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Exploring the role of digital infrastructure in school accreditation across types and geographies

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Abstract: This study examines the role of digital infrastructure in shaping school accreditation outcomes across public and private institutions in urban and suburban settings in Indonesia. Utilizing a quantitative correlational approach, data from 643 schools, including information on digital infrastructure, school types, geographical location, and accreditation scores, were analyzed. The results revealed a moderate positive correlation between digital infrastructure availability and accreditation outcomes, with public schools and urban schools generally outperforming their counterparts in suburban areas. Public schools benefited from superior access to digital tools, such as high-speed internet and smart classrooms, due to government funding, while private schools often faced resource limitations. Geographical disparities were also evident, with urban schools achieving higher digital readiness and better accreditation scores compared to suburban schools. These findings highlight systemic inequities in digital access that influence accreditation outcomes, emphasizing the need for targeted policies to bridge the digital divide. Interventions should prioritize under-resourced private schools and suburban areas to promote equitable educational opportunities and improve accreditation standards. This research contributes to the broader discourse on education equity and provides actionable insights for policymakers and educators aiming to enhance digital infrastructure in diverse educational contexts.

Keywords: *Digital infrastructure, Geographical areas, School accreditation, School types.*

1. Introduction

School accreditation is a vital indicator of educational quality, reflecting a school's adherence to established standards and its capacity to provide a conducive learning environment (Fishman, 2024; Shal et al., 2024). Kayyali (2024) states that the process of accreditation evaluates various dimensions, including academic outcomes, institutional management, and the availability of resources that support student success.

One of the influential resources for accreditation is the digital infrastructure (Harintama & Muslimin, 2024). It has emerged as a pivotal component of educational quality, influencing both teaching methodologies and student learning outcomes (Almutlaq & Alshammari, 2024). It is also recognized as essential for fostering 21st-century skills (Kalyani, 2024). Facilities such as computers, high-speed internet, smart classrooms, and digital learning tools enhance the teaching-learning process by enabling access to diverse educational resources and innovative pedagogical practices. However, disparities in the availability and utilization of such infrastructure often align with systemic inequalities (Nicoletti et al., 2022). For instance, rural schools frequently face challenges related to limited access to technology compared to their urban counterparts, potentially impacting their accreditation outcomes.

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Studies have indicated that urban schools tend to perform better in accreditation due to superior access to resources, including digital infrastructure (PISA, 2021).

The type of school—whether public or private—also plays a significant role in determining the availability and quality of digital infrastructure (Muslimin et al., 2023). Private schools often have greater financial autonomy and access to external funding, enabling them to invest more in technological advancements. In contrast, public schools may depend heavily on government allocations, which can vary significantly by region. This disparity raises questions about the equity and fairness of accreditation processes, as schools with limited resources may struggle to meet the same standards as their well-funded counterparts (Mncube et al., 2023).

Geographical location is another critical factor influencing school accreditation and the availability of digital infrastructure (Brownie et al., 2023). In Indonesia, for example, schools in metropolitan areas often have better access to digital tools and resources compared to those in remote or underdeveloped regions. This urban-rural divide highlights the need for targeted policies to address infrastructural gaps and ensure equitable educational opportunities. The Indonesian Ministry of Education and Culture has recognized this issue and initiated programs to enhance digital access in rural schools. However, the impact of these initiatives on accreditation outcomes remains under-researched (Mariyono, 2024).

Existing literature underscores the interconnectedness of digital infrastructure, school type, and geographical context in shaping educational quality. For instance, a study by Ibrahim and Aldawsari (2023) found a strong correlation between the presence of digital infrastructure and higher accreditation scores in schools across Southeast Asia. Similarly, Johnes and Virmani (2019) reported that private schools in urban areas consistently outperformed public schools in rural regions regarding technology integration and accreditation outcomes. These findings suggest that addressing disparities in digital infrastructure could have a significant impact on leveling the playing field in school accreditation.

Despite these insights, there is limited research exploring the combined influence of digital infrastructure, school type, and geographical location on accreditation outcomes. Most studies tend to focus on one or two variables in isolation, leaving a gap in understanding the complex interplay between these factors. This article aims to fill that gap by conducting a comprehensive analysis using data from Indonesian schools. The dataset includes accreditation scores, details on digital infrastructure, school type (public or private), and geographical classifications (urban and suburban).

This research is particularly relevant in the context of Indonesia's efforts to achieve equitable and inclusive education, as outlined in the Sustainable Development Goals (SDGs). Understanding how digital infrastructure and contextual factors influence accreditation can inform policy decisions and resource allocation, ultimately contributing to the improvement of educational quality across diverse settings (Irawan et al., 2024). Furthermore, the findings could have broader implications for other countries facing similar challenges, offering insights into how systemic inequalities in education can be addressed.

In light of these considerations, this study seeks to address the following research questions:

1. What is the correlation between school accreditation scores and the availability of digital infrastructure in Indonesian schools?
2. How do geographical areas and school type (public vs. private) influence the schools' digital infrastructure?
3. Is there a significant interaction between school type and geographical location in determining the schools' accreditation?

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2. Methodology

2.1. Research Design

This study employs a quantitative research design to examine the relationship between digital infrastructure (DI) and school accreditation (SA), across the school types (ST) and geographical areas (GA). A correlational approach is adopted to analyze the interactions between these variables, using data collected from Indonesian schools (Friedman et al., 2022). The research utilizes a cross-sectional design, analyzing data from schools across Indonesia in 2023. This design enables the exploration of relationships among variables at a single point in time, providing a snapshot of current trends in accreditation and digital infrastructure. The focus of the research is to identify patterns and correlations rather than establish causation, making the design particularly suited to the objectives of this study.

2.2. Data Sources

Data for the research were obtained from a primary source, the National Accreditation Agency for Schools and Madrasahs (BAN-S/M) of West Nusa Tenggara Province, Indonesia, which provided accreditation scores and detailed reports for schools, including public and private institutions across urban areas (cities in Lombok Island) and suburban areas (cities in Sumbawa and Bima-Dompu). This source also contains data on the digital infrastructure owned by the schools, the school types (public/private), and the geographical areas where the schools are. The selection of the research settings was due to some reasons such as the reachability and accessibility of data and the unique research setting where West Nusa Tenggara Province is known as a mid-low-income province (ranking 18th in GDP nationally in 2023) with two big islands (Lombok Island and Sumbawa-Bima-Dompu island) that have different wealth (Indonesia, 2023).

The collected source contains 643 schools' accreditation data that were analyzed to ensure the comprehensive coverage of variables relevant to the research objectives. The schools in this study context were the schools in elementary, junior high, and senior high levels from both private and public types. The details of the schools' descriptions as data are shown in Table 1.

Table 1.
The data description.

Categories	Data	Number of schools
Areas (in West Nusa Tenggara Province, Indonesia)	Bima Dompu	94
	Sumbawa	63
	Lombok Area	486
School Types	Public	408
	Private	235
Accreditation Results/Grades	A	226
	B	322
	C	91
	TT (unaccredited)	4

Regarding accreditation results, Table 1 shows that 'A' represents the highest results of school accreditation and TT represents the worst accreditation results for the school. Also, the area in West Nusa Tenggara Province, Indonesia, is divided into three because of the convention by the province's governor.

2.3. Variables

The research examines several variables. The dependent variable is the school accreditation score, measured on a scale from A, B, C, and TT (unaccredited). Independent variables include digital

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infrastructure indicators such as internet bandwidth, computer availability, and the presence of smart classrooms. Additionally, school type (public or private) and geographical location (urban or suburban) are analyzed as independent variables. These variables were carefully selected to capture the multifaceted nature of the factors influencing school accreditation.

2.4. Data Analysis

The analysis involved both descriptive and inferential statistical techniques. Descriptive statistics applying the SPSS 24 version, including frequencies, means, and standard deviations, were calculated to summarize the distribution of accreditation scores and digital infrastructure indicators across school types and geographical locations. Correlation analysis was conducted using Pearson's correlation coefficient to examine the relationships between variables. The conceptual model of the variable's correlation is shown in Figure 1.

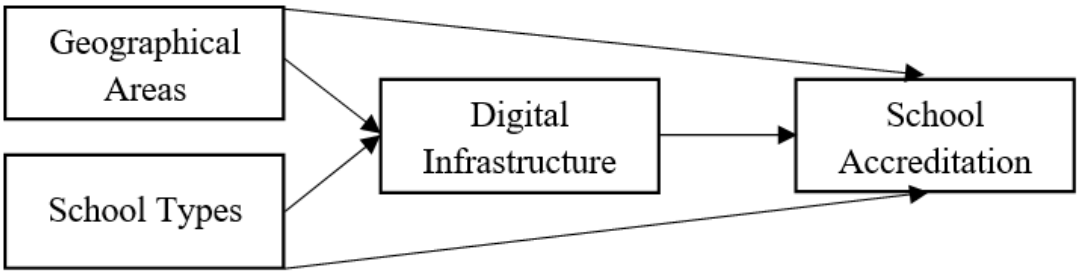

Figure 1.
The variable's correlation conceptual model.

2.5. Ethical Considerations

Ethical considerations were prioritized throughout the research. Ethical approval was obtained from the National Accreditation Agency for Schools and Madrasahs (BAN-S/M) of West Nusa Tenggara Province, Indonesia, and all data were anonymized to protect the identities of schools and stakeholders. These measures ensured that the study adhered to ethical standards and respected the privacy of participants (O'Sullivan et al., 2020).

3. Findings

This study is intended to examine the relationship between digital infrastructure (DI) and school accreditation (SA), across the school types (ST) and geographical areas (GA). Therefore, the findings are provided following the intended objectives as also prescribed in the research questions.

The Correlation Between School Accreditation Scores and the Availability of Digital Infrastructure in Indonesian Schools

The first research question explores the correlation between DI and SA statistically. Hence, it is required to have both DI and SA's quantitative data or scores to be able to find their correlation.

As shown by Table 1, it is clear that the majority of schools, from the total schools of 643, had achieved a 'B' level of accreditation. Then some of them (four schools) were unsuccessful in fulfilling the accreditation standard, resulting in being unaccredited. Then, to make this data analyzable statistically, the accreditation score conversion was conducted with the conversion score as shown in Table 2.

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Table 2.
SA-level conversion scores.

SA level	Scores
A	3
B	2
C	1
TT	0

Table 2 shows that the schools that obtained an 'A' level of accreditation were scored '3' for correlation statistical calculation. Therefore, all SA scores were calculable in SPSS version 24.

The second variable, DI, had already been documented in the form of scores by the National Accreditation Agency for Schools and Madrasahs (BAN-S/M) of West Nusa Tenggara Province, Indonesia. The summary of the DI data is shown in Table 3.

Table 3.
The descriptive data of DI.

DI scores	Total of schools
4	406
3	219
2	18
1	0

Table 3 shows that most of the schools scored highest from the accreditation score range (range of 1-4). Only a few of them had low scores or two points. This table shows that DI data is also statistically calculable. Henceforth, the correlation of both DI and SA is shown in Table 4.

Table 4.
DI and SA statistical correlation.

		SA	DI
SA	Pearson correlation	1	.539**
	Sig. (2-tailed)		.000
	N	643	643
DI	Pearson correlation	0.539**	1
	Sig. (2-tailed)	0.000	
	N	643	643

Note: **. Correlation is significant at the 0.01 level (2-tailed).

Table 4 describes that the correlation coefficient between SA and DI is 0.539. This indicates a moderate positive correlation between the two variables, with a Pearson score between 0.40 to 0.599 (see Table 5). A positive value means that as one variable increases, the other tends to increase as well. Then, the p-value for this correlation is 0.000, which is less than the conventional threshold of 0.01. This means the correlation is statistically significant, indicating that the observed relationship is unlikely to be due to chance.

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Table 5.
Correlation coefficient guideline (Meghanathan, 2016).

(+/-) 0.00 – 0.119	Very low
(+/-) 0.20 – 0.399	Low
(+/-) 0.40 – 0.599	Moderate
(+/-) 0.60 – 0.799	Strong
(+/-) 0.80 – 1.00	Very strong

3.1. The Relationship of Geographical Areas and School Type on the Schools' Digital Infrastructure

The second research question is intended to know the correlation of ST and GA with DI. To unravel the facts, the descriptive statistical calculation was conducted using SPSS version 24 to correlate those variables' data. The results are shown in Table 6 and Table 7.

Table 6.
The relationship between GA and DI.

DI across GA	Assessment scores	Total of schools	% In GA
Bima Dompu cities	4	66	70.21
	3	23	24.47
	2	5	5.32
	1	0	0.00
Sumbawa cities	4	48	76.19
	3	14	22.22
	2	1	1.59
	1	0	0.00
Lombok area	4	292	60.08
	3	182	37.45
	2	8	1.65
	1	4	0.82

Table 6 The table illustrates the relationship between digital infrastructure (DI) levels in schools and their geographical areas (GA), focusing on three regions: Bima Dompu Cities, Sumbawa Cities, and the Lombok Area. Schools are categorized into four DI assessment scores, ranging from 1 (lowest) to 4 (highest), and the data reflects the distribution and percentage of schools within each score category across these regions.

In Bima Dompu Cities, the majority of schools (70.21%) are categorized at DI Score 4, indicating a strong prevalence of high-quality digital infrastructure. An additional 24.47% of schools are at DI Score 3, reflecting moderately high infrastructure, while a small fraction (5.32%) falls under Score 2. No schools in this region are classified at the lowest level of DI (Score 1).

Similarly, Sumbawa Cities demonstrates a high concentration of schools with superior digital infrastructure, with 76.19% achieving DI Score 4. Schools at Score 3 account for 22.22%, while only 1.59% fall under Score 2. As with Bima Dompu Cities, no schools in Sumbawa Cities are at the lowest DI level. This region exhibits the highest proportion of schools with top-tier digital infrastructure among the three areas.

In the Lombok Area, while the largest absolute number of schools (292) are at DI Score 4, this constitutes a lower percentage (60.08%) compared to the other regions. Schools at Score 3 make up 37.45%, while 1.65% and 0.82% are categorized under Scores 2 and 1, respectively. The presence of

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schools with lower DI levels (Scores 2 and 1) is more noticeable in this region, highlighting variability in infrastructure availability.

Overall, the findings on the GA relationship to DI reveal a regional disparity in digital infrastructure. Both Bima Dompu Cities and Sumbawa Cities exhibit a stronger prevalence of schools with high DI levels, while the Lombok Area shows a broader distribution, with a notable portion of schools facing infrastructural challenges. These results underscore the need for targeted interventions to enhance digital infrastructure in less-equipped schools, particularly in the Lombok Area.

Another relationship is also shown by ST and DI as shown in Table 7.

Table 7.
The relationship between ST and DI.

DI across ST	Assessment scores	Total of schools	% In ST
Public	4	268	65.69
	3	131	32.11
	2	9	2.21
	1	0	0.00
Private	4	138	58.72
	3	88	37.45
	2	9	3.83
	1		0

Table 7 illustrates the relationship between school types (public and private) and their digital infrastructure (DI), categorized by assessment scores ranging from 1 to 4. Public schools exhibit higher proportions of advanced digital infrastructure compared to private schools. Among public schools, 65.69% achieved a score of 4, indicating a robust DI, while 32.11% scored 3, and only 2.21% scored 2. None of the public schools received a score of 1, reflecting the absence of minimal DI in this category.

In contrast, private schools showed slightly lower performance in digital infrastructure. A total of 58.72% achieved the highest score of 4, while 37.45% scored 3. A marginal 3.83% of private schools scored 2, and none fell into the lowest category of 1. These findings suggest that while both public and private schools demonstrate commendable digital readiness, public schools have a slight edge in achieving higher DI standards. The data underscores the need for targeted interventions to enhance DI in private schools to bridge the digital gap between the two sectors.

3.2. The Interaction Between School Type and Geographical Location in Determining the Schools' Accreditation

The last research question is intended to know the relationship of ST and GA with SA. The results are shown in Table 8 and Table 9.

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Table 8.
The relationship of GA and SA.

SA across GA	Accreditation grade	Total of schools	% In GA
Bima Dompu cities	A	48	51.06
	B	27	28.72
	C	19	20.21
	TT	0	0.00
Sumbawa cities	A	36	57.14
	B	23	36.51
	C	4	6.35
	TT	0	0.00
Lombok area	A	142	29.22
	B	272	55.97
	C	68	13.99
	TT	4	0.82

Table 8 examines the relationship between geographical areas (GA) and school accreditation (SA) grades across three regions: Bima Dompu Cities, Sumbawa Cities, and Lombok Area. The data highlight regional variations in the distribution of accreditation grades (A, B, C, and TT, representing no accreditation).

In Bima Dompu Cities, the majority of schools (51.06%) hold an accreditation grade of A, followed by 28.72% with grade B and 20.21% with grade C. Notably, no schools in this region are unaccredited (TT). Similarly, in Sumbawa Cities, 57.14% of schools achieved grade A, marking the highest proportion of top accreditation among the three regions. Schools with grade B account for 36.51%, while 6.35% received grade C, and none are unaccredited.

In contrast, the Lombok Area presents a different distribution. Only 29.22% of schools are accredited with grade A, while the majority (55.97%) hold grade B, indicating a focus on mid-tier accreditation. Schools with grade C constitute 13.99%, and 0.82% remain unaccredited. These findings reveal significant disparities in accreditation quality across regions, with Sumbawa Cities leading in high-quality accreditations and Lombok Area showing the largest percentage of mid-tier accreditations. The results emphasize the need for tailored strategies to address regional differences and improve overall accreditation standards.

Instead of the relationship between GA and SA, this study also unveils how SA was related to the ST. The results of the analysis are shown in Table 9.

Table 9.
The relationship between ST and SA.

SA across ST	Accreditation grade	Total of schools	% In ST
Public	A	153	37.50
	B	219	53.68
	C	36	8.82
	TT		0.00
Private	A	73	31.06
	B	103	43.83
	C	55	23.40
	TT	4	1.70
	TT	4	1.70

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Table 9 presents the relationship between school types (ST), categorized as public and private, and their accreditation grades (SA). Public schools demonstrate a stronger performance in higher accreditation grades compared to private schools. In public schools, the majority (53.68%) hold accreditation grade B, followed by 37.50% achieving the highest-grade A. A smaller proportion (8.82%) received grade C, and none are unaccredited (TT). These figures indicate a robust accreditation profile for public schools, with most schools falling within the top two accreditation categories.

Private schools, however, display a broader distribution across accreditation grades. While 43.83% of private schools achieved grade B, a smaller percentage (31.06%) earned grade A. Notably, 23.40% of private schools received grade C, and a small fraction (1.70%) remain unaccredited (TT). This contrasts with public schools, which show no unaccredited institutions.

The findings highlight a significant gap in accreditation quality between public and private schools, with public schools generally achieving higher accreditation levels. This disparity underscores the need for targeted efforts to support private schools in improving their accreditation status.

4. Discussion

The discussion of this study's findings offers a deeper understanding of the role of digital infrastructure (DI) in shaping school accreditation (SA) outcomes, emphasizing the complexities of this relationship across different types of schools (ST) and geographic contexts (GA). The results reveal that digital infrastructure is not merely an auxiliary component but a significant factor influencing the educational quality and accreditation performance of schools (Harintama & Muslimin, 2024; Ibrahim & Aldawsari, 2023; Johnes & Virmani, 2019; Kalyani, 2024). These insights contribute to the broader discourse on educational equity and highlight the pressing need for targeted interventions to address disparities in digital access.

One of the key findings of this research is the moderate positive correlation between digital infrastructure and school accreditation scores. This relationship underscores the importance of digital readiness in achieving high accreditation standards (Wang & Wang, 2023). Schools equipped with advanced digital tools, such as high-speed internet and smart classrooms, demonstrated superior accreditation outcomes (Almutlaq & Alshammari, 2024). This finding aligns with previous studies, such as those by Valverde-Berrocoso et al. (2022), Ibrahim and Aldawsari (2023), and Johnes and Virmani (2019), which also identified a strong link between technological resources and educational performance. However, this study's focus on the Indonesian context adds a new dimension, particularly by highlighting regional disparities and their impact on accreditation.

The geographic analysis presented in this research reveals significant regional disparities in digital infrastructure and accreditation levels. Schools in urban areas, such as the Lombok region, exhibited higher levels of digital readiness and better accreditation outcomes (seen from the total number of 'A' and 'B' accreditation results) compared to their counterparts in suburban areas like Sumbawa and Bima Dompu Cities. This urban-suburban divide is consistent with global patterns observed in developing nations, where resource allocation often favors urban centers (Cattaneo et al., 2022; Muslimin, 2024). These findings call for policies that prioritize digital infrastructure development in underserved regions to bridge the gap and promote equitable educational opportunities.

In terms of school type, public institutions generally outperformed private schools in digital infrastructure and accreditation scores. Bernardo et al. (2014) highlight that public schools in the Philippines often benefit from government-funded facilities and resources, which can create a more conducive learning environment and positively influence student achievement. Derder et al. (2023) emphasize that public schools often outperform private schools due to superior access to digital

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infrastructure, technical support, and professional development, which enhance teaching effectiveness and student outcomes. This trend can be attributed to the government's role in funding and supporting public schools, which contrasts with the financial constraints faced by many private institutions. Despite their autonomy, private schools often lack the resources to invest in advanced digital tools, resulting in lower accreditation outcomes (Green, 2020). This disparity highlights the need for targeted support for private schools, including funding initiatives and partnerships to enhance their technological capabilities.

While this study provides valuable insights, it is not without limitations. The research focuses on schools within West Nusa Tenggara Province, Indonesia, which may limit the generalizability of the findings to other regions with different socioeconomic or geographic characteristics. Additionally, the cross-sectional design of the study captures data at a single point in time, potentially overlooking longitudinal trends or changes in digital infrastructure and accreditation. Future research could address these limitations by adopting a longitudinal approach and expanding the geographic scope to include diverse regions.

Another area for future investigation is the exploration of qualitative aspects of digital infrastructure utilization. While this study emphasizes the quantitative relationship between digital tools and accreditation outcomes, understanding how schools integrate and use these resources could provide a more nuanced perspective. For instance, examining the role of teacher training, student engagement, and administrative support in leveraging digital infrastructure could yield actionable insights for improving educational quality.

Finally, this study underscores the critical role of digital infrastructure in shaping school accreditation outcomes, highlighting disparities across school types and geographic contexts (Derder et al., 2023). The findings call for systemic efforts to enhance digital readiness in underserved regions and support private schools in achieving accreditation standards. By addressing these challenges, policymakers and educators can foster a more equitable and high-quality education system, ensuring that all schools have the resources necessary to thrive in a digitally connected world.

5. Conclusion

In conclusion, this study offers significant insights into the relationship between digital infrastructure, school type, and geographical location in shaping school accreditation outcomes in Indonesia. The findings reveal a moderate positive correlation between the availability of digital infrastructure and accreditation scores, indicating that schools with advanced technological resources tend to achieve higher accreditation levels. Additionally, public schools generally outperform private institutions in terms of digital readiness and accreditation, while urban schools demonstrate better outcomes compared to their suburban counterparts. The theoretical implications of this research suggest that existing educational frameworks should incorporate the role of digital infrastructure as a critical factor influencing accreditation and educational quality. Practically, the study underscores the necessity for policymakers to prioritize investments in digital resources, particularly in underserved regions, to bridge the urban-suburban divide and enhance educational equity. However, the research is limited by its focus on a specific region, which may affect the generalizability of the findings, and it does not explore longitudinal trends or qualitative aspects of digital infrastructure utilization. Future research should aim to include a broader geographical scope and investigate additional factors such as teacher training and student engagement, which could further illuminate the complexities of how digital infrastructure influences educational quality and accreditation across diverse contexts. By addressing

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these gaps, subsequent studies can contribute to a more comprehensive understanding of systemic inequalities in education and inform policies aimed at fostering equitable access to digital resources.

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