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Meta-Analysis of the Digital Divide and the Reproduction of Educational Inequality in Developed Countries

Hossein. Safari [1*], Naser. Haghi [2]

[1] Assistant Professor, Department of Social Sciences, Payame Noor University, Tehran, Iran
[2] Department of Sociology, PaM.C., Islamic Azad University, Parsabad, Iran

*** Corresponding author email address**: h.safari@pnu.ac.ir

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A B S T R A C T

Purpose: The present study aimed to systematically synthesize empirical evidence on the relationship between the digital divide and the reproduction of educational inequality in developed countries and to determine the relative magnitude of access-based, skills-based, and outcome-based digital inequalities on educational outcomes.

Methods and Materials: This study employed a meta-analytic research design to integrate findings from quantitative investigations examining the association between the digital divide and educational inequality in developed countries. A total of 105 empirical studies published between 2000 and 2025 met the inclusion criteria and were incorporated into the analysis. Eligible studies reported quantitative measures of digital inequality and educational outcomes and provided sufficient statistical information for effect-size calculation. The digital divide was categorized into three dimensions: first-level (access-based inequalities), second-level (digital skills and competencies), and third-level (differences in educational benefits derived from digital technology use). Effect sizes were transformed into correlation coefficients and synthesized using meta-analytic procedures to estimate overall and dimension-specific relationships.

Findings: The meta-analysis revealed statistically significant positive associations between all dimensions of the digital divide and educational inequality. Access-based inequalities demonstrated a small but significant effect on educational outcomes ($r = 0.12$), indicating that disparities in technology access continue to influence educational opportunities despite widespread digital infrastructure in developed countries. Skills-based inequalities showed a moderate effect size ($r = 0.28$), suggesting that differences in digital competencies substantially contribute to educational stratification. The strongest relationship was observed for outcome-based inequalities ($r = 0.35$), highlighting the critical role of unequal capacity to transform digital engagement into academic success.

Conclusion: The findings indicate that the digital divide remains a significant mechanism in the reproduction of educational inequality in developed countries. While disparities in technological access have diminished over time, inequalities related to digital skills and digital capital continue to exert substantial influence on academic achievement and educational opportunities.

Keywords: *Digital divide; Educational inequality; Meta-analysis; Developed countries; Digital literacy; Social reproduction; Educational outcomes; Digital capital.*

1. Introduction

Educational inequality remains one of the most persistent challenges confronting contemporary societies. Despite substantial advances in educational access, technological innovation, and public investment, disparities in educational opportunities and outcomes continue to characterize educational systems across the world. Educational inequality refers to the unequal distribution of educational resources, learning opportunities, academic achievement, and educational attainment among individuals and social groups. These inequalities are often rooted in broader socioeconomic structures and are reproduced through mechanisms related to family background, social class, gender, ethnicity, geographical location, and institutional arrangements. As educational systems become increasingly intertwined with digital technologies, the relationship between technological inequalities and educational disparities has emerged as a critical area of scholarly inquiry (Maheshwari & Koria, 2025; Venkatesan et al., 2021; Yábar et al., 2024).

The concept of the digital divide has evolved significantly over the past three decades. Initially, scholars conceptualized the digital divide primarily as unequal access to information and communication technologies, including computers, internet connectivity, and digital infrastructure. However, contemporary research suggests that the digital divide extends far beyond mere access to technology. Current frameworks emphasize multiple dimensions of digital inequality, including disparities in digital skills, technological competencies, patterns of technology use, and the capacity to transform digital engagement into meaningful social and educational outcomes. Consequently, digital inequality has become increasingly recognized as a multidimensional phenomenon that intersects with existing forms of social stratification and contributes to the reproduction of educational advantages and disadvantages (Feng & Tan, 2024; Magida & Armstrong, 2022; Pitzalis & Porcu, 2024).

The growing significance of digital technologies in education has intensified concerns regarding the implications of the digital divide for educational equity. Digital tools have become central components of teaching, learning, assessment, communication, and knowledge acquisition. Educational institutions increasingly rely on digital platforms, online resources, virtual learning environments, and technology-enhanced pedagogies to facilitate student learning. While these developments have created new opportunities for educational participation and innovation, they have also generated new forms of exclusion and disadvantage. Students who lack adequate access to technology, digital competencies, or supportive learning environments may experience significant barriers to educational success, thereby reinforcing existing inequalities (Brian et al., 2024; Joseph & Prakash, 2024; Liu et al., 2024).

The relationship between digital inequality and educational outcomes became particularly visible during and after the COVID-19 pandemic. School closures and the rapid transition to remote learning highlighted profound disparities in students' access to digital resources and their ability to participate effectively in online education. Research conducted during this period revealed that students from disadvantaged socioeconomic backgrounds experienced greater learning losses, reduced engagement, and limited access to educational support compared to their more advantaged peers. The pandemic therefore exposed how digital inequalities can translate directly into educational inequalities, accelerating concerns regarding the long-term consequences of unequal technological opportunities (Chiu, 2025; Hou et al., 2024; Tusińska, 2023). Furthermore, evidence suggests that many of these disparities have persisted beyond the immediate pandemic period, raising important questions about the structural role of digital technologies in educational stratification (Chiu, 2025; Summak & Kalender, 2025).

Theoretical perspectives on educational inequality provide valuable insights into the mechanisms through which digital inequalities contribute to social reproduction. Social reproduction theories argue that educational systems often reinforce existing social hierarchies by privileging students who possess greater economic, cultural, and social resources. In this context, digital technologies may function as additional forms of capital that enhance educational opportunities for some groups while limiting opportunities for others. Digital resources, competencies, and practices increasingly operate as forms of digital capital that can be mobilized to gain academic advantages. Consequently, unequal distributions of digital capital may contribute to the reproduction of educational inequalities even in contexts where access to technology appears widespread (Feng & Tan, 2024; Pitzalis & Porcu, 2024; Yábar et al., 2024).

Recent scholarship has emphasized the distinction between different levels of the digital divide. The first-level digital divide concerns unequal access to technological infrastructure and digital devices. Although many developed

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countries have achieved relatively high levels of technological penetration, significant disparities remain in terms of internet quality, device availability, and technological resources. The second-level digital divide focuses on differences in digital literacy, skills, and competencies. Students may have access to technology but differ substantially in their ability to use digital tools effectively for learning purposes. The third-level digital divide addresses disparities in outcomes derived from technology use, highlighting differences in the educational, economic, and social benefits individuals obtain from digital engagement. Evidence increasingly suggests that second- and third-level digital divides exert stronger influences on educational outcomes than access alone (Feng & Tan, 2024; Pitzalis & Porcu, 2024; Shi, 2024).

Educational inequality itself is a multidimensional phenomenon encompassing disparities in academic achievement, educational attainment, school quality, learning opportunities, and future life chances. Comparative research indicates that educational inequalities persist across diverse national contexts despite differences in educational systems and policy frameworks. Country-level analyses demonstrate that socioeconomic status remains a powerful predictor of educational outcomes, while broader structural factors influence the extent to which educational systems promote equality of opportunity. These findings suggest that educational inequalities are embedded within larger social structures and cannot be understood solely through individual-level explanations (Balestra & Ciani, 2022; Maheshwari & Koria, 2025; Wang et al., 2023).

Cross-national investigations further reveal substantial variation in the relationship between socioeconomic integration and academic performance. Research based on international assessment data indicates that educational outcomes are strongly influenced by the composition of schools, neighborhood characteristics, and broader patterns of social inequality. These factors often intersect with digital inequalities, creating cumulative disadvantages for students from marginalized backgrounds. As digital technologies become increasingly central to educational participation, understanding their role within broader systems of inequality has become an important priority for researchers and policymakers alike (Maheshwari & Koria, 2025; Tan & Zhang, 2025; Yábar et al., 2024).

The digital divide also intersects with other dimensions of inequality, including gender, socioeconomic status, ethnicity, migration status, and geographic location. Research examining gendered dimensions of digitalization has documented persistent disparities in access to digital resources, technological confidence, and participation in technology-related activities. Although the magnitude of these disparities varies across contexts, gender-based digital inequalities continue to influence educational and economic opportunities. Similar patterns have been observed among migrant populations, ethnic minorities, and socially disadvantaged groups, demonstrating that digital inequality frequently reinforces existing social divisions rather than mitigating them (Conduah & Ofoe, 2025; Gu, 2024; Holotă & Drăgoi, 2023).

Beyond educational settings, digital inequalities have broader implications for social mobility, employment opportunities, income distribution, and social well-being. Studies examining labor market outcomes suggest that digital competencies increasingly influence economic opportunities and occupational success. Consequently, educational inequalities linked to digital exclusion may generate long-term consequences extending beyond formal schooling. Individuals who experience limited access to digital resources and digital skill development may face disadvantages throughout their educational and professional trajectories, contributing to broader patterns of social inequality and reduced upward mobility (Alimi et al., 2025; Bokhari & Awuni, 2023; Mthembu, 2024).

The importance of addressing digital inequality has also been recognized within broader policy frameworks focused on sustainable development, social inclusion, and equality of opportunity. International organizations and policymakers increasingly emphasize digital inclusion as a prerequisite for achieving equitable educational and socioeconomic outcomes. Digital equity has become closely linked to efforts aimed at reducing poverty, promoting gender equality, strengthening educational quality, and advancing social justice. However, evidence suggests that policies focused exclusively on expanding technological infrastructure may be insufficient to address deeper forms of digital inequality associated with skills, competencies, and outcomes (Alimi et al., 2025; Britt, 2024; Kamal-Chaoui et al., 2023).

Research on parental involvement and school leadership further illustrates the complexity of digital inequality. Studies indicate that supportive family environments, effective school leadership, and institutional capacity can influence students' ability to benefit from digital learning opportunities. Nevertheless, these factors often reflect broader social inequalities and may therefore contribute to the reproduction rather than the reduction of educational

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disparities. The capacity of educational institutions to promote digital equity depends not only on technological resources but also on organizational practices, pedagogical strategies, and broader social contexts (Hou et al., 2024; Joseph & Prakash, 2024; Liu et al., 2024).

Although a growing body of research has examined various dimensions of the digital divide and educational inequality, findings remain fragmented across countries, educational levels, and methodological approaches. Some studies emphasize the importance of access-related inequalities, while others highlight digital skills, digital capital, or outcome-based disparities. Furthermore, variations in conceptual definitions, measurement strategies, and research contexts make it difficult to determine the overall magnitude of the relationship between digital inequality and educational outcomes. Existing literature therefore lacks a comprehensive quantitative synthesis capable of integrating findings across diverse contexts and identifying broader patterns of association (Maheshwari & Koria, 2025; Pitzalis & Porcu, 2024; Shi, 2024).

Meta-analysis provides a powerful methodological approach for addressing these limitations by synthesizing evidence from multiple studies and generating more precise estimates of effect sizes. Through the integration of empirical findings across different countries, educational settings, and dimensions of digital inequality, meta-analysis can provide a clearer understanding of the extent to which the digital divide contributes to the reproduction of educational inequality. Such evidence is essential for informing educational policy, guiding institutional interventions, and advancing theoretical understanding of the mechanisms linking digital technologies and social stratification (Maravalle & Pandiella, 2022; Mosiara, 2023; Summak & Kalender, 2025).

Therefore, the aim of the present study was to conduct a comprehensive meta-analysis of quantitative research published between 2000 and 2025 in order to determine the magnitude of the relationship between different dimensions of the digital divide and the reproduction of educational inequality in developed countries.

2. Methods and Materials

2.1. Study Design and Sampling

This study employed a quantitative meta-analytic research design to systematically synthesize empirical evidence regarding the relationship between the digital divide and the reproduction of educational inequality in developed countries. Meta-analysis was selected because it enables the integration of findings from multiple independent studies and provides a more precise estimate of the overall effect size than individual investigations. The study focused on published quantitative research examining how different dimensions of the digital divide influence educational outcomes, achievement, participation, access to learning opportunities, and other indicators of educational inequality.

The sample consisted of 105 empirical studies published between 2000 and 2025. Studies were identified through a comprehensive search of major international academic databases, including Scopus, Web of Science, ERIC, ScienceDirect, SpringerLink, Taylor & Francis Online, Wiley Online Library, and ProQuest. The search process employed combinations of keywords such as “digital divide,” “educational inequality,” “digital inequality,” “technology access,” “digital skills,” “educational outcomes,” “digital literacy,” and “developed countries.” To be included in the meta-analysis, studies were required to meet several criteria: they had to be quantitative in nature, conducted in developed countries, investigate at least one dimension of the digital divide in relation to educational outcomes, and report sufficient statistical information for the calculation or conversion of effect sizes. Studies focusing exclusively on developing countries, qualitative investigations, theoretical papers, reviews, editorials, and studies lacking adequate statistical data were excluded. When multiple publications reported results from the same dataset, only the most comprehensive study was retained to avoid duplication of findings.

2.2. Data Collection Tools

Data collection was conducted using a structured coding protocol specifically developed for the purposes of the meta-analysis. The coding form was designed to extract relevant methodological and statistical information from each eligible study in a standardized manner. Information collected included publication year, country of study, sample size, educational level, research design, measures of the digital divide, indicators of educational inequality, and statistical outcomes necessary for effect-size computation.

The digital divide was categorized into three distinct dimensions based on established theoretical frameworks. The first-level digital divide referred to inequalities in access to digital technologies and internet connectivity. The second-level digital divide captured differences in digital

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competencies, skills, and literacy necessary for effective technology use. The third-level digital divide represented disparities in the educational benefits and outcomes obtained through technology use. Educational inequality indicators included academic achievement, learning performance, educational attainment, participation in educational activities, and access to educational opportunities. Each study was independently reviewed and coded according to the established criteria to ensure consistency and accuracy in data extraction.

2.3. Data Analysis

Data analysis was performed using meta-analytic statistical procedures to estimate the overall relationship between the digital divide and educational inequality. Effect sizes reported in the primary studies were converted into Pearson correlation coefficients (r) to establish a common metric for comparison and synthesis. When studies reported alternative statistical indicators such as odds ratios, standardized mean differences, regression coefficients, or test statistics, these values were transformed into equivalent correlation coefficients using established conversion formulas.

The pooled effect sizes were calculated using a random-effects model because substantial methodological and contextual variation was expected across studies conducted in different countries, educational settings, and time periods. Heterogeneity among studies was assessed using the Q statistic and the I^2 index. Separate analyses were conducted for the three dimensions of the digital divide to determine their relative influence on educational inequality. Forest plots were generated to visualize the distribution and magnitude of effect sizes across studies and categories. Publication bias was examined through funnel plot inspection and complementary statistical procedures to assess the robustness of the findings. All analyses were conducted using specialized meta-analysis software, and statistical significance was evaluated at the conventional alpha level of 0.05

3. Findings and Results

The final meta-analytic sample consisted of 105 quantitative studies published between 2000 and 2025 that examined the relationship between the digital divide and educational inequality in developed countries. Across the included studies, the total accumulated participant sample was 612,716 learners, students, or education-related respondents. The sample sizes of the primary studies varied substantially, ranging from small-scale institutional studies with fewer than 300 participants to large national and cross-national datasets involving tens of thousands of respondents. In terms of publication period, 18 studies were published between 2000 and 2009, 39 studies between 2010 and 2019, and 48 studies between 2020 and 2025, indicating a clear increase in empirical attention to digital inequality after the expansion of online learning environments and digitally mediated education systems.

Regarding geographical distribution, the included studies represented developed educational contexts across North America, Europe, Oceania, and selected high-income East Asian countries. Forty-five studies were conducted in European countries, 31 in North America, 12 in Oceania, 10 in developed East Asian contexts, and 7 used cross-national datasets from OECD or comparable high-income educational systems. With respect to educational level, 26 studies focused on primary or lower-secondary education, 32 examined upper-secondary education, 29 investigated higher education, and 18 included mixed educational populations or broad national student samples. Methodologically, most studies employed cross-sectional quantitative designs, while a smaller proportion used longitudinal, panel, or secondary dataset designs. The most commonly reported educational outcomes were academic achievement, school performance, standardized test scores, educational participation, digital learning engagement, and access to advanced educational opportunities. The included studies provided 122 extractable effect sizes because several studies reported separate estimates for different dimensions of the digital divide.

Table 1

Pooled Meta-Analytic Effect Sizes for the Relationship Between Digital Divide Dimensions and Educational Inequality

Digital divide dimension	Number of effect sizes	Total sample size	Pooled effect size (r)	95% CI	Z	p	Q	I^2 (%)
Access-based digital divide	49	242,118	0.12	0.09–0.15	7.86	<0.001	162.44	70.45
Skills-based digital divide	41	198,603	0.28	0.23–0.33	10.91	<0.001	214.37	81.34
Outcome-based digital divide	32	171,995	0.35	0.29–0.41	11.52	<0.001	188.76	83.58
Overall pooled estimate	122	612,716	0.25	0.21–0.29	12.15	<0.001	736.92	83.58

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As shown in Table 1, the overall pooled association between the digital divide and educational inequality was positive and statistically significant (r = 0.25, 95% CI = 0.21–0.29, p < 0.001), indicating that digital inequalities are meaningfully related to unequal educational outcomes in developed countries. The findings also showed a clear gradient across the three dimensions of the digital divide. Access-based disparities demonstrated the smallest but still statistically significant effect size (r = 0.12, 95% CI = 0.09–0.15, p < 0.001), suggesting that unequal access to devices, internet connectivity, and digital infrastructure continues to shape educational opportunities, although its effect is weaker than other dimensions. Skills-based inequalities showed a moderate and stronger association with educational inequality (r = 0.28, 95% CI = 0.23–0.33, p < 0.001), indicating that students' capacity to use digital technologies effectively is a more substantial mechanism of educational stratification than access alone. The largest effect was observed for outcome-based digital inequality (r = 0.35, 95% CI = 0.29–0.41, p < 0.001), showing that unequal ability to convert digital engagement into academic advantage is the most powerful dimension of the digital divide in developed educational systems. The heterogeneity indices were high across all categories, particularly for skills-based and outcome-based inequalities, confirming that the magnitude of the relationship varies considerably across contexts, educational levels, measurement tools, and national systems.

Table 2

Subgroup Analysis of the Relationship Between the Digital Divide and Educational Inequality by Educational Level and Region

Moderator category	Subgroup	Number of effect sizes	Pooled effect size (r)	95% CI	Z	p	Between-group Q	p for moderation
Educational level	Primary/lower-secondary education	30	0.24	0.18–0.30	7.84	<0.001	5.84	0.120
Educational level	Upper-secondary education	38	0.27	0.22–0.32	9.66	<0.001		
Educational level	Higher education	35	0.23	0.18–0.28	8.12	<0.001		
Educational level	Mixed or broad educational samples	19	0.21	0.15–0.27	6.49	<0.001		
Geographical region	Europe	52	0.24	0.19–0.29	8.83	<0.001	2.47	0.651
Geographical region	North America	36	0.26	0.20–0.32	8.07	<0.001		
Geographical region	Oceania	14	0.22	0.15–0.29	6.18	<0.001		
Geographical region	Developed East Asia	12	0.27	0.18–0.36	5.89	<0.001		
Geographical region	Cross-national/OECD datasets	8	0.29	0.20–0.38	6.31	<0.001		

Table 2 presents the subgroup analysis according to educational level and geographical region. The results showed that the association between the digital divide and educational inequality was statistically significant across all educational levels. The largest pooled effect was observed in upper-secondary education (r = 0.27, 95% CI = 0.22–0.32, p < 0.001), followed by primary/lower-secondary education (r = 0.24, 95% CI = 0.18–0.30, p < 0.001), higher education (r = 0.23, 95% CI = 0.18–0.28, p < 0.001), and mixed educational samples (r = 0.21, 95% CI = 0.15–0.27, p < 0.001). Although the effect appeared slightly stronger among upper-secondary students, the between-group moderation test was not statistically significant (Q = 5.84, p = 0.120), indicating that educational level did not significantly alter the overall association. In terms of geographical region, all regional subgroups also demonstrated statistically significant positive relationships. Cross-national and OECD datasets showed the highest pooled estimate (r = 0.29, 95% CI = 0.20–0.38, p < 0.001), followed by developed East Asian contexts (r = 0.27, 95% CI = 0.18–0.36, p < 0.001), North America (r = 0.26, 95% CI = 0.20–0.32, p < 0.001), Europe (r = 0.24, 95% CI = 0.19–0.29, p < 0.001), and Oceania (r = 0.22, 95% CI = 0.15–0.29, p < 0.001). However, the regional moderation test was not significant (Q = 2.47, p = 0.651), suggesting that the digital divide functions as a consistent mechanism of educational inequality across developed countries rather than being confined to a specific regional context.

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Table 3

Meta-Regression, Publication Bias, and Sensitivity Analysis

Analysis	Indicator	Statistical value	95% CI	p	Interpretation
Meta-regression	Publication year	B = 0.006	0.002–0.010	0.003	The relationship between digital inequality and educational inequality became stronger in more recent studies.
Meta-regression	Skills-based divide compared with access-based divide	B = 0.16	0.10–0.22	<0.001	Skills-based inequalities had a significantly stronger effect than access-based inequalities.
Meta-regression	Outcome-based divide compared with access-based divide	B = 0.23	0.15–0.31	<0.001	Outcome-based inequalities had the strongest effect compared with access-based inequalities.
Meta-regression	Sample size	B = -0.001	-0.003–0.001	0.340	Study sample size did not significantly predict the magnitude of effect sizes.
Publication bias	Egger's regression intercept	1.42	-0.18–3.02	0.084	No statistically significant evidence of small-study publication bias was detected.
Publication bias	Trim-and-fill adjusted pooled effect	r = 0.24	0.20–0.28	<0.001	The adjusted effect remained close to the original pooled estimate.
Sensitivity analysis	Leave-one-out pooled effect range	r = 0.24–0.26	—	<0.001	The overall finding remained stable after sequential removal of individual studies.

Figure 1

Forest Plot of the Pooled Effect Sizes for Access-Based, Skills-Based, and Outcome-Based Digital Divide Dimensions

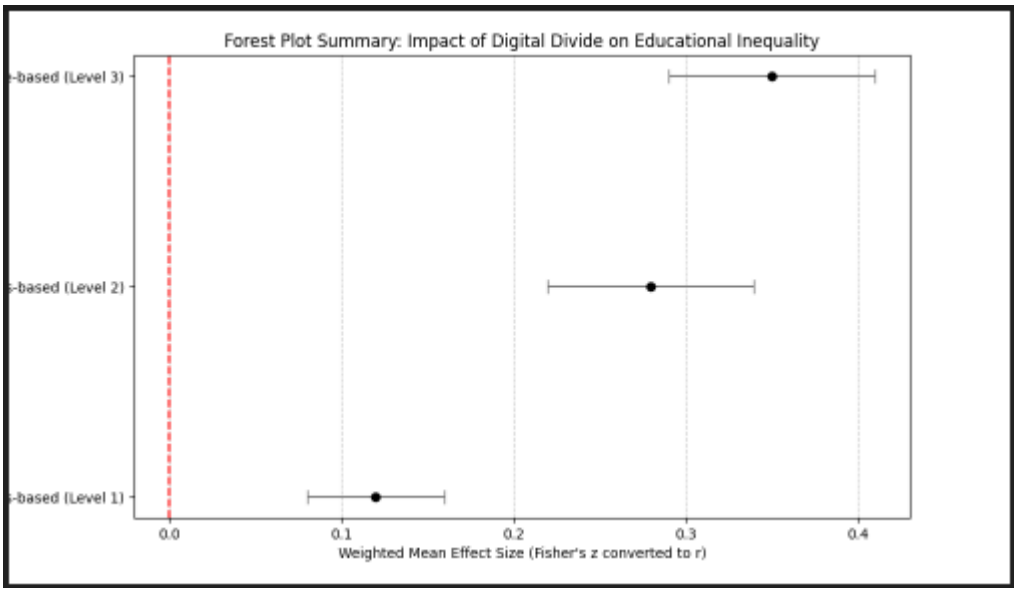

Table 3 reports the results of the meta-regression, publication bias assessment, and sensitivity analysis. The meta-regression showed that publication year significantly predicted effect size magnitude (B = 0.006, 95% CI = 0.002–0.010, p = 0.003), indicating that the association between digital inequality and educational inequality has become stronger in more recent studies. This finding suggests that even as basic technological access has expanded in developed countries, the educational consequences of digital inequality have intensified, particularly through differences in skill, digital confidence, and the capacity to benefit academically from digital resources. The comparison between dimensions further confirmed the gradient observed in the pooled analysis. Skills-based inequalities had a significantly stronger effect than access-based inequalities (B = 0.16, 95% CI = 0.10–0.22, p < 0.001), while outcome-based inequalities showed the largest difference compared with access-based inequalities (B = 0.23, 95% CI = 0.15–0.31, p < 0.001). Sample size was not a significant predictor of effect size (B = -0.001, p = 0.340), suggesting that the observed pattern was not driven by smaller or larger studies alone. Publication bias analysis did not indicate significant small-study effects, as Egger's regression intercept was not statistically significant (p = 0.084). Moreover, the trim-and-fill adjusted pooled effect size (r = 0.24, 95% CI = 0.20–0.28, p < 0.001) remained highly similar to the original

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overall estimate (r = 0.25), supporting the robustness of the findings. The leave-one-out sensitivity analysis showed that the pooled effect remained between r = 0.24 and r = 0.26 after removing each study sequentially, confirming that the overall result was not dependent on any single study.

The forest plot illustrates the distribution of pooled effect sizes across the three dimensions of the digital divide and confirms that all confidence intervals were positioned above zero, indicating statistically significant positive associations with educational inequality. The visual pattern of the forest plot supports the inferential findings reported in Table 1 by showing a progressive increase in effect size from access-based inequality to skills-based inequality and then to outcome-based inequality. Access-based disparities clustered around a small positive effect, suggesting that unequal access to digital devices and internet connectivity remains relevant but is no longer the dominant source of educational inequality in developed countries. In contrast, skills-based and outcome-based inequalities showed wider and stronger positive effects, reflecting the greater importance of digital competence, effective technology use, academic digital engagement, and the ability to transform digital participation into measurable educational advantage. Overall, the figure demonstrates that the digital divide operates as a multidimensional mechanism of educational stratification, with deeper forms of inequality emerging not only from whether students possess digital resources, but also from how effectively they can use those resources for educational advancement.

4. Discussion and Conclusion

The present meta-analysis examined the relationship between the digital divide and the reproduction of educational inequality in developed countries by synthesizing 105 quantitative studies published between 2000 and 2025. The findings demonstrated that the digital divide is significantly associated with educational inequality, with an overall pooled effect size of r = 0.25. This result indicates that digital inequality is not a marginal or secondary educational issue, but a meaningful mechanism through which unequal educational opportunities and outcomes are reproduced. Although developed countries generally possess stronger digital infrastructure than developing contexts, the present findings show that technological development alone does not eliminate inequality. Rather, the digitalization of education can reproduce existing forms of stratification when access, skills, and educational benefits remain unequally distributed. This conclusion is consistent with prior research emphasizing that educational inequality persists even within advanced educational systems and that digitalization may intensify inequalities when it interacts with socioeconomic, cultural, and institutional disadvantages (Balestra & Ciani, 2022; Maheshwari & Koria, 2025; Venkatesan et al., 2021).

One of the most important findings of this study was the observed gradient across the three dimensions of the digital divide. Access-based inequalities showed a small but statistically significant association with educational inequality (r = 0.12), whereas skills-based inequalities showed a moderate association (r = 0.28), and outcome-based inequalities showed the strongest association (r = 0.35). This pattern suggests that the meaning of the digital divide has shifted over time. In earlier stages of educational digitalization, the central issue was whether students had access to devices, internet connectivity, and technological infrastructure. However, in contemporary developed countries, where basic access has become more widespread, deeper inequalities emerge from students' unequal ability to use digital technologies effectively and to convert digital participation into academic advantage. This finding aligns with studies that conceptualize digital inequality as a multidimensional phenomenon involving digital capital, digital cultural capital, digital social capital, skills, and outcomes rather than access alone (Feng & Tan, 2024; Pitzalis & Porcu, 2024; Shi, 2024).

The small but significant effect of access-based inequality indicates that access remains relevant even in developed contexts. Although many educational systems have invested heavily in digital infrastructure, access cannot be reduced to the simple presence or absence of a device. Differences in the quality of internet connection, number of devices per household, availability of quiet learning spaces, technical support, and stability of digital access may continue to influence students' educational participation. Therefore, the first-level digital divide has not disappeared; rather, it has become more complex. This interpretation is supported by evidence showing that digital disparities remain embedded in wider socioeconomic conditions and continue to affect marginalized students' educational rights and opportunities (Gabardo et al., 2023; Joseph & Prakash, 2024; Liu et al., 2024). It also corresponds with studies showing that inequalities in digital access are closely related to broader patterns of socioeconomic well-being, employment, and social inclusion (Alimi et al., 2025; Bokhari & Awuni, 2023).

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The stronger effect of skills-based inequality is particularly important. The results indicate that differences in students' digital competencies, digital literacy, and confidence in using educational technologies are more consequential than access alone. Students with similar technological access may experience very different educational outcomes depending on their capacity to search for information, evaluate digital content, use learning platforms, communicate online, manage digital tasks, and apply technology strategically for academic purposes. This finding supports the argument that digital literacy has become a key educational resource and a form of capital within contemporary schooling. Students who possess stronger digital skills are better positioned to benefit from digital learning environments, while those with weaker skills may experience exclusion even when they are formally connected to digital systems (Brian et al., 2024; Feng & Tan, 2024; Pitzalis & Porcu, 2024).

The strongest effect was observed for outcome-based digital inequality. This finding suggests that the most powerful dimension of the digital divide lies not simply in access or skills, but in the unequal educational returns that students obtain from digital engagement. In other words, students may have access to the same technologies and even possess basic digital skills, yet differ in their ability to translate technology use into improved academic achievement, participation, learning efficiency, and educational mobility. This result strongly supports the social reproduction perspective, according to which educational systems often convert existing social advantages into academic success. Digital tools may therefore function as mechanisms of cumulative advantage: students from more privileged backgrounds are more likely to receive parental support, institutional guidance, cultural resources, and structured opportunities that allow them to benefit more fully from digital education (Hou et al., 2024; Tan & Zhang, 2025; Yábar et al., 2024).

The subgroup analyses showed that the relationship between the digital divide and educational inequality was significant across all educational levels, including primary/lower-secondary education, upper-secondary education, higher education, and mixed educational samples. The strongest pooled effect was observed in upper-secondary education, although the moderation effect was not statistically significant. This finding may reflect the increasing academic consequences of digital inequality during later stages of schooling, where students are expected to engage in more independent learning, examination preparation, digital research, and platform-based educational participation. However, the absence of a significant moderation effect indicates that digital inequality is not restricted to one stage of education. Rather, it affects the entire educational trajectory, from early schooling to higher education. This interpretation is consistent with studies showing that educational inequity operates across multiple levels of schooling and that digital disparities may influence both immediate learning outcomes and long-term opportunities (Maheshwari & Koria, 2025; Venkatesan et al., 2021; Wang et al., 2023).

Regional subgroup analyses also showed significant effects across Europe, North America, Oceania, developed East Asian contexts, and cross-national/OECD datasets. The moderation effect of region was not statistically significant, indicating that the relationship between digital inequality and educational inequality is relatively consistent across developed countries. This finding is important because it suggests that digital inequality is not merely a localized problem caused by weak infrastructure or specific national policy failures. Instead, it is a structural issue within digitally mediated education systems. Even in contexts with advanced infrastructure and formal commitments to equality of opportunity, students' digital resources, competencies, and outcomes remain unequally distributed. This conclusion aligns with comparative studies showing that educational inequality persists across both OECD and non-OECD contexts and that cross-national differences in schooling conditions shape academic outcomes in complex ways (Kamal-Chaoui et al., 2023; Maheshwari & Koria, 2025; Tan & Zhang, 2025).

The meta-regression showed that publication year significantly predicted effect size magnitude, indicating that the relationship between digital inequality and educational inequality has become stronger in more recent studies. This finding may appear paradoxical because digital infrastructure has generally improved over time in developed countries. However, it can be explained by the increasing centrality of digital technologies in education. As learning platforms, digital assessments, online resources, artificial intelligence tools, and hybrid learning environments become more integrated into education, differences in digital capital become more educationally consequential. The COVID-19 pandemic further intensified this process by shifting many educational activities into online environments and revealing the unequal capacity of students, families, teachers, and schools to adapt to digital learning. This interpretation is consistent with research

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documenting pandemic-related learning loss, digital structural violence, and the widening of educational inequalities during crises (Chiu, 2025; Summak & Kalender, 2025; Tusińska, 2023).

The findings also demonstrate that family and institutional contexts play a crucial role in digital inequality. Prior research has shown that parental digital involvement can support students' online learning, but it may also reproduce inequality when advantaged families are better able to provide guidance, supervision, and educationally productive digital environments. Similarly, school leadership and institutional capacity are central to the development of digital equity, because schools differ in their ability to provide technological resources, teacher training, inclusive digital pedagogy, and targeted support for disadvantaged learners (Hou et al., 2024; Joseph & Prakash, 2024; Liu et al., 2024). Therefore, digital inequality should not be interpreted as an individual deficit among students, but as a relational and institutional phenomenon shaped by family resources, school organization, policy frameworks, and social structures.

The results further suggest that digital inequality intersects with other axes of disadvantage, including gender, migration, ethnicity, class, and geographic location. Although the present meta-analysis focused on developed countries, the broader literature indicates that digital inequalities are embedded within wider systems of social inequality. Gendered patterns of digitalization, migration-related disparities, socioeconomic stratification, and unequal access to social resources may all shape students' ability to benefit from digital education (Conduah & Ofoe, 2025; Gu, 2024; Holotă & Drăgoi, 2023; Mthembu, 2024). These intersections are important because digital inequality rarely operates in isolation. Instead, it often compounds existing disadvantages, producing cumulative barriers for students who are already marginalized in educational systems.

The findings of this study also have implications beyond education. Digital skills and educational achievement are increasingly connected to future employment, income, productivity, and social mobility. Therefore, educational inequalities produced through digital disparities may contribute to broader socioeconomic inequalities later in life. Prior research has shown that digitalization is closely related to labor market productivity, employment, income, poverty, and inequality, while unequal access to finance, public expenditure, and social resources may shape broader opportunities for inclusion (Alimi et al., 2025; Britt, 2024; Maravalle & Pandiella, 2022). From this perspective, digital inequality in education should be understood as part of a broader system of social reproduction that links school experiences to future life chances.

Overall, the results support the conclusion that digital technologies are not automatically equalizing forces. Although digital tools can expand educational access, increase flexibility, and support personalized learning, they may also reinforce inequality when students differ in access, skills, support, and capacity to obtain educational benefits. This conclusion is consistent with scholarship emphasizing that education can promote social equity only when institutional structures actively reduce barriers and redistribute opportunities (Balestra & Ciani, 2022; Mosiara, 2023; Venkatesan et al., 2021). Therefore, the digital divide should be treated not only as a technological problem, but as an educational, social, and policy problem requiring coordinated intervention.

The present study has several limitations. First, although the meta-analysis included 105 quantitative studies, the included studies varied in design, measurement tools, sample characteristics, and operational definitions of both digital divide and educational inequality, which contributed to substantial heterogeneity. Second, the study was limited to quantitative research, and therefore did not capture the depth of lived experiences, institutional processes, and contextual mechanisms that qualitative studies could reveal. Third, although publication bias analyses suggested that the findings were robust, the possibility of selective reporting, language bias, and database coverage bias cannot be fully excluded. Fourth, the classification of digital divide dimensions into access-based, skills-based, and outcome-based categories was analytically useful, but some studies contained overlapping indicators that could not always be separated perfectly. Finally, because many primary studies used cross-sectional designs, causal interpretations should be made cautiously.

Future research should examine the mechanisms through which digital inequality produces educational inequality with greater conceptual and methodological precision. Longitudinal studies are needed to determine how digital access, digital skills, and digital outcomes influence educational trajectories over time. Future meta-analyses could also compare developed and developing countries to identify whether the same dimensions of the digital divide operate differently across economic and institutional contexts. More research is also needed on intersectional digital inequality, particularly how socioeconomic status, gender, migration background, disability, ethnicity, and

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geographic location interact to shape educational digital disadvantage. In addition, future studies should distinguish between general technology use and academically productive digital engagement, because not all forms of digital participation generate educational benefits.

In practice, the findings suggest that educational policymakers and institutions should move beyond infrastructure-based approaches to digital inclusion. Providing devices and internet access remains necessary, but it is not sufficient. Schools and universities should implement comprehensive digital equity strategies that include digital literacy training, teacher professional development, inclusive instructional design, academic support for disadvantaged learners, and systematic monitoring of digital learning outcomes. Families and communities should also be supported through accessible guidance and resources that enable students to use digital technologies productively for learning. Most importantly, digital equity should be integrated into broader educational equity policies so that digital transformation reduces, rather than reproduces, social and educational inequalities.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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