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Factors of digital accessibility and infrastructure on critical thinking skills of elementary school students in Bululawang village, Blitar

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Abstract

School participation across regions in Indonesia reflects significant disparities in access to and quality of education. This study aims to analyze the relationship between digital accessibility and infrastructure on the critical thinking abilities of elementary school students in Bululawang Village, Blitar Regency. Despite being one of the smallest villages with a low population, it still reflects a substantial educational gap between elementary schools within the same locality. This research employs a comparative method with a quantitative-qualitative approach, collecting data through interviews, observations, documentation studies, and focus group discussions (FGD). The U Mann-Whitney test analysis results indicate a significant difference in the distribution of critical thinking abilities, with UPT SD N Bululawang 01 performing significantly better than UPT SD N Bululawang 02. Better infrastructure, such as adequate roads and facilities, contributes to superior outcomes compared to other schools that still rely on unpaved roads and limited facilities. Interview findings also indicate an accessibility gap affecting teachers and students, reinforcing the importance of equitable educational infrastructure. This research aligns with efforts to improve the quality of education in Indonesia, particularly in reducing technology-based educational disparities in rural areas.

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1. Introduction

The disparity in school participation across regions in Indonesia reaches 30.14% (Perdana, 2024), indicating a significant inequality in access to education. Various primary and secondary education issues, such as school quality and accessibility, pose major challenges that the Ministry of Primary and Secondary Education (Kemendikdasmen) must urgently address to ensure educational equity (Nur, 2024). One of the primary factors exacerbating this disparity is the limited school infrastructure. A National Center for Education Studies (2023) study revealed that 40% of schools in 3T (frontier, outermost, and underdeveloped) regions suffer from inadequate classrooms and a lack of essential facilities such as libraries and laboratories. Consequently, children in these areas face significant barriers in accessing quality education.

Additionally, disparities in teacher distribution further exacerbate this situation. Data from the Ministry of Education and Culture (2023) indicate that 60% of qualified teachers are concentrated in urban areas, while schools in remote regions struggle with a shortage of competent educators. This

imbalance results in a significant gap in educational quality between rural and urban areas. Even when schools are available, insufficiently qualified educators lead to poor learning outcomes. Moreover, economic factors play a crucial role in perpetuating educational disparities. The 2023 National Socioeconomic Survey (Susenas) found that children from low-income families are three times more likely to drop out of school than those from wealthier backgrounds. This finding underscores that financial constraints often prevent families from affording education for their children despite government efforts to provide schooling.

Given these various challenges, it is evident that educational disparity is not merely a secondary issue but rather a major obstacle in developing human capital in Indonesia. If left unaddressed, this inequality will continue to widen the social and economic divide in the future. The National Coordinator of the Indonesian Education Monitoring Network (Kormas JPPI), Ubaid Matraji, emphasized that frequent curriculum changes hinder improvements in education quality and stressed the importance of a consistent and sustainable curriculum (cited in Toekan, 2024). Furthermore, limited access to education contributes to Indonesia's declining Human Development Index (HDI) ranking, where education is a key indicator (Perdana, 2024). In line with efforts to improve the quality of education in Indonesia, this study investigates the factors affecting students' learning conditions, particularly concerning digital accessibility and infrastructure in Bululawang Village, Blitar Regency, East Java, Indonesia.

Research Context: Bululawang Village is one of the smallest-populated villages in Bakung District, located on the southern coast of Java. Geographically, Bululawang is surrounded by hills and beaches, making it a promising area for agrotourism and local commodity development. According to local oral history, corroborated by village elders, the name Bululawang originates from a large tree called "bolu," whose roots split a pathway, resembling a door ("Lawang"). Despite its natural potential, most of the village's population relies on the agricultural sector (Damayanti et al., 2014; Noviarita et al., 2021; Sungkawati et al., 2022: 868).

A significant challenge in Bululawang Village pertains to educational accessibility. With a total area comprising only 1.16% of the district, Bululawang has only two primary schools. This limitation compels many parents to enrol their children in schools outside the village, even at the primary level, indicating underlying issues in the quality of local education. Another major challenge relates to digital accessibility. Field observations conducted over 50 days in the village revealed that internet connectivity scored only 2 out of 5, whereas urban areas scored 5. Moreover, Wi-Fi speed in schools frequently falls below 1 Mbps, with some reporting even lower speeds, highlighting a significant digital divide between rural and urban regions.

Table 1. Studies on relevant topics

Year	Research Topic
2024	Critical Thinking Skills for Developing 21st-Century Competencies in Students
2024	The Use of Interactive Multimedia to Enhance Elementary School Students' Critical Thinking Skills
2024	Enhancing Engaging Learning Media through Quiz Applications to Improve (Collaboration, Creativity, and Critical Thinking) in Elementary/Islamic Elementary School Students
2024	Digitalized Learning: The Impact of Educational Games on Students' Critical Thinking Skills

Educational accessibility should not differ between rural and urban areas. Education is a fundamental right for every child in a nation, particularly in rural areas. Furthermore, the "Why Rural Matters 2023" report emphasizes that rural areas have long served as incubators for innovative practices utilizing scalable models to enhance student learning and community well-being. The disparity in internet speed between rural and urban areas is one of the primary issues contributing to unequal access to knowledge resources. Therefore, this study focuses on Bululawang Village to better understand how these accessibility challenges impact the quality of education, particularly in

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fostering critical thinking skills among primary school students. Previous research has explored critical thinking abilities in primary education, albeit with some differences.

Building on previous research, this study further develops existing studies on critical thinking skills among students, particularly in educational environments facing significant challenges, such as those in Desa Bululawang. The challenges related to digital accessibility and infrastructure form the foundation of this research. Based on the background outlined above, the research problem can be formulated as follows:

> *"Is there a positive and significant relationship between digital accessibility and infrastructure and the critical thinking skills of elementary school students in Bululawang Village, Blitar Regency?"*

Thus, this study, titled "The influence of digital accessibility and infrastructure on the critical thinking skills of elementary school students in Bululawang, Blitar regency," aims to explore the relationship between external factors and education, particularly in developing the critical thinking skills of elementary school students in Bululawang village.

2. Literature Review

Though often overlooked in development discourse, rural areas play a crucial role in a nation's social and economic structure. As urbanization accelerates, rural regions experience population decline and inadequate infrastructure development, limiting their ability to compete in a knowledge-driven economy (Yang and Wang, 2024). These structural challenges are particularly evident in education, where disparities between urban and rural areas persist, restricting social mobility, economic growth, and human capital development (Suhernik and Cahyani, 2020). One of the key educational barriers in rural areas is the limited development of students' higher-order thinking skills (HOTS), essential for fostering critical thinking and problem-solving abilities. Without adequate support for HOTS, rural students remain disadvantaged in the modern labour market and broader socioeconomic participation.

This study employs Bloom's Taxonomy as a conceptual framework to examine the barriers in rural education. Originally developed by Bloom (1956) and later revised by Anderson and Krathwohl (2001), the taxonomy categorizes cognitive development into six hierarchical levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. This model is particularly relevant in assessing cognitive skill development in rural education, where students often struggle to progress beyond lower-order thinking skills (LOTS), such as memorization and comprehension, due to insufficient pedagogical support (Qasrawi & Abdelrehman, 2020). The significance of this challenge extends beyond academic performance, as HOTS are instrumental in developing problem-solving abilities required in both professional and everyday contexts (Ngatminiati, Hidayah, and Suhono, 2024).

Education in Indonesia is not merely a means of knowledge transmission but also a vehicle for fostering national consciousness and identity. Hatta (1954) emphasized the importance of education in shaping Indonesian cultural identity. However, the structural limitations in rural education often compel parents to send their children outside their villages to seek better schooling. Riziq, Vazrin, and Prayitno (2023) argue that education is not isolated; we must work together. It means parent not only send their child but also guide their child. This phenomenon of educational migration further exacerbates disparities in learning quality, as rural schools remain under-resourced and ill-equipped to nurture HOTS effectively. Riziq et al. (2023) further argue that rural education is deeply entangled with socioeconomic conditions, meaning that any improvement in HOTS development must also address broader infrastructural and economic limitations.

The contemporary education landscape, shaped by digitalization and rapid technological advancement, presents opportunities and challenges for rural education. Education is increasingly

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perceived as an investment in human capital that enhances employment opportunities and quality of life (Riziq, Vazrin, and Prayitno, 2023). Over the past decade, digital learning has emerged as a potential solution to bridge rural-urban educational gaps by providing students with self-directed learning opportunities and access to cognitive skill development resources (Hasibuan et al., 2024). Afif (2019) argues that digital learning fosters engagement with project-based methods, which is crucial for transitioning students from LOTS to HOTS. However, despite its potential, the effective implementation of digital learning in rural areas is hindered by infrastructural and economic barriers, preventing students from fully benefiting from these technological advancements (Wicaksono, 2021).

One of the most promising aspects of digital education is integrating artificial intelligence (AI) into learning management systems. AI-driven education tools can personalize learning pathways, progressively challenging students to develop higher-order cognitive skills in line with Bloom's Taxonomy (Gursoy, 2024). This adaptive learning approach aligns with Ennis' (1996) conceptualization of critical thinking as a reflective decision-making process based on reasoned judgment. However, as Keta and Sinaj (2024) cautioned, the ethical implementation of digital education must ensure that technological advancements adhere to the principle of "*Faster, Better, Cheaper, but with Ethical Principles*." Without this ethical oversight, digital learning risks exacerbating existing inequalities rather than mitigating them.

Despite the theoretical advantages of digital learning, rural students face significant limitations in accessing digital tools. Economic constraints are a key factor, as illustrated by Ayuningtyas' (2024) analysis of rural household income, which reveals that self-employed agricultural workers earn an average monthly income of Rp1,462,600, making digital education a lower priority for household spending. This economic reality highlights the structural nature of the digital divide, demonstrating that the availability of technology alone is insufficient without addressing affordability and accessibility concerns.

The development of HOTS is particularly crucial in fostering critical thinking skills, which are essential in an era characterized by rapid technological change and information overload. Hamby (2015) defines critical thinking as the intellectual discipline required to evaluate information critically before forming conclusions. It aligns with Bloom's upper cognitive levels—Analyzing, Evaluating, and Creating—indicating that effective education must move beyond rote memorization to cultivate independent thought (Ngatminiati, Hidayah, and Suhono, 2024). However, as Dila et al. (2024) note, the lack of educational infrastructure in rural schools impedes the ability of students to develop these cognitive skills. Facilities such as well-equipped classrooms, modern learning media, and technological support systems are essential for promoting HOTS, yet they remain largely unavailable in rural settings.

This study employs Focus Group Discussions (FGD) to analyze elementary school students' critical thinking abilities within Bloom's Taxonomy framework. By engaging directly with students and educators, this research aims to identify barriers preventing cognitive skill progression beyond LOTS and explore potential interventions that could enhance HOTS development. Grounding the analysis in Bloom's Taxonomy allows for a structured understanding of how educational disparities in rural areas impact cognitive skill development, ultimately informing policy recommendations for fostering critical thinking and problem-solving abilities in rural education.

3. Method

The research design refers to the structured procedures used to collect and process data to obtain scientific knowledge (Telaumbanua et al., 2024). This study adopts a comparative research model based on Research Methods in Philosophy by Bakker and Zubair (1990). The study employs a mixed-method approach, combining quantitative statistical analysis and qualitative thematic interpretation to understand these relationships comprehensively.

The integration of qualitative and quantitative data occurs in two ways: (a) Descriptive statistical analysis of students' critical thinking scores (from FGD assessments), and (b) Thematic analysis of

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interviews, FGDs, and observational data offers contextual explanations for the observed statistical differences. Combining these methods ensures that the numerical results are not interpreted in isolation but supported by qualitative insights.

The qualitative data collection techniques used in this research include (1) interviews, (2) observations, (3) documentation studies, and (4) Focus group discussions (FGDs) (Rahardjo, 2011). In addition to data collection techniques, the data is classified into two types: primary and secondary. Primary data refers to data sources that directly provide information to the collector (Sugiyono, 2018). This study's primary data is obtained through interviews and FGDs during the community service program (KKN). Secondary data consists of literature reviews from books and previous research. The sampling method used in this study is purposive sampling, analyzed with a mixed-method approach involving descriptive statistical analysis for quantitative data and thematic analysis for qualitative data.

Table. 2 Assessment indicators

Indicator	Purpose
Clarity	Can students express their opinions clearly and understandably?
Depth	Are students able to explore solutions in detail and logically?
Relevance	Do students connect arguments with their experiences or knowledge?
Logic	Are students' arguments consistent and reasonable?
Collaboration	Are students actively collaborating in discussions?

The sampling method used in this study is purposive sampling, analyzed with a mixed-method approach involving descriptive statistical analysis for quantitative data and thematic analysis for qualitative data. The research procedure is divided into three stages: planning, implementation, and reporting. In the planning stage, the following activities are conducted: (a) Preparation of permission letters to conduct research and teaching at UPT SD Bululawang 01 and UPT SD Bululawang 02; (b) Conducting preliminary observations, creating a research schedule and formulating FGD topics and in-depth interview procedures; and (c) The field supervisor (DPL) / expert judgment validates the research instruments.

Collected data are analyzed using descriptive statistical analysis for quantitative data and thematic analysis for qualitative data. Statistical analysis is used to calculate the average scores of students' critical thinking skills based on FGD results, while thematic analysis is conducted through transcription and coding of qualitative data from discussions and interviews. A comparative test is performed as a follow-up step using the t-test or Mann-Whitney U test.

Table 3. FGD topics by week

Week	Discussion Topic	Purpose
1-2	Logical Problem Solving	To measure students' ability to analyze problems and generate
3-4	Social Situation Analysis	To observe how students understand conflict situations and evaluate
5-6	Evaluation of Information	To assess students' ability to distinguish between facts and opinions
7	Final Reflection	To compare students' development from the first week to the last

According to Anugerah (2024), the t-test is a statistical method used to compare the means of two data groups. Meanwhile, the Mann-Whitney test is a non-parametric test used to determine the differences in the median of two independent samples (Qolby, 2014). The choice between the t-test and the Mann-Whitney test depends on the characteristics of the data used in the analysis. If the data are of interval or ratio scale and meet the necessary assumptions, the t-test may be chosen. To operationalize the comparative model, the researcher divides participants into two groups based on digital accessibility, infrastructure, and learning conditions: (a) High access group, classified by better internet access, road conditions, and classroom facilities (UPT SD N Bululawang 01); (b) Low access

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group, characterized by limited digital infrastructure and less favourable learning environments (UPT SD N Bululawang 02); and (c) The comparison uses quantitative statistical tests and thematic analysis, ensuring a holistic understanding of how digital accessibility influences critical thinking skills.

4. Results

First, the FGD conducted at UPT SD Bululawang 01 (SD1) and UPT SD Bululawang 02 (SD2) underwent an observation phase lasting 1–1.5 hours per session. Next, the points presented by each student were recorded on the observation sheet, and finally, a t-test or Mann-Whitney U-test was conducted on the two samples. Different methods were used to compare the two groups—SD1 and SD2. SD1 refers to the school with better digital access and infrastructure than SD2. Since the data was not normally distributed—due to the differing sample sizes—the Mann-Whitney U-test was utilized for the analysis.

Table 4. FGD observation and assessment results

Assessment Results		**Bululawang 01 (n=55)**		**Bululawang 02 (n=34)**	
Week 1		n	%	n	%
	Clarity	4.0	72.73	3.2	52.94
	Depth	4.2	76.36	3.0	50.00
	Relevance	4.1	74.55	3.3	55.88
	Logic	4.1	74.55	2.9	47.06
	Collaboration	4.0	72.73	3.5	51.47
Week 2					
	Clarity	4..0	78.18	3.4	58.82
	Depth	4.1	74.55	3.1	54.41
	Relevance	4.3	78.18	3.5	58.82
	Logic	4.0	72.73	3.0	50.00
	Collaboration	4.4	80.00	3.6	52.94
Week 3					
	Clarity	4.2	76.36	4.2	61.76
	Depth	4.0	72.73	4.0	58.82
	Relevance	4.1	74.55	4.3	63.24
	Logic	4.0	72.73	4.1	60.00
	Collaboration	4.2	76.36	4.0	58.82
...	...	..		...	...
Week 7					
	Clarity	4.5	81.82	4.1	60.00
	Depth	4.4	80.00	4.2	61.76
	Relevance	4.6	83.64	4.3	63.24
	Logic	4.2	76.36	4.0	58.82
	Collaboration	4.3	78.18	4.4	64.71

Decision Making :
If the probability value of significance > 0.05, then Ho is accepted
If the probability value of significance < 0.05, then Ho is rejected.

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Table 5. Calculation between first week and last week

Value	Week-1		Week -7	
	SD1	SD2	SD 1	SD2
$\bar{X}$ Clarity	4.107	3.885	4.574	4.209
S	0.115	0.093	0.073	0.126
$\bar{X}$ Depth	4.182	3.985	4.690	4.188
S	0.122	0.093	0.084	0.134
$\bar{X}$ Relevance	4.058	3.812	4.500	4.218
S	0.057	0.130	0.065	0.131
$\bar{X}$ Logic	4.078	3.932	4.504	4.197
S	0.071	0.127	0.064	0.153
$\bar{X}$ Collaboration	4.027	3.885	4.490	4.171
S	0.065	0.093	0.064	0.151

The comparison between Week 1 and Week 7 shows that both schools improved, but the gap between them persisted. For example, SD1 consistently scored higher in all domains, suggesting that better digital access and infrastructure may contribute to stronger critical thinking and collaboration skills.

Table 6. Results of Mann-Whitney test for week 1 & week 7

Value	Weeks	Minggu ke-7
u1	8995.0	9984.0
p1	1.67×10^{-22}	4.14×10^{-34}
u2	8840.0	9993.0
p2	6.51×10^{-21}	3.16×10^{-34}
u3	9664.0	9337.0
p3	4.44×10^{-30}	3.12×10^{-26}
u4	8760.0	9776.0
p4	4.08×10^{-20}	1.85×10^{-31}
u5	8686.0	9683.0
p5	2.15×10^{-19}	2.60×10^{-30}

Data showed that all p-values obtained (below 1.67 x 10^-22 for Week 1 and 1.85 x 10^-31 for Week 7) are far below the threshold of 0.05; thus, H0 is rejected. It indicates a significant change in the values between the two measured weeks, highlighting important dynamics in the analyzed data. Therefore, there is a significant difference in critical thinking skills between the two groups. Then, the following compares the average data without using the Mann-Whitney test, where the scores of 89 students between SD1 and SD2, which are different groups, were compared. The results indicate a gap in abilities. Once again, these scores were obtained by involving 10 researchers who assessed the students based on the given indicators, as shown in the following histogram.

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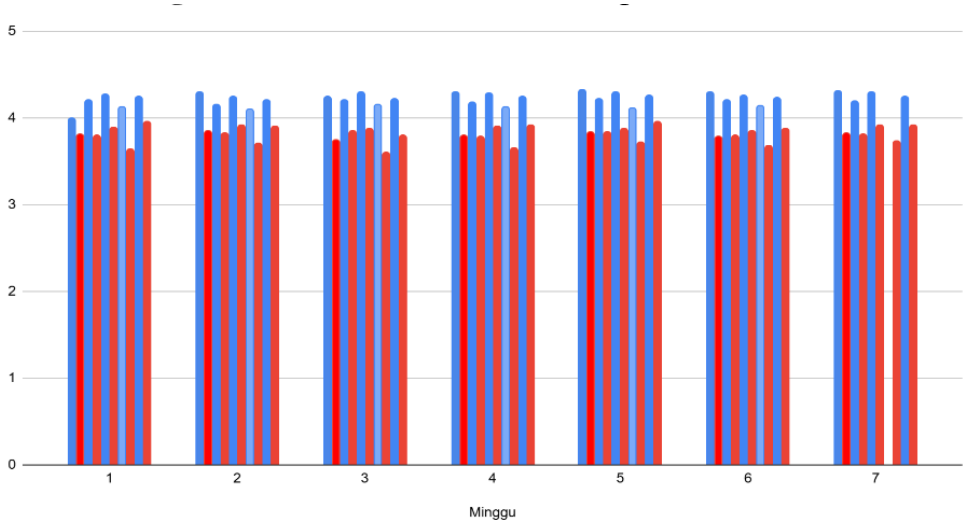

Figure. 1 Histogram (Blue SD1; Red SD2).

Secondly, the researcher sought to identify the differences between SD1 and SD2 to understand the reasons behind the gap in critical thinking skills in the two schools in Bululawang Village. The researcher conducted field observations. The documentation results from the observations indicate a significant difference, particularly concerning road infrastructure. SD1 (in red) has well-paved asphalt roads, while SD2 (in blue) only has dirt and stone roads, creating a difference in access. The availability of good roads at SD1 allows for easier access to support economic activities and other events. In contrast, the damaged and limited roads at SD2 may hinder mobility and reduce opportunities for students and the community to access resources.

Figure. 2 Infrastructure condition (Blue SD1; Red SD2).

Furthermore, interviews were conducted with teachers and students to delve into the impact of infrastructure and digitalization on learning. These interviews are essential because they provide direct perspectives from those involved in the daily learning process. Through interviews, the researcher can gather in-depth information about how existing infrastructure affects the quality of education, the interaction between students and teachers, and the use of technology in learning. Interviews allow researchers to capture experiences and challenges that quantitative data may not reveal. They allow participants to express their thoughts, feelings, and insights in their own words, leading to a richer understanding of the educational context. Additionally, interviews can uncover nuanced issues and subjective experiences that surveys or observational data might overlook, thus enhancing the overall research findings.

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In this study, we conducted both indirect and direct interviews during teaching sessions or post-FGD discussions with teachers and students. In rural areas of Indonesia, it is often challenging to obtain complete answers when formal interviews are conducted. Therefore, we primarily relied on indirect interviews to promote flexibility in data collection and encourage openness among participants. This approach makes respondents feel more comfortable sharing their thoughts and experiences, leading to richer and more nuanced data. Indirect interviews can facilitate a more conversational atmosphere, which is particularly beneficial in settings where formal interactions might inhibit candid responses.

Table 7. Interview results – illustrative data on learning in various categories

Domain	Description	Bululawang 01	Bululawang 02
Digital Accessibility	Availability and use of digital technology in the learning process.	"The internet here is indeed slow, but we always find ways to stay connected to useful information." — Teacher.	"The signal here is nonexistent. We struggle to get the information we need." — 4th-grade student
Infrastructure	Quality and availability of physical facilities that support learning.	"Our classroom is quite comfortable, but we still lack some facilities." — 6th-grade student	"The lack of facilities and resources makes our challenges even greater." — Teacher.
Critical Thinking Development	Students' ability to think critically and analyze the information they receive.	"We try to encourage students to think more critically, but they still need more guidance." — Teacher.	"Without a clear curriculum, we struggle to guide students to think critically." — Teacher.
Collaborative Learning	Collaborative learning experiences among students to enhance critical thinking skills.	"We sometimes learn in groups, but it is not always effective." — 6th-grade student	"We rarely do group work but spend more time playing volleyball." — 3rd-grade student
Learning Resources	Availability of diverse learning resources, both digital and physical, to support learning.	"We strive to present various learning materials, even though our resources are limited." — Teacher.	"The limitations of learning resources make it difficult for us to enrich the material being taught." — Teacher.

Thirdly, the researchers interviewed several times with teachers and students. Based on the interviews conducted with teachers and students at both schools, there were notable differences in several domains of learning that affected the learning experiences at UPT SD Bululawang 01 (SD1) and UPT SD Bululawang 02 (SD2). The disparity in digital accessibility between SD1 and SD2 underscores a critical challenge in rural education: the uneven distribution of technological infrastructure. In SD1, while slow internet connectivity poses a barrier, teachers and students demonstrate resilience by finding ways to stay connected to useful information. It suggests a degree of adaptability and resourcefulness, but it also highlights the limitations of existing infrastructure. Slow internet speeds can disrupt online learning, hinder access to real-time information, and limit digital tools that require stable connections, such as video conferencing or interactive platforms.

In contrast, SD2 faces a more severe issue with the complete absence of a signal, effectively cutting students off from digital resources altogether. This stark difference points to systemic inequities in allocating technological resources, likely influenced by geographical isolation, lack of investment, or prioritization of more accessible areas. The digital divide between these schools affects students' ability to access information and perpetuates educational inequalities, as students in SD2

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are denied opportunities to develop digital literacy skills that are increasingly essential in the modern workforce. Addressing this issue requires more than just infrastructure development; it necessitates targeted policies that ensure equitable access to technology and training programs to help teachers and students effectively utilize digital tools.

Infrastructure challenges in both schools reveal a deeper issue of underinvestment in rural education. At SD1, while classrooms are described as comfortable, the lack of certain facilities—such as science labs, libraries, or updated teaching aids—limits the quality of education. For instance, the absence of a science lab restricts students' ability to engage in hands-on experiments, which are crucial for understanding scientific concepts. Similarly, lacking a library or diverse learning materials narrows students' exposure to knowledge, confining them to a limited curriculum. In SD2, the situation is more dire, with the lack of basic facilities exacerbating challenges in the learning process. Poor infrastructure affects academic performance, students' motivation, and sense of self-worth, as they may perceive their education as less valued than their urban counterparts. These infrastructure gaps are symptomatic of broader funding disparities between urban and rural areas, where rural schools often receive less financial support due to lower economic activity in their regions. It creates a vicious cycle: poor infrastructure leads to lower educational outcomes, limiting economic development and perpetuating underinvestment. Breaking this cycle requires a multi-pronged approach, including increased government funding, community-driven initiatives, and partnerships with NGOs or private sector organizations to bridge the resource gap.

The development of critical thinking skills emerges as a significant challenge in both schools, albeit for different reasons. At SD1, teachers acknowledge their efforts to encourage critical thinking but admit that students still require more guidance. It suggests a gap in pedagogical strategies, where traditional teaching methods may prioritize rote learning over analytical or problem-solving skills. At SD2, the lack of a clear curriculum further complicates matters as teachers struggle to provide structured guidance in fostering critical thinking. It highlights a systemic issue in rural education, where curricula are often not tailored to local contexts or the needs of 21st-century learners. Critical thinking is essential for students to navigate an increasingly complex world, yet limited resources, inadequate teacher training, and a lack of emphasis in the curriculum hinder its development. To address this, schools could adopt project-based learning approaches that encourage students to analyze, evaluate, and create solutions to real-world problems. Additionally, teacher training programs should equip educators with the skills to facilitate critical thinking, such as asking open-ended questions, promoting classroom discussions, and integrating interdisciplinary topics into lessons.

Collaborative learning reveals a stark contrast between the two schools, reflecting broader challenges in fostering teamwork and cooperation in rural settings. At SD1, students participate in group learning, but its effectiveness is limited, suggesting a need for more structured and purposeful collaborative activities. At SD2, collaborative learning is almost absent from academic activities, with students developing teamwork skills through non-academic pursuits like volleyball instead. While this demonstrates that collaboration can be nurtured outside the classroom, it also highlights a missed opportunity to integrate these skills into the academic curriculum. Collaborative learning is crucial for developing communication, problem-solving, and interpersonal skills, all essential for success in the modern workforce. The lack of emphasis on academic collaboration at SD2 may stem from teacher training, limited resources, or a curriculum prioritizing individual achievement over group work. To address this, schools could introduce structured group projects, peer-to-peer learning activities, and teacher training programs focused on collaborative teaching methods. Additionally, integrating non-academic activities like sports into the broader educational framework could help bridge the gap between academic and social skill development.

Finally, regarding learning resources, teachers at SD1 made efforts to present varied learning materials despite their limitations, while teachers at SD2 felt that the scarcity of learning resources severely impacted the quality of the materials being taught. Education is a crucial component in the development of a country, and educational management is the process of implementing educational strategies that effectively utilize resources to achieve educational goals (Ajmila, Sulistianingsih, and

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A'yun, 2023). Therefore, a good education is vital and significant because it plays a critical role in achieving the nation's and country's aspirations (Baro'ah, 2020). Thus, all aspects of education need attention, focusing on one factor and multiple disciplines, such as accessibility.

5. Discussion

The findings of this study reveal significant differences in critical thinking and collaborative learning skills between students at UPT SD Bululawang 01 (SD1) and UPT SD Bululawang 02 (SD2), as evidenced by the results of the Mann-Whitney U test. The p-values obtained (e.g., 1.67 x 10^-22 for Week 1 and 1.85 x 10^-31 for Week 7) indicate that the differences between the two schools are statistically significant and not due to random chance. It underscores the impact of varying digital access and infrastructure levels on educational outcomes in rural areas.

Key findings and interpretation: (a) Digital Access and Infrastructure, SD1, which has better digital access and infrastructure, consistently outperformed SD2 across all domains (clarity, depth, relevance, logic, and collaboration). It aligns with previous research highlighting the role of technology in enhancing learning outcomes (Hasibuan et al., 2024). The availability of digital tools and internet connectivity likely enabled students at SD1 to access a wider range of learning resources, engage in self-directed learning, and participate in collaborative activities more effectively. In contrast, the absence of a reliable internet connection at SD2 severely limited students' ability to access information and develop critical thinking skills, perpetuating educational inequities; (b) Improvement over time: Both schools improved critical thinking and collaboration skills from Week 1 to Week 7, as indicated by the increase in average scores. However, the gap between SD1 and SD2 persisted, suggesting that while interventions or natural learning progression may have benefited both groups, the underlying disparities in resources and infrastructure remained a significant barrier for SD2. This finding highlights the need for targeted interventions to address the specific challenges faced by schools with limited resources; and (c) Collaborative learning: The results also reveal differences in collaborative learning experiences between the two schools. At SD1, students engaged in group activities, albeit with varying levels of effectiveness. At SD2, collaborative learning was largely absent from academic activities, with students developing teamwork skills through non-academic pursuits like volleyball. While this demonstrates that collaboration can be nurtured outside the classroom, it also underscores the need to integrate collaborative learning into the academic curriculum to ensure students develop these skills in an educational context.

6. Conclusion and Implications

Throughout the research period, this research aims to explore the differences in critical thinking skills between two groups of students, namely UPT SD N Bululawang 01 (SD1) and UPT SD N Bululawang 02 (SD2). SD1 is a school with better digital access and infrastructure than SD2: (a) Difference in critical thinking skills: The p-values obtained from all measurements (below 1.67 x 10^-22 for the first week and 1.85 x 10^-31 for the last week) are far below the significance threshold of 0.05, indicating that H0 is rejected. This low p-value provides evidence of a significant difference in critical thinking skills between SD1 and SD2; (b) Digital accessibility and infrastructure: The availability of better infrastructure at SD1 facilitates students' access to educational resources and services, while the less supportive conditions at SD2 create challenges; and (c) Reasons for the critical thinking gap: The research reveals that despite teachers' efforts to develop students' critical thinking abilities, different challenges are faced.

Conclusions were derived from a comprehensive quantitative and qualitative data analysis collected throughout the research period. For the critical thinking skills assessment, pre-and post-test results were statistically analyzed, revealing significant differences in performance between students at SD1 and SD2. The remarkably low p-values indicate that the differences observed were not due to random chance, thus confirming the hypothesis that students' critical thinking skills vary based on the

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educational context. Regarding digital accessibility and infrastructure, the study provided clear insights into how the availability of modern resources at SD1 enhances student engagement and learning outcomes. Conversely, SD2's lack of adequate infrastructure posed significant barriers to student learning, reinforcing that access to quality resources is crucial for effective education.

Examining the reasons behind the critical thinking gap highlighted the distinct challenges faced by educators in both environments. While both schools aimed to foster critical thinking, the obstacles encountered—such as unclear curriculum guidelines at SD2—revealed the complexities of implementing effective educational strategies in diverse contexts. The findings of this research align with the study's objectives, demonstrating that differences in educational environment significantly impact students' critical thinking skills. By illuminating the relationship between infrastructure, digital accessibility, and student outcomes, the research underscores the importance of creating supportive educational settings to promote critical thinking and effective learning.

The findings of this study have important implications for educational policy and practice, particularly in rural areas: (a) Equitable access to technology: The disparity in digital access between SD1 and SD2 highlights the urgent need for policies that ensure the equitable distribution of technological resources in rural schools. Initiatives such as expanding internet infrastructure, providing affordable devices, and offering digital literacy training for teachers and students could help bridge the digital divide; (b) Teacher training and curriculum development: As reported by teachers, the lack of clarity in the curriculum at SD2 points to the need for curriculum reforms that emphasize critical thinking and collaborative learning. Additionally, teacher training programs should equip educators with the skills to facilitate these competencies, even in resource-constrained settings effectively; and (c) Community and stakeholder engagement: Addressing rural schools' challenges requires a collaborative effort involving local governments, communities, and non-governmental organizations. For example, community-driven initiatives could help improve infrastructure, while partnerships with NGOs could provide additional resources and teacher training.

7. Limitation

Based on the conclusions, further research should be conducted, especially regarding areas we did not address: (a) The role of village government: Future research could focus on analyzing the role of the village government in enhancing the accessibility of educational infrastructure. Examining the policies implemented and the contributions of local government in educational infrastructure development can provide deeper insights into factors influencing students' critical thinking abilities; (b) Sample size and generalizability: The unequal sample sizes (n=55 for SD1 and n=34 for SD2) and the focus on two schools in a specific region limit the generalizability of the findings. Future studies could include a larger and more diverse sample to validate these results; (c) Role of parents: Parents significantly influence their children's education. Further research is needed to explore how parental involvement in education shapes children's critical thinking patterns. Additionally, it is important to understand how parents' expectations and attitudes toward education can impact their children's critical mindset; and (d) Other factors affecting accessibility: This research could include other factors influencing infrastructure and educational accessibility, such as economic conditions. Understanding the social and economic contexts surrounding schools can help formulate more effective policies to address educational disparities.

Credit authorship contribution statement

Aryasatya Rafa Prayitno: Conceptualization, Methodology, Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review & Editing, Supervision, Project Administration. (Led the research design, developed the FGD criteria, determined the research direction and methodology, analyzed the data, and wrote the manuscript.). **Angelina Sekar Larasati** : Data Collection (SD1), Resources, Validation. (Collected data at SD1 and contributed to resource gathering and validation of findings.). **Azka Putri Akbar**: Data Collection (SD1), Resources, Validation. (Collected data at SD1 and contributed to resource gathering and validation of findings.).

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