ORIGINAL ARTICLE

ADAPTIVE PRINCIPAL LEADERSHIP FOR DEVELOPING TEACHERS' DIGITAL COMPETENCE IN RESOURCE-CONSTRAINED SCHOOLS

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ABSTRACT
This study examines how principal leadership supports the development of teachers' digital competence in a resource-constrained faith-based junior high school in Nabire, Papua. A descriptive qualitative case-study design was used to investigate the leadership process within one school. The principal served as the primary participant, while teacher informants provided supporting perspectives. Data were generated through semi-structured interviews and direct school-based observations and analyzed through data condensation, data display, and conclusion drawing and verification. The findings identify six interrelated practices: role modelling and motivation, participatory digital-program planning, annual training and peer mentoring, technology-focused supervision, incremental resource mobilization, and adaptive responses to internet and device constraints. Participant accounts and observations indicated increased use of presentations and instructional videos and greater student engagement during some technology-supported lessons. The study did not directly measure achievement gains or establish causal effects. The case suggests that digital leadership in resource-constrained schools operates as an adaptive support cycle combining professional learning, distributed peer expertise, supervision, and infrastructure improvisation. The findings are transferable primarily to schools with comparable organizational and infrastructural conditions.

Keywords: digital leadership, qualitative case study, remote education, school principal, teacher digital competence

INTRODUCTION

Digital transformation has altered classroom instruction, school administration, professional learning, and the expectations placed on educational leaders. Schools are increasingly expected to treat digital technologies not as isolated tools but as components of organizational strategy, professional practice, and learning design (Oliveira & De Souza, 2022; Timotheou et al., 2023). International scholarship also emphasizes that digital competence is multidimensional: it includes technical knowledge, pedagogical judgment, professional collaboration, ethical practice, and the capacity to adapt technology use to specific learner and institutional needs (Caena & Redecker, 2019; Falloon, 2020; Pettersson, 2018). This broader conception is especially important in schools where access to devices and stable connectivity remains uneven.

School leaders shape the organizational conditions under which technology integration becomes possible. Principals influence strategic direction, teacher learning opportunities, supervision, resource allocation, and the development of a school culture that supports experimentation and collaboration (Karakose et al., 2021; Navaridas-Nalda et al., 2020). Evidence from school-level studies suggests that digital adoption is stronger when top-down leadership and bottom-up teacher participation complement one another, rather than when innovation is driven by only one side (Petko et al., 2015). Leadership support also interacts with infrastructure, goal clarity, teacher beliefs, and formal and informal exchange among colleagues (Blau & Shamir-Inbal, 2017; Petko et al., 2018). These relationships indicate that digital transformation is an organizational process, not simply the accumulation of individual technical skills.

Teacher digital competence refers to the capacity to use digital technologies purposefully, safely, and pedagogically in teaching, communication, assessment, and continuous professional development. It includes operational knowledge of devices and platforms, the ability to design or select digital learning resources, pedagogical integration, digital communication, and attention to ethical and professional responsibilities (Caena & Redecker, 2019; Falloon, 2020; Reisoğlu, 2022; Tkachov et al., 2023). Digital competence should therefore be distinguished from simple technology use: a teacher may be able to operate a device without being able to select an appropriate tool, redesign instruction, assess learner needs, or evaluate the educational consequences of technology use. Research on teacher preparation similarly shows that institutional leadership, modelling, and coherent professional learning are necessary for digital competence to become part of routine professional practice (Instefjord & Munthe, 2017).

The adoption of technology also depends on teachers' motivation, confidence, beliefs about usefulness, and access to relevant support. Meta-analytic evidence indicates that perceived usefulness, attitudes, and behavioral intentions are important in explaining teachers' adoption of digital technologies (Scherer et al., 2019; Scherer & Teo, 2019). Studies of teacher adaptation during abrupt shifts to online instruction also show that prior competence and teacher-education experiences affect how quickly educators can reorganize their teaching (König et al., 2020). A systematic review of teacher professional development further identifies persistent gaps in training and argues that digital competence development requires structured, sustained, and context-sensitive opportunities rather than one-off technical workshops (Fernández-Batanero et al., 2022).

In this study, educational quality is treated primarily as the quality of the learning process perceived or observed within the case, including teacher preparedness, instructional efficiency, student participation, and the school's capacity to support technology-based learning. This definition is deliberately narrower than student achievement or overall school effectiveness because the available evidence does not include standardized achievement records, pre-post measurements, or a comparison group. Existing research nevertheless indicates that teacher digital competence and technology-supported instruction can be associated with instructional quality and learner engagement when appropriate pedagogical and organizational conditions are present (Althubyani, 2024; Runge et al., 2023).

Initial observations at Anak Panah Nabire Christian Junior High School identified several practical challenges. Some teachers experienced difficulty operating digital learning media, using online platforms, and developing interactive materials. Technology use was also constrained by limited training, uneven teacher readiness, unstable internet access, and insufficient personal devices. These conditions are consistent with broader Indonesian discussions of digital school management and infrastructure, but they are particularly consequential in remote settings where school-level leadership must combine formal professional development with local problem-solving and the strategic use of limited facilities (Masinambow et al., 2025; Nashrullah et al., 2025).

Previous studies have established that principal leadership can support classroom technology innovation, teacher professional learning, and the development of a school digital culture (Fuad et al., 2022; Håkansson Lindqvist, 2019; Keane et al., 2020). Other studies have examined teachers' professional digital competence and the roles of training, learning communities, and motivation in technology integration (Garzón Artacho et al., 2020; Gudmundsdottir & Hatlevik, 2018; Liu et al., 2024). However, this literature offers less detail about how leadership practices interact in a single resource-constrained school where formal training is infrequent, infrastructure must be improvised, and teacher readiness is uneven. Pettersson (2018) specifically notes that research often concentrates on individual competence while giving less attention to organizational infrastructure and strategic leadership.

The research gap is therefore not merely geographic. The unresolved issue concerns the process through which a principal combines role modelling, motivation, participatory planning, peer mentoring, supervision, and resource mobilization when connectivity and device access are limited. Examining this process can clarify how established digital-leadership practices are configured under specific organizational constraints and what forms of support appear feasible for comparable schools. The novelty of this study lies in formulating an adaptive support cycle from the interaction among leadership practice, distributed teacher expertise, supervision, and infrastructure constraints rather than presenting the school location itself as the principal contribution.

The study uses a context-responsive digital instructional leadership framework. The framework links four domains: principal practices, including vision, role modelling, planning, supervision, and resource provision; enabling or constraining conditions, including teacher motivation, peer mentoring, connectivity, and devices; the development of teacher digital competence through practice and professional learning; and proximal, perceived changes in the learning process. The framework draws on scholarship that treats teacher competence as a professional and organizational construct and does not assume that leadership practices directly cause gains in student achievement (Berkovich & Hassan, 2024; Caena & Redecker, 2019; Sterrett & Richardson, 2020).

Accordingly, the study addresses three questions: How does the principal support the development of teachers' digital competence? What organizational and infrastructural conditions enable or constrain these leadership practices? What perceived or observed changes in teaching and learning are associated with the school's digital-competence initiatives? The objective is to develop a context-sensitive explanation of principal leadership for teacher digital competence in a resource-constrained school and to identify analytically transferable lessons for comparable settings.

METHOD

Research Design and Case Boundaries

This research employed a single-site descriptive qualitative case-study design. The bounded case was the set of principal leadership practices used to support teachers' digital competence at Anak Panah Nabire Christian Junior High School. The unit of analysis was the leadership process within the school, including the interaction among professional support, supervision, teacher learning, and infrastructure constraints. A case-study orientation was appropriate because the inquiry sought an in-depth, context-sensitive account of practices in a real school setting rather than a population-level estimate of effectiveness.

Setting and Participants

The study was conducted at Anak Panah Nabire Christian Junior High School in Nabire, Papua. The principal served as the primary participant because the position carries responsibility for policy, school management, teacher development, supervision, and resource allocation. Teacher informants were included to provide supporting perspectives on the implementation of digital learning and the support received from school leadership. The study therefore relied on purposive access to participants who could provide direct information about the leadership process and its implementation within the bounded case.

Data Collection

Data were generated through semi-structured interviews and direct school-based observation. Interviews addressed the principal's strategies, teacher-development activities, barriers to technology use, supervision, resource provision, and perceived changes in teaching

and learning. Observations focused on technology-supported classroom activities, available facilities, teacher use of digital media, and interactions relevant to the research questions. The combination of interviews and observations enabled comparison between participant accounts and practices or conditions observable in the school environment.

Data Analysis

Data analysis followed the interactive procedures of data condensation, data display, and conclusion drawing and verification described by Miles, Huberman, and Saldaña (2014). Interview and observation data were selected, simplified, and organized according to the research questions. The analysis generated six themes concerning leadership through role modelling and motivation, participatory digital-program management, training and peer mentoring, supervision and resource support, perceived learning-process changes, and constraints and adaptive responses. Interpretations were continuously compared with the available data sources so that participant perceptions were distinguished from directly observed conditions and from claims that could not be verified within the study design.

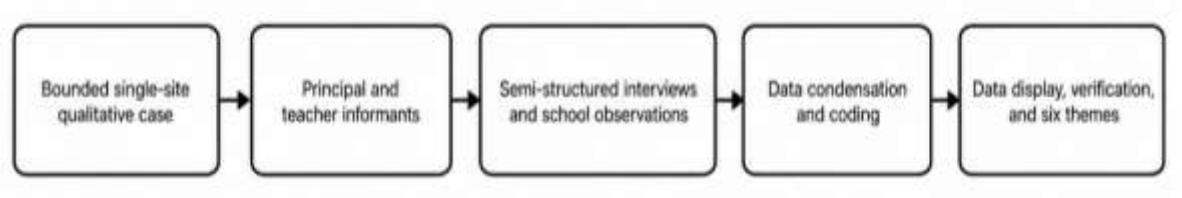

Figure 1. Research procedure and analytic flow

Trustworthiness and Reflexivity

The principal's account, teacher informants, and direct observations provided a basis for source triangulation. Findings were phrased according to the strength of the evidence: statements based on participant accounts were identified as perceptions, while observations were treated as evidence of visible practices rather than proof of broader outcomes. This distinction strengthened credibility by preventing perceived changes in engagement or instruction from being presented as verified causal effects.

Ethics and Data Governance

Because the study concerns a named school and observations may involve minors, the final manuscript must report institutional permission, informed-consent procedures, confidentiality safeguards, participant identifiers or pseudonyms, data anonymization, secure storage, access controls, retention, and disposal. These details are required to demonstrate that participation and data handling were appropriate for a school-based qualitative inquiry.

RESULTS AND DISCUSSION

Leadership Through Role Modelling and Motivation

The principal described technology as an important component of contemporary school improvement and encouraged staff to adapt to technological developments. The principal also used technology in administrative work and encouraged teachers to participate in workshops organized by the education office and the school foundation. Observational notes identified a concrete example: the principal developed a manual assessment application that was used before data were entered into the school's electronic report system. Support was reportedly adjusted to teachers' different levels of readiness rather than applied uniformly.

These data support an interpretation of the principal as a role model, motivator, and local problem solver. Visible modelling can reduce uncertainty by showing teachers that technology

use is an expected and attainable part of professional work. This pattern is consistent with research that positions principal leadership, school culture, and role modelling as important conditions for sustained technology integration (Blau & Shamir-Inbal, 2017; Karakose et al., 2021; Keane et al., 2020). It also reflects evidence that complementary leadership and teacher participation are more productive than innovation driven only from the top or only from individual teachers (Petko et al., 2015). The evidence from this case, however, concerns leadership practice within one school and does not demonstrate school-wide transformation or achievement effects.

Participatory Digital-Program Management

The principal planned technology training and workshops with the involvement of the vice principal and the head of administration. Internet availability was identified as a central planning concern. Program monitoring occurred through observation of how teachers and other staff used technology in carrying out their duties, followed by efforts to identify practical solutions when implementation was not optimal.

The pattern indicates participatory program management rather than a principal acting alone. Planning and evaluation were closely tied to infrastructural limitations, which meant that program decisions had to consider both human capacity and material access. This finding supports evidence that school readiness and teacher readiness are mutually related and that leadership support, resources, goal clarity, and professional exchange operate together in technology integration (Petko et al., 2018). It also aligns with studies emphasizing coordination among leadership, human resources, and technological capacity (Navaridas-Nalda et al., 2020; Timotheou et al., 2023). The case nevertheless relied on informal monitoring; explicit indicators would be needed to assess progress consistently over time.

Annual Training, Peer Mentoring, and Teacher Practice

Formal technology training and mentoring were reported to occur approximately once a year. Between formal activities, teachers with stronger technology skills acted as peer mentors for colleagues who needed assistance. Teachers practiced using presentation-based media and instructional videos, and repeated practice was described as an important means of building confidence and competence. Teacher motivation varied and influenced the extent to which technology was used in lessons.

This finding reveals a tension between the school's intention to provide continuing development and the infrequency of formal training. Continuity depended substantially on informal peer mentoring, individual motivation, and practice in daily work. The importance of coherent professional learning and institutional modelling is consistent with research on digitally competent teacher development (Instefjord & Munthe, 2017) and with systematic evidence that one-off training is insufficient for sustained professional change (Fernández-Batanero et al., 2022). Professional learning communities and peer collaboration can strengthen the transfer of digital innovation, but dependence on a small number of proficient teachers may make the model vulnerable if mentoring is not distributed or recognized institutionally (Garzón Artacho et al., 2020; Liu et al., 2024; Stumbrienė et al., 2024). Motivation is also consequential because teachers' perceptions of usefulness and confidence influence technology adoption (Scherer et al., 2019; Scherer & Teo, 2019).

Supervision and Resource Support

The principal monitored technology use during classroom supervision, observed student participation and teachers' use of digital tools, and provided praise and encouragement after observations. The school used its annual school budget plan to prioritize technology-related

facilities and included unmet needs in subsequent procurement plans. The earlier claim that facilities were 'approximately 70% adequate' was not retained because the basis for that percentage was not reported.

Supervision in this case functioned as both monitoring and motivational support. Resource provision was incremental and depended on annual budgeting. These findings align with studies showing that principal supervision, infrastructure, and organizational support affect teacher professional practice and technology integration (Amelia et al., 2022; Arjanto & Telussa, 2024; Lubis et al., 2025). They also reinforce Pettersson's (2018) argument that digital competence should be understood in relation to organizational infrastructure and strategic leadership rather than as an isolated teacher attribute. The data do not establish the objective adequacy of resources, but they indicate that the principal treated infrastructure planning as part of the teacher-development strategy.

Perceived and Observed Changes in the Learning Process

The principal and teacher informants associated technology use with more engaging and efficient lessons. Observations indicated that students appeared more active and enthusiastic when digital media were used and when they were given opportunities to interact directly with technology. Teachers were also described as beginning to use presentations and instructional videos more frequently.

These findings should be interpreted as perceived and observed changes in the learning process. Students were not reported as research participants, and the study did not analyze achievement records, pre-post data, or a comparison condition. Consequently, the evidence cannot support causal statements that technology use improved student achievement or overall educational quality. The findings are more appropriately framed as indications of changes in instructional practice and student engagement that warrant further verification. This calibrated interpretation is consistent with research linking teacher digital competence to instructional quality while distinguishing association from causal proof (Althubyani, 2024; Runge et al., 2023).

Constraints and Adaptive Responses

The principal and teacher informants identified limited internet access, uneven digital skills, and insufficient personal laptops as the main constraints. The school's responses included motivational support, assistance from more proficient teachers, the use of shared school facilities, procurement planning, and an intention to provide training more frequently.

Table 1. Summary of themes, evidence sources, and case-based interpretations

Theme	Principal practice	Evidence source(s)	Case-based interpretation
Role modelling and motivation	Uses technology in administration, demonstrates a local assessment application, encourages participation in training, and adjusts support to teacher readiness.	Principal interview and school observation	Leadership establishes expectations and reduces uncertainty through visible practice and individualized encouragement.

Theme	Principal practice	Evidence source(s)	Case-based interpretation
Participatory program management	Plans training with the vice principal and administrative head; monitors implementation and seeks solutions.	Principal interview and observation	Digital initiatives are organized collaboratively but remain constrained by connectivity and informal monitoring.
Training and peer mentoring	Provides annual formal training and relies on more proficient teachers to mentor colleagues.	Principal and teacher interviews; observation	Continuity depends on peer learning, repeated practice, and individual motivation between formal training events.
Supervision and resources	Observes technology use in lessons, gives feedback and encouragement, and includes digital facilities in the school budget.	Principal interview and observation	Supervision and incremental resource allocation are treated as components of competence development.
Perceived learning-process changes	Supports presentation-based media, instructional videos, and opportunities for student interaction with technology.	Participant accounts and observation	Evidence indicates perceived engagement and instructional change, not verified causal effects on achievement.
Constraints and adaptation	Responds to limited internet, uneven skills, and device shortages through shared resources, peer support, procurement planning, and proposed additional training.	Principal and teacher interviews; observation	Digital leadership is adaptive and context-dependent, with sustainability linked to infrastructure and distributed expertise.

The constraints demonstrate that teacher competence development cannot be separated from infrastructure and access. The principal's response was adaptive but remained dependent on available resources and the willingness of teachers to support one another. Similar challenges have been reported in Indonesian studies of remote or resource-limited digital education (Nashrullah et al., 2025; Sesmiarni, 2025; Setiawati et al., 2025). International research likewise shows that school digital capacity emerges from the interaction of infrastructure, leadership, teacher competence, and organizational culture (Pettersson, 2018; Timotheou et al., 2023). The proposed increase in training frequency should therefore be accompanied by realistic competence targets, protected time for peer learning, and monitoring criteria that reflect available connectivity and devices.

An Adaptive Digital-Competence Support Cycle

The central contribution of the case is not the identification of isolated leadership activities, many of which are already recognized in the literature, but the way these activities were combined under resource constraints. The findings suggest an adaptive digital-competence support cycle in which the principal models technology use and communicates expectations, organizes formal training, activates peer mentoring and repeated practice, supervises classroom

use, mobilizes available resources, and adjusts the program in response to connectivity, device, and motivation constraints. This cycle is an analytical proposition derived from the case rather than a tested causal model.

The proposed cycle extends digital and instructional leadership scholarship by showing how formal and informal support can compensate for one another without becoming equivalent. Formal training occurred approximately once a year, so peer mentoring and day-to-day practice became the mechanisms that sustained teacher learning. This configuration illustrates Falloon's (2020) argument that teacher digital competence encompasses pedagogical, professional, and ethical capabilities rather than discrete technical skills. It also reflects the multi-level logic of DigCompEdu, in which teacher development, collaboration, reflective practice, and institutional support are interdependent (Caena & Redecker, 2019). In a resource-constrained setting, continuity may therefore depend on distributed expertise, local improvisation, and the principal's capacity to sustain motivation and align limited resources with professional-learning priorities (Berkovich & Hassan, 2024; Sterrett & Richardson, 2020).

Contextual Tensions and Boundary Conditions

Four tensions define the boundary conditions of the proposed cycle. First, the school intended to provide continuous competence development, but formal training was infrequent. Second, peer mentoring expanded access to support but risked creating dependence on a small number of proficient teachers. Third, supervision encouraged technology use, yet the absence of explicit competence indicators limited the transparency of evaluation. Fourth, the principal attempted to mobilize resources, but internet access and device ownership remained structural constraints that school-level leadership could not fully resolve.

These tensions explain why similar leadership practices may produce different outcomes across schools. Digital leadership is more likely to be sustainable when professional learning, infrastructure, teacher motivation, and monitoring systems develop together. The case is consistent with research on school digital culture and organizational readiness (Blau & Shamir-Inbal, 2017; Fuad et al., 2022; Siswadi et al., 2025), while also showing that infrastructure limitations can narrow what leadership practices achieve in the short term. The findings therefore support contextual transfer rather than statistical generalization: the proposed cycle may be analytically useful in other remote or resource-constrained schools, but its implementation will depend on staffing, governance, connectivity, access to devices, and external professional-development support.

Practical and Policy Implications

For the principal, a feasible next step is to convert the current informal approach into a staged competence-development plan. The plan could begin with a needs assessment structured around recognized dimensions of teacher digital competence, identify peer mentors for specific skills, schedule short practice sessions between annual workshops, and integrate observable technology-use indicators into academic supervision. Relevant indicators might include participation in professional learning, the pedagogical appropriateness of digital resources in lesson plans, teacher confidence, collaborative problem-solving, and the reliability and accessibility of devices and internet connectivity. Competence frameworks should guide reflection and progression rather than operate as decontextualized compliance checklists (Caena & Redecker, 2019; Falloon, 2020).

For the school foundation and local education office, professional development should be coordinated with minimum infrastructure priorities. Stable connectivity, shared devices, maintenance support, and protected time for peer learning are likely to be more useful than isolated workshops without implementation support. Evidence on technology adoption shows

that teacher readiness, school readiness, leadership, and resources reinforce one another (Petko et al., 2018; Scherer et al., 2019). Policymakers and infrastructure providers should therefore recognize that school-level motivation cannot compensate indefinitely for structural access limitations. Support programs should combine teacher learning, device and network planning, technical maintenance, and realistic monitoring of implementation.

Limitations and Future Research

The study is limited by its single-school design and its reliance on one principal as the primary participant, supplemented by an unspecified number of teacher informants. The source manuscript does not report the temporal scope of fieldwork, detailed participant characteristics, interview and observation duration, coding procedures, researcher positionality, or complete trustworthiness procedures. These reporting gaps restrict assessment of information power, dependability, and reproducibility. The evidence also relies substantially on self-report and general observation, which may be affected by social-desirability bias.

Students were not reported as participants, no direct measures of achievement or instructional quality were analyzed, and no comparison condition was used. The study therefore cannot determine whether the reported leadership practices caused improvements in student outcomes. Future research should include multiple schools, fuller teacher and student perspectives, documented competence indicators, longitudinal observation, and relevant learning-process or achievement data. Comparative case studies could examine whether the proposed adaptive support cycle changes under different levels of infrastructure, governance, and external support, while mixed-method designs could test relationships among leadership practice, teacher readiness, technology adoption, and learning-process indicators (König et al., 2020; Petko et al., 2018; Scherer & Teo, 2019).

CONCLUSION

This qualitative case study shows how a principal combined role modelling, motivation, participatory planning, annual training, peer mentoring, supervision, and incremental resource provision to support teachers' digital competence in a resource-constrained school. The process was shaped by unstable internet access, uneven teacher readiness, and limited devices. Participant accounts and observations indicated changes in teachers' use of presentations and instructional videos and greater student engagement during some technology-supported lessons, but the study did not establish causal effects on achievement or overall educational quality. The case contributes an analytical proposition that digital leadership operates as an adaptive support cycle linking professional learning, distributed peer expertise, supervision, resource mobilization, and continuous adjustment to local constraints. Its practical implication is that teacher development and infrastructure planning should be coordinated. The conclusions remain bounded to this case and may be transferred only to settings with sufficiently similar organizational and infrastructural conditions.

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