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Disparities in access to educational technology and its impact on performance across socio-economic and racial groups in U.S. public schools

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Abstract

This study explores the disparities in access to educational technology and their impact on academic performance across different socio-economic and racial groups in U.S. public schools. The digital divide, which refers to the gap between those who have access to modern information and communication technology (ICT) and those who do not, remains a significant barrier to equitable educational opportunities. This research examines how socio-economic factors, such as household income, geographic location, and racial background, influence students' access to essential digital tools, including devices, broadband, and digital literacy training. Drawing on existing literature, and recent surveys, this study identifies the ways in which unequal access to technology exacerbates educational inequalities. The findings suggest that students from low-income and minority backgrounds are disproportionately affected by these disparities, resulting in lower academic performance, reduced engagement, and diminished college readiness. Policy interventions, such as the expansion of broadband access, targeted funding for schools, and integration of digital literacy into curricula, are proposed to mitigate these challenges and foster more inclusive learning environments. The study calls for systemic reforms to bridge the digital divide and ensure that all students have equal access to the tools and resources needed for academic success in the digital era.

Keywords: Digital divide; Student performance; Internet and computer devices; Racial group; Socio-Economic

1 Introduction

Access to educational technology is increasingly recognized as a critical determinant of academic success, yet significant disparities persist across socioeconomic and racial groups in the U.S. public school system. These disparities, often referred to as the "digital divide," have far-reaching implications for student performance and equity in education. The digital divide in education, defined as the gap between individuals who have access to modern information and communication technologies (ICT) and those who do not, reflects both resource inequities and broader socio-economic and racial disparities within the U.S. educational system [1].

Research has shown that students from lower socio-economic and minority racial groups are disproportionately affected by limited access to digital tools and resources, further exacerbating existing achievement gaps [1]. These gaps, defined as disparities in academic performance among students of different socio-economic, racial, and ethnic groups, remain a persistent challenge in U.S. education. Despite national efforts to narrow these disparities, recent trends indicate a stagnation or reversal, with the COVID-19 pandemic amplifying inequities caused by disruptions to in-person learning.

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The concept of the digital divide extends beyond mere access to technology, encompassing the skills, usage, and socio-economic structures that shape digital inclusion. According to Ragnedda and Muschert (2013)[2], digital inequality is intrinsically linked to broader social inequalities, including income, education, and race. Their analysis underscores that digital divides perpetuate systemic inequities, reinforcing existing gaps in opportunities and outcomes. These insights are particularly relevant to the U.S. public school system, where structural factors such as funding disparities and community socio-economic conditions dictate access to educational technology. Understanding these dynamics provides a framework for analyzing how disparities in technology access affect student performance.

Before the pandemic, some progress had been made in narrowing racial and ethnic achievement gaps. For example, the Educational Opportunity Monitoring Project reported that white-Black and white-Hispanic gaps decreased by approximately 0.05 to 0.9 standard deviations per decade nationally. However, progress was uneven across states, reflecting differences in educational quality and socio-economic conditions Stanford CEPA (2023)[3]. The pandemic exacerbated these disparities, particularly in high-poverty districts that adopted prolonged remote learning. For instance, high-poverty schools experienced nearly half a standard deviation decline in math achievement during the 2020–2021 school year, resulting in an estimated $2 trillion in lifetime earnings losses for affected students (Harvard Gazette Staff, 2022) [4].

While educational technology holds promise for transforming learning, its potential has not been equitably realized. Many underserved communities continue to lack access to necessary digital resources, perpetuating achievement gaps. The technification of the field has also restricted access to cutting-edge tools, limiting their broader adoption and effectiveness (Spector, 2001) [5]. Moreover, the oversimplification of theoretical approaches, such as constructivist learning models, has hindered the effective integration of technology into complex educational environments.

This research paper seeks to examine the extent of disparities in access to educational technology in U.S. public schools and explore their implications for academic performance across socio-economic and racial groups. By addressing the root causes of these inequities and evaluating evidence-based solutions, the study aims to inform policies that bridge the digital divide and ensure equitable access to learning opportunities for all students.

2 The Digital Divide and Its Causes

The concept of the digital divide refers to the gap between those who have access to modern information and communication technology (ICT) and those who do not. The digital divide is shaped by a range of socio-economic and institutional factors, including family income, geographic location, racial background, and educational infrastructure.

Studies have consistently shown that socioeconomic and racial factors are major determinants of this divide. For example, Warschauer [1] highlights how the lack of digital tools in low-income communities perpetuates educational inequalities, with minority students disproportionately affected. Mossberger et al., [6] further explore how digital access correlates with civic and educational participation, emphasizing its role in social inclusion.

The digital divide extends beyond the mere availability of devices, encompassing a range of financial and systemic barriers that perpetuate educational inequities. While the declining cost of computers has improved affordability, the total cost of ownership remains a significant hurdle, particularly for low-income households and underfunded institutions. The total cost includes not only the purchase price but also expenses for software, maintenance, peripherals, training, and administrative oversight in institutional settings. Furthermore, corporate-driven product obsolescence often necessitates frequent upgrades, adding to the financial strain on families and schools.

In addition to cost-related challenges, disparities in broadband access significantly affect students' ability to engage with online educational resources. High-speed internet, critical for modern learning environments, remains less accessible in rural and low-income urban areas, exacerbating the divide. Moreover, differences in digital literacy, such as the skills and confidence needed to use computers effectively further disadvantage certain demographic groups. Language barriers and the lack of culturally relevant online content also hinder the inclusion of diverse communities, particularly non-English speakers [7]. According to the same paper above, after reviewing data on Internet penetration, the paper describes five dimensions of digital inequality - in equipment, autonomy of use, skill, social support, and the purposes for which the technology is employed - that deserve additional attention.

Recent studies by Pierce & Cleary [8] highlight that these disparities are not merely technological but are deeply rooted in demographic and socio-economic inequalities. A 2019 survey of over 23,000 school-aged children revealed that 28% did not use the internet either at home or school, while 22.8% only had internet access at home. These statistics illustrate how unequal distribution of resources limits students' ability to fully engage with technology-driven curricula.

Moreover, systemic barriers such as underfunded schools and limited household resources magnify these inequities, calling for urgent interventions to bridge the digital divide.

Low-income families are less likely to have reliable internet access or personal devices, which can severely limit students' ability to participate in online learning, complete assignments, or engage with educational resources [9]. This issue became especially evident during the COVID-19 pandemic when remote learning became the norm for many students. A Pew Research Center survey conducted in 2021 highlighted significant disparities in technology access based on income levels. Roughly 43% of U.S. adults from households earning less than $30,000 annually lack home broadband, and 41% do not own a desktop or laptop computer. By contrast, these technologies are nearly ubiquitous in households earning $100,000 or more, with only 1% of such households lacking access to devices or broadband [10]. This digital divide underscores the ongoing challenges low-income students face in accessing consistent digital resources compared to their higher-income peers.

These disparities in technology access highlight the intersection of socio-economic status and the digital divide, revealing how students from lower-income families face compounded educational barriers. Racial disparities in access to educational technology are intrinsically tied to socioeconomic and cultural inequalities, as highlighted by Miras et al. [11]. The digital divide reflects a combination of insufficient access to technological resources and varying levels of digital literacy among students from historically marginalized groups, such as Black, Hispanic, and Native American communities. These disparities often result in social exclusion, as limited access to digital tools outside of school settings—often influenced by the socio-economic status of families—hinders the development of essential digital competencies.

The COVID-19 pandemic further accentuated these challenges, serving as a global turning point in education and digital pedagogy. During this period, underfunded schools faced significant obstacles in transitioning to remote learning, disproportionately affecting students from marginalized communities. As Miras et al. [11] emphasize, the pandemic not only highlighted the pre-existing inequalities in access to digital resources but also underscored the urgent need for systemic solutions to bridge the gap and promote inclusive learning environments.

The persistent inequality in the American education system, especially for African American and other minority students, underscores a troubling divide in learning opportunities. Darling-Hammond [12] highlights that these students often face substantial disparities in access to well-qualified teachers, high-quality curricula, and smaller class sizes, factors closely tied to academic performance. Standard-based reforms, while promising greater equity, have failed to address the unequal distribution of educational resources. Instead of bridging the gap, these reforms often exacerbate disparities by holding all students to uniform standards without ensuring equal access to the necessary tools for learning.

These systemic inequities parallel racial disparities in access to educational technology, where underfunded schools serving minority populations struggle with insufficient technological infrastructure and trained personnel. The compounded effects of inequities in both traditional educational resources and digital tools further widen the achievement gap, underscoring the urgency of implementing reforms to provide equitable access to all students.

Efforts to address these disparities should focus on enhancing access to digital tools, improving digital literacy programs, and providing targeted support to underprivileged schools. By addressing these critical gaps, stakeholders can help ensure equitable opportunities for academic success across all racial and socio-economic groups.

3 Impact of Technology Disparity on Academic Performance

Educational technology holds immense potential for improving learning outcomes by offering personalized learning, fostering collaboration, and enabling access to diverse educational resources. However, without equitable access, many students remain excluded from these benefits. Limniou [13], investigated the relationships between digital device usage, self-regulation, and academic performance. Their research indicated that access to digital tools, combined with their effective use, enhances student engagement and learning outcomes. They found a significant variation in academic performance based on how students utilized applications during lectures. Specifically, students who used a single application focused on lecture-related tasks achieved higher academic performance, as they were less distracted and better able to process and retain information. Similarly, Monserate [14] identified a significant relationship between students' academic performance, their computer literacy, and family income. While the study revealed that students' technology utilization positively influenced their academic outcomes, it also emphasized that teachers' self-efficacy and competence in technology alone do not guarantee improved student performance. This finding underscores the

importance of addressing broader factors, such as effective teaching methods and equitable access to technology, to fully leverage the benefits of educational technology.

The integration of Information and Communications Technology (ICT) in education has enhanced opportunities for interactive learning, collaboration, and access to vast educational resources [15-17]. However, the unequal distribution of these resources significantly affects students' academic performance, particularly those from underprivileged backgrounds.

Students without reliable access to digital devices or internet services face significant barriers, such as challenges completing assignments, engaging in virtual learning, and accessing supplemental materials. During the COVID-19 transition to remote learning, approximately 16%–19% of college students experienced technological barriers, including inadequate computer hardware or internet connections. These challenges were especially pronounced among lower-income students (20%–30%), Black (17%–29%), and Hispanic (23%–28%) students compared to their higher-income and White peers. Students in rural areas (14%–25%) also reported higher rates of technology inadequacy compared to those in urban or suburban settings (16%–20%).

These disparities significantly impacted academic outcomes, as students with inadequate technology reported greater difficulty meeting deadlines and experienced a sharper decline in their perceived success as college students. They were also more likely to opt for a "Pass/No-Pass" grading option, reflecting struggles with online coursework regardless of academic or demographic background [18].

Furthermore, socio-economic challenges disproportionately affect racial and ethnic minority groups, who are more likely to attend under-resourced schools with limited technological infrastructure. These disparities further entrench the achievement gap, leaving many students of color at a disadvantage compared to their peers in well-funded schools with superior access to technology [19].

The diversity in EdTech tools and their varying levels of effectiveness underscores the importance of designing tailored interventions to address these inequities. Research emphasizes the need for rigorous and context-sensitive approaches to ensure that educational technologies serve all students equitably, regardless of their socio-economic or demographic backgrounds [19]. By investing in targeted and high-quality EdTech solutions, educational systems can mitigate the adverse effects of the digital divide and create more inclusive learning environments.

4 Addressing the Digital Divide: Policy and Solutions

Several initiatives have been proposed to address the digital divide and reduce the impact of unequal access to technology on student performance. Policy solutions have focused on increasing funding for schools in underserved communities to ensure equitable access to technology. For example, the Federal Communications Commission (FCC) has worked to expand broadband access in rural and low-income areas through initiatives like the E-Rate program, which helps schools and libraries in low-income areas acquire internet access and technology [20]. Additionally, local and state governments have launched programs to provide discounted or free devices and internet services to low-income families, aiming to bridge the gap in access to educational technology.

To address affordability, the Affordable Connectivity Program (ACP) has played a vital role. This U.S. government initiative was designed to make high-speed internet more accessible for low-income households. The program provided up to $30 per month for internet services, or $75 for families residing on Tribal lands, and offered a $100 subsidy to assist with the purchase of a desktop, laptop, or tablet. These measures significantly contributed to bridging the digital divide, particularly for students and families in need [21].

In spring 2022 [22], the U.S. Department of Education’s Office of Educational Technology (OET) launched the Digital Equity Education Roundtables (DEER) Initiative, aimed at advancing digital equity. Through DEER, OET facilitated national discussions with leaders from community-based organizations, families, and learners who are furthest from digital opportunities. These conversations informed the development of the resource titled “Advancing Digital Equity for All,” which outlines the barriers faced by underserved communities and highlights promising solutions to increase access to technology for learning.

This initiative has helped shape community-based recommendations for developing effective digital equity plans, focusing on closing the digital divide and enabling technology-empowered learning for all students, particularly those from disadvantaged backgrounds.

According to Silaji [23], strategies such as comprehensive policy interventions, infrastructure development, community training programs, and partnerships with private organizations offer viable solutions to address the digital divide. These efforts are crucial for ensuring digital inclusivity, emphasizing that all students, regardless of their socioeconomic background, have equitable access to the tools needed for success in the digital era.

Another approach is to integrate technology into teacher training and curriculum development. Ensuring that educators are well-equipped to use technology effectively in the classroom can help mitigate some of the disadvantages faced by students without consistent access to devices. Moreover, focusing on digital literacy as part of the curriculum can help students from disadvantaged backgrounds develop the critical thinking, problem-solving, and collaboration skills needed to succeed in an increasingly digital world. Feola, [24] work emphasizes the importance of developing both technical skills and cognitive-metacognitive abilities, as well as fostering ethical and social awareness in students. Integrating these dimensions of digital literacy into the curriculum can empower students to navigate and critically engage with technology, bridging the gap between education and real-world applications. This approach aligns with efforts to create a more holistic digital learning environment where technology is not only a tool for content delivery but also an avenue for cultivating deeper learning and reflection in students.

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5 Conclusion

The disparities in access to educational technology in U.S. public schools are a significant contributor to the growing achievement gap between students from different socio-economic and racial backgrounds. As this study has highlighted, students from low-income households and marginalized racial groups face considerable barriers in accessing digital tools, such as computers, internet connectivity, and essential digital literacy training. These inequities limit their ability to fully engage in modern learning environments, participate in online education, and access vital academic resources, ultimately affecting their academic performance and future opportunities.

Efforts to address these disparities must be multifaceted. First, increased funding for schools in underserved communities and targeted programs to expand broadband access are critical steps in bridging the digital divide. Additionally, integrating technology training into teacher professional development and embedding digital literacy into the curriculum can help empower both educators and students to leverage technology effectively in the classroom. Policymakers and educational leaders must recognize the intersectionality of socio-economic and racial disparities in education and prioritize interventions that address the root causes of the digital divide.

Ultimately, the goal should be to create equitable learning environments where all students, regardless of their socio-economic status or racial background, have the tools and resources needed to succeed academically. By closing the digital divide, educational systems can foster greater inclusivity, reduce educational inequalities, and ensure that all students are prepared for success in an increasingly digital world.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest related to this research.

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The views expressed in this article are those of the authors and do not necessarily represent the official policies or positions of any affiliated institutions.

Authorship

All authors contributed equally to the conceptualization, writing, and editing of this article without any external writing assistance.

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