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Bridging the Digital Divide: Inclusive Technology Pathways for Girls of Color in STEM Education

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Abstract **Original Research Article**

This paper explores the persistent and multi-layered digital divide affecting girls of color in STEM education, drawing on global data from UNICEF (2023) and secondary sources in gender equity, education, and digital literacy. While access to the internet has expanded globally, adolescent girls remain systematically disadvantaged in both access and skills development. This exclusion is particularly pronounced among girls of color, who face intersecting barriers rooted in gender, race, class, and geography. The analysis highlights disparities in internet use, digital skill acquisition, and intra-household access patterns, revealing how social norms and educational systems limit meaningful engagement with technology. Using comparative data and intersectional theory, the paper situates global trends within the specific experiences of girls of color in high-income contexts such as the United States. Findings underscore that access alone is not sufficient; inclusive pedagogical practices, family engagement, policy reform, and digital safety are necessary to foster equitable digital learning environments. The paper concludes with actionable recommendations to create culturally responsive and gender-just pathways into STEM fields. Bridging this divide is essential for ensuring that girls of color are not excluded from the educational and economic opportunities of the digital age.

Keywords: Digital divide, girls of color, STEM education, digital equity, intersectionality, inclusive technology.

1. INTRODUCTION

The digital divide has emerged as one of the most pressing educational and social equity challenges of the 21st century. As education, labor, and civic engagement become increasingly dependent on digital access and skills, individuals without adequate connectivity or technological fluency face significant disadvantages. Among the most affected are girls of color, particularly those from low-income backgrounds, who often experience compounded barriers due to the intersection of race, gender, and socioeconomic status (Crenshaw, 1989). These systemic inequities create significant obstacles to their full participation in science, technology, engineering, and mathematics (STEM) education pathways. Globally, access to the internet and the acquisition of digital skills remain deeply unequal along gendered lines. According to UNICEF (2023), adolescent girls and young women are significantly less likely to use the internet or develop basic digital skills compared to their male counterparts. In low-income countries, as many as nine out of ten adolescent girls and young women aged 15 to 24 remain offline. Even within households that have internet access, digital devices and learning opportunities are often distributed in ways that favor boys (UNICEF, 2023). This aligns with long-standing research showing that gender bias within families affects how resources are allocated and who benefits from them (Quisumbing & Maluccio, 2000).

Moreover, the gap in digital skills is not merely an access issue. The ability to use digital tools effectively for learning and participation in STEM-related fields requires both access and meaningful use. In this context, the Organisation for Economic Co-operation and Development (2018) has emphasized that while the internet can be a tool to reduce real-world inequalities, its benefits remain inaccessible to many girls due to entrenched social norms and institutional barriers. Similarly, the United Nations (2018) has noted that nearly 90 percent of global jobs now require some form of digital competence, underscoring the urgency of addressing digital exclusion. Despite improvements in foundational education, such as literacy and numeracy,

digital skills have not followed suit for many girls of color. In the United States, for example, research by Ong *et al.,*(2011) has found that underrepresented girls in STEM face not only material barriers but also social isolation and stereotype threat. These barriers begin early and extend into academic and professional environments, limiting both entry and retention. Scott *et al.,*(2018) further argue that the structural barriers faced by girls of color in STEM are exacerbated by a lack of culturally relevant pedagogy and mentorship.

As the world turns increasingly to digital platforms for education delivery, particularly in response to disruptions like the COVID-19 pandemic, these disparities have only deepened. The rapid shift to remote learning revealed how ill-prepared many education systems were to provide equitable digital access. This was especially true for marginalized populations. As noted by the United Nations (2022), universal internet access is now being recognized as a fundamental component of the right to education. However, access alone is insufficient without strategies that also target the skills gap, safety, and support structures that are crucial for girls to thrive in digital spaces. To better understand and address these challenges, this paper focuses on the global and comparative dimensions of the digital divide while centering the experiences and potential pathways for girls of color in STEM. Using data from UNICEF (2023) and secondary sources cited within that report, the paper analyzes key patterns of exclusion, links them to broader structural inequities, and proposes targeted interventions for bridging the digital divide in STEM education.

The research aims of this paper are as follows:

1. To analyze gender disparities in internet access and digital skill development based on global data, with emphasis on adolescent girls and young women.
2. To explore how intrahousehold and societal biases contribute to the digital exclusion of girls, particularly in educational contexts.
3. To examine how these global trends reflect or diverge from the specific experiences of girls of color in STEM education in higher-income countries.
4. To propose inclusive technology and education policy pathways that can promote equity in digital and STEM learning outcomes.

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Understanding the digital divide through a gendered and racialized lens requires an interdisciplinary approach that draws from education, sociology, communication studies, and critical race theory. The framework for this study integrates digital divide theory, intersectionality, and feminist critiques of technology access to provide a comprehensive understanding of the barriers faced by girls of color in STEM education.

Digital divide theory, as outlined by van Dijk (2006), distinguishes among multiple levels of inequality: access to technology, skills in using it, and meaningful outcomes derived from that usage. While early research focused heavily on physical access, contemporary discourse emphasizes the more persistent and complex barriers related to digital skills acquisition and usage (van Dijk, 2006). This shift aligns with the findings presented by UNICEF (2023), which highlight that even in households with internet connectivity, girls often lack opportunities to use digital tools in meaningful, skill-building ways. To better grasp the multifaceted nature of exclusion, this analysis incorporates the theory of intersectionality, first introduced by Crenshaw (1989), which describes how systems of oppression overlap to create distinct experiences for individuals who inhabit multiple marginalized identities. In the context of STEM education, girls of color face unique and overlapping challenges due to their gender, race or ethnicity, and socioeconomic status. These intersections must be addressed to avoid a one-size-fits-all approach to digital inclusion.

The literature on educational equity supports the need for intersectional approaches. Ong *et al.,*(2011) found that women of color in STEM often experience racial and gender microaggressions that undermine their sense of belonging. These challenges are compounded by a lack of role models, limited access to advanced coursework, and systemic underrepresentation in gifted and talented programs. Building on this, Scott *et al.,*(2018) assert that race-conscious and culturally sustaining pedagogy is essential for retaining girls of color in STEM pathways. From a global perspective, gender inequalities in digital access reflect more profound structural inequities. According to the United Nations (2018), digital technologies can serve as tools for empowerment only when integrated with equitable educational practices and inclusive design. However, many educational systems remain unprepared to deliver such equity. The OECD (2018) further highlights that access to the internet alone does not guarantee equitable use or benefit. In many countries, boys receive more encouragement, time, and training to use digital tools, which results in unequal skill development.

Within households, the unequal distribution of digital resources often reflects and reinforces traditional gender norms. Quisumbing and Maluccio (2000) demonstrated that families frequently allocate resources based on gendered expectations, giving boys greater access to devices and educational opportunities. UNICEF (2023) corroborates this with data showing that girls aged 15 to 24 are less likely than boys of the same age to own mobile phones or possess basic digital skills, even within the same households. These patterns are not coincidental but rather reflective of systemic bias in the allocation of educational capital. Another dimension of the digital divide that disproportionately affects girls of

color is digital safety. The World Wide Web Foundation (2020) reported that online spaces often reproduce offline violence, with adolescent girls experiencing higher rates of harassment, cyberbullying, and surveillance. Concerns over digital safety may also contribute to family-level restrictions on girls' internet use, further limiting their opportunities to develop confidence in navigating digital spaces.

Moreover, the perceived neutrality of technology masks how platforms, algorithms, and curricula can perpetuate exclusion. UNESCO (2022) argues that digital skill-building programs must not only teach technical competencies but also address the social dimensions of technology, without explicit efforts to challenge gendered assumptions about who belongs in technology spaces. Digital education risks replicating offline inequities in virtual environments. Even foundational education patterns contribute to digital exclusion. While girls often outperform boys in reading literacy across many countries, this advantage does not consistently translate into gains in digital skills or interest in STEM fields (UNICEF, 2023). As demonstrated in comparative data, foundational skills alone are insufficient when the broader social and cultural environment discourages girls from applying those skills in digital or technical domains.

The literature reveals a consistent pattern: the digital divide is not merely technological. It is social, cultural, and deeply embedded in the structures of education and society. Addressing it requires interventions that go beyond device distribution to include pedagogical reform, gender-sensitive curricula, and structural changes to how digital skills are taught and valued. This study draws upon these theoretical insights and empirical findings to analyze how inclusive technology pathways can be designed for girls of color to create more equitable and empowering STEM learning environments.

3. METHODS AND DATA SOURCE

This study employs a comparative secondary data analysis approach to examine global gender disparities in digital access and skill development among youth, with a particular focus on how these disparities inform inclusive pathways for girls of color in STEM education. The methodology is centered on analyzing quantitative data from a globally recognized source and interpreting the findings through an intersectional lens informed by existing literature on education equity and gendered technology access.

The primary source of data for this analysis is the UNICEF (2023) report titled *Bridging the Gender Digital Divide: Challenges and an Urgent Call for Action for Equitable Digital Skills Development*. This report is based on data from the Multiple Indicator Cluster Surveys (MICS) and the Demographic and Health Surveys (DHS), which were conducted across 54 countries and territories, predominantly in low and lower-middle-income contexts. These nationally representative surveys provide disaggregated data by age and sex on a range of indicators, including internet use, digital skills acquisition, mobile phone ownership, and household-level access to digital technologies.

The UNICEF report draws on Sustainable Development Goal indicators, including SDG 4.4.1, which measures information and communications technology skills among youth and adults; SDG 5.b.1, which tracks mobile phone ownership by gender; and SDG 17.8.1, which measures internet use across populations. These indicators serve as the backbone for understanding the gender digital divide on a global scale (UNICEF, 2023). While the report's core data originates from countries primarily outside of the United States, the patterns of exclusion it documents offer meaningful comparative insights that are relevant for understanding the digital marginalization of girls of color in high-income countries.

The secondary data cited within the UNICEF report further strengthens its analytical foundation. For instance, Quisumbing and Maluccio (2000) provided a critical basis for assessing intra-household gender disparities in resource allocation. Their findings underscore the tendency for families to prioritize boys' access to education-related tools, a pattern that persists in the digital era. Similarly, the United Nations (2018) established that approximately 90 percent of all jobs worldwide now require some form of digital literacy, making skill acquisition a key determinant of future economic opportunity. OECD (2018) contributed to the understanding that internet access alone does not ensure meaningful engagement or skill development, particularly when gendered norms and biases shape usage patterns. These foundational studies are cited as independent secondary sources in this paper to trace the theoretical and empirical basis for the arguments made in UNICEF (2023).

Although the focus of the dataset is international, the study is methodologically positioned to apply comparative reasoning to contexts such as the United States. This approach draws from critical education research that emphasizes cross-contextual applicability while accounting for localized structural dynamics (Ong et al., 2011; Scott et al., 2018). For instance, while UNICEF data illustrate the gendered digital skill gaps in places like Nepal, Chad, or Pakistan, similar patterns of exclusion are documented in urban and rural school districts across the United States, particularly among Black, Latina, and Indigenous girls. These parallels allow the paper to draw comparative inferences while remaining rooted in context-specific analysis. Three tables from the UNICEF (2023) dataset are selected and adapted for this paper to support core analytical claims. These include: gender parity ratios in

internet use by country, digital skill acquisition by sex and country, and gender gaps in digital skills within the same household. These tables are integrated into the analysis as Figures 1, 2, and 3, respectively, and are referenced where relevant in the results and discussion sections. All data are attributed directly to the UNICEF source, with separate references made to any other studies cited in the original report.

Limitations of the method include the challenge of extrapolating findings from low-income countries to high-income settings without oversimplifying contextual differences. However, the analysis is careful to highlight these distinctions while using global data trends as a mirror to reflect persistent disparities within more affluent societies. Furthermore, the data's strength lies in its scope, consistency, and rigorous disaggregation by age and sex, which enables a focused exploration of gender-based digital exclusion at both macro and micro levels. By leveraging this multi-layered data strategy, the study provides a nuanced foundation for analyzing the digital divide not as a monolithic barrier but as a complex and layered system of exclusion. It sets the stage for a deeper investigation into the structural, social, and educational factors that shape access to digital tools and pathways into STEM fields for girls of color.

4. FINDINGS AND ANALYSIS

4.1 Access Inequities

One of the most fundamental dimensions of the digital divide is the inequitable access to internet connectivity among youth. While access is often measured at the household level, this metric alone fails to capture the nuances of individual use, particularly as it pertains to adolescent girls. The data analyzed in this study reveal that significant gender-based disparities exist not only in whether youth have internet access, but also in who can use the internet within connected households. These disparities carry substantial implications for educational and economic opportunities, especially in an increasingly digitized world.

The UNICEF (2023) data provide a sobering illustration of global access inequities. Across 54 countries and territories surveyed, the gender gap in internet use among youth aged 15 to 24 is both pervasive and persistent. Only eight of the countries analyzed have achieved gender parity in internet use, meaning that in most contexts, girls and young women are systematically excluded from accessing digital tools. In many low-income countries, the situation is especially stark. For example, in Chad, only 15 adolescent girls use the internet for every 100 adolescent boys. In Pakistan's Balochistan province, the ratio is similarly low, at 18 girls for every 100 boys. The median gender parity ratio across all countries is 0.71, indicating that for every 100 male youth who use the internet, only 71 female youth do (UNICEF, 2023). These disparities are more than statistical anomalies; they reflect deep-rooted gender norms and systemic inequities. Girls are often assigned greater household responsibilities, face more mobility restrictions, and experience stricter digital surveillance, all of which limit their access to internet-enabled devices. Additionally, families may prioritize the digital needs of boys due to perceived future returns on investment in their education and careers (Quisumbing & Maluccio, 2000). This results in a cycle where boys receive more exposure to digital tools and environments, leading to greater confidence, familiarity, and ultimately, better outcomes in both school and the labor market.

At a structural level, this exclusion is perpetuated by unequal infrastructure development. According to the International Telecommunication Union (cited in UNICEF, 2023), rural areas in many developing countries lack the broadband infrastructure necessary to support affordable and consistent internet access. Even when infrastructure is present, the cost of mobile data and digital devices creates additional barriers, particularly for households in the lowest income quintiles. Girls, who are often deprioritized in household budgeting, are less likely to benefit from available resources. While the global data centers on low- and middle-income countries, these patterns resonate strongly with research from higher-income contexts such as the United States. Studies by Rideout and Robb (2019) and the Pew Research Center (2021) show that Black and Latina girls are less likely to have access to a computer at home or a reliable internet connection compared to their white peers. Moreover, even when devices are present, they may be shared among multiple family members, reducing the opportunity for consistent use. In these cases, digital access becomes a limited resource subject to negotiation, often to the detriment of girls who face competing responsibilities and restrictive gender norms.

Another critical dimension is the digital readiness of schools. According to the United Nations (2022), equitable access to digital learning is not just about home connectivity but also about school infrastructure and pedagogical capacity. In many public schools serving underrepresented communities, outdated equipment, inadequate bandwidth, and insufficient digital training for teachers create a learning environment that hinders the development of digital literacy. As a result, girls of color in underserved school districts often fall further behind their peers, reinforcing broader academic disparities. The compounded effect of limited access at home and in school environments results in what van Dijk (2006) refers to as a second-level digital divide. This stage is not about physical access alone but also about the quality, frequency, and context of use. Girls who have intermittent access to the internet or must rely on limited school-based exposure are less likely to develop the habitual and critical use of technology required for advancement in STEM disciplines.

In this light, the gender disparity in internet access cannot be viewed in isolation. It is intricately linked to socio-cultural norms, economic inequalities, and policy gaps. For instance, policies aimed solely at increasing broadband infrastructure or distributing devices may fail to address the gendered dynamics of usage and control. What is needed are multi-layered interventions that incorporate digital literacy training, family and community engagement, and targeted support for girls in educational settings. Only by addressing these structural and social barriers can equitable access be realized. Furthermore, it is important to emphasize the temporal urgency of these disparities. As digital platforms become the primary medium for learning, socialization, and employment, each day without adequate internet access sets girls further behind. The loss is not only educational but also psychological, as girls may begin to internalize feelings of inferiority or exclusion from the digital world. This can have long-term effects on their academic motivation and career aspirations, particularly in STEM fields where digital fluency is a prerequisite for entry and success.

The analysis of global access disparities thus lays a critical foundation for understanding the broader digital divide. It demonstrates that access is not a neutral variable but a socially constructed and unevenly distributed resource. The inequitable patterns observed globally find echoes in localized contexts, revealing the need for transnational strategies that are both gender-responsive and equity-driven. The table below (Figure 1) highlights selected countries and their corresponding gender parity ratios in internet use among youth aged 15 to 24, offering a clear visual representation of the scale and variation of this divide.

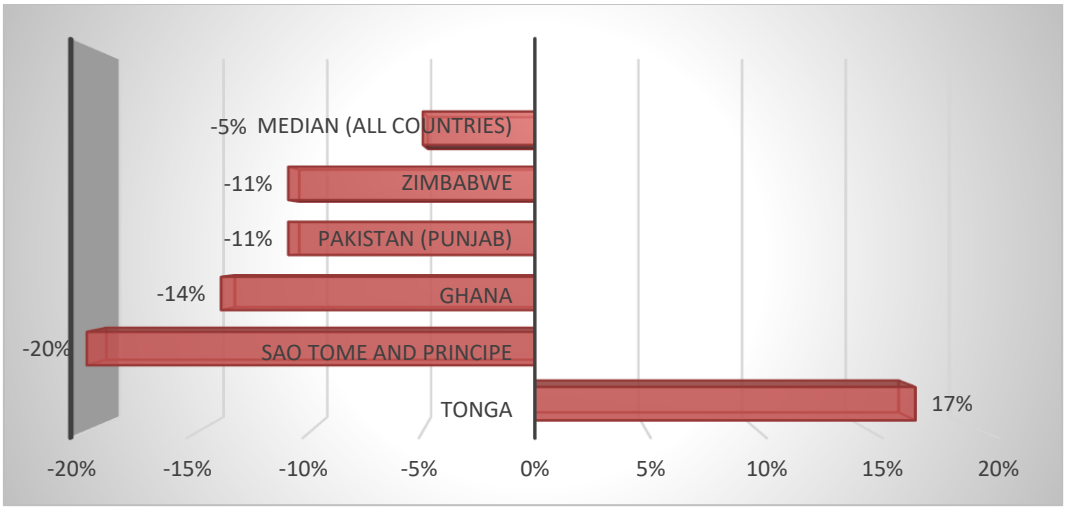

Figure 1: Gender Parity Ratio in Internet Use Among Youth Aged 15–24 (Selected Countries)

4.2 Digital Skill Disparities

Access to the internet, while essential, is not sufficient in itself to prepare youth for participation in a digitally driven society. The second layer of the digital divide relates to the ability to use digital technologies effectively. This includes foundational activities such as sending emails, copying files, using basic productivity tools, and more advanced skills like configuring software or writing code. As UNICEF (2023) emphasizes, even in households where internet access is available, there is no guarantee that adolescents, particularly girls, are acquiring the skills necessary to participate in education, employment, or civic life in the digital age. The data on digital skills reveals an even deeper level of inequality than internet access alone. In many countries, adolescent boys are significantly more likely than their female counterparts to demonstrate basic ICT competencies. According to UNICEF (2023), among 32 countries and territories with available data, the median percentage of male youth aged 15 to 24 who had at least one digital skill was 20 percent, while for female youth it was only 9 percent. This disparity is not merely numerical but structural. A host of factors, including educational inequality, family dynamics, sociocultural norms, and targeted gender bias in technology engagement, drive it.

These gender disparities in skill development are particularly alarming in contexts where girls outperform boys in foundational education, such as reading literacy. As noted by UNESCO (2022), while girls tend to excel in basic literacy, these strengths often do not translate into digital competence. UNICEF (2023) further confirms this disconnect, indicating that foundational academic advantages among girls do not ensure equivalent outcomes in digital skill acquisition. The implication is clear: despite early academic promise, girls are not being given equal opportunities to build on those foundations in technology-enhanced learning environments. In certain countries, the gender gap in digital skills is vast. In Chad and the Central African Republic, for example, the proportion of girls who report having any digital skill is less than 3 percent. In these same countries, boys have slightly higher but still very low levels of digital proficiency. The Pakistan province

of Baluchistan shows a similar pattern, with digital skill acquisition among girls nearly non-existent. By contrast, countries like the Turks and Caicos Islands and Samoa demonstrate more promising figures, with relatively high rates of digital skills among both boys and girls and even slight advantages for girls in some cases (UNICEF, 2023).

However, even these exceptions should be interpreted with caution. As van Dijk (2006) argues, meaningful digital engagement requires not only access and technical skills but also the opportunity to apply those skills in ways that generate social and economic value. Without this third level of digital inclusion, technical literacy remains a fragile and limited asset. The barriers to digital skills development for girls are both systemic and localized. At the societal level, educational systems often reflect and reinforce gender roles. Curricula may unintentionally position technology as a male-dominated field, and teachers may hold implicit biases that influence how they engage students based on gender (Scott et al., 2018). In many settings, boys are encouraged to experiment with digital tools from an early age, while girls are discouraged or relegated to more passive roles. This results in a confidence gap that manifests not only in skill levels but in long-term aspirations related to STEM careers (Ong *et al.,* 2011).

The family environment also plays a critical role. According to Quisumbing and Maluccio (2000), families often allocate educational resources in ways that favor boys. UNICEF (2023) substantiates this with evidence showing that even within the same household, girls have fewer digital skills than their male siblings. This suggests that gendered expectations and control over technology use are deeply embedded within domestic spaces. Furthermore, the development of digital skills is frequently shaped by the type of exposure youth receive. Passive consumption of technology, such as watching videos or browsing social media, is fundamentally different from active, skill-building use like programming, content creation, or data analysis. Rideout and Robb (2019) observed that youth from underrepresented groups are more likely to use digital tools for entertainment than education, a pattern that can reinforce existing inequalities. If girls are not provided with structured opportunities to use technology in academically and professionally meaningful ways, they are less likely to acquire skills that translate into upward mobility.

Another factor contributing to the digital skills gap is the lack of inclusive role models and mentoring. Girls of color, in particular, face a noticeable absence of representation in digital education and STEM careers. According to the National Center for Women and Information Technology (NCWIT, 2021), women of color remain vastly underrepresented in computer science programs and the tech industry. Without visible pathways for success, many girls disengage from technology-related subjects during key decision-making points in their educational trajectory. The long-term implications of these disparities are profound. In a world where digital competence is increasingly tied to employment, healthcare access, financial services, and social participation, the failure to develop these skills among girls deepens cycles of poverty and exclusion. As the United Nations (2018) observed, digital skills are becoming as essential as literacy and numeracy for full participation in society.

Addressing this second-level digital divide requires coordinated intervention. Educational systems must prioritize digital skills for all students and implement policies that directly address gender disparities. Community programs that create safe and supportive environments for girls to learn digital skills are also critical. These interventions must be paired with policies that tackle broader gender norms in families and society, ensuring that the digital future does not continue to replicate the exclusions of the past. The table below (Figure 2) presents selected data on the percentage of youth aged 15 to 24 who report having digital skills, disaggregated by sex. It visually captures the stark contrast between male and female youth, reinforcing the urgent need for gender-equitable digital education strategies.

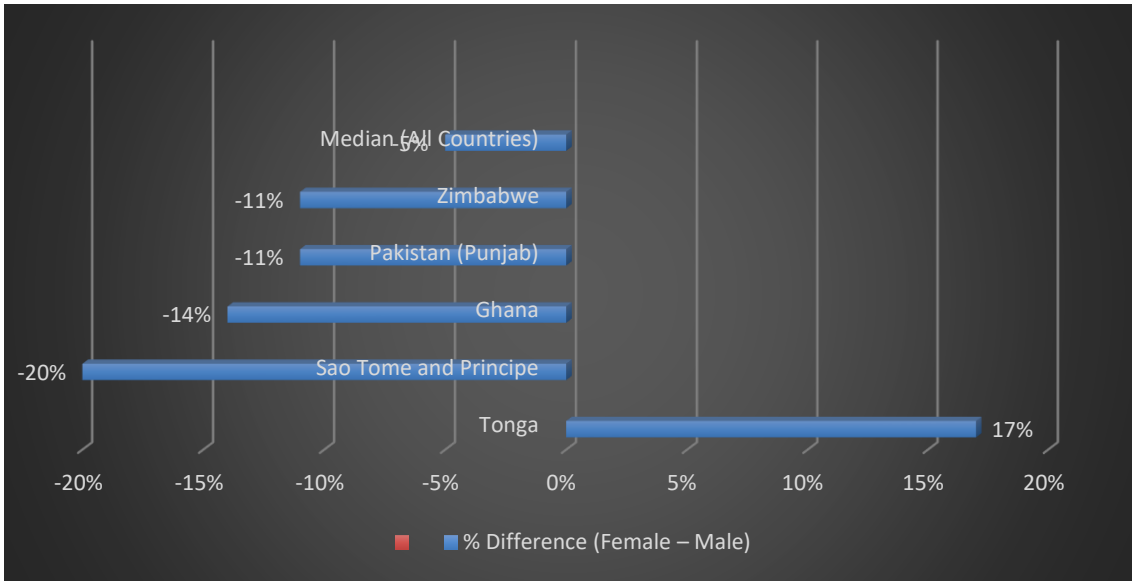

Figure 2: Percentage of Youth (15–24) with Digital Skills by Sex and Country (Selected)

4.3 WITHIN-HOUSEHOLD GENDER BIAS

While national and regional statistics on internet access and digital skills are crucial to understanding the digital divide, these figures often obscure the inequalities that exist **within** households. In many cases, even when a family has access to the internet and digital devices, girls and boys within the same household do not benefit equally. Intra-household gender bias plays a pivotal role in determining who has control over digital resources and who develops the skills necessary to thrive in a digital world. The UNICEF (2023) analysis provides compelling evidence that adolescent girls and young women aged 15 to 24 are less likely than their male counterparts to demonstrate digital skills, even when they reside in the same household. This finding is crucial, as it eliminates the confounding variables of income level, regional infrastructure, or general household access, and instead isolates gender as a key determinant of digital opportunity. In a sample of 30 countries, girls had lower digital skill levels than boys in 22 of them, despite sharing the same home environment. In some countries, the disparities reached over 15 percentage points (UNICEF, 2023).

These gaps can be attributed to several interrelated factors. At the core is gendered socialization, the process by which children learn societal norms and expectations regarding appropriate behaviors based on their gender. According to Quisumbing and Maluccio (2000), parents often make educational and technological investments in children based on future perceived returns, which are heavily gendered. Boys are more likely to be seen as future earners in STEM or digital careers, while girls are often expected to assume caregiving or domestic roles. These assumptions directly influence who gets to use the computer, who receives technical support, and who is encouraged to engage with digital content beyond entertainment. Furthermore, household dynamics often reflect broader patriarchal structures. Girls are typically assigned more domestic responsibilities, limiting their time and availability to engage with digital tools for skill development (UNESCO, 2022). Even in households that promote education, the expectation that girls help with chores or care for younger siblings can significantly reduce their opportunities for focused and uninterrupted digital learning. Boys, in contrast, may be given more autonomy and fewer responsibilities, allowing them more leisure time and time for learning with digital devices.

Another powerful influence within the home is parental control over technology use, particularly in contexts where internet safety is a concern. According to the World Wide Web Foundation (2020), girls face higher risks of online harassment, cyberbullying, and surveillance. In response, many parents impose stricter digital restrictions on girls, sometimes barring them from using devices altogether. While these protective instincts are understandable, they often result in unintended consequences. By shielding girls from digital spaces rather than equipping them with the skills to navigate them safely, families inadvertently widen the gender digital divide. The data from UNICEF (2023) also reveal that gender bias in digital skill development is not confined to poor households. In fact, in many of the countries analyzed, the gender gap in digital skills was wider among wealthier families. This counterintuitive finding suggests that simply increasing household income or digital infrastructure does not automatically lead to equitable outcomes. In more affluent households, devices may be more plentiful, but so are the cultural norms and gendered expectations that guide their use. In these settings, boys may still be granted more access, more support, and more encouragement to use digital tools for skill-building purposes.

These intra-household patterns have broader implications for educational and workforce readiness. If

girls are denied opportunities to build digital skills during adolescence, they enter higher education and the labor market at a significant disadvantage. Their lack of exposure can reduce confidence, reinforce stereotypes about gendered aptitude in STEM, and ultimately dissuade them from pursuing careers in technology-related fields. Ong *et al.,*(2011) noted that such early disparities, even when seemingly minor, can accumulate over time, leading to systemic underrepresentation of women of color in STEM professions. These findings challenge traditional policy models that assume households are neutral or equitable units of intervention. Many digital inclusion policies focus on providing devices or subsidizing internet connections at the household level. However, these strategies may fail to reach the intended beneficiaries if they do not account for intra-household gender dynamics. As van Dijk (2006) asserts, digital inequality is a layered phenomenon that requires analysis not only across class or national boundaries but also within the private spaces of the home. Efforts to address within-household bias must start with targeted awareness campaigns that address gender stereotypes among parents and caregivers. These campaigns should emphasize the value of digital skills for girls and provide families with strategies for equitable digital engagement. Programs such as after-school IT clubs for girls, mentorship schemes led by women in tech, and safe online learning platforms tailored to girls' needs can help counteract the effects of domestic bias. Additionally, policies that promote digital education in schools must also guide families in supporting girls' learning outside the classroom.

One promising approach is integrating digital literacy training into community centers and girl-focused safe spaces, particularly in marginalized communities. These environments provide girls with access to devices, instruction, and peer support that may be lacking at home. They also create opportunities for collective resistance to limiting gender norms and the development of a shared identity as capable digital learners. In the long term, reducing intra-household gender bias in digital education requires both cultural change and policy innovation. Families must begin to see girls as future technologists, engineers, and creators—not just as passive consumers of technology. When homes become sites of inclusion rather than exclusion, the potential for digital equity becomes more than a policy objective; it becomes a lived reality. The table below (Figure 3) presents selected country-level data on the probability differences in digital skills between girls and boys within the same households. The negative values indicate where girls are at a disadvantage, while positive values indicate where girls outperform boys. These figures underscore the role of domestic environments in shaping digital futures.

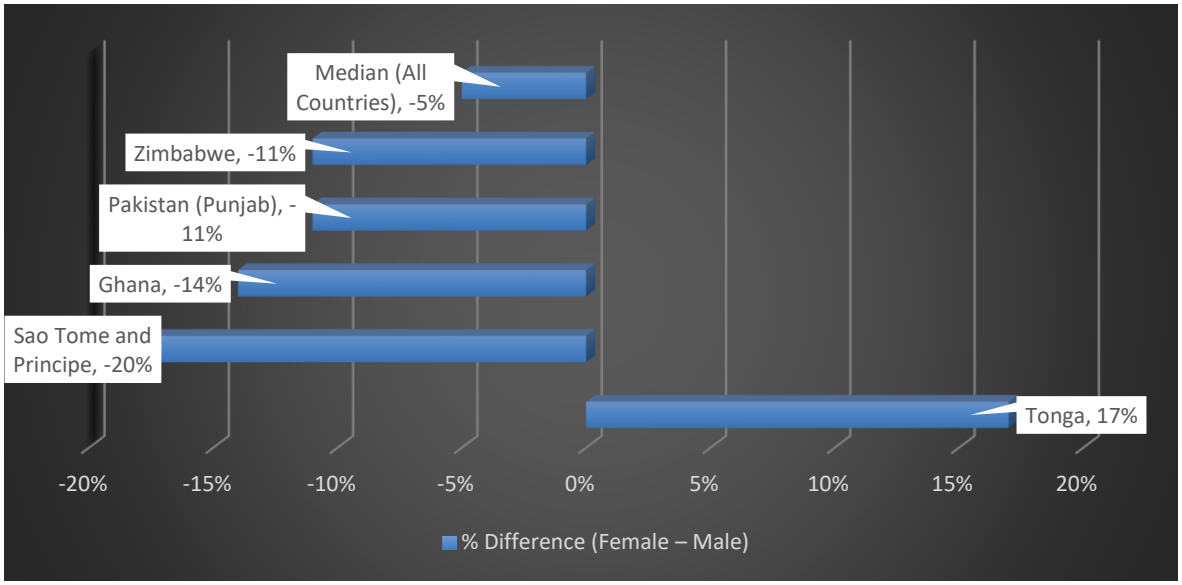

Figure 3: Gender Gap in Digital Skills (Female–Male Difference Within the Same Household)

5. DISCUSSION

The findings presented in this paper offer compelling evidence that digital inequity is not merely a technological issue but a profoundly social one. The data show that girls, especially those from underrepresented racial and ethnic groups, face a layered and persistent form of exclusion in digital access and skills acquisition. These barriers are shaped by social norms, family dynamics, economic status, and systemic bias in education. This section interprets the patterns identified in the preceding analyses. It connects them to the broader context of STEM education for girls of color, particularly in high-income countries such as the United States. Globally, access disparities remain the most visible sign of the digital divide. As illustrated in Figure 1, in many countries, adolescent girls are significantly less likely than boys to access the internet. While this gap is most severe in low-income countries such as Chad and parts of Pakistan, the underlying causes, patriarchal norms, resource prioritization, and safety concerns are echoed in

wealthier nations. In the United States, for instance, research by Rideout and Robb (2019) found that students from low-income and minority households are less likely to have consistent access to high-speed internet or personal computers. This limitation disproportionately affects girls of color, who already experience intersecting disadvantages due to race, gender, and class.

However, access alone does not tell the whole story. As shown in Figure 2, even where internet connectivity exists, girls are far less likely to possess basic digital skills. This gap is particularly concerning in the context of STEM education. According to the National Center for Women and Information Technology (2021), girls of color are significantly underrepresented in computer science courses and digital literacy programs. The lack of early exposure and encouragement results in a confidence gap that discourages participation in more advanced STEM tracks. This phenomenon aligns with what Ong *et al.,*(2011) describe as a "double bind", girls of color in STEM must navigate both racial and gendered expectations, often without institutional or familial support. The data presented in Figure 3 deepens this concern by showing that within the same household, girls often have fewer digital skills than boys of the same age. This suggests that the home, typically viewed as a neutral or even protective environment, is in many cases a site of gendered resource distribution and control. Quisumbing and Maluccio (2000) emphasized that gender norms frequently drive intra-household resource allocation, and the digital era is no exception. If girls are consistently deprived of both time and tools to engage meaningfully with technology, the gap between them and their male counterparts widens regardless of national wealth or policy.

These findings hold particular implications for girls of color in the United States. While they may have access to digital tools in schools or community centers, they still contend with under-resourced schools, cultural stereotypes, and limited exposure to role models in tech fields. Scott *et al.,* (2018) argue that many STEM education initiatives fail because they do not account for the racialized experiences of girls. Programs that are not culturally responsive often alienate rather than empower. Without integrating race-conscious and gender-sensitive strategies, efforts to expand digital and STEM access will fall short of addressing the root causes of exclusion. Another theme emerging from the analysis is the role of safety and surveillance. The Web Foundation (2020) reported that girls face higher risks of online harassment, leading many families to restrict their internet usage. While these restrictions may be well-intentioned, they often result in girls being denied the digital practice necessary to build confidence and competence. Safety concerns must be addressed through education and protection, not through exclusion. As UNESCO (2022) points out, digital inclusion efforts must also include digital safety training, particularly for girls who are more likely to experience cyber violence.

A related concern is the disparity in how digital tools are used. As Rideout and Robb (2019) observed, youth from underrepresented groups often use technology more for entertainment than for skill development or educational enrichment. This pattern can reinforce existing educational inequalities if not counterbalanced by structured opportunities for engagement in digital creation, coding, research, and design. Schools and community programs play a critical role here, but must be adequately resourced and culturally aligned to meet the needs of girls of color. To counteract these layers of exclusion, interventions must be multi-dimensional. At the policy level, governments must mandate sex-disaggregated data collection and evaluation in digital education programs. School systems must adopt curricula that normalize girls' participation in technology and provide teachers with the training to identify and dismantle gender bias in classroom interactions. At the community level, families and local organizations should be engaged in shifting cultural expectations around girls and technology. Programs such as after-school coding clubs or digital maker spaces that center girls of color can provide the inclusive environments needed to foster skill development and a sense of belonging.

Importantly, these interventions must also include a forward-looking component. As noted by the United Nations (2018), 90 percent of future jobs will require digital skills. The cost of inaction is not only the exclusion of a generation of girls from STEM fields but also their disconnection from the tools needed to participate fully in modern civic and economic life. Without urgent action, the digital divide will deepen existing inequalities, locking girls of color into a cycle of marginalization that begins in school and continues into adulthood. The patterns identified in this study, limited access, lower skill acquisition, and within-household bias, are interdependent and reinforcing. They call for an intersectional approach that recognizes girls of color as uniquely positioned at the crossroads of multiple forms of exclusion. Bridging the digital divide for these populations is not simply about inclusion; it is about justice, opportunity, and the right to thrive in a digitally connected world.

6. CONCLUSION

The digital divide is not a singular issue of connectivity but a complex intersection of access, skill, and social power. For girls of color, particularly those from underserved communities, this divide is widened by layers of structural inequality rooted in race, gender, and class. As this paper has shown through a synthesis of global data and critical scholarship, bridging this divide requires more than distributing devices or expanding broadband. It necessitates dismantling the social, cultural, and institutional barriers that shape who gets to participate in digital spaces and who gets left behind. The UNICEF (2023) report offers a global lens on the

problem, revealing stark gender disparities in internet use and digital skills among youth aged 15 to 24. Girls in low- and middle-income countries are significantly less likely than boys to use the internet, develop digital competencies, or own mobile devices. These disparities persist even within households, highlighting the role of domestic gender norms in restricting digital engagement. While these findings are drawn from a global dataset, they resonate powerfully with research on girls of color in higher-income contexts. Studies by Rideout and Robb (2019) and the National Center for Women and Information Technology (2021) reveal similar patterns of exclusion in the United States, where race and socioeconomic status often determine the quality of digital access and instruction. What emerges is a consistent pattern of marginalization: girls of color are denied not only the tools but also the encouragement, training, and cultural validation necessary to thrive in digital learning environments. This exclusion has profound consequences for their future participation in STEM education and careers. According to the United Nations (2018), digital fluency is now as essential as traditional literacy for participating in the modern economy. Without targeted intervention, the digital divide threatens to become a permanent feature of educational inequality, locking girls of color into cycles of economic and social exclusion. However, the findings also point to clear opportunities for change. Schools can become spaces of transformation by adopting inclusive curricula and equitable teaching practices. Community-based programs can provide safe and affirming environments for girls to explore technology, develop skills, and imagine futures in STEM. Families, when supported and informed, can be powerful advocates for their daughters' digital growth. Policymakers have the tools to institutionalize these changes through targeted investments, regulation, and public education campaigns. Equally important is the need to center girls' voices in these efforts, ensuring that they are not merely beneficiaries but active participants in shaping their digital futures.

Bridging the digital divide for girls of color is both an educational and moral imperative. It is about ensuring equal opportunity, expanding human potential, and preparing an inclusive generation for the digital age. The data and insights explored in this paper serve as both a warning and a call to action. If digital equity is to be achieved, then the systemic biases that inhibit it must be addressed with urgency, intentionality, and sustained commitment. The future of STEM, and indeed the future of society, depends on it.

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