When Digitalizing Education VS Infrastructure Constraints: How School Leadership Manages AI-Based Learning?

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Abstract
Artificial intelligence (AI) is increasingly promoted in education, yet its implementation remains uneven, particularly in schools with limited infrastructure. This study examines how school principals manage AI-based learning in infrastructure-constrained settings and how leadership practices are adapted to local realities. The paper aims to analyze the contextual leadership practices of principals in managing AI-based learning in public junior high schools in Aceh Besar, Indonesia, with a focus on vision and local policy, teacher capacity building, infrastructure and resource management, and stakeholder collaboration. Used a qualitative phenomenological design, data were collected through semi-structured interviews, field notes, school documents, and limited observation, and were analyzed using six stages of thematic analysis. The findings reveal four interrelated patterns: AI was positioned as a practical tool rather than a systemic transformation; teacher capacity was developed mainly through internal, practice-based learning; infrastructure limitations shaped adaptive strategies such as offline materials and shared device use; and collaboration with teachers, parents, and school committees became an essential support mechanism. These findings showed that AI implementation in constrained environments does not follow a linear digital transformation model but evolves through incremental, context-driven adaptation. The study concludes that principal leadership in such settings is best understood as contextualized AI leadership, in which infrastructural limitations, teacher capacity, and social capital are integrated into a responsive and sustainable leadership approach.

1. Introduction

The development of artificial intelligence (AI) in education opens up vast opportunities to enhance personalized learning, improve teacher efficiency, and enable data-driven decision-making (Chen et al., 2020; Kamalov et al., 2023). However, UNESCO emphasizes that the use of AI also brings ethical risks, privacy issues, potential biases, and governance challenges that could widen the gap if not properly regulated (Bond et al., 2024). Therefore, AI in education cannot be understood solely as a technological issue, but also as a matter of leadership and educational policy (Bahroun et al., 2023; Chen et al., 2020). At the international level, the implementation of AI in schools showed increasingly tangible progress, but the adoption rate still varies significantly between countries. OECD through TALIS 2024 reported that about one-third of teachers use AI in their work, with significant variation across education systems (Bond et al., 2024). These findings indicated that the mere availability of technology is not sufficient to ensure meaningful AI integration in schools; the readiness of the school ecosystem, organizational culture, and leadership capacity are determining factors in managing AI-based learning (Ali et al., 2024).

In Indonesia, the process of digital transformation in the field of education continues to accelerate through various policies implemented and increased internet access. The Central Statistics Agency recorded that in 2024, 72.78 percent of Indonesia's population had accessed the internet (Hazin et al., 2025; Nashrullah et al., 2025). However, the increase in access to digital facilities has not been fully supported by the readiness of infrastructure at the school level. The Central Statistics Agency also noted that the percentage of junior high schools with access to computers still reaches 27.10 percent (Astari & Yulianto, 2025; Prihatin, 2025). This condition highlights a significant disparity between the national plan for digital development and the schools' ability to implement it, particularly in areas with limited resources (Asadoma et al., 2025; Hazin et al., 2025; Revaldhi et al., 2025).

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De jure, the role of the principal as a strategic actor in educational transformation has been affirmed in the Regulation of the Director General of Teachers and Educational Personnel Number 7327/B.B1/HK.03.01/2023 concerning the Principal Competency Model (Perdirjen, 2023; Ramadhan et al., 2024). This regulation states that one of the professional duties of a school principal is to lead learning that meets the needs of students. This policy serves as a reference for the development of competency mapping instruments, performance assessments, and continuous competency development (Dewi, 2023; Ramadhan et al., 2024). Thus, school principals have formal legitimacy as well as strategic responsibility in directing the implementation of technology-based learning, including AI (Dewi, 2023; Kartini, 2023). In practice, many schools, especially in areas with limited infrastructure, still face issues of unstable electricity, limited internet access, and a lack of adequate digital devices (Graves et al., 2021; Olanrewaju et al., 2021). These limitations make the implementation of AI not uniform, but rather must be adjusted to local conditions, teacher capacity, and available resource support (Castro et al., 2025; Lin et al., 2023). Therefore, managing AI-based learning requires school principals not only to understand the technology but also to be able to guide changes contextually and gradually.

Several studies have shown that school leadership influences teacher readiness, pedagogical innovation, and technology adoption in schools (Ghamrawi et al., 2024; Yang et al., 2024). However, most of these studies still start from the assumption that schools have relatively adequate infrastructure (Ruloff & Petko, 2025; Sliwka et al., 2024). As a result, there is still a limited understanding of how school leadership operates in the context of infrastructure limitations, especially when AI begins to enter learning spaces as an operational aid, rather than as a fully integrated digital system (Olanrewaju et al., 2021; Sliwka et al., 2024).

These conditions indicated a significant research gap. First, there are still limited studies that integrated school leadership and AI-based learning management within a comprehensive analytical framework. Second, existing research generally has not adequately explained how leadership practices are implemented in schools with limitations in electricity, internet, and devices. Therefore, the context of this research becomes relevant to understand how school principals adaptively manage AI in less-than-ideal situations. Based on this background, this research is directed to analyze the leadership practices of school principals in managing AI-based learning in public junior high schools in areas with limited infrastructure in Aceh Besar Regency. Specifically, this research focused on how local vision and policies are built, how teacher capacity is developed, how resources are managed, and how collaboration with stakeholders is adaptively carried out in the context of limitations.

This study addresses three research concerns in accordance with the identified gap: how do school principals manage AI-based learning in the context of infrastructure limitations? From the main question, this research is divided into four sub-questions: 1) How do school principals formulate local visions and policies related to AI; 2) How is the capacity of teachers developed; 3) How is infrastructure and resources managed; and 4) How is collaboration with stakeholders conducted. According to the problem formulation, this study intends to perform a thorough analysis of the principal's leadership practices in managing AI-based learning contextually, with a focus on the process of adapting to infrastructure constraints, enhancing teacher capacity, managing resources, and fostering collaboration within the school setting.

The concept of contextualized digital leadership in constrained environments, a leadership framework that explicitly positions infrastructure limitations not just as obstacles but as constitutive variables shaping leadership practices in AI integration, is what makes this research novel. This research showed that AI deployment in limited circumstances happens through adaptive, incremental, and socially capital-based tactics, in contrast to other studies that typically begin with the premise of adequate resource availability. Thus, by offering a more realistic contextual perspective on the conditions of schools in disadvantaged locations, this research conceptually broadens the study of digital leadership. Practically speaking, the research's conclusions offer an empirical foundation for developing inclusive, adaptable, and long-lasting school leadership practices and policies when using AI. Practically, the findings of this research provide an empirical basis for formulating school leadership policies and practices that are more inclusive, flexible, and sustainable in implementing AI in resource-constrained environments.

2. Method

2.1. Research Design

This study employed a phenomenological design and a qualitative methodology (Alhazmi & Kaufmann, 2022; Neubauer et al., 2019). This approach was used in order to gain a thorough understanding of how school principals and teachers manage AI-based learning in institutions with limited infrastructure (Sibeoni et al., 2021; Sundler et al., 2019). When evaluating leadership practices, adaptation techniques, challenges, and operational decision-making in a constrained digital context, the phenomenological methodology enables researchers to capture the subjective meaning of participants' experiences (Alhazmi & Kaufmann, 2022; Neubauer et al., 2019). In order to ensure that the meanings generated in this study are genuinely derived from the experiences of the participants, the researcher used the bracketing concept. This method used actual data

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from the field to offer the research report in a descriptive manner that thoroughly illustrates the phenomenon under study.

2.2. Participant

This study was carried out at a public junior high school in Aceh Besar Regency, Indonesia, which is in a location with poor infrastructure, particularly access to electricity, the internet, and digital gadgets (Campbell et al., 2020; Olanrewaju et al., 2021). The location was chosen purposefully, taking into account the school's characteristics, which represent the environment of infrastructure restrictions and have already established beginning practices of using technology or AI in learning (Alhazmi & Kaufmann, 2022; Ravi et al., 2021). Purposive sampling methods with clearly stated criteria were used to choose participants in order to guarantee conformity with the goals of the study. Three primary factors were taken into account when choosing participants: (1) direct involvement in managing or implementing learning in schools; (2) experience utilizing or adapting digital/AI technology under constraints; and (3) understanding of the dynamics of policy and learning practices at the school level (Ahmad & Wilkins, 2025; Campbell et al., 2020). Refer to Table 1.

Table 1. Purposive Sampling Criteria

Code	Participant Category	Academic Qualification	Inclusion Criteria
P1	School Principal	Bachelor's in Education	Serving for at least 1 year in the target school, having a key role in policy-making and learning management, involved in decision-making related to the use of technology/AI under conditions of infrastructure limitations.
P2 – P10	Teachers	Bachelor's in Education	Having at least 2 years of teaching experience in targeted schools, having used or tried digital/AI technology in learning, and being actively involved in learning practices under conditions of infrastructure limitations.
P11 – P12	Supervisor/school committee/parents	-	Having direct involvement in monitoring, support, or collaboration with schools, understanding school policies related to digital learning, and having experience interacting with technology-based learning practices in schools.

A total of 12 participants were selected for this study using Table 1. They were picked because they have empirical experience that is relevant to the topic under study, in addition to their role importance.

2.3. Instruments and Techniques for Data Collection

This study's primary tool is a semi-structured interview guide that was created using sub-indicators of the principal's professional competence in directing and overseeing learning in accordance with students' needs (Aquino et al., 2025; Ralebese et al., 2025). The creation of this tool relates to the primary areas of learning leadership, which include: (1) comprehending the learning needs of students; (2) developing local vision and policies regarding the use of AI; (3) organizing instruction, teachers, and resources; (4) managing infrastructure and learning facilities under constraints; (5) putting supervision, mentoring, and learning evaluation into practice; and (6) fostering collaboration with stakeholders (Aquino et al., 2025; Ralebese et al., 2025). According to the phenomenological approach, each area is expanded into adaptable open-ended questions that enable a thorough investigation of contextual leadership experiences, tactics, and practices (Campbell et al., 2020).

Semi-structured in-depth interviews served as the primary method of data gathering (Adeoye-Olatunde & Olenik, 2021). The purpose of the interviews was to investigate participants' perspectives, experiences, and interpretations of leadership practices in AI-based learning management. Each interview lasted roughly 45 to 60 minutes, was videotaped with participants' permission, and was verbatim transcribed to ensure the accuracy of the data. In addition to interviews, field notes, brief observations of the school environment, and examination of pertinent documents such as the School Work Plan, meeting minutes, and school policy instruments are used to support data collection. The goal of using many data sources is to increase trust through triangulation, resulting in rich, comprehensive, and mutually reinforcing data (Hitt & Tucker, 2016).

2.4. Data Analysis Technique

Six steps of a thematic analysis method based on Ahmed et al. (2025) were used in this study's data analysis. In order to fully comprehend the data context and discover preliminary impressions of the phenomenon under study, the researcher regularly reads interview transcripts, field notes, and documents during the familiarization stage of the analysis process. The researcher then identifies units of meaning pertinent to the research focus, namely those pertaining to leadership practices in AI-based learning management, in order to generate initial codes. In order to identify thematic patterns that arose from the data, the next step is to search for themes. To do this, the initial codes that have been generated are sorted into larger groups. Following that, the reviewing themes stage is carried out to confirm the coherence and consistency of the themes as well as to reevaluate the alignment between the developed themes and the empirical facts. The

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stage of defining and naming themes, which entails determining the fundamental meaning and identifying the themes that conceptually describe the phenomenon, further develops the validated themes. Writing the report is the last step, which entails assembling the analysis findings into a methodical, persuasive story backed by factual data from the field (Ahmed et al., 2025).

To guarantee depth of interpretation, the entire analysis process is carried out iteratively, with researchers constantly comparing data, codes, and themes. Beginning with the data gathering phase in January and continuing in parallel with the data analysis procedure until March 2026, this study method took around four months to complete. The researchers were able to continuously modify the emphasis of inquiry based on early results in the field since the theme analysis was carried out concurrently from the beginning of data collection rather than linearly after all the data was collected. NVivo 14 software was used for data management in order to facilitate transparency and traceability of the analytical process. Additionally, source triangulation, member checking, and audit trails were used in this study to preserve the findings' integrity and guarantee that the interpretation results could be held to academic standards.

2.5. Ethical Considerations

The guidelines of social and educational research ethics are taken into consideration when conducting this study. Prior to gathering data, the researcher used the informed consent process to get participants' written approval and permission from the relevant authorities. The goal of the study, their choice to decline or stop taking part, and the assurance of data confidentiality were all explained to the participants. Each participant was given a code, ranging from P1 to P12, and so on, based on the chronology of the interviews, in order to preserve their anonymity. Anonymization is also applied to school names, localities, and other identifying details that might identify individuals. Only the study team has secure access to digital material, such as recordings and interview transcripts.

3. Results and Discussion

3.1. Results

The primary research question of this study is how school principals oversee AI-based learning in settings with limited infrastructure. This question is further broken down into four interconnected dimensions: stakeholder collaboration, infrastructure and resource management, teacher capacity development, and local vision and policies. Four major themes that directly relate to these qualities emerged from the thematic analysis of field notes, school papers, and interviews. Refer to Figure 1.

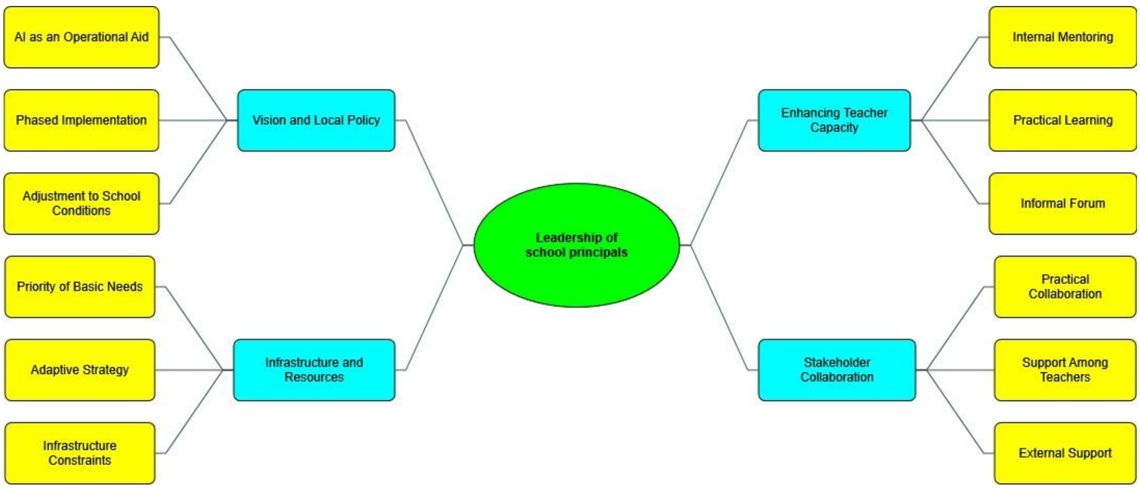

Figure 1. Mind Map of Data Analysis Results

When taken as a whole, these themes demonstrated that the contextual application of AI-based learning in schools with limited infrastructure is mostly shaped by the leadership of school administrators. In order to give an empirical picture of the practices, tactics, and limitations that the participants faced, the results are presented descriptively. Figure 1 illustrates how the principal's leadership serves as a key factor in coordinating and integrating the four primary facets of AI-based learning management. When taken as a whole, these themes demonstrated that the contextual application of AI-based learning in schools with limited infrastructure is mostly shaped by the leadership of school administrators. In order to give an empirical picture of the practices, tactics, and limitations that the participants faced, the results are presented descriptively. Figure 1 illustrates how the principal's leadership serves as a key factor in coordinating and integrating the four primary facets of AI-based learning management.

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Table 2 provides a methodical mapping between the primary themes, sub-themes, and sources of empirical information supporting each category in order to support these conclusions. This mapping confirms that all of the elements in Figure 1 are conceptual and consistently identified from a variety of data sources, such as school records, observations, and interviews. As a result, the connections between themes and subthemes not only showed an analytical structure but also represent leadership practices that are shaped by the interplay of infrastructure conditions, teacher capacity, policy direction, and contextual school environment support.

Table 2. Summary of Themes, Subthemes, and Evidence Sources

Main Themes	Subthemes	Primary Sources of Evidence
Vision and Local Policy	AI as an Operational Aid, Phased Implementation, and Adjustment to School Conditions	Interviews with school principals, school documents, and meeting observations
Enhancing Teacher Capacity	Internal Mentoring, Practical Learning, and Informal Forum	Principal and teacher interviews, and field notes
Infrastructure and Resources	Infrastructure Constraints, Adaptive Strategy, and Priority of Basic Needs	Interviews, observations, and school inventory documentation
Stakeholder Collaboration	External Support, Support Among Teachers, and Practical Collaboration	Interviews, meeting minutes, and collaboration documents

Table 2 showed that every theme found in the thematic map has a consistent empirical foundation and is backed by a variety of complementary data sources, including observations, interviews, and school records. This consistency confirms that the four primary elements shown in Figure 1 represent the leadership practices that are actually used in the field, in addition to acting as a conceptual framework. Additionally, the connections between themes and sub-themes showed that the management of AI-based learning is formed by the mutually influencing interactions between infrastructure conditions, teacher capacity, policy direction, and school environment support. To put it another way, the principal's leadership techniques in this situation are contextual, adaptive, and integrative to the constraints encountered.

3.1.1. Vision and Local Policy

The results demonstrated that the vision and AI policies in schools are developed contextually in accordance with the demands of the school and the constraints encountered, rather than as formal, strict, and standardized programs. As a result, the principal's leadership in this area seems to be more of an adaptive approach that directs the progressive and useful application of AI. According to data, teachers and school principals view AI mainly as an operational tool to help with the creation of instructional materials, the construction of lesson plans, and the performance of administrative duties. The goal of using AI is to promote learning and increase job productivity, not to take the place of teachers. The statements made by the participants reflect this:

> "We do not see AI as something that should be fully implemented right away, but rather as a tool to assist in making teachers' jobs easier." — P1 — School Principal, 2 years of experience.

This view demonstrated that the policies being drafted were still pragmatic and focused on the school's operating requirements. Moreover, it seems that AI-related policies are being established gradually. Discussions concerning AI are more frequently found in the context of practical needs, such as the creation of instructional materials or teacher productivity, rather than as a formal and distinct digital transformation agenda, according to school records and meeting observations. As a result, rather than through direct and thorough policy acceptance, AI is implemented in schools through an adjustment process that takes into account the internal dynamics of the institutions. These studies also suggest that judgments about using AI are significantly influenced by the school's actual conditions, particularly infrastructure and human resource limits. Principals and teachers stressed that AI implementation cannot be done uniformly, but must be tailored to the local situation. The participants' statements reflect this:

> "The use of AI still needs to be adjusted to the limited conditions of our school. It cannot be equated with schools that have complete facilities." — P2 — Teacher, 7 years of experience.

Therefore, in this setting, the vision and local policies are not only administrative documents but rather a leadership direction that strikes a balance between the school's empirical conditions and learning demands.

3.1.1.1. AI as an Operational Aid

According to the data, principals and teachers view AI as a tool that helps with operational work, especially when it comes to creating instructional materials, coming up with lesson plans, and finishing administrative

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duties. The goal of using AI is to enhance efficiency and offer options in the learning process, not to take the place of teachers.

> "We do not see AI as something that should be fully implemented right away, but rather as a tool to assist in making teachers' jobs easier." — P1 — School Principal, 2 years of experience.

The quotation demonstrated that the understanding of AI in the context of the schools under study is still functional, i.e., it supports educational activities rather than acting as a primary system that completely changes the educational process. This pattern, which reflects a pragmatic and contextual implementation perspective, is regularly seen across a number of participants who highlight the usage of AI on a small scale and based on needs.

3.1.1.2. Phased Implementation

The results also showed that rather than emerging as a distinct digital transformation agenda, conversations on AI more frequently occur in the context of practical needs, such as the creation of instructional materials or the effectiveness of teachers' work. This is consistent with the experiences of educators, who claim that the application of AI evolves progressively in accordance with learning requirements.

> "The use of AI still needs to be adjusted to the limited conditions of our school, it cannot be equated with schools that have complete facilities." — P2 — Teacher, 7 years of experience.

Furthermore, the viewpoint of the stakeholders demonstrated that the adoption of AI is motivated by practical needs at the school level rather than by formal, organized rules.

> "The use of technology like AI usually develops on its own according to the school's needs, there isn't an immediate special program." — P3 — Teacher, 4 years of experience.

These results suggest that AI is implemented through a process of gradual adaptation that follows the school's internal dynamics, leading to evolutionary policies rather than those that are the product of strict strategic planning. Therefore, rather than enforcing top-down, uniform regulations, leadership approaches in this setting promote adaptability and responsiveness to actual demands.

3.1.1.3. Adjustment to School Conditions

According to interview data, the real state of the school, specifically, its infrastructure and human resource constraints, has a significant impact on judgments on the deployment of AI. Teachers and principals highlighted that AI adoption must be tailored to each school's unique local environment rather than being uniform.

> "The use of AI should be adjusted to the conditions of our limited school, it cannot be equated with schools that have complete facilities." — P2 — Teacher, 7 years of experience.

The quotation showed that the readiness of the school ecosystem as a whole, in addition to the availability of technology, is the primary factor to be taken into account while using AI. These results suggest that a contextual approach is employed, in which decisions about implementation are developed by weighing learning requirements against available resources.

3.1.2. Enhancing Teacher Capacity

The results showed that internal school methods that are practical, collaborative, and needs-based are more important for teacher capacity development than formal, structured training. The principle promoted the development of teachers' capacity in the face of constraints by ongoing informal conversations, direct instruction, and internal mentoring. Internal mentorship is one of the primary methods of developing teacher capacity. According to data, teachers shared their experiences and methods for utilizing technology in the classroom, and more experienced educators frequently serve as mentors to their colleagues. The statements made by the participants demonstrated this:

> "We often learn from fellow teachers; if someone already knows, we usually share immediately." — P3 — Teacher, 4 years of experience.

These results suggest that rather than a strict top-down strategy, teachers' capacity develops through social ties within the school. Furthermore, in the process of improving teachers' competencies, practical learning has taken center stage. Instead of receiving extensive formal training, teachers typically learn how to handle

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technology, including artificial intelligence, through practical experience in the classroom. statements made by participants:

> "Official training rarely has activities, so we learn on our own and directly from practice in the classroom." — P3 — Teacher, 4 years of experience.

Demonstrated how teaching experience takes center stage in the development of digital literacy and adaptive abilities. To put it another way, learning by doing is how capacity building occurs in this setting. Additionally, field notes showed that informal teacher forums are essential to developing professional ability. After-class discussions and internal school meetings serve as forums for problem-solving, experience sharing, and idea sharing about technology use. The conclusion that school leadership in teacher capacity building used adaptable, contextual, and long-lasting social mechanisms is supported by this pattern.

3.1.2.1. Internal Mentoring

According to data, teachers shared their experiences and methods for utilizing technology in the classroom through an internal mentorship system that helps them build their competencies. Teachers who are more adept at using technology might sometimes act as resources for their peers.

> "We often learn from fellow teachers; if someone already knows, we usually share immediately." — P3 — Teacher, 4 years of experience.

The quotation demonstrated how teacher capacity development is a collaborative process built on firsthand experience. This internal mentorship grows as a habit incorporated into everyday interactions within the educational setting, rather than always being formalized in the form of official programs. These results showed that the principal's leadership promotes the development of a collegial professional learning ecosystem where knowledge transmission takes place both contextually and horizontally.

3.1.2.2. Practical Learning

Data indicated that the main strategy for improving teachers' abilities is now practical learning in addition to internal mentorship. Instead of receiving structured formal training, teachers typically learn how to use technology, including AI, through practical experience in educational activities.

> "Official training rarely has activities, so we learn on our own and directly from practice in the classroom." — P3 — Teacher, 4 years of experience.

The quotation demonstrated how teachers' primary source of learning is firsthand teaching experience. This pattern demonstrated that competency development is more of a learning-by-doing process, where teachers modify their use of technology to meet the needs of their students. This research highlights that the efficacy of capacity development in the context of limits is dependent on the teacher's ability to experiment, reflect on practices, and continuously adapt rather than formal training.

3.1.2.3. Informal Forum

Field notes reveal the existence of casual conversations among educators, which are now a crucial part of the professional development process. These conversations typically occur outside of scheduled events, including after classes or during internal school meetings. The experiences of the participants, which highlight the value of casual connections as venues for practice sharing and problem-solving, further support this.

> "Usually, we share with each other after teaching. If someone tries something new (AI technology), we discuss it together immediately." — P8 — Teacher, 5 years of experience.

Additionally, the viewpoint of the stakeholders demonstrated that these unofficial exchanges also aid in the development of a collaborative school culture.

> "Discussions among teachers often happen spontaneously, and they greatly help us in developing learning even if not in an official forum." — P5 — Teacher, 10 years of experience.

The casual exchanges provided a forum for problem-solving, experience sharing, and idea sharing on the use of technology in education. According to data, this informal forum fosters a social, adaptable, and durable pattern of teacher capacity building in addition to strengthening the internal mentoring process and hands-on learning. Therefore, in this setting, teacher professional development takes place through social interactions that are tailored to the needs of the school rather than just through formal frameworks.

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3.1.3. Infrastructure and Resources

The results showed that the structural elements that most directly impact the use of AI-based learning are infrastructural constraints. In this case, the principal is responsible for both setting priorities and controlling the use of technology in order to maintain a realistic and long-lasting learning process. The primary obstacles the school faces are erratic internet connectivity, a restricted supply of electricity, and a dearth of digital equipment like PCs and laptops, according to data from observations, interviews, and inventory documentation. Because not all teachers have simultaneous access to devices and networks, this circumstance restricts the use of technology in education, including artificial intelligence. These results demonstrated that basic infrastructure readiness and AI-based learning management in schools are inextricably linked.

In order to overcome these constraints and continue to use technology, the school created adaptable strategies. Using offline resources, that is, storing digital instructional materials ahead of time so they may still be used when the network is down, is one of the most popular tactics. The quotes from the participants reflect this:

> "Here, the internet is usually unstable, so the materials are saved first so they can be used without a network." — P6 — Teacher, 3 years of experience.

Additionally, some schools used devices on a rotational basis to make the most of their limited resources. This tactic demonstrated how the principal's leadership promoted workable solutions that enable learning to proceed. The results also showed that before the widespread use of technology was widely extended, schools typically gave priority to basic needs. Meeting basic infrastructure needs continues to be the key priority, according to school papers, including procurement proposals and facility needs reports. The principal stressed in an interview that after basic necessities are satisfied, technology development is done gradually. In this sense, infrastructure management is a strategic choice that strikes a balance between the reality of resource constraints and the ideal of digital transformation.

3.1.3.1. Infrastructure Constraints

According to data, schools' biggest challenges are related to erratic internet connectivity, a restricted supply of electricity, and a lack of digital equipment like laptops or desktops. These circumstances have a direct bearing on how little technology is used in education, especially artificial intelligence. Some participants highlighted that the use of online-based applications is unsustainable because internet connectivity is not always reliable.

> "The internet at school is sometimes available, sometimes not, so we can't always rely on online-based learning." — P7 — Teacher, 4 years of experience.

Furthermore, not all teachers have simultaneous access to technology due to the restricted number of devices. Stakeholders' viewpoint also suggests that this requirement is a structural limitation.

> "The facilities available here are still very limited, so the use of AI technology must be adjusted to the existing conditions." — P1 — School Principal, 2 years of experience.

Interviews consistently revealed these conclusions, and the school's observational data supported them. As a result, infrastructural limits not only present technological challenges but also operational limitations in the use of AI-based learning, requiring modifications to educational methods at the school level.

3.1.3.2. Adaptive Strategy

In order to continue using technology in the classroom, the school created a number of adaptable solutions. The usage of offline materials, which entails storing digital teaching resources ahead of time so they may be accessed without an internet connection, is one of the most popular tactics.

> "Because the internet is often unstable, the available materials are stored first so they can be used without a network." — P9 — Teacher, 10 years of experience.

The quotation demonstrated how educators modify their use of technology to maintain the learning process. Additionally, some schools rotate the usage of devices so that everyone can take advantage of the facilities' limits. These results showed that the created adaptation solutions are long-lasting and have been incorporated into standard procedures in the educational setting. Therefore, rather than totally impeding the use of technology, infrastructure constraints promote the development of creative, needs-based, and contextual methods.

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3.1.3.3. Priority of Basic Needs

Additionally, data indicated that schools typically place a higher priority on the continuation of fundamental learning activities than on the widespread adoption of technology. When resources are scarce, choices about the use of AI and other technologies are increasingly focused on the most pressing and practical requirements to be fulfilled. Participants' remarks highlighting the significance of addressing fundamental requirements prior to more technological advancement support this.

> "We prioritize focusing first on the basic learning needs; once those are met, we can think about using technology further." — P10 — Teacher, 5 years of experience.

Stakeholders who believed that the school's priorities still center on core issues likewise voiced a similar opinion,

> "The important thing is that the learning process continues, and AI technology can adapt to the school's capabilities." — P9 — Teacher, 10 years of experience.

Meeting basic infrastructure needs continues to be the top priority, according to school papers, including procurement proposals and facility needs data. The school principals have stressed in multiple interviews that technological growth is done gradually after basic needs are satisfied. These results showed that infrastructure management takes into account both technical and strategic factors when deciding how to allocate resources. Therefore, realistic assessments of the school's circumstances and capabilities are taken into account in addition to innovation prospects when making judgements about the application of AI.

3.1.4. Stakeholder Collaboration

The results demonstrated that in order to preserve the sustainability of technology-based learning implementation, the principal does not only rely on the school's internal resources but also cultivates support from a variety of internal and external parties. In addition to being a reaction to constraints, this partnership was a crucial tool for assisting the school in adjusting. According to data, schools actively encouraged learning activities by including parents, school committees, and other outside parties. While the type of support offered is not always large, it frequently plays a significant role in addressing the fundamental requirements of the school, such as the supply of facilities or involvement in school programming. Documents from the school, such as minutes from meetings and activity logs, demonstrated that outside assistance is an extra resource that the school used to deal with internal constraints.

The growth of AI-based learning also heavily depends on teacher collaboration, in addition to outside assistance. Teachers who are more adept at using technology can help their colleagues learn. The following sentence reflects this:

> "Teachers who are more knowledgeable about AI technology usually enjoy helping others." — P1 — School Principal, 2 years of experience.

These results showed that through horizontal knowledge transfer, collaboration takes place in schools both at the structural level and at the level of everyday activities. All things considered, the partnership that has developed is useful, adaptable, and focused on meeting the actual requirements of the school. statements made by participants,

> "Support from parents and supervisors has been very helpful to us, even tho it may seem very simple." — P4 — Teacher, 7 years of experience.

Confirming that even seemingly insignificant contributions have a big influence on promoting learning continuity. As a result, stakeholder cooperation in this study is an essential component of the principal's leadership approach to managing AI in a limited setting, not just an add-on.

3.1.4.1. External Support

According to data, schools actively encouraged learning activities by including outside parties like parents and school committees. Support is not usually given on a huge scale; instead, it frequently takes the shape of modest contributions that help the school achieve its essential needs, such as facilities, activity support, or involvement in school programs. The experiences of educators who directly witness the involvement of outside parties in educational activities also reflect this.

> "Parents and the committee sometimes help according to their abilities, for example, in school activities or specific needs." — P1 — School Principal, 2 years of experience.

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Additionally, the viewpoint of the stakeholders demonstrated that the help is given flexibly in accordance with the circumstances of the school.

> "We try to help as much as we can, as long as it supports the learning activities at school."
> — P11 and P12 — Parents

The participation of outside parties in a variety of learning development-related activities is also demonstrated in school records, such as meeting minutes and activity notes. These results show that outside assistance is not only supplemental but also a valuable tool for assisting the school in overcoming internal constraints, particularly those related to infrastructure.

3.1.4.2. Support Among Teachers

Data indicated that teacher engagement is a crucial component of the technological adaptation process in schools, in addition to outside assistance. Teachers who are more adept at using technology can help their colleagues learn.

> "We often learn from fellow teachers; if someone already knows, we usually share immediately." — P3 — Teacher, 4 years of experience.

The quotation demonstrated how teachers horizontally transfer knowledge. In addition to bolstering the capacity-building process previously discussed, this peer support shows that collaboration occurs naturally in day-to-day activities inside the school setting. As a result, the principal's leadership in this situation also promotes the development of a cooperative culture that makes it possible for technology to be adapted in a way that is more sustainable and inclusive.

3.1.4.3. Practical Collaboration

Additionally, data indicated that the types of collaboration that take place in schools are typically pragmatic and focused on meeting actual needs. Support from internal and external stakeholders is mostly focused on initiatives to keep learning going in the face of constraints.

> "Some external support has had a positive impact on us." — P1 — School Principal, 2 years of experience.

The quotation showed that contributions don't need to be substantial or formal in order to have a big influence on learning activities. These results showed that the partnership is adaptable and contextual, changing according to the school's real needs. As a result, the partnership not only provides extra assistance but also develops into an adaptable tactic that allows the school to keep using technology-based instruction despite infrastructure constraints.

3.2. Discussion

This study addressed the central question of how school principals manage AI-based learning in contexts characterized by infrastructure limitations. The findings indicated that leadership does not operate through immediate technological transformation but through contextual adaptation shaped by local constraints and opportunities. In the process, principals function as mediators who align vision and policy, teacher capacity development, infrastructure management, and stakeholder collaboration. These interconnected dimensions illustrate that AI implementation in resource-constrained schools is less about technological adoption and more about leadership-driven adaptation.

Importantly, the findings suggest that AI in the studied school functions as a complementary instructional tool rather than a disruptive innovation. This challenges dominant narratives that frame AI adoption as a transformative shift requiring comprehensive institutional restructuring. Instead, the study highlights that in constrained contexts, leadership prioritizes practical integration, incremental development, and sustainability. Consequently, AI leadership should be understood as a contextual and adaptive process that dynamically connects resources, capacities, and policy directions.

3.2.1. School Principals' Role in Formulating AI-Related Vision and Local Policies

The findings indicate that AI-related vision and policies emerge gradually and contextually rather than through formalized strategic frameworks. In the studied schools, AI is primarily positioned as a supportive tool to enhance teaching effectiveness and administrative efficiency. This orientation reflects a pragmatic leadership approach in which policy development is shaped by feasibility and operational needs rather than by formal institutional mandates.

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These findings align with Göçen & Döğer (2025) and Renta-Davids et al. (2025), who emphasize the importance of leadership capacity and institutional readiness in AI adoption. However, this study extends their work by demonstrating that leadership in infrastructure-constrained settings involves managing uncertainty and translating technological possibilities into contextually feasible strategies. In this sense, policy development becomes an adaptive leadership practice rather than a formal administrative procedure.

Furthermore, the findings suggest that AI leadership in constrained environments follows an incremental trajectory. Policies evolve through continuous adjustments to local realities, teacher readiness, and infrastructure availability. This interpretation refines the linear adoption model often implied in the AI implementation literature. Rather than progressing toward full systemic integration, AI adoption emerges as a gradual and context-sensitive process shaped by leadership responsiveness (Cheng & Wang, 2023). This finding contributes to a more nuanced understanding of AI leadership as a dynamic and evolving practice.

3.2.2. Enhancing Teacher Capacity

The findings reveal that teacher capacity development in AI-based learning occurs primarily through collaborative and practice-based mechanisms. Instead of relying heavily on formal training programs, teachers engage in peer learning, informal mentoring, and experiential learning processes. The principal plays a facilitative role by fostering a supportive professional environment that encourages experimentation and knowledge sharing.

These findings are consistent with Yang et al. (2024) and Nazaretsky et al. (2022), who highlight the importance of internal support systems in strengthening teacher readiness for technology integration. However, this study advances the discussion by demonstrating that internal learning mechanisms become central rather than complementary in constrained contexts. Limited access to formal training and contextual mismatches between training content and school needs further reinforce the importance of school-based professional learning.

The findings, therefore, suggest a shift from traditional training-based capacity building toward a socially embedded professional learning model. Teachers develop competencies through collaborative reflection, practical experimentation, and continuous interaction. This perspective challenges assumptions that formal training is the primary pathway for digital competency development. Instead, practice-oriented and community-based learning emerges as a more adaptive strategy in resource-limited environments (Jin et al., 2025). These results highlight the importance of leadership in fostering collaborative professional cultures that support sustainable AI integration

3.2.3. Management of Infrastructure and Resources

Infrastructure limitations emerge as a key structural factor shaping the implementation of AI-based learning. Constraints related to internet connectivity, electricity stability, and device availability influence not only technological access but also instructional planning and pedagogical decisions. Consequently, infrastructure management becomes an integral component of leadership practice rather than merely a technical challenge.

These findings are consistent with Deogaonkar (2025) and Kafa (2025), who identify infrastructure gaps as a major barrier to digital transformation. However, this study extends the literature by showing that schools actively develop adaptive strategies to overcome these limitations. Practices such as device sharing, offline resource utilization, and phased implementation demonstrate how constraints can foster pragmatic innovation and flexible leadership responses.

These findings contribute to the digital divide literature by shifting the focus from structural limitations to adaptive responses. While previous studies emphasize disparities in access, this study highlights how school-level actors navigate these constraints through contextual strategies. Within this framework, infrastructure limitations are not only barriers but also conditions that shape leadership innovation and decision-making (Pamungkas et al., 2024). This perspective enriches the understanding of how technology integration unfolds in resource-constrained educational environments.

3.3. Implementation of Collaboration with Stakeholders

The findings indicated that stakeholder collaboration plays a critical role in sustaining AI-based learning under infrastructure constraints. Principals actively mobilize support from teachers, parents, school committees, and external stakeholders to supplement limited internal resources. Collaboration thus functions as a strategic leadership approach to maintaining learning continuity.

These findings align with Bulathwela et al. (2024) and Mulatiwi et al. (2024), who emphasized the role of social capital in supporting educational innovation. However, this study extends the discussion by showing that

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collaboration often develops informally and adaptively rather than through formal partnerships. Even modest contributions from stakeholders significantly support the implementation of technology-based learning.

These findings challenge deficit-oriented perspectives that portray resource-constrained schools solely in terms of limitations. Instead, the findings demonstrate that social capital can be effectively mobilized through contextual leadership practices (Mustafa et al., 2024). In this sense, collaboration becomes both a leadership strategy and a sustainability mechanism. The study, therefore, highlights that successful AI implementation depends not only on infrastructure availability but also on the principal's ability to mobilize and integrate social resources.

3.4. Limitations and Future Research Directions

When evaluating the results, it is important to take into account the many limitations of this study. First, because the study was restricted to a single area, its findings are contextual and not meant to be widely applied. Second, the potential for subjectivity cannot be completely eliminated when using a qualitative technique because the interpretation of results is heavily reliant on the viewpoints of participants and researchers. Furthermore, as the impact of AI use on student learning outcomes has not been quantitatively measured in this study, the results are more concerned with leadership practices and procedures than with quantifiable learning effectiveness.

Future research is advised to create a more thorough strategy, such as mixed methods, to concurrently combine process and learning outcome analysis in light of these limitations. To assess the application of the findings in different educational situations, it is also crucial to broaden the scope of research areas and contexts. In order to have a more thorough knowledge of the AI-based learning ecosystem, future research can also investigate the dynamics of long-term AI implementation and incorporate multi-actor views, including students. Therefore, it is anticipated that future studies will deepen our understanding of AI leadership techniques in diverse educational situations and strengthen external validity.

4. Conclusion

This study showed how adaptable, contextual, and progressive techniques helped school leadership manage AI-based learning in places with limited infrastructure. The development of pragmatic and needs-based vision and policies, the development of teacher capacity through internal mechanisms and direct practices, the management of infrastructure through adaptive strategies, and the strengthening of collaboration with stakeholders as a pillar of sustainability are the four main dimensions that the research findings consistently address. Overall, our results confirm that the adoption of AI in schools is an adaptation process impacted by local circumstances, resource constraints, and the ability of actors at the school level, rather than a linear and standardized digital revolution. The concept of contextualized AI leadership in limited environments, which views infrastructure constraints, teacher capacity, and social capital as constitutive aspects in digital leadership practices, is a scientific contribution made by this research. By demonstrating that AI integration is formed by contextual and sustained adaptation processes rather than always following the ideal pattern of technological transformation, this viewpoint broadens the body of literature on educational leadership. The research's practical implications help policymakers and school principals create practical, needs-based, and regionally relevant AI adoption methods. However, the research's contextual and qualitative constraints point to the necessity for more studies with a wider scope, a mixed-methods approach, and an investigation of the effects of AI on student learning outcomes and direct user viewpoints. Therefore, it is anticipated that further research will improve our comprehension of AI integration in education in a more thorough and cross-contextual way.

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Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

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Declaration on AI Use

The authors stated that the Artificial Intelligence (AI) based application - Grammarly, is used to check the accuracy of language structure under strict human oversight. Other stages in the research process and report preparation are all carried out by the authors without AI assistance.

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