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Leading Digital Transformation in the AI Era: A Multisite Qualitative Study of Rural Elementary School Leadership

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Abstrak

The integration of artificial intelligence (AI) in rural elementary schools presents opportunities for instructional innovation but remains shaped by resource constraints, teacher readiness, and responsible use. This study examines how school leaders mediate digital transformation and how leadership practices interact with pedagogical needs and contextual conditions. A multisite qualitative study was conducted in 12 public elementary schools across six school clusters in Alian District, Kebumen, Central Java, Indonesia. Data were collected from 36 informants (12 principals, 12 upper-grade teachers, and 12 lower-grade teachers) through semi-structured interviews, non-participant observations, and document analysis, followed by thematic within-site and cross-site analysis. Three patterns emerged. First, adaptive resource governance was evident in 10 schools (83.3%) that reported reallocating operational funds to support connectivity, while all 12 schools used professional networks for collaborative learning and resource sharing. Second, AI use varied by instructional needs: upper-grade teachers emphasized planning and assessment, whereas lower-grade teachers focused on visual materials, literacy, numeracy, and storytelling. Reported time savings reflected teachers' perceptions rather than objectively measured efficiency. Third, responsible AI integration required peer mentoring, content verification, contextual adaptation, and attention to student data protection. The findings conceptualize rural digital leadership as adaptive mediation among resource governance, pedagogical AI use, teacher learning, and human oversight. Because the study involved purposively selected schools in one district, its findings offer contextual insights rather than nationally representative estimates.

Keywords: artificial intelligence; digital leadership; digital transformation; rural elementary schools; qualitative study

Introduction

The rapid development of digital technologies and generative artificial intelligence (AI) is reshaping teaching, assessment, professional learning, and school management. In this context, digital transformation extends beyond the adoption of technological tools to include changes in resource allocation, teacher development, organizational practices, and pedagogical decision-making. School principals therefore play an important role in translating technological opportunities into meaningful educational practices. Research in Indonesia has associated digital leadership with teacher performance, self-efficacy, and technology integration, while also highlighting the importance of teacher readiness, professional

development, and supporting infrastructure (Timan et al., 2022; Hidayat & Patras, 2024; Hikmah & Sutapa, 2024; Kasim & Surya, 2025).

These challenges are particularly significant in rural elementary schools, where internet connectivity, access to digital devices, financial resources, and opportunities for sustained professional development may vary across school settings. Under such conditions, school leaders must make context-sensitive decisions about competing priorities, including connectivity, technological resources, and teacher capacity development. Digital transformation consequently depends not only on the availability of technology but also on how leaders mobilize existing resources, strengthen professional collaboration, and respond to the needs of their school communities. Previous research has identified infrastructure and teacher competence as continuing barriers to technology integration, even when school leaders demonstrate commitment to digital development (Hidayat & Patras, 2024; Kasim & Surya, 2025).

The emergence of generative AI adds another dimension to these leadership responsibilities. AI can assist teachers in preparing instructional materials, developing assessments, differentiating learning activities, and organizing educational information. However, AI-generated outputs may contain inaccurate information, inappropriate representations, cultural mismatches, or recommendations that do not align with students' developmental needs. Its educational value therefore depends on teachers' ability to evaluate, adapt, and contextualize the generated content. International research emphasizes that AI offers opportunities for instructional improvement and organizational support while raising concerns about ethics, equity, privacy, accountability, and human agency (Arar et al., 2025; Renta-Davids et al., 2025). School leaders must consequently support pedagogical experimentation while maintaining professional judgment and responsible oversight.

Recent studies have begun to explain how leadership influences AI integration in education. Zeng et al. (2025) highlight resource allocation, professional development, learning communities, and supportive school culture as mechanisms associated with teachers' AI integration. Other research has examined AI in instructional leadership, administrative work, decision-making, and school improvement (Bixler & Ceballos, 2025; Ghamrawi et al., 2025; Göçen & Döğer, 2025). Indonesian studies have also explored digital leadership in relation to teacher performance, professional learning, digital culture, and educational uses of generative AI (Hikmah & Sutapa, 2024; Widiyan & Takayoshi, 2024; Sitinjak et al., 2025; Zahro et al., 2025). Collectively, this literature establishes the relevance of leadership and teacher capacity in digital transformation. However, further contextual investigation is needed to explain how these processes unfold in rural elementary schools where infrastructure, resources, and teacher readiness may differ across sites.

One important issue concerns the relationship between leadership decisions and the differentiated pedagogical uses of AI. Teachers' instructional responsibilities vary across grade levels, potentially shaping the purposes for which they use AI. Upper-grade teachers may employ AI to support differentiated lesson planning, assessment development, diagnostic analysis, and higher-order thinking questions. Lower-grade teachers may prioritize visual materials, literacy, numeracy, and storytelling activities that respond to younger learners' developmental needs. These distinctions suggest that AI integration should not be understood as a uniform process. Instead, it requires attention to how teachers interpret and adapt AI tools in relation to instructional objectives, student characteristics, and available school resources.

A related issue is the role of human judgment in responsible AI integration. Teachers remain responsible for determining whether AI-generated content is accurate, developmentally

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appropriate, pedagogically useful, and culturally meaningful. This responsibility becomes especially important in elementary education, where instructional materials must respond to students' learning needs and local contexts. Responsible AI use also requires attention to the handling of students' personal information and the establishment of appropriate school-level guidance. Research on responsible AI emphasizes the importance of accountability, ethical judgment, and human oversight rather than unrestricted technological automation (Polat et al., 2025; Renta-Davids et al., 2025). School leadership is therefore relevant not only to enabling AI use but also to creating conditions for critical evaluation, peer support, and responsible professional practice.

Despite these developments, an integrated understanding of rural digital leadership remains necessary. In particular, further research is needed to explain how school leaders negotiate resource constraints, facilitate collaborative teacher learning, respond to differences in pedagogical AI use, and support the verification and contextual adaptation of AI-generated materials across multiple school settings. These processes are difficult to understand through an examination of technology adoption alone because leadership practices are shaped by the interaction of infrastructure, teacher capacity, organizational conditions, and local educational needs. A multisite qualitative approach can illuminate both recurring patterns and context-specific adaptations in how schools navigate these interconnected challenges.

This study addresses this need through a multisite qualitative investigation of 12 public elementary schools across six school clusters in Alian District, Kebumen Regency, Central Java, Indonesia. Drawing on the perspectives of school principals and teachers, the study examines how digital transformation is mediated through resource management, professional collaboration, pedagogical AI use, and responsible human oversight. The study offers three related contributions. First, it develops a context-sensitive understanding of digital leadership by examining adaptive resource governance rather than focusing solely on technology acquisition. Second, it identifies how pedagogical purposes shape AI use across upper- and lower-grade teaching contexts. Third, it highlights the role of teachers as human mediators who evaluate, adapt, and contextualize AI-generated outputs before classroom implementation. Together, these contributions frame rural digital transformation as an adaptive process connecting resource decisions, teacher learning, pedagogical practice, and responsible AI use.

Accordingly, this study addresses the following research question: How do school leaders enact and mediate digital transformation in rural elementary schools in the AI era, and how do leadership practices interact with teacher capacity, pedagogical needs, and contextual constraints across school sites? By examining this question across multiple schools, the study seeks to provide context-specific empirical insights that can inform school leadership, collaborative professional development, and responsible AI integration in rural elementary education.

Method

This study employed a multisite qualitative research design to examine how elementary school leaders and teachers navigated digital transformation in the era of artificial intelligence (AI) in rural public elementary schools. A qualitative approach was selected because the study sought to understand participants' experiences, practices, challenges, and interpretations of AI integration within their actual school contexts. The multisite design enabled the researchers to examine both shared patterns and differences across schools situated in different school clusters within the same district.

The study focused on leadership practices, teachers' instructional use of AI, school infrastructure, professional learning, and considerations related to the responsible use of AI. Rather than measuring the effectiveness of a particular AI application or testing causal relationships, the study explored how school-level conditions and collaborative practices shaped the ways principals and teachers incorporated AI into their educational work.

The study was informed by qualitative multisite research principles and iterative thematic analysis. Data were examined within individual school sites before being compared across sites and school clusters. This approach supported a contextualized understanding of digital transformation while avoiding the assumption that experiences in the selected schools represented all rural elementary schools.

The research was conducted in public elementary schools in Alian District, Kebumen Regency, Central Java, Indonesia. The district comprised 32 elementary schools, consisting of 31 public schools and one private school. Twelve public elementary schools were purposively selected from six school clusters: Kertinegara, Astrabaya, Kendilwesi, Sabdoguna, Badranala, and Kolopaking. Two schools were included from each cluster to enable comparisons between schools operating within different local conditions.

The participating schools were:

1. Kertinegara Cluster: SDN 1 Surotrunan and SDN 2 Surotrunan.
2. Astrabaya Cluster: SDN 1 Sawangan and SDN 3 Sawangan.
3. Kendilwesi Cluster: SDN 1 Wonokromo and SDN 2 Wonokromo.
4. Sabdoguna Cluster: SDN 2 Kalirancang and SDN 3 Kalirancang.
5. Badranala Cluster: SDN 1 Kalijoyo and SDN 2 Kalijoyo.
6. Kolopaking Cluster: SDN Jatimulyo and SDN 1 Karangtanjung.

The sites were selected purposively because the study required information-rich cases in which school leaders and teachers had experience using AI in educational activities. All 12 selected schools reported using AI. This criterion enabled the researchers to investigate the forms, purposes, enabling conditions, and challenges of AI integration in practice. However, the selection was not intended to estimate the prevalence of AI use across the district or among rural schools more broadly. The finding that all participating schools reported AI use therefore applies only to the selected sample.

The study involved 36 informants from the 12 participating schools. Each school contributed three informants: one principal, one upper-grade teacher teaching Grades IV–VI, and one lower-grade teacher teaching Grades I–III. The participant group consisted of 12 principals, 12 upper-grade teachers, and 12 lower-grade teachers.

Purposive sampling was used to recruit participants who could provide relevant information about school leadership, classroom instruction, and the use of AI in elementary education. Principals were included because of their roles in school management, resource allocation, infrastructure planning, and teacher development. Upper-grade and lower-grade teachers were included to explore instructional practices across different grade levels and to identify similarities and differences in their reported experiences.

The inclusion of participants from two grade-level groupings enabled descriptive comparisons of teachers' reported AI practices. These comparisons were intended to identify contextual patterns rather than establish causal differences between grade levels. The study did not treat grade level as an independently tested explanatory variable.

To protect individual participants, interview excerpts and other participant-specific information were identified using codes rather than personal names. School names were retained for reporting with the permission obtained for their publication. The use of actual

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school names was intended to preserve the geographical and institutional context of the multisite analysis without disclosing the identities of individual informants.

Data were collected from May to July 2026 using three complementary sources: semi-structured interviews, non-participant observations, and school document analysis. Combining these sources enabled the researchers to compare participants' accounts with observable school practices and available institutional records.

Semi-structured interviews were conducted with all 36 informants. The interviews explored principals' leadership practices, teachers' use of AI for instructional planning and assessment, access to digital infrastructure, professional learning opportunities, perceived benefits and limitations of AI, and concerns about responsible use.

Questions for principals focused on school-level decisions concerning connectivity, digital resources, teacher support, and the integration of AI into school activities. Questions for upper-grade and lower-grade teachers addressed their experiences using AI for lesson preparation, assessment development, learning materials, literacy, numeracy, and other classroom activities appropriate to their teaching responsibilities.

The interviews also explored the challenges participants encountered, including connectivity limitations, device access, confidence in using digital tools, the need to verify AI-generated content, and concerns about the handling of student information. Interview data were treated as participants' accounts of their experiences. Numerical estimates and descriptions of time saved were not automatically interpreted as independently measured outcomes.

Non-participant observations were conducted to examine the school contexts and practices relevant to the study without making the researchers' participation part of the activities being observed. The observations focused on the availability and use of digital devices, connectivity-related conditions, teachers' preparation and use of AI-supported materials, collaborative learning activities, and practical adaptations to school resource limitations.

The observations also provided contextual information for interpreting interview statements. For example, descriptions of device access and instructional preparation were considered alongside the conditions observed at the participating schools. Observational evidence was used to corroborate a claim only when the relevant practice or condition was actually recorded in the observation notes. Interview statements that could not be directly corroborated were retained as reported experiences rather than presented as independently observed facts.

School documents were examined to provide institutional and documentary context for the findings and to support triangulation with interview and observation data. The documentary sources available for the study included records relating to school operational assistance (Bantuan Operasional Satuan Pendidikan, or BOS), documentation of co-curricular training and professional learning activities, and records or notes relevant to digital infrastructure and school practices.

BOS allocation documents were considered in examining school-level financial support for connectivity and digital learning infrastructure. These documents provided a basis for checking whether participants' accounts of resource allocation were consistent with available school records. The analysis did not assume that the presence of a budget allocation, by itself, demonstrated the effectiveness of the expenditure or established the resulting quality of connectivity.

Documentation of co-curricular training and professional learning activities was examined to contextualize participants' descriptions of teacher development and collaborative

support. These materials were compared with interview accounts of professional learning through school-cluster forums, teacher working groups, and in-house training activities where relevant documentation was available.

Connectivity information was treated cautiously. A bandwidth figure of 15–20 Mbps was recorded as reported information about school connectivity, not as an independently verified measurement of network performance. Unless a contemporaneous technical record or direct measurement established otherwise, the figure was not interpreted as a continuous or independently measured speed. Similarly, the reported availability of approximately 12–20 Chromebooks per school and an estimated student-to-device ratio of 1:7 were treated as descriptive estimates. These figures were not presented as a verified inventory or a precisely calculated ratio unless the corresponding device and enrolment records supported that interpretation.

Document analysis therefore served two purposes: to contextualize participants' accounts and to assess the extent to which specific claims were supported by documentary evidence. When the sources did not provide sufficient information to verify a numerical claim, the finding was reported with an explicit qualification rather than being treated as an established measurement.

The research was conducted in several stages. First, the researchers established the study focus and selected the participating schools and informants based on the study's multisite qualitative design. Second, data were collected through interviews, non-participant observations, and the examination of available school documents during the May–July 2026 research period.

Third, the researchers organized the data by school site, participant group, and source type. Interview accounts were considered alongside observation notes and relevant institutional records. Particular attention was given to claims involving school resources, connectivity, teacher development, instructional practices, and responsible AI use.

Fourth, the researchers conducted within-site analysis to develop an understanding of each school's circumstances and practices. The researchers then compared the findings across the 12 schools and six clusters to identify recurring patterns, contextual differences, and cases that qualified or challenged emerging interpretations. Finally, the findings were organized thematically and interpreted in relation to the study's research focus.

The data were analyzed thematically through an iterative process of familiarization, coding, theme development, comparison, and interpretation. The analysis combined within-site examination with cross-site and cross-cluster comparison.

First, the researchers reviewed interview records, observation notes, and available documents to become familiar with the content and context of the data. Second, relevant passages and recorded observations were coded according to their substantive meaning. Initial codes addressed school leadership, connectivity and digital infrastructure, teacher professional learning, instructional uses of AI, perceived time savings, verification of AI-generated content, resource constraints, and responsible AI use.

Third, related codes were grouped into broader analytical categories. These categories were reviewed against the original data to ensure that the emerging themes reflected participants' accounts and the available supporting evidence. Fourth, the researchers compared findings within each school and across the six school clusters. This comparison was used to identify common practices as well as contextual variations in access to devices, connectivity, professional support, and the integration of local considerations into AI-supported learning.

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The analysis distinguished among three forms of evidence: participants' reported experiences, practices or conditions recorded through observation, and information supported by school documents. Where multiple sources converged, the researchers considered the claim more strongly corroborated. Where sources differed or documentary support was incomplete, the discrepancy or limitation was retained in the interpretation.

Numerical information was used descriptively to clarify the distribution of reported experiences within the selected sample. Counts and percentages referred to the participating informants or schools, as appropriate, and were not used to infer population-wide prevalence. Reported time savings were interpreted as participants' estimates or perceptions unless supported by systematic timing records. Likewise, connectivity and device figures were qualified according to the nature and completeness of the available evidence.

The final themes were developed to explain how school leadership, infrastructure, professional learning, instructional practices, and responsible-use concerns interacted within the participating schools. Differences between upper-grade and lower-grade teachers were interpreted descriptively and contextually, not as evidence of causal effects.

Several strategies were used to strengthen the trustworthiness of the findings. First, source triangulation was undertaken by comparing interview accounts with non-participant observation notes and available school documents. The purpose was not to assume that all sources would necessarily agree, but to establish which claims were corroborated, which reflected participants' perceptions, and which remained insufficiently verified.

Second, the multisite design enabled the researchers to compare patterns across 12 schools and six school clusters. Cross-site comparison helped distinguish recurring experiences from conditions that appeared specific to particular school contexts. Third, the researchers maintained an organized record of the research process, including the data sources considered, coding decisions, and development of themes, to support an audit trail.

Where feasible, interpretations were checked against the context of the original accounts to reduce the risk of removing statements from their intended meaning. Any participant feedback used to clarify or confirm interpretations was treated as a trustworthiness measure only to the extent that it was actually conducted and documented. The analysis also retained qualifications where documentary evidence was incomplete, rather than overstating the certainty of a finding.

The study addressed confidentiality, school identification, and the responsible handling of research information. The participating schools were identified by their actual names for reporting with permission for publication. Individual participants were represented through codes, and personal names were not used to identify interviewees in the reported findings.

The study also considered concerns related to student information entered into AI applications. Participants' accounts indicated that identifiable student information had at times been entered into AI applications and that caution had been communicated informally. The available information did not establish a complete formal school procedure governing this practice. Accordingly, the study reports this issue as a concern regarding responsible data handling and does not infer that a confirmed data breach occurred or claim the existence of safeguards that were not documented.

The researchers interpreted participants' accounts and school records within the limits of the evidence available. Particular care was taken not to disclose unnecessary personal information or to present unverified numerical estimates as independently established facts. Claims concerning school resources, professional learning, and AI practices were reported in a manner consistent with the supporting interviews, observations, and documents.

Results

Digital Transformation Across the Participating Schools

The analysis of 12 public elementary schools across six school clusters revealed that digital transformation was shaped by the interaction of school resources, teacher learning, pedagogical needs, and local working conditions. All 12 participating schools reported using artificial intelligence (AI), but they did not follow a uniform approach. Some placed greater emphasis on connectivity and access to devices, while others relied more heavily on peer support, advance preparation, or the adaptation of learning materials to local conditions.

Three interconnected patterns emerged from the data. School leaders sought to make AI use feasible by managing available resources and mobilizing professional networks. Teachers then used AI for different instructional purposes, depending on the demands of their grade levels. Across these activities, human support and verification remained important because access to AI did not automatically ensure that its outputs were accurate, appropriate, or ready for classroom use.

These patterns were visible in the accounts of principals and teachers, as well as in the comparison of interview data, observation notes, and available school documents. The findings below describe the practices reported in the selected schools; they are not intended to represent the prevalence of AI use across all rural elementary schools.

Managing Resources to Make AI Use Possible

Connectivity was a recurring concern in principals' accounts of digital transformation. Ten of the 12 schools (83.3%) reported reallocating school operational assistance (Bantuan Operasional Satuan Pendidikan, or BOS) resources to strengthen internet connectivity. The bandwidth figure reported for the schools was approximately 15–20 Mbps. Principals described internet access as a practical requirement for teachers who wanted to explore online platforms, prepare digital materials, and use AI-supported applications. One principal from SDN 1 Surotrunan explained:

> "Kepemimpinan di sekolah itu kuncinya ada pada kepastian sarana dasar. Tanpa koneksi Wi-Fi yang stabil, diskusi tentang AI hanya akan jadi bahan teori yang memicu kebingungan guru." (KS-KRT01)

The statement reflects the practical nature of the challenge. For this principal, digital transformation was not simply a matter of encouraging teachers to try new tools. Teachers also needed basic conditions that allowed them to use those tools in their daily work.

BOS allocation records were available and were considered alongside participants' accounts of resource prioritization. These documents provided institutional context for the reported decisions, but the presence of an allocation alone did not establish that connectivity had improved or that network performance was consistently reliable. Accordingly, the reported bandwidth figure is treated as contextual information rather than an independently verified measurement of network performance.

Device availability presented a related challenge. Participating schools reported approximately 12–20 Chromebooks per school, with an estimated student-to-device ratio of around 1:7. These figures provide a general indication of device availability and should not be interpreted as a uniform, independently verified inventory across all sites. Where devices were insufficient for simultaneous use, schools arranged access through scheduling and rotation. At SDN 2 Kalijoyo, for example, the principal reported managing 15 Chromebooks through a rotation system so that different classes could use the available devices.

The accounts also showed that schools did not rely solely on resources within individual institutions. All 12 principals reported using the Kelompok Kerja Kepala Sekolah

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(K3S) and Kelompok Kerja Guru (KKG) for professional learning, discussion, and resource sharing. Schools in the Kertinegara and Astrabaya clusters reported conducting in-house training (IHT) approximately two to four times per semester. Available documentation of co-curricular training and professional learning activities provided additional context for these accounts.

Taken together, the findings show that resource management involved both direct investment and collective support. Connectivity and devices remained important, but professional networks helped schools share knowledge and respond to limitations that could not always be resolved through individual school resources.

Different Pedagogical Uses of AI Across Grade Levels

Although all 12 upper-grade teachers and all 12 lower-grade teachers reported using AI, the purposes of use differed. The contrast was most apparent in the tasks teachers wanted to accomplish, rather than in whether they adopted AI at all.

Upper-grade teachers primarily described AI as a resource for lesson planning, differentiation, and assessment. All 12 reported using AI for activities such as preparing differentiated learning materials, generating higher-order thinking skills (HOTS) questions, developing P5 assessment rubrics, assisting with diagnostic analysis, and preparing examinations. Commonly mentioned platforms included ChatGPT, Google Gemini, Quizizz AI, and Canva for Education.

The accounts illustrated how AI was incorporated into existing teaching responsibilities. GKT-KDL01, for example, reported using AI to adapt instructional materials and assessment items to different levels of student achievement. GKT-SBG02 described using AI to assist with diagnostic data and student-score analysis. Other teachers used AI to develop question variations and draft assessment rubrics.

Teachers also reported that AI reduced the time they spent preparing some materials. Preparing a differentiated teaching module was estimated to have decreased from approximately 120–180 minutes to 30–45 minutes. The preparation of P5 assessment rubrics was reported to have decreased from around 90–120 minutes to 15–20 minutes, while generating 10–15 HOTS questions was estimated to have decreased from 60–90 minutes to 15–25 minutes. GKT-AST01 described the change in the following terms:

> “Dulu waktu saya habis hingga berjam-jam hanya untuk mengetik rubrik penilaian P5 dan menyusun variasi soal HOTS matematika. Sekarang dengan bantuan ChatGPT, draf kerangkanya selesai dalam 15 menit.” (GKT-AST01)

The account illustrates the perceived value of AI in preparing initial drafts and generating alternatives. However, these time estimates reflect participants’ reported experiences, not experimentally measured productivity gains. The findings indicate that teachers perceived AI as helping them prepare materials more quickly; they do not establish that the materials were automatically more accurate or pedagogically effective.

Lower-grade teachers described a different set of priorities. All 12 reported using AI primarily to prepare visual, literacy, numeracy, storytelling, and other materials intended to support younger learners. Examples included illustrated stories, phonics cards, number and letter materials, customized worksheets, coloring activities, songs, audio stories, classroom displays, and comics based on the local environment.

The examples reveal how teachers adapted the presentation of learning content. GKR-KRT01 reported using Canva AI to develop illustrated local stories, while GKR-AST02 described preparing songs and audio stories. GKR-KDL01 created visual materials for letters and numbers, GKR-SBG02 developed customized phonics flashcards, and GKR-KLP02 produced educational comics based on the village environment.

Lower-grade teachers reported preparing approximately three to five customized visual worksheets per week. One teacher estimated that a worksheet combining a story and illustrations, which had previously required around 90 minutes, could be prepared in approximately 30 minutes with AI assistance. As with the upper-grade estimates, this comparison represents a reported experience rather than an independently timed assessment.

The distinction between the two groups was therefore one of pedagogical purpose. Upper-grade teachers emphasized planning, assessment, and analytical preparation, whereas lower-grade teachers emphasized visual accessibility, early literacy, numeracy, and storytelling. These patterns were descriptive and should not be interpreted as evidence that one group used AI more effectively than the other.

Teacher Readiness and the Importance of Peer Support

Access to AI tools did not mean that every teacher felt equally confident using them. Five of the 12 lower-grade teachers (41.7%), identified in the study data as senior teachers over 45 years of age, reported initial anxiety when learning to use AI-supported tools. Their accounts included hesitation when operating digital devices, concern about making mistakes, and difficulty formulating prompts. Some also described challenges with English-language prompts or interface instructions.

These experiences made teacher readiness an important part of the implementation process. For some teachers, the challenge was not simply learning what an AI tool could do, but becoming comfortable enough to experiment with it during their everyday work.

Participants reported that all 12 schools had some form of peer mentoring or *tutor sebaya*. Teachers who were more confident using digital tools helped colleagues navigate applications, formulate prompts, and prepare learning materials. In some settings, individual mentoring was reported to take approximately 30 minutes per week. These arrangements provided opportunities for teachers to ask questions and practice with support. GKR-SBG01 described this experience:

> "Awalnya saya takut sekali pegang laptop untuk AI, rasanya rumit. Tapi Pak Guru Kelas 6 mendampingi saya dengan sangat sabar setiap hari Jumat setelah jam pulang." (GKR-SBG01).

The account conveys how regular, patient support helped make an unfamiliar tool feel more manageable. Rather than learning entirely on their own, teachers could turn to colleagues who understood both the technology and the practical demands of classroom teaching.

Some teachers who initially experienced anxiety later reported being able to use visual AI platforms more independently. This does not mean that every teacher followed the same trajectory or that initial difficulties disappeared completely. Rather, the accounts show how peer support helped some teachers participate in AI-related activities while they were still developing their confidence.

Professional learning also took place through K3S and KKG networks. All 12 principals reported using these forums for discussion, resource sharing, and teacher development. In the Kertinegara and Astrabaya clusters, IHT activities were reported approximately two to four times per semester. Available training documentation helped contextualize these accounts, while interviews provided information about the forms of support teachers described experiencing.

The findings therefore indicate that teacher learning occurred through a combination of organized professional activities and everyday collegial assistance. Formal training and informal mentoring were both part of the ways participating schools supported teachers' engagement with AI.

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Verification, Professional Judgment, and Local Relevance

Teachers' accounts also revealed a limitation of AI-supported preparation: generated content could not always be accepted without checking. All 12 principals described AI as an instructional assistant rather than a replacement for teachers. In their accounts, AI could help generate drafts and alternatives, but teachers remained responsible for deciding whether the outputs were accurate and suitable for classroom use.

This responsibility was particularly visible among upper-grade teachers. Eight of the 12 (66.7%) reported encountering inaccurate AI-generated information. The examples recorded in the study included local historical information and scientific or logical formulas. Teachers described checking the content before incorporating it into learning materials or assessments.

These experiences show that preparing materials with AI involved more than generating an initial response. Teachers still needed to check factual accuracy, assess alignment with learning objectives, and determine whether explanations and examples were appropriate for their students. The perceived time savings in drafting therefore did not remove the need for professional review.

Local relevance was another concern. Principals in the Badranala and Kolopaking clusters placed particular emphasis on checking whether AI-generated examples, terminology, illustrations, and learning situations were appropriate for students' rural environments and cultural references. KS-AST02 emphasized the need to consider whether generated content would be familiar to students, while KS-KLP01 connected AI use with ethical considerations and the verification of local wisdom. At SDN KLP02, the principal's account reflected an approach that encouraged innovation while retaining teachers' responsibility for instructional quality.

These accounts indicate that verification extended beyond identifying factual errors. Teachers and principals also considered whether materials were understandable, culturally relevant, and connected to students' everyday experiences. A generated example could be technically plausible yet still be unsuitable for a particular class if it relied on unfamiliar settings or references.

Human review was thus a recurring feature of reported AI use across the participating schools. All principals emphasized the assistant role of AI, while the specific concerns and methods of verification varied across sites. Badranala and Kolopaking placed particular emphasis on cultural relevance and local wisdom, showing how contextual considerations shaped the ways participants evaluated AI-generated content.

Practical Adaptations to School Constraints

The implementation of AI was also shaped by material limitations. Ten of the 12 schools (83.3%) reported limited access to color-printing facilities. This was especially relevant to lower-grade teachers, whose learning materials often relied on illustrations and visual cues.

Teachers responded by adapting their prompts to generate black-and-white line drawings that could be printed using conventional printers. The resulting materials could be used as coloring sheets, literacy worksheets, or other visual learning resources. This practice allowed teachers to retain the visual elements they considered useful while adapting the output to available printing facilities.

Limited device availability prompted another response. With an estimated student-to-device ratio of approximately 1:7, schools could not necessarily provide simultaneous Chromebook access to every student. Scheduling and rotation were used to distribute access across classes. At SDN 2 Kalijoyo, for example, the principal reported managing 15 Chromebooks through a rotation system. The accounts describe an effort to organize access, although they do not establish that all students received equal amounts of device time.

Connectivity conditions also affected when teachers prepared and accessed materials. At SDN 2 Kalirancang, teachers reportedly prepared or downloaded materials in advance so that resources remained available during periods of unstable internet access. This approach shifted some AI-related work away from real-time online preparation and toward advance preparation followed by offline classroom use.

The reported bandwidth figure of 15–20 Mbps provides context for the schools' connectivity conditions, but it does not independently establish the consistency or quality of network performance. The qualitative accounts instead show how participants responded to connectivity as they experienced it in their everyday work.

Across these examples, teachers and school leaders adapted their practices to the resources available rather than relying on a single implementation model. Some adjustments involved managing access to devices; others involved changing the format of learning materials or preparing resources in advance. The specific response depended on the constraints encountered at each site.

Cross-Site Patterns and Contextual Differences

Comparison across the six school clusters revealed shared concerns alongside differences in the emphasis placed on particular responses. These differences are best understood as contextual patterns in the data rather than fixed characteristics of every school within a cluster.

In Kertinegara and Kendilwesi, participants emphasized connectivity and access to digital infrastructure. In Astrabaya, teacher readiness and professional learning featured prominently, including reported IHT activities and collaboration through professional networks. Sabdoguna provided an example of adapting to unstable connectivity through advance preparation and offline use of materials.

In Badranala, participants described device rotation alongside peer support and attention to the contextual suitability of AI-generated materials. In Kolopaking, the accounts placed particular emphasis on local wisdom, ethics, and reviewing generated content before it was used in teaching.

Peer support and human review appeared across the participating schools, but the ways they were organized and the concerns they addressed differed. Some accounts emphasized scheduled mentoring, while others highlighted assistance from digitally confident colleagues or learning through cluster networks. Similarly, all principals described AI as an assistant rather than a replacement for teachers, although their particular emphases on accuracy, cultural relevance, and practical classroom use varied.

The cross-site findings therefore show a combination of shared practices and locally adapted responses. Digital transformation was not implemented through one standardized strategy. Instead, schools combined resource management, professional learning, pedagogical experimentation, and human review in ways that reflected their particular conditions.

Discussion

The findings suggest that digital transformation in rural elementary schools is better understood as an ongoing process of adaptation than as the simple introduction of new technology. Across the 12 participating schools, principals and teachers had to make practical decisions about connectivity, devices, professional learning, instructional needs, and the reliability of AI-generated materials. These decisions were interdependent: access to technology created opportunities, but the value of those opportunities depended on teachers'

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capacity to use the tools and their judgment in deciding what could appropriately enter the classroom.

The first implication concerns the nature of digital leadership in resource-constrained settings. Ten schools reported reallocating BOS resources to strengthen connectivity, while all 12 principals reported mobilizing K3S and KKG networks for professional learning and resource sharing. These findings indicate that leadership involved both managing resources within schools and drawing on support beyond individual institutions. The reported availability of approximately 12–20 Chromebooks per school and an estimated student-to-device ratio of 1:7 further illustrates why technology access had to be organized rather than assumed. Scheduling, device rotation, and advance preparation were practical responses to the conditions described by participants.

This pattern extends perspectives that emphasize infrastructure and technological vision by showing how leadership is enacted through choices about priorities and workable alternatives. Zeng et al. (2025) identify resource allocation, professional development, learning communities, and organizational support as important elements of AI integration. Research in Indonesia likewise connects principals' digital leadership with teacher self-efficacy, technology integration, and organizational change (Hikmah & Sutapa, 2024; Kasim & Surya, 2025; Suryaman et al., 2024). The present findings add a contextual dimension: in rural schools, leadership also involves deciding how available resources can be combined with collaboration when not every technical need can be met directly. This supports a view of rural digital leadership as community-anchored adaptive leadership, in which school leaders align digital initiatives with local capacity, professional networks, and practical constraints.

The second implication concerns the relationship between leadership and teacher learning. Infrastructure and encouragement alone did not remove the difficulties some teachers experienced when beginning to use AI. Five of the 12 lower-grade teachers reported initial technological anxiety, including uncertainty about operating devices and formulating prompts. Their accounts of learning with colleagues suggest that peer mentoring helped translate broad encouragement into practical participation. Rather than requiring every teacher to become independently proficient at the outset, schools created opportunities for colleagues to share knowledge and work through difficulties together.

This finding is consistent with Indonesian research emphasizing teacher empowerment and professional development in relation to digital leadership (Hikmah & Sutapa, 2024; Widiyan & Takayoshi, 2024). It also highlights the organizational value of K3S and KKG: professional networks can support the circulation of practical knowledge, while peer mentoring can make learning more responsive to individual teachers' immediate needs. The evidence does not establish that mentoring alone caused improvements in competence, but it shows that teachers described collegial support as part of their experience of becoming more comfortable with AI. For school leaders, this suggests that professional learning should include repeated opportunities for practice and assistance, not only one-off training sessions.

A third implication is that AI use in elementary education is shaped by pedagogical purpose. Upper-grade teachers primarily reported using AI for differentiated planning, HOTS questions, assessment rubrics, diagnostic analysis, and examination preparation. Lower-grade teachers more often described visual, literacy, numeracy, and storytelling materials. These differences suggest that the question is not merely whether teachers use AI, but what instructional task they want the technology to help them accomplish.

This distinction matters for teacher development. Upper-grade teachers may benefit from support in critically evaluating generated questions, assessment materials, and diagnostic interpretations. Lower-grade teachers may need more attention to visual content,

age-appropriate language, early literacy and numeracy, and the suitability of generated illustrations. Such differentiation should not imply that one group's use is more advanced or valuable than the other. Rather, it recognizes that meaningful AI integration depends on the relationship between technology and the instructional needs of a particular class.

Teachers' reported reductions in preparation time also need to be interpreted carefully. The accounts suggest that AI helped some teachers produce initial drafts and variations more quickly. However, these estimates were based on participants' recollections and experiences, not controlled measurements. Faster drafting does not necessarily mean that total preparation time is reduced to the same extent, particularly when teachers need to check accuracy, adapt examples, and revise materials. The findings therefore support a claim about perceived efficiency and practical usefulness, not a general claim that AI objectively improves teacher productivity or learning outcomes.

The need for verification provides a fourth, closely related insight. Eight upper-grade teachers reported encountering inaccurate AI-generated information, and all principals positioned AI as an assistant rather than a replacement for teachers. These accounts suggest that the use of AI did not remove the need for professional expertise; it changed some of the work through which that expertise was exercised. Teachers had to evaluate generated content, identify inaccuracies, consider alignment with learning objectives, and decide whether the materials were suitable for their students.

This responsibility was also cultural and contextual. Participants in Badranala and Kolopaking placed particular emphasis on local wisdom and the appropriateness of generated examples and illustrations. Such concerns are especially relevant in elementary education, where students' understanding is often supported by familiar settings, language, and everyday experiences. A resource can be grammatically polished or technically plausible while still being inappropriate for a particular classroom. The findings therefore support a human-centered understanding of AI governance in which factual checking, pedagogical judgment, and cultural adaptation remain part of teachers' professional responsibilities. This interpretation aligns with scholarship emphasizing ethics, accountability, human agency, and contextual implementation in educational leadership (Arar et al., 2025; Polat et al., 2025; Renta-Davids et al., 2025).

The findings also show that contextual adaptation was not limited to the content generated by AI. Teachers adapted the conditions under which the technology could be used. Black-and-white line drawings addressed limited access to color printing; device rotation helped schools manage limited Chromebook availability; and advance preparation at SDN 2 Kalirancang reduced dependence on continuous connectivity during classroom activities. These examples show how teachers adjusted the format, timing, and delivery of AI-supported resources to the conditions of their schools. The adaptations did not eliminate the underlying limitations, but they enabled teachers to continue working within them.

Taken together, the findings support a context-sensitive conceptualization of rural digital leadership involving adaptive resource governance, differentiated pedagogical AI use, teacher learning, and human-cultural AI governance. These dimensions should not be treated as a rigid sequence. Resource decisions can enable experimentation, while experimentation can reveal new training needs or problems with AI-generated content. Peer learning can help teachers address those problems, and successful adaptations can be shared through professional networks. Digital transformation therefore develops through an ongoing relationship between leadership decisions, classroom practice, and professional judgment.

The study has practical implications for school leaders and education stakeholders. Investment in connectivity and devices remains important, but it should be accompanied by sustained professional learning, peer mentoring, and opportunities for teachers to exchange

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usable materials. Professional development should address the different instructional purposes for which teachers use AI, while school-level guidance should clarify expectations for checking accuracy, cultural relevance, age appropriateness, and alignment with learning objectives. Given the concerns raised about student information entered into AI applications, schools also need clear and practical guidance on responsible data handling. The present findings indicate that informal caution was reported, but they do not establish the existence of a complete formal procedure across the participating schools.

Several limitations should be considered when interpreting these findings. The study involved 12 public elementary schools in one district, selected purposively because they reported experience with AI. The fact that all participating schools used AI must not be interpreted as evidence that all or most rural schools use it. In addition, the reported preparation-time reductions represent participants' experiences rather than experimentally measured efficiency gains. The connectivity and device figures provide contextual estimates and should not be treated as uniform technical measurements or verified inventory totals without supporting records. Finally, the study examined principals' and teachers' accounts and practices; it did not directly measure changes in student learning outcomes.

Future research could examine how peer mentoring and professional learning influence teachers' AI practices over time, using longitudinal or mixed-methods designs. Further studies could also investigate whether differentiated AI-supported activities are associated with measurable changes in students' literacy, numeracy, engagement, or conceptual understanding. Comparisons across rural and urban settings would help determine which elements of the proposed conceptualization are specific to the resource conditions examined here and which may be relevant across broader educational contexts.

Overall, the study indicates that responsible AI integration in rural elementary schools depends not only on whether technology is available, but on how school leaders and teachers make it workable, pedagogically relevant, and appropriate for their students. Resource management creates possibilities; professional learning helps teachers use those possibilities; and human judgment determines how AI-generated content is evaluated and adapted before it enters the classroom.

Conclusion

This study explored how school leaders and teachers navigate AI-related digital transformation across 12 public elementary schools in six school clusters in Alian District, Kebumen, Central Java. The findings suggest that the integration of artificial intelligence (AI) in rural elementary education is shaped by the interaction between resource management, teachers' pedagogical needs, and the professional judgment required to use AI responsibly. Rather than representing a uniform process of technology adoption, digital transformation emerged as a context-dependent process influenced by school infrastructure, collaborative professional learning, and the capacity of educators to adapt AI-generated materials to their instructional contexts.

Three interconnected findings characterize this process. First, school leaders and teachers described adaptive responses to resource constraints through the use of available infrastructure, resource allocation, teacher collaboration, and peer support. These practices indicate the importance of leadership that connects technological provision with the practical conditions of teaching and learning. Second, teachers reported using AI for different instructional purposes. Upper-grade teachers emphasized lesson planning, assessment development, and the preparation of higher-order thinking questions, whereas lower-grade

teachers focused more on visual learning materials, literacy, numeracy, and storytelling. Although participants reported reductions in the time needed to prepare certain materials, these estimates represent participants' accounts and should not be interpreted as independently verified measures of efficiency. Third, the findings highlight the continuing role of teachers in reviewing AI-generated content, adapting learning materials to local contexts, and addressing the risks associated with the use of students' personal information. Reports of inaccurate AI-generated content and initial difficulties experienced by some teachers reinforce the need for ongoing professional support and responsible-use guidance.

These findings have practical implications for school leadership and teacher development. School leaders should integrate infrastructure planning with sustained, collaborative professional learning rather than treating access to AI tools as sufficient for successful digital transformation. Teacher development should address not only the technical use of AI but also the evaluation of content accuracy, the adaptation of materials to students' developmental and cultural contexts, and the responsible handling of personal information. Schools also need clear procedures governing the entry of student information into AI applications. Such procedures are particularly important because the use of AI in educational settings involves considerations of privacy and professional responsibility in addition to instructional convenience.

The findings must, however, be interpreted in light of the study's methodological boundaries. The research involved 12 purposively selected public elementary schools within one district and therefore does not establish the prevalence or representativeness of AI adoption across rural schools in Indonesia. In addition, the findings draw on interviews, observations, and school documents, while the reported time savings and some descriptions of technological resources are not presented as independently measured outcomes. The study also did not primarily assess changes in student learning outcomes. Accordingly, its contribution lies in providing context-specific insights into leadership practices and teachers' experiences, rather than demonstrating the causal effectiveness of AI integration.

Future research could extend this work to schools in different rural and non-rural settings and use longitudinal or mixed-methods designs to examine how leadership practices, infrastructure, teacher readiness, and professional development relate to the quality of AI-supported instruction. Further studies could also evaluate structured AI literacy programs, the implementation of school-level data-protection procedures, and the effects of AI-supported teaching on student learning. Overall, this study underscores that responsible AI integration in rural elementary education depends not simply on the availability of technology but on the capacity of school communities to use it critically, collaboratively, and in ways that remain responsive to educational purposes and local contexts.

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