant barrier to consistent digital learning. Frequent blackouts or limited daily access to power can interrupt virtual classes, hinder device charging, and reduce the overall effectiveness of technology-based education[101]. This instability affects students and limits educators' ability deliver content effectively and manage online platforms. To address this challenge, innovative and sustainable energy solutions are essential. One promising approach is the deployment of solar-powered internet hubs and charging stations in schools and community centres[102]. These off-grid systems can provide reliable power for digital devices and connectivity tools, ensuring uninterrupted learning even in regions with minimal electrical infrastructure. Partnering with renewable energy providers, NGOs, and local governments can accelerate the implementation of such systems[103]. Education systems can overcome power-related barriers by investing in resilient energy alternatives and creating more inclusive, equitable access to digital learning environments.

5.3.3. Technological disparities between urban and rural areas

Significant technological gaps exist between urban and rural educational settings, with students in urban areas often enjoying superior access to digital devices, high-speed internet, and tech-integrated curricula. In contrast, rural students frequently face limited access to reliable hardware, software, and connectivity, which hinders their participation in digital learning opportunities. This disparity contributes to a growing educational divide, placing rural learners at a distinct disadvantage in developing essential 21st-century skills. Bridging this gap requires focused investment in rural infrastructure, including high-speed broadband deployment, provision of digital learning devices, and establishment of tech-enabled learning hubs within schools and communities[105]. Equally important is the development of localized support systems for maintenance, training, and digital literacy[30].

5.4. Socioeconomic and cultural barriers

Economic disparities and cultural attitudes toward technology are significant barriers to digital access in many communities. For low-income households, the cost of devices, internet subscriptions, and necessary software remains a major obstacle, limiting their ability to participate in digital learning[84] fully. In addition, some cultural perspectives may undervalue or distrust technology, particularly in rural or traditional communities with limited exposure to its educational benefits[8]. This can result in resistance to new technologies, leaving students without crucial resources. Furthermore, parents who are less familiar with technology may struggle to support their children's online learning, exacerbating educational inequalities[1]. Addressing these challenges requires a multifaceted approach, including affordable access to digital tools,

awareness campaigns to change cultural perceptions, and community engagement to demonstrate the positive impact of technology on education.

5.4.1. Income inequality and technology access

For families in lower-income brackets, the financial strain of meeting basic needs such as food, housing, and healthcare often takes precedence over acquiring digital tools for education[2]. As a result, many students from these households are left without the necessary devices and internet access to fully participate in digital learning environments. This creates a significant barrier to educational equity, as these students are disadvantaged compared to their peers in wealthier families. To address this issue, policies that provide targeted subsidies, tax incentives, or government-sponsored technology programs are essential[106]. Such initiatives can make digital tools more affordable, ensuring that all students can access the resources needed for academic success regardless of their economic background. 5.4.2 Gender Disparities in Digital Access

In certain communities, deeply rooted cultural norms and societal expectations limit female students' access to digital tools and technology, creating significant gender-based educational disparities. In these settings, girls may be discouraged from pursuing tech-related subjects or lack the same opportunities to use digital devices as their male counterparts[107]. This disparity hampers their ability to develop digital literacy skills, crucial for academic success and future career opportunities. Addressing these gender disparities requires the implementation of gender-inclusive policies that promote equal access to technology for all students, regardless of gender. Programs that encourage girls' participation in technology, such as targeted mentorship, scholarships, and digital literacy initiatives, can help empower female students and challenge the cultural norms that restrict their educational growth[108].

5.4.2. Language and content barriers

Many digital educational resources are primarily available in dominant languages, such as English, leaving students from non-dominant linguistic backgrounds at a distinct disadvantage[109]. This language barrier can hinder their ability to engage with the content fully, limiting their learning opportunities and academic performance. For students whose first language is not the dominant language of instruction, accessing educational materials in their native language can be crucial for understanding complex concepts and enhancing their learning experience[110]. To address this issue, developing multilingual digital content is essential. This approach not only ensures that educational resources are accessible to a broader range of students but also promotes inclusivity and cultural diversity in digital education [111, 112].

5.5. Policy and governance challenges

Effective policy implementation is essential for bridging the digital divide and ensuring equitable access to technology in education. However, governance challenges often hinder progress, such as a lack of coordination among government agencies, insufficient funding, and delays in the rollout of infrastructure projects[113]. In many regions, policies aimed at expanding digital access may not be effectively enforced or face opposition from various stakeholders. Additionally, political instability, bureaucratic inefficiencies, and competing priorities can divert resources away from digital initiatives[114]. To overcome these obstacles, robust governance structures, clear policy frameworks, and cross-sectoral collaboration are necessary. Governments must prioritize digital inclusion by allocating adequate resources, fostering partnerships with private sector stakeholders, and involving local communities in decision-making[115].

5.5.1. Lack of clear digital equity policies

Many countries face the challenge of lacking well-defined policies for digital inclusion in education, resulting in inconsistent efforts to address digital disparities. Without a comprehensive framework, initiatives

to bridge the digital divide may be fragmented or fail to reach their intended impact[10]. A lack of clear digital equity policies can result in unequal access to technology, inadequate educational training, and limited support for students in underserved communities. Establishing national digital equity frameworks is essential for a structured, coordinated approach to tackling these challenges[116]. Such frameworks should ensure equal access to digital tools, connectivity, and resources while addressing teacher training and community engagement issues. A robust digital equity policy would guide governments in allocating resources, implementing effective programs, and measuring progress toward closing the digital divide, ensuring that all students have the opportunity to succeed in the digital age[117].

5.5.2. Inconsistent policy enforcement

While many countries have developed policies to address digital inclusion in education, weak enforcement mechanisms often result in inadequate implementation. Inconsistent policy enforcement can lead to disparities in technology access, an uneven distribution of resources, and gaps in educational outcomes[118]. This issue arises from a lack of clear accountability, limited monitoring systems, or insufficient capacity within institutions responsible for policy execution. As a result, policies intended to bridge the digital divide may be poorly enforced or ignored, undermining their potential impact. Strengthening oversight institutions is crucial to ensure that policies are developed and effectively implemented. Enhanced monitoring, regular audits, and establishing clear accountability structures can help ensure that digital inclusion initiatives are carried out as intended[119]. By reinforcing policy enforcement, governments can create a more consistent and equitable digital learning environment, helping to close the digital gap for all students, regardless of their socioeconomic background.

5.5.3. Public-private collaboration challenges

Collaboration between governments and private entities is essential for expanding digital access, as it leverages the resources, expertise, and innovation of both sectors. However, conflicting interests, such as differing priorities, financial incentives, or timelines, often slow progress[120]. For example, while governments may prioritize affordable access and social equity, private companies may focus on profitability and market expansion[121]. These differences can create barriers to effective cooperation and hinder achieving broader digital inclusion goals. Developing transparent partnership frameworks is crucial to align stakeholders toward common goals. Clear agreements on objectives, responsibilities, and outcomes can help ensure that both public and private sectors work cohesively. Furthermore, these frameworks should include accountability and regular evaluation mechanisms, fostering trust and ensuring that digital access initiatives are sustainable and impactful[122].

5.6. Future directions for bridging the digital divide

To achieve digital equity, future strategies must focus on sustainable, scalable, and inclusive solutions that address the diverse challenges faced by different communities. Policymakers, educators, and stakeholders should prioritize initiatives that ensure access to affordable and reliable technology for all students, particularly those from underserved communities[123]. Key recommendations include expanding broadband infrastructure in rural and remote areas, enhancing digital literacy programs for students, parents, and educators, and providing targeted support to low-income families through subsidies or technology donation programs[124]. Additionally, it is crucial to foster public-private partnerships to develop resilient and sustainable digital

education systems. Policymakers should also ensure that digital equity is integrated into national education frameworks, with clear guidelines for resource allocation and accountability [5].

5.6.1. Sustainable infrastructure development

To ensure digital equity, sustainable infrastructure development is critical in overcoming geographical and resource-based barriers to technology access. Governments must prioritize broadband expansion initiatives, focusing on underserved rural and remote areas. Public-private partnerships can accelerate broadband deployment by combining government funding with private sector expertise and innovation [125]. Additionally, alternative connectivity solutions, such as satellite internet, community Wi-Fi networks, and mesh networking, provide effective internet access to areas where traditional broadband infrastructure is not feasible [126]. These technologies can bridge the connectivity gap, ensuring no community is left behind. Furthermore, renewable energy-powered learning centres, such as solar-powered digital hubs, can provide consistent access to technology in regions with unreliable electricity [127].

5.6.2. Affordable technology access and digital inclusion

Ensuring all students can access digital tools is essential for bridging the digital divide. Subsidized device distribution programs can be a key strategy in making technology more affordable, with governments and NGOs collaborating to provide low-cost or free devices to needy students[82]. These programs can ensure equitable access to educational resources, especially for low-income families. Additionally, tax incentives for tech purchases can ease the financial burden on low-income households by making devices, internet services, and educational software more affordable [128]. Such incentives can motivate families to invest in essential technology for their children's education. Furthermore, refurbished device initiatives can significantly increase accessibility[129].

5.6.3. Enhancing digital literacy and skills development

Digital literacy is critical for both students and educators in a technology-driven world. Governments should prioritize teacher training programs to ensure educators have the skills to integrate technology effectively in classrooms. These programs should focus on digital pedagogies, ensuring teachers can guide students in using digital tools for learning [38]. Additionally, student-centred digital literacy curricula should be integrated into core curricula starting early, allowing students to develop critical digital skills as they grow [130]. By embedding digital literacy into the educational framework, schools can confidently prepare students to navigate a digital world. Moreover, parental digital skills workshops are essential for bridging the digital divide at home. Community-driven initiatives can empower parents with the skills to support their children's digital learning [131], creating a more collaborative environment for education and ensuring that digital literacy is reinforced beyond the classroom.

5.6.4. Community-based and school-led interventions

Community-based and school-led initiatives play a pivotal role in bridging the digital divide. Establishing technology hubs in schools and libraries provides public access points to digital resources for underserved students, enabling them to engage with educational content and develop digital skills. These hubs can also act as community resources, offering free computer and internet access. Additionally, after-school digital learning programs can enhance student competencies in a structured environment outside regular school hours [133]. By offering courses in coding, digital literacy, and online research, these programs can equip students with the necessary tools to succeed academically and professionally. Furthermore, public-private digital inclusion

partnerships can unite governments and corporations to provide funding and resources for digital education initiatives. Corporate sponsorships, grants, and in-kind donations can help establish and sustain these interventions, ensuring they are effective and long-lasting [134].

5.6.5. Policy recommendations and advocacy efforts

To achieve digital equity, governments must develop comprehensive national digital equity frameworks to guide interventions and ensure that all citizens, regardless of their socioeconomic background, have access to essential digital resources. These frameworks should prioritize inclusive digital education policies, infrastructure development, and accessible Internet services [135]. Additionally, telecom providers should be regulated to ensure that internet service providers (ISPs) offer affordable, high-quality internet service to low-income households [2]. This would bridge the affordability gap and make digital resources accessible to those who need them most. Furthermore, monitoring and evaluation mechanisms must be implemented to assess the effectiveness of digital inclusion initiatives [136]. Periodic assessments can ensure that policies are being implemented as intended and that programs are achieving their objectives.

6. Conclusion

Bridging the digital divide is critical to ensuring educational equity in an increasingly technology-driven world. The disparities in access to digital resources, exacerbated by socioeconomic inequalities, hinder students' ability to engage in meaningful learning experiences and limit their future opportunities. This review highlights key barriers to digital inclusion, including infrastructural limitations, financial constraints, and disparities in digital literacy.

Effective strategies to address these challenges include expanding broadband infrastructure, subsidizing internet access and digital devices, implementing digital literacy programs, and fostering public-private partnerships. Community-based initiatives, such as school technology hubs and public Wi-Fi programs, have also successfully increased access for students in low-income communities. Moreover, strong policy frameworks and advocacy efforts are essential to sustaining long-term progress in digital equity.

Despite these efforts, challenges remain, including funding limitations, resistance to technology adoption, and the need for continuous program evaluation. Addressing these issues requires a multi-stakeholder approach involving governments, educational institutions, private organizations, and community groups. Future research should focus on assessing the long-term impact of digital inclusion programs and identifying scalable, cost-effective solutions for marginalized populations.

Ultimately, closing the digital divide is not just about providing access to technology but about fostering an inclusive learning environment where all students, regardless of socioeconomic background, can thrive. By implementing targeted interventions and sustaining collaborative efforts, policymakers and educators can create a more equitable education system that empowers students with the digital skills necessary for success in the 21st century.

Conflict of interest

The authors declare no conflict of interest

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

References

1. Christanti, M. F.; Mawangir, M.; Arevin, A. T.; Ramadhan, I.; Limijadi, E. K. S., The digital divide in education: Bridging gaps in the era of online learning. Migration Letters 2024, 21 (S4), 1070-1079.
2. Correa, M. Bridging the Digital Divide: Effective Strategies for Enhancing Broadband Connectivity and Digital Literacy in Low-Income Communities. CALIFORNIA STATE UNIVERSITY, NORTHRIDGE, 2024.
3. Van Deursen, A. J.; Van Dijk, J. A., The first-level digital divide shifts from inequalities in physical access to inequalities in material access. New media & society 2019, 21 (2), 354-375.
4. Van De Werfhorst, H. G.; Kessenich, E.; Geven, S., The digital divide in online education: Inequality in digital readiness of students and schools. Computers and Education Open 2022, 3, 100100.
5. Memon, F. N.; Memon, S. N., Digital Divide and Equity in Education: Bridging Gaps to Ensure Inclusive Learning. In Impact of Digitalization on Education and Social Sustainability, IGI Global: 2025; pp 107-130.
6. Jamil, S., From digital divide to digital inclusion: Challenges for wide-ranging digitalization in Pakistan. Telecommunications Policy 2021, 45 (8), 102206.
7. Adako, O.; Adeusi, O.; Alaba, P., Integrating AI tools for enhanced autism education: a comprehensive review. International Journal of Developmental Disabilities 2024, 1-13.
8. Bandyopadhyay, S.; Bardhan, A.; Dey, P.; Bhattacharyya, S., Bridging the education divide using social technologies. Springer: 2021.
9. Younus, M.; Zaenuri, M., Public-Private Collaboration to Overcome the Digital Divide in Digital Transformation of Government. Digital Zone: Jurnal Teknologi Informasi dan Komunikasi 2024, 15 (1), 28-41.
10. Khan, S., Mapping the Digital Divide: Bridging Inequalities in Access to Information and Technology. Policy Journal of Social Science Review 2024, 2 (02), 48-55.
11. Van Thang, N., Data-Driven Insights into Socio-Economic Disparities in Urban Transportation Accessibility. Open Journal of Robotics, Autonomous Decision-Making, and Human-Machine Interaction 2025, 10 (2), 1-8.
12. Haleem, A.; Javaid, M.; Qadri, M. A.; Suman, R., Understanding the role of digital technologies in education: A review. Sustainable operations and computers 2022, 3, 275-285.
13. Monteiro, A.; Leite, C., Digital literacies in higher education: Skills, uses, opportunities and obstacles to digital transformation. Revista de Educación a Distancia (RED) 2021, 21 (65).
14. Kulal, A.; Dinesh, S.; Abhishek, N.; Anchan, A., Digital access and learning outcomes: a study of equity and inclusivity in distance education. International Journal of Educational Management 2024, 38 (5), 1391-1423.
15. Adako, O. P.; Adeusi, O. C.; Alaba, P. A., Revolutionizing Autism Education: Harnessing AI for Tailored Skill Development in Social, Emotional, and Independent Learning Domains. Journal of Computational and Cognitive Engineering 2024, 3 (4), 348-359.
16. Murro, R.; Lobo, J.; Inso, A.; Chavez, J., Difficulties of parents with low educational attainment in assisting their children in modular distance learning during pandemic. Environment and Social Psychology 2023, 9 (1), 1957.
17. Philip, L. J.; Cottrill, C.; Farrington, J., 'Two-speed'Scotland: patterns and implications of the digital divide in contemporary Scotland. Scottish Geographical Journal 2015, 131 (3-4), 148-170.
18. Reddick, C. G.; Enriquez, R.; Harris, R. J.; Sharma, B., Determinants of broadband access and affordability: An analysis of a community survey on the digital divide. Cities 2020, 106, 102904.
19. Ben Youssef, A.; Dahmani, M.; Ragni, L., ICT use, digital skills and students' academic performance: Exploring the digital divide. Information 2022, 13 (3), 129.
20. Ahmed, A., The Digital Divide: Access to Technology in Rural vs. Urban Areas. Review Journal of Social Psychology & Social Works 2024, 1 (2), 61-73.
21. Boden, R.; Kenway, J.; James, M., Private schools and tax advantage in England and Wales—the longue duree. Critical Studies in Education 2022, 63 (3), 291-306.
22. James, M.; Boden, R.; Kenway, J., How capital generates capitals in English elite private schools: Charities, tax and accounting. British Journal of sociology of Education 2022, 43 (2), 179-198.
23. Choudhary, H.; Bansal, N., Barriers affecting the effectiveness of digital literacy training programs (DLTPs) for marginalised populations: a systematic literature review. Journal of Technical Education and Training 2022, 14 (1), 110-127.
24. Kerkhoff, S. N.; Makubuya, T., Professional development on digital literacy and transformative teaching in a low-income country: A case study of rural Kenya. Reading Research Quarterly 2022, 57 (1), 287-305.
25. Schuett, K. C. Exploring the Definitions and Experiences of the Digital Divide—It Is More than a Digital Distraction: A Case Study in One Midwestern Suburban High School during the COVID-19 Pandemic. Concordia University Chicago, 2022.
26. Adako, O. P.; Adeusi, O. C.; Alaba, P. A., Enhancing education for children with ASD: a review of evaluation and measurement in AI tool implementation. Disability and Rehabilitation: Assistive Technology 2025, 1-18.
27. Castaño-Muñoz, J.; Moreno-Morilla, C.; Reina-Parrado, M.; Lopez-Cobo, I., Unheard voices: Identifying aspects for an inclusive digital education through the lens of low-income contexts schools. Education and Information Technologies 2025, 1-22.

28. Ashraf, M. A.; Yang, M.; Zhang, Y.; Denden, M.; Tlili, A.; Liu, J.; Huang, R.; Burgos, D., A systematic review of systematic reviews on blended learning: Trends, gaps and future directions. Psychology Research and Behavior Management 2021, 1525-1541.
29. Thelma, C. C.; Sain, Z. H.; Mpolomoka, D. L.; Akpan, W. M.; Davy, M., Curriculum design for the digital age: Strategies for effective technology integration in higher education. International Journal of Research 2024, 11 (07), 185-201.
30. Choudhary, H.; Bansal, N., Addressing digital divide through digital literacy training programs: A systematic literature review. Digital Education Review 2022, (41), 224-248.
31. Oyeyemi Patricia Adako, O. C. A., Peter Adeniyi Alaba, Enhancing Educational Inclusivity for Autistic Children: The Imperative of Individualization and Personalization in AI Tools. Journal of Neurology and Neurological Disorder 2024, 10 (2), 201.
32. Levine, L., Broadband adoption in urban and suburban California: Information-based outreach programs ineffective at closing the digital divide. Journal of Information, Communication and Ethics in Society 2020, 18 (3), 431-459.
33. Papamichail, G.; Rosiello, A.; Wield, D., Addressing public policy implementation challenges in lagging regions through the analytical lens of smart specialisation. Journal of the Knowledge Economy 2023, 14 (1), 356-381.
34. Mehra, B.; Sikes, E. S.; Singh, V., Scenarios of technology use to promote community engagement: Overcoming marginalization and bridging digital divides in the Southern and Central Appalachian rural libraries. Information Processing & Management 2020, 57 (3), 102129.
35. Banerjee, M., The digital divide and smartphone reliance for disadvantaged students in higher education. Journal of Systemics, Cybernetics and Informatics 2022, 20 (3), 31-39.
36. Chetty, K.; Aneja, U.; Mishra, V.; Gcora, N.; Josie, J., Bridging the digital divide in the G20: skills for the new age. Economics 2018, 12 (1), 20180024.
37. Rich, M. J.; Pather, S., A response to the persistent digital divide: Critical components of a community network ecosystem. Information Development 2021, 37 (4), 558-578.
38. Falloon, G., From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educational technology research and development 2020, 68 (5), 2449-2472.
39. Afzal, A.; Khan, S.; Daud, S.; Ahmad, Z.; Butt, A., Addressing the digital divide: Access and use of technology in education. Journal of Social Sciences Review 2023, 3 (2), 883-895.
40. Salsbury, M.; Hansen, M. A., Bridging the digital divide: Wi-Fi hot spots as a means of digital equity. portal: Libraries and the Academy 2022, 22 (1), 199-219.
41. FCC Emergency Connectivity Fund: Helping Schools and Libraries
42. Close the Homework Gap. https://www.fcc.gov/emergency-connectivity-fund (accessed April 10, 2025).
43. Gonzales, A. L.; Yan, H. Y., Non-profit reuse as a solution to reducing digital divides and technology maintenance inequalities. In Organizing inclusion, Routledge: 2020; pp 73-89.
44. Stone, E.; Early, N.; D'Arcy, J.; Harris, R.; Yates, S., Public sector pioneers: Reusing it equipment to bridge the digital divide. 2023.
45. UNICAF Strategies for Building Effective Online Research Skills. https://www.unicaf.org/strategies-for-building-effective-online-research-skills/.
46. Arishi, A. A.; Kamarudin, N. H.; Bakar, K. A. A.; Shukur, Z. B.; Hasan, M. K., Cybersecurity Awareness in Schools: A Systematic Review of Practices, Challenges, and Target Audiences. integration 2024, 15 (12).
47. Seale, J.; Schoenberger, N., Be internet awesome: A critical analysis of google's child-focused internet safety program. Emerging Library & Information Perspectives 2018, 1 (1), 34–58-34–58.
48. EC Digital Education Action Plan (2021-2027). https://education.ec.europa.eu/focus-topics/digital-education/action-plan.
49. US-Chamber Broadband funding in the Infrastructure Investment and Jobs Act. https://www.uschamber.com/technology/broadband/broadband-funding-in-the-infrastructure-investment-and-jobs-act.
50. Africa-Blog Unlocking Digital Opportunity in Africa.
51. Meta Technology Leaders Launch Partnership to Make Internet Access Available to All. https://about.fb.com/news/2013/08/technology-leaders-launch-partnership-to-make-internet-access-available-to-all/.
52. OLPC One Laptop per Child. https://laptop.org/aboutolpc/.
53. NDIA With digital equity, we all win. https://www.digitalinclusion.org/.
54. Naidoo, P. Redefining South African Government School Typologies to Encourage Lifelong Learning Potential. University of Pretoria (South Africa), 2020.
55. Oyedokun, T. T., Assistive Technology and Accessibility Tools in Enhancing Adaptive Education. In Advancing Adaptive Education: Technological Innovations for Disability Support, IGI Global Scientific Publishing: 2025; pp 125-162.

56. Amano, T.; Ramírez-Castañeda, V.; Berdejo-Espinola, V.; Borokini, I.; Chowdhury, S.; Golivets, M.; González-Trujillo, J. D.; Montaño-Centellas, F.; Paudel, K.; White, R. L., The manifold costs of being a non-native English speaker in science. PLoS Biology 2023, 21 (7), e3002184.
57. Rachfal, C. L., The Digital Divide: What Is It, Where Is It, and Federal Assistance Programs. Congressional Research Service (CRS) Reports and Issue Briefs 2021, NA-NA.
58. FCC Affordable Connectivity Program. https://www.fcc.gov/acp.
59. ITU, Global broadband less affordable in 2021: New ITU-A4AI study shows fixed and mobile broadband costs taking an upturn during the COVID-19 pandemic. Albertini, M., Ed. International Telecommunication Union: 2025.
60. UNESCO National distance learning programmes in response to the COVID-19 education disruption: case study of Finland. https://unesdoc.unesco.org/ark:/48223/pf0000382447.
61. So, H.-J.; Jang, H.; Kim, M., Trends and Issues of Digital Learning in Korea. Trends and Issues of Promoting Digital Learning in High-Digital-Competitiveness Countries: Country Reports and International Comparison 2023.
62. DUGGAN, S., AI in education: change at the speed of learning;UNESCO IITE policy brief. UNESCO Institute for Information Technologies in Education: 2020.
63. Lai, Z.; Liu, W.; Wu, Q.; Li, H.; Xu, J.; Wang, Y.; Li, Y.; Liu, J., SpaceRTC: Unleashing the Low-latency Potential of Mega-constellations for Wide-Area Real-Time Communications. IEEE Transactions on Mobile Computing 2024.
64. Admane, R.; Sawale, P. S.; Jayasree, R.; Kurup, S. J.; Thomas, S. A., Artificial Intelligence in Education: Tailoring Curriculum to Individual Student Needs through AI-Based Systems. Library of Progress-Library Science, Information Technology & Computer 2024, 44 (3).
65. Wikipedia One Laptop per Child. https://en.wikipedia.org/wiki/One_Laptop_per_Child (accessed 2025).
66. Ames, M. G., The charisma machine: The life, death, and legacy of one laptop per child. Mit Press: 2019.
67. DLP DIGITAL LITERACY PROGRAMME MANAGEMENT GUIDELINES. https://publicadministration.un.org/unpsa/Portals/0/UNPSA_Submitted_Docs/2018/F6520F09-6F26-48A7-852D-2EFB5991C720/DIGISCHOOL%20GUIDELINES%20VERSION%202.pdf?ver=1439-05-26-155541-053.
68. MICDE Digital Literacy Programme (DLP). https://ict.go.ke/digital-literacy-programmedlp/.
69. Kanakkupillai PMGDISHA Initiative: Bridging the Digital Divide in India. https://www.kanakkupillai.com/learn/pmgdisha-initiative-bridging-the-digital-divide-in-india/.
70. GKTODAY Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA). https://www.gktoday.in/advancements-in-indias-digital-literacy-initiatives/.
71. ITU The national strategy for connected schools in Brazil. https://www.itu.int/en/ITU-D/Documents/FCDO/The-national-strategy-for-connected-schools-in-brazil-case-study.pdf.
72. TechFinancials The Role Of Vodacom e-School In Democratising Access To Education. https://techfinancials.co.za/2021/12/01/the-role-of-vodacom-e-school-in-democratising-access-to-education-2/.
73. CFS Computers for Schools Plus: From Innovation, Science and Economic Development Canada. https://ised-isde.canada.ca/site/computers-for-schools-plus/en.
74. McClane, M. Case Studies on Inclusive Digital Success. https://morrismclane.com/case-studies-on-inclusive-digital-success/.
75. Djatmiko, G. H.; Sinaga, O.; Pawirosumarto, S., Digital Transformation and Social Inclusion in Public Services: A Qualitative Analysis of E-Government Adoption for Marginalized Communities in Sustainable Governance. Sustainability 2025, 17 (7), 2908.
76. Watkins, S. C.; Cho, A., The digital edge: How Black and Latino youth navigate digital inequality. New York University Press: 2018.
77. Danet, M., Parental concerns about their school-aged children's use of digital devices. Journal of Child and Family Studies 2020, 29 (10), 2890-2904.
78. Lata, S., Equity in Literacy: Addressing the Urban-Rural Divide. In Literacy Policies for Equity and Inclusion, IGI Global Scientific Publishing: 2025; pp 189-214.
79. Sun, S.; Ahmed, S., Navigating and Overcoming Barriers to Digital Energy Transition for Carbon Neutrality in China. Energies 2024, 17 (23), 5888.
80. Yaacoub, E.; Alouini, M.-S., A key 6G challenge and opportunity--connecting the remaining 4 billions: a survey on rural connectivity. arXiv preprint arXiv:1906.11541 2019.
81. de Clercq, M.; D'Haese, M.; Buysse, J., Economic growth and broadband access: The European urban-rural digital divide. Telecommunications Policy 2023, 47 (6), 102579.
82. Oh, H. J.; Mistur, E.; Ashuri, B., Critical Review of Public–Private Partnership Business Models for Enhancing Broadband Initiatives in the United States. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction 2024, 16 (1), 04523047.
83. Onoja, J. P.; Ajala, O. A., Innovative telecommunications strategies for bridging digital inequities: A framework for empowering underserved communities. GSC Advanced Research and Reviews 2022, 13 (01), 210-217.

84. Gonzales, A., The contemporary US digital divide: From initial access to technology maintenance. Information, Communication & Society 2016, 19 (2), 234-248.
85. Wamuyu, P. K., Bridging the digital divide among low income urban communities. Leveraging use of Community Technology Centers. Telematics and Informatics 2017, 34 (8), 1709-1720.
86. Berei, E. B.; Pusztai, G., Learning through digital devices—Academic risks and responsibilities. Education Sciences 2022, 12 (7), 480.
87. Sharma, R., Ten digital skills to foster in Children: Role of parents and teachers online. IJAR 2025, 11 (2), 01-06.
88. Moustaghfir, S.; Brigui, H., Navigating critical thinking in the digital era: An informative exploration. International Journal of Linguistics, Literature and Translation 2024, 7 (1), 137-143.
89. Livingstone, S.; Blum-Ross, A.; Pavlick, J.; Ólafsson, K., In the digital home, how do parents support their children and who supports them? 2018.
90. McKnight, K.; O'Malley, K.; Ruzic, R.; Horsley, M. K.; Franey, J. J.; Bassett, K., Teaching in a digital age: How educators use technology to improve student learning. Journal of research on technology in education 2016, 48 (3), 194-211.
91. Alenezi, A., Obstacles for teachers to integrate technology with instruction. Education and Information Technologies 2017, 22, 1797-1816.
92. Jesson, R.; McNaughton, S.; Rosedale, N.; Zhu, T.; Cockle, V., A mixed-methods study to identify effective practices in the teaching of writing in a digital learning environment in low income schools. Computers & Education 2018, 119, 14-30.
93. Huang, G.; Li, X.; Chen, W.; Straubhaar, J. D., Fall-behind parents? The influential factors on digital parenting self-efficacy in disadvantaged communities. American behavioral scientist 2018, 62 (9), 1186-1206.
94. Head, E., Digital technologies and parental involvement in education: the experiences of mothers of primary school-aged children. British Journal of Sociology of Education 2020, 41 (5), 593-607.
95. Abiddin, N. Z.; Ibrahim, I.; Aziz, S. A., Advocating digital literacy: Community-based strategies and approaches. Academic Journal of Interdisciplinary Studies 2022, 11 (1), 198-211.
96. Kaiser, N.; Barstow, C. K., Rural transportation infrastructure in low-and middle-income countries: a review of impacts, implications, and interventions. Sustainability 2022, 14 (4), 2149.
97. Tissenbaum, M.; Slotta, J. D., Developing a smart classroom infrastructure to support real-time student collaboration and inquiry: a 4-year design study. Instructional Science 2019, 47, 423-462.
98. Hennessy, S.; D'Angelo, S.; McIntyre, N.; Koomar, S.; Kreimeia, A.; Cao, L.; Brugha, M.; Zubairi, A., Technology use for teacher professional development in low-and middle-income countries: A systematic review. Computers and Education Open 2022, 3, 100080.
99. Valentín-Sívico, J.; Canfield, C.; Egbue, O., Push them forward: Challenges in intergovernmental organizations' influence on rural broadband infrastructure expansion. Government Information Quarterly 2022, 39 (4), 101752.
100. Ferri, F.; Grifoni, P.; Guzzo, T., Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. Societies 2020, 10 (4), 86.
101. Junod, A. N.; Scally, C. P.; Sawo, M.; Ferrara, L. Expanding Digital Opportunity: A Framework and Road Map for Strengthening Digital Inclusion; Urban Institute: 2025.
102. Onyekachi, N. I. Assessment of Electricity Access and Education Outcomes in Nigerian Universities. Oslo Metropolitan University, 2024.
103. Haces-Fernandez, F., Sustainable Electric Vehicle Development in the United States Through Solar Powered Electric Vehicle Charging Station Expansion in Colleges. Sustainability 2024, 16 (23), 10422.
104. Sovacool, B. K., Expanding renewable energy access with pro-poor public private partnerships in the developing world. Energy Strategy Reviews 2013, 1 (3), 181-192.
105. Srinivasan, M.; Jishnu, D.; Shamala, R., COVID-19 and online education: Digital inequality and other dilemmas of rural students in accessing online education during the pandemic. World of Media. Journal of Russian Media and Journalism Studies 2021, (4), 33-54.
106. Singh, M.; Chand, K.; Singh, M., Navigating Challenges and Innovations in Global Healthcare. In Driving Global Health and Sustainable Development Goals With Smart Technology, IGI Global Scientific Publishing: 2025; pp 303-338.
107. Calano, C., Bridging the Digital Divide in Education throug the Every Student Succeeds Act. 2021.
108. George, A. S., Bridging the Gender Gap in STEM: Empowering Women as Drivers of Technological Innovation. Partners Universal Innovative Research Publication 2024, 2 (2), 89-105.
109. Aslam, A.; Abidi, S. N. M.; Rizvi, S. S. A., Digital Literacy and Women's Empowerment: Bridging the Gender Gap in Technology for Achieving Sustainable Development Goals (SDGs). Pakistan Journal of Gender Studies 2024, 24 (2), 93-106.
110. Wang, S.-h.; Lang, N.; Bunch, G. C.; Basch, S.; McHugh, S. R.; Huitzilopochtli, S.; Callanan, M. In Dismantling persistent deficit narratives about the language and literacy of culturally and linguistically minoritized children and youth: Counter-possibilities, Frontiers in education, Frontiers Media SA: 2021; p 641796.

111. de la Fuente, M. J.; Goldenberg, C., Understanding the role of the first language (L1) in instructed second language acquisition (ISLA): Effects of using a principled approach to L1 in the beginner foreign language classroom. Language Teaching Research 2022, 26 (5), 943-962.
112. Akintayo, O. T.; Eden, C. A.; Ayeni, O. O.; Onyebuchi, N. C., Cross-cultural instructional design: A framework for multilingual and interdisciplinary education. International Journal of Applied Research in Social Sciences 2024, 6 (5), 785-800.
113. Mouboua, P. D.; Atobatele, F. A.; Akintayo, O. T., Multilingual education and social equity: A comparative study of integration policies in multicultural societies. GSC Advanced Research and Reviews 2024, 19 (2), 032-042.
114. Gooding, K.; Bertone, M. P.; Loffreda, G.; Witter, S., How can we strengthen partnership and coordination for health system emergency preparedness and response? Findings from a synthesis of experience across countries facing shocks. BMC health services research 2022, 22 (1), 1441.
115. Nahruddin, Z., Bureaucratic Reform Strategy to Realize Quality Digital Public Services. Mahogany Journal De Social 2024, 1 (3), 79-90.
116. Mokadam, E.; Musa, H. G.; Kumalasari, A.; Istighfaroh, F., Public Policy Challenges in the Digital Age: Balancing Innovation, Governance, and Equity. JIAN-Jurnal Ilmiah Administrasi Negara 2025, 9 (1), 102-109.
117. Bailey, L. E.; Nyabola, N., Digital equity as an enabling platform for equality and inclusion. Pathfinders for Peaceful, Just, and Inclusive Societies/NYU Center on International Cooperation, June 2021, https://cic. nyu. edu/resources/digital-equityas-an-enabling-platform-for-equality-and-inclusion 2021.
118. Turin, T. C.; Subroto, S.; Raihan, M. M.; Koch, K.; Wiles, R.; Ruttan, E.; Nesset, M.; Chowdhury, N., Identifying challenges, enabling practices, and reviewing existing policies regarding digital equity and digital divide toward smart and healthy cities: protocol for an integrative review. JMIR Research Protocols 2022, 11 (12), e40068.
119. Schmidt, W.; McKnight, C., Inequality for all: The challenge of unequal opportunity in American schools. Teachers College Press: 2015.
120. Saner, R.; Yiu, L.; Nguyen, M., Monitoring the SDGs: Digital and social technologies to ensure citizen participation, inclusiveness and transparency. Development policy review 2020, 38 (4), 483-500.
121. Casady, C. B.; Eriksson, K.; Levitt, R. E.; Scott, W. R., (Re) assessing public–private partnership governance challenges: an institutional maturity perspective. In Public–Private Partnerships for Infrastructure Development, Edward Elgar Publishing: 2019; pp 188-204.
122. Marx, A., Public-private partnerships for sustainable development: Exploring their design and its impact on effectiveness. Multidisciplinary Digital Publishing Institute: 2019; Vol. 11, p 1087.
123. Leal Filho, W.; Dibbern, T.; Dinis, M. A. P.; Cristofoletti, E. C.; Mbah, M. F.; Mishra, A.; Clarke, A.; Samuel, N.; Apraiz, J. C.; Abubakar, I. R., The added value of partnerships in implementing the UN sustainable development goals. Journal of Cleaner Production 2024, 438, 140794.
124. Khoyaled, S., Impact of education policies for accessing quality education. International Journal of Education and Learning Research 2023, 6 (1), 57-75.
125. Graves, J. M.; Abshire, D. A.; Amiri, S.; Mackelprang, J. L., Disparities in technology and broadband internet access across rurality: implications for health and education. Family & community health 2021, 44 (4), 257-265.
126. Rumiantsev, A.; Morozov, V.; Panikar, G., Innovation at the Crossroads: How Public-Private Partnerships Drive Technological Development in Europe. Actual Problems of International Relations 2024, 1 (159), 94-108.
127. Yaacoub, E.; Alouini, M.-S., A key 6G challenge and opportunity—Connecting the base of the pyramid: A survey on rural connectivity. Proceedings of the IEEE 2020, 108 (4), 533-582.
128. Kumar, M.; Sharma, S., Renewable Energy and Sustainable Transportation. In Role of Science and Technology for Sustainable Future: Volume 1: Sustainable Development: A Primary Goal, Springer: 2024; pp 375-414.
129. Deganis, I.; Haghian, P. Z.; Tagashira, M.; Alberti, A., Leveraging digital technologies for social inclusion. United Nations Department of Economic and Social Affairs 2021.
130. Dhiman, D.; Jaiswal, A.; Sail, K. S.; Wavhale, A. In Unlocking Access: The Role of Refurbished Mobile Phones in Digital Inclusion and Sustainable Development, 2024 ITU Kaleidoscope: Innovation and Digital Transformation for a Sustainable World (ITU K), IEEE: 2024; pp 1-8.
131. Dongxue, T.; Nagappan, R., Pedagogical strategies in media literacy education and their alignment with student-centered learning. International journal of academic research in business and social sciences 2024, 14 (9).
132. Machin-Mastromatteo, J. D., Community-driven and social initiatives. SAGE Publications Sage UK: London, England: 2023; Vol. 39, pp 393-401.
133. Olivanti, F.; Gastaldi, L., Evaluating digital skills policies: Assessing the potential impact of outreach programs in Italy. Telecommunications Policy 2024, 48 (8), 102811.
134. Kerai, S.; Ibrahim, M.; Molyneux, T. M.; Hussain, U.; Gadermann, A.; Kassam, R.; Pardhan, A.; Oberle, E., Out-of-school time use in Pakistan: A qualitative study featuring youth's voices. Journal of Research on Adolescence 2024, 34 (2), 296-312.

135. Oliveira, J. H.; Moreira, L. F.; dos Santos, F. A., The Role of Parental Engagement in Improving Academic Performance: Evidence from Brazilian Public Schools. Research and Advances in Education 2025, 4 (1), 28-37.
136. Siddiqi, M. M., Future of digital education: inclusive, immersive, equitable. MediaSpace: DME Media Journal of Communication 2024, 5 (01), 8-24.
137. Pawluczuk, A.; Lee, J.; Gamundani, A. M., Bridging the gender digital divide: an analysis of existing guidance for gender digital inclusion programmes' evaluations. Digital Policy, Regulation and Governance 2021, 23 (3), 287-299.