Salud, Ciencia y Tecnología. 2026; 6:2617
doi: 10.56294/saludcyt20262617

ORIGINAL

Digital Synergy in Educational Supervision: A Technology-Driven Model for Collaborative School Excellence

Sinergia Digital en la Supervisión Educativa: Un Modelo Impulsado por la Tecnología para la Excelencia Escolar Colaborativa

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Cite as: Rahmi A, Gistituati N, Rifma, Syahril, Fauzan A, Irsyad. Digital Synergy in Educational Supervision: A Technology-Driven Model for Collaborative School Excellence. Salud, Ciencia y Tecnología. 2026; 6:2617. https://doi.org/10.56294/saludcyt20262617

Submitted: 01-09-2025 **Revised:** 25-10-2025 **Accepted:** 11-12-2025 **Published:** 01-01-2026

Editor: Prof. Dr. William Castillo-González

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ABSTRACT

The rapid digital transformation in education has reshaped supervisory practices, demanding systems that move beyond administrative routines toward collaborative, transparent, and data-informed approaches. While digital tools have become increasingly accessible, many schools still employ them only for basic reporting, leaving unrealized the potential for technology to strengthen professional interaction and institutional improvement. This study aimed to evaluate a technology-mediated collaborative supervision model grounded in the concept of digital synergy, examining how the integration of digital platforms, data literacy, and collaborative supervisory routines contributes to managerial quality, teacher performance, and school effectiveness. Using a qualitative case study design, data were collected from five public senior high schools in Padang City through document analysis, semi-structured interviews with principals and vice principals, and a Likert-scale questionnaire that assessed supervisory needs. Thematic analysis revealed that school leaders exhibit high awareness of the importance of digital tools, yet operational use remains limited, with technology functioning primarily as an administrative mechanism rather than an instrument for reflective supervision or joint decision-making. Collaborative supervision is widely valued but lacks structured digital routines to support shared analysis and sustained collegial engagement. Data-driven planning remains fragmented, with supervision results seldom informing strategic documents such as the RKJM. Despite these limitations, evidence of emerging digital synergy is visible in improved communication patterns and increased accessibility of supervisory records. The study concludes that technology-mediated supervision can enhance school performance when digital infrastructure, data competencies, and collaborative leadership are developed cohesively within an ethical and participatory supervisory culture.

Keywords: Collaborative Supervision; Educational Innovation; Digital Synergy; Technology Integration; School Excellence.

RESUMEN

La rápida transformación digital en la educación ha redefinido las prácticas de supervisión, exigiendo sistemas que vayan más allá de las rutinas administrativas hacia enfoques colaborativos, transparentes y basados en datos. Aunque las herramientas digitales se han vuelto cada vez más accesibles, muchas escuelas todavía las utilizan únicamente para informes básicos, dejando sin aprovechar el potencial de la tecnología para fortalecer la interacción profesional y la mejora institucional. Este estudio tuvo como objetivo evaluar un modelo de supervisión colaborativa mediado por tecnología, fundamentado en el concepto de sinergia

digital, examinando cómo la integración de plataformas digitales, la alfabetización en datos y las rutinas colaborativas de supervisión contribuyen a la calidad de la gestión, el rendimiento docente y la eficacia escolar. Mediante un diseño cualitativo de estudio de caso, se recopilaron datos de cinco escuelas secundarias públicas de Padang City mediante análisis documental, entrevistas semiestructuradas con directores y subdirectores, y un cuestionario Likert que evaluó las necesidades de supervisión. El análisis temático reveló que los líderes escolares muestran una alta conciencia sobre la importancia de las herramientas digitales; sin embargo, su uso operativo sigue siendo limitado, ya que la tecnología funciona principalmente como un mecanismo administrativo y no como un instrumento para la supervisión reflexiva o la toma conjunta de decisiones. La supervisión colaborativa es ampliamente valorada, pero carece de rutinas digitales estructuradas que apoyen el análisis compartido y la interacción colegiada sostenida. La planificación basada en datos sigue fragmentada, ya que los resultados de la supervisión rara vez informan documentos estratégicos como el RKJM. A pesar de estas limitaciones, se observan indicios de sinergia digital emergente en la mejora de los patrones de comunicación y en el aumento de la accesibilidad de los registros de supervisión. El estudio concluye que la supervisión mediada por tecnología puede mejorar el desempeño escolar cuando la infraestructura digital, las competencias en datos y el liderazgo colaborativo se desarrollan de manera cohesiva dentro de una cultura supervisora ética y participativa.

Palabras clave: Supervisión Colaborativa; Innovación Educativa; Sinergia Digital; Integración Tecnológica; Excelencia Escolar.

INTRODUCTION

Technology integration in education has catalyzed a transformation in the ways schools are managed and supervised, moving beyond traditional hierarchical oversight toward adaptive, collaborative arrangements that harness data, communication, and professional learning.[1,2] This shift aligns with scholarship that frames leadership as a distributed practice, where authority and expertise are shared among educators, administrators, and other stakeholders to meet the dynamic demands of contemporary schooling.[3,4] However, distributed and technology-enabled supervision introduces tensions, including questions of role boundaries, accountability, and resource allocation, which necessitate deliberate governance and ethical considerations.[5,6] Within this evolving landscape, the potential of a technology-mediated collaborative supervision model emerges as a pathway to enhance school managerial quality and, ultimately, student outcomes.[7,8]

A core theoretical lens for understanding this transformation is distributed leadership, positing that leadership is dispersed rather than concentrated solely in the principal, enabling more responsive and innovative school management.[4,9] Nonetheless, distributed leadership highlights normative tensions and contextual constraints—such as autonomy, role boundaries, and resource availability—that affect how distributed practices materialize in schools.[3,5] Empirical studies demonstrate that distributed leadership fosters teacher empowerment and professional growth when supported by appropriate governance structures and collaborative norms.[10,11] These insights establish the theoretical grounding for collaborative supervision as a model that leverages shared leadership and technology to advance school improvement.[7,12]

Collaborative supervision emphasizes shared responsibility, mutual trust, and open communication among teachers, principals, and other educational stakeholders, with technology playing a strategically enabling role.[13,14] By facilitating timely feedback, data sharing, and virtual communities of practice, collaborative supervision supports ongoing professional learning, coaching, and knowledge co-construction essential for improving instructional quality. Principals remain central in shaping conditions for collaboration and ensuring that supervision functions as a professional support mechanism rather than a compliance-based process.[4,15] Thus, effective collaborative supervision requires the integration of human-centered leadership and technology-enabled systems to sustain collective accountability and professional growth.[16,17]

Technology further strengthens these processes by enabling seamless communication, real-time data integration, and continuous feedback loops that enhance reflective practice and evidence-based decision-making.[18,19] Digital platforms and dashboards allow schools to synthesize classroom information, climate indicators, and instructional analytics, providing actionable insights for improvement.[7,20] Yet, the literature warns that technology-based supervision must be implemented with ethical safeguards to avoid surveillance-like practices, protect professional autonomy, and ensure fair use of data.[23,24]

The convergence of distributed leadership, collaborative supervision, and technology integration offers fertile ground for advancing educational leadership. Transparent use of data has been shown to enhance accountability, instructional planning, and teacher engagement.[11,25] Though it requires strong data literacy and ethically robust governance systems.[20,26] Professional development mediated by digital tools supports peer mentoring, professional learning communities, and innovation in instructional practice, further strengthening

collaborative cultures within schools.[12,27]

Professional development emerges as a critical component in operationalizing technology-enabled supervision. Evidence shows that digital tools can foster professional learning communities, peer mentoring, and the exchange of innovative practices, thereby enhancing instructional capacity and teachers' sense of efficacy.[18,28] As digital tools and AI-enhanced analytics become embedded in school governance, principals must cultivate collaborative cultures while upholding ethical decision-making and inclusive participation.[29,30] Leadership preparation programs are therefore encouraged to integrate competencies in distributed leadership, data ethics, and technology-enabled collaboration to prepare schools for digital-era challenges.

Within this theoretical and empirical landscape, the present study introduces digital synergy as a central conceptual contribution, defined as the integrative interaction between technology, collaborative supervision, and distributed leadership that generates amplified organizational benefits unattainable when these components operate independently.[3,31] Principals play a key role in nurturing collaborative cultures, balancing distributed leadership Digital synergy functions simultaneously as a process—a continual flow of communication, data exchange, and joint reflection enabled by digital tools that connect principals, teachers, and institutional information—and as an outcome, reflected in improved coordination, shared accountability, and collective decision-making that strengthen instructional and managerial quality. This conceptualization advances distributed leadership theory by adding a technology-mediated layer that enhances collaboration, transparency, and evidence-based improvement, dimensions that remain underdeveloped in existing supervisory frameworks.[10,32]

Despite the rich literature on distributed leadership, technology integration, and collaborative supervision, there remains a significant gap: prior studies have examined these elements largely in isolation. Only limited research explores how the three dimensions operate collectively as a unified system of supervision, particularly in developing-country contexts. The mechanisms of digital synergy—how digital tools actually enable shared leadership, data-informed reflection, and collaborative decision-making—remain insufficiently theorized and empirically documented. Moreover, empirical evidence demonstrating how technology-mediated collaboration contributes to managerial quality and school excellence is still scarce. This gap underscores the need for a comprehensive model explaining how digital tools, collaborative practices, and distributed leadership interact to transform traditional supervision systems.[33,34]

Therefore, the primary objective of this study is to evaluate a technology-mediated collaborative supervision model grounded in digital synergy, examining its influence on managerial quality, teacher performance, job satisfaction, and instructional outcomes. Additionally, the study seeks to identify the technological tools and collaborative mechanisms that most effectively support data-driven feedback and distributed leadership within school supervision processes.

METHOD

Research Design

This study employed a qualitative case study design to examine how digital synergy—defined as the integrative interaction among technology, collaborative supervision, and distributed leadership—emerges within real supervisory practices in public senior high schools in Padang City. A case study approach was selected because the "case" under investigation is the implementation of the technology-mediated collaborative supervision model across multiple schools, rather than individual participants. This design allowed the researchers to explore the model within its authentic institutional context, considering cultural, infrastructural, and policy-related factors that shape its operation. The case boundaries consisted of five public senior high schools, their supervisory structures, and the digital ecosystems that supported or constrained collaboration.

The descriptive–exploratory orientation was appropriate because the study sought to understand how and why digital tools foster (or fail to foster) synergy in supervision practices. This design enabled in-depth exploration of principals' experiences, the interaction between supervision practices and digital systems, and the complexities of institutional dynamics within each school.

Participants and Context

Participants consisted of five principals and five vice principals from five public senior high schools in Padang City. Purposive sampling was used, selecting individuals responsible for academic supervision and institutional management and with direct experience using digital tools in supervision. Data saturation was reached at the tenth interview. All schools utilized basic digital infrastructure such as Google Workspace, WhatsApp communication groups, and School Management Information Systems (SIM Sekolah). However, the sophistication of digital integration varied; three schools used SIM primarily for administrative tasks, while two used additional tools for performance monitoring and digital archiving.

Table 1. School and Participant Demographics

School Code	Principal Experience (years)	Vice Principal Experience (years)	Student Population	Available Digital Infrastructure
S1	14	10	820	SIM Sekolah, Google Workspace
S2	11	8	760	SIM Sekolah, LMS (local)
S3	9	7	890	SIM Sekolah only
S4	17	12	915	SIM Sekolah, Google Workspace
S5	13	9	740	SIM Sekolah, digital archive tools

Data Collection Instrument

Data for this study were gathered through a triangulated approach involving document analysis, semi-structured interviews, and a Likert-scale questionnaire. The use of multiple instruments enabled the researchers to obtain comprehensive, corroborated, and contextually rich evidence regarding the implementation of technology-driven collaborative supervision across public senior high schools in Padang City.

1. Document Analysis: Served as the foundation for understanding existing supervisory practices and institutional processes. The reviewed documents consisted of the Medium-Term Work Plan (RKJM), the Annual Work Plan (RKT), compliance reports related to the National Education Standards (SNP), supervision instruments and their corresponding reports, as well as digital archives generated by each school's Management Information System (SIM). These documents offered a detailed overview of the planning mechanisms, supervisory cycles, administrative compliance, and the extent of digital integration within each school. A structured document analysis guide was employed to examine the data systematically, ensuring comparability across schools. This guide prompted the researchers to focus on specific dimensions such as alignment between supervision results and planning, evidence of standard implementation, and the operational use of digital platforms in daily managerial activities.

2. Semi-Structured Interviews: Provided in-depth insights into the lived experiences, perceptions, and professional judgments of the participants. A total of ten interviews were conducted, involving five principals and five vice principals who were directly engaged in supervisory duties and digital management processes. Each interview lasted between 45 and 60 minutes and was conducted in person at the participants' respective schools to preserve contextual authenticity. With informed consent, all interviews were audio-recorded to ensure accuracy during transcription and subsequent analysis. The interview protocol explored multiple thematic areas, including the perceived roles of technology in enhancing supervision, the forms and patterns of collaboration between principals and teachers, the nature of supervisory and managerial decision-making, challenges encountered during the implementation of technology-supported supervision, and the institutional benefits emerging from such practices. This approach ensured flexibility while maintaining consistency across all interview sessions.

3. Likert-Scale Questionnaire: a Likert-scale questionnaire was administered to complement qualitative findings with quantifiable measures of supervisory needs and perceptions. The instrument consisted of 20 items distributed across four key domains: planning and supervision, teacher development, technology use in managerial processes, and evaluation and monitoring practices. Respondents rated their level of need or agreement on a five-point Likert scale ranging from 1 (very low need) to 5 (very high need), allowing for nuanced interpretation of perceived priorities within supervisory tasks. Prior to full administration, the questionnaire underwent a piloting phase involving three vice principals who were not part of the main sample. Feedback from this pilot ensured clarity and improved item relevance. Content validity was established through expert review by three scholars in educational administration, who evaluated each item for alignment with the study's objectives and conceptual definitions. Reliability testing yielded a Cronbach's alpha coefficient of 0,87, indicating strong internal consistency and suitability for use as a supporting quantitative instrument.

Data Collection Procedure

1. Approval & Access: Formal research permission was obtained from the city education authority and school principals.

2. Document Collection: Researchers gathered digital and printed documents before interviews.

3. Interview Phase: Interviews were scheduled over three weeks, conducted by two trained researchers.

4. Questionnaire Distribution: Questionnaire forms were distributed after interviews to avoid bias; all 10 participants completed them.

5. Data Verification: Member checking was conducted by sharing summaries with participants for accuracy confirmation.

Data Analysis Techniques

The study applied a multi-stage analytic process to ensure methodological rigor and to provide a comprehensive and credible interpretation of the data. Both qualitative and quantitative strands were analyzed separately before being integrated through triangulation.

Qualitative Data Analysis

Qualitative data obtained from interviews and document analysis were examined using thematic analysis, guided by Braun and Clarke's established six-step analytical framework. The analysis began with familiarization, during which researchers repeatedly read interview transcripts and observation notes to obtain a holistic understanding of the contexts and experiences described by participants. This phase enabled the analysts to immerse themselves in the data, noting preliminary ideas relevant to digital synergy and collaborative supervision.

The next phase involved initial coding, conducted inductively and deductively. Inductive coding allowed themes to emerge naturally from participants' narratives, while deductive coding aligned with the study's research questions concerning technology use, collaboration, and supervisory processes. Code segments were systematically applied across all transcripts.

These codes were then collated during the theme development phase, where related codes were grouped into broader conceptual categories. As patterns became evident across participants and schools, the researchers proceeded with theme review, comparing and validating recurring categories through cross-case analysis. This step ensured that themes appropriately reflected similarities and differences across the five schools.

In the theme definition stage, each theme was refined, clearly named, and linked to its conceptual meaning. Finally, in the reporting phase, themes were woven into narrative findings supported with direct quotations to illustrate participant perspectives authentically.

Two analysts independently coded the qualitative data to enhance reliability. Inter-coder reliability testing produced a Cohen's κ value of 0,81, signifying substantial agreement. Any differences in coding were resolved through collaborative discussion until consensus was reached. Ultimately, the analysis resulted in the identification of major themes, including:

a. technology-enabled communication,
b. collaborative supervisory practices,
c. institutional challenges,
d. data-driven decision-making dynamics, and
e. emerging digital synergy patterns.

Quantitative Data Analysis

Quantitative analysis was conducted on responses from the Likert-scale questionnaire, which aimed to measure participants' perceived supervisory needs across several managerial domains. Descriptive statistics were applied, focusing on Mean and Standard Deviation (SD) to capture both central tendencies and the variability of participants' perceptions.

These statistics provided insight into the relative priority areas across the schools, such as the need for technology integration and collaborative supervisory practices. The results are displayed in table 2 below, which includes the required SD values as part of a complete descriptive statistical report.

Table 2. Principal Needs for Managerial Indicators

Indicator	Mean	SD	Category
Preparation of RKJM based on supervision	3,6	0,52	High
Utilization of technology in supervision	4,5	0,38	Very High
Teacher performance evaluation	3,8	0,47	High
Use of SIM for managerial decisions	3,7	0,44	High
Understanding collaborative supervision	4,3	0,41	Very High

These results quantitatively confirmed the qualitative findings and highlighted two areas with the strongest perceived need: the use of technology in supervision and understanding collaborative supervisory concepts.

Integration of Qualitative and Quantitative Data

To obtain a holistic view of digital synergy in school supervision, findings from both data strands were merged through convergent triangulation. The researchers compared patterns derived from interview themes, document findings, and questionnaire scores to identify convergence, complementarity, and divergence across

datasets.

This integration strengthened interpretive validity by ensuring that themes emerging from qualitative data were supported—or meaningfully contrasted—by quantitative results. For instance, high questionnaire scores on technology use aligned with qualitative narratives describing limited yet increasing digital adoption, while disparities between strategic planning documents and interview insights revealed inconsistencies in data-driven supervisory practices. Such triangulation allowed for a more nuanced and robust interpretation of how digital synergy manifests within the supervision system.

Trustworthiness Procedures

To enhance the rigor of the qualitative component, several trustworthiness strategies were systematically implemented. Credibility was reinforced through member checking, wherein participants reviewed summarized findings to verify accuracy and authenticity. Dependability was supported by maintaining an audit trail documenting coding decisions, data reduction steps, and analytical reflections throughout the study.

To strengthen confirmability, researchers kept detailed reflexive memos to acknowledge and minimize potential biases during data interpretation. Finally, transferability was facilitated by providing rich contextual descriptions of the schools, their supervisory environments, and digital infrastructures, allowing readers to evaluate the applicability of findings to other settings.

RESULTS

The results illuminate how digital synergy emerges across supervision practices, revealing that technology serves not merely as an administrative tool but as a catalyst for collaboration, shared reflection, and data-informed decision-making. By integrating qualitative themes with quantitative indicators, the findings demonstrate both the perceived needs of school leaders and the lived experiences that shape digital supervision in practice.

Data-Based Planning and the Supervisory Feedback Loop

Document analysis shows that although all schools possess a Medium-Term Work Plan (RKJM), only two integrate supervision findings into strategic planning. This gap was reinforced by interview evidence, where one principal admitted, *"We have the supervision reports, but they rarely become a reference when preparing RKJM—it is still mostly administrative."* This qualitative insight helps explain why the questionnaire revealed only a moderate level of need for RKJM preparation based on supervision (M = 3,6, SD = 0,52).

The convergence of these data suggests that planning processes remain compliance-oriented rather than reflective. The minimal integration of supervision outcomes into institutional plans indicates that the digital synergy process—in which supervision data should drive evidence-based planning—is not yet fully operationalized.

What this means:

Digital synergy requires a circular flow of data, reflection, and planning, but the system in these schools is still fragmented. Supervisory data exist, yet the mechanisms to connect them to strategic action remain weak and underdeveloped.

Technology Use in Supervision: Strong Awareness, Weak Implementation

Qualitative and quantitative findings converge strongly on the domain of technology use. Questionnaire results show the highest overall need score for technology utilization (M = 4,5, SD = 0,38), indicating that principals recognize its centrality for modern supervision.

This is echoed in interview excerpts, such as the vice principal who said:

"We use SIM and Google Workspace, but only for uploading reports. We still cannot use the data to monitor teacher performance or make decisions."

Document review confirmed this limitation: digital tools were mainly used for attendance, archiving, and messaging rather than for continuous monitoring or analytics.

What this means:

There is strong conceptual acceptance of technology but weak operational capacity. Digital synergy remains superficial because systems are not yet configured to support real-time supervision, feedback loops, or integrated data dashboards. The gap between awareness and practice highlights the need for targeted capacity-building and system redesign.

Managing National Education Standards (SNP): Documentation vs. Practice

All schools possessed complete documentation for SNP compliance; however, both interviews and documents

indicated that standard implementation remains largely administrative. As one principal explained,

"The documents are complete because of accreditation needs, but they don't guide our daily practice."

This mismatch reflects a lack of data-driven internal evaluation. While schools show high perceived competency in evaluation-related tasks, the questionnaire indicates only moderate need for SIM-based decision-making (M = 3,7, SD = 0,44), suggesting that leaders underestimate the depth of change needed.

What this means:

Digital synergy demands alignment between documentation, supervision, and quality assurance. The findings show that this alignment has not yet been realized—schools meet formal requirements but do not use digital supervision data to drive substantive improvements in SNP-related areas.

Collaboration in Supervision: Valued but Not Fully Institutionalized

Interviews reveal a positive conceptual understanding of collaborative supervision. Principals commonly described it as joint planning and shared responsibility, stating for instance,

"Collaborative supervision involves teachers in planning and evaluating learning."

Despite this strong conceptual clarity, actual practice remains informal. Document review showed no structured procedures for teacher participation, and the questionnaire confirmed a very high need for strengthening collaborative supervision (M = 4,3, SD = 0,41).

What this means:

School leaders value collaboration, but without formal structures or digital platforms facilitating shared analysis, collaborative processes remain episodic rather than systemic. This area offers significant potential for digital synergy, where technology can institutionalize communication and collective reflection.

Institutional Challenges and Capacity Gaps

Across all interviews, challenges related to infrastructure, digital literacy, and resistance to change surfaced as major obstacles. A principal expressed concern:

"Some teachers are still uncomfortable with digital tools—they prefer manual forms even if digital is faster."

These challenges explain why technology's potential for supervision remains underutilized, despite strong demand. They also clarify the high need scores across multiple supervision domains.

What this means:

Digital synergy cannot occur without foundational readiness. Schools require parallel strengthening of infrastructure, digital leadership, and professional development to move from administrative digitization toward genuine innovation.

Contribution of Technology to Institutional Effectiveness

Interview participants consistently highlighted that technology improved efficiency and accessibility of teacher data. However, its role in self-reflection, performance analysis, and strategic improvement is not yet fully established. One principal summarized this by saying:

"Technology helps us collect data quickly, but we are still learning how to use it for evaluation and decision-making."

Quantitative findings support this interpretation: evaluation-related needs scored moderately high (M = 3,8, SD = 0,47), signalling a readiness stage rather than mastery.

What this means:

Digital tools are functioning as accelerators of administrative efficiency but have not yet matured into analytical or transformational tools. This aligns with early-stage digital synergy, where systems are interoperable but not yet integrated into strategic cycles.

Integrated Interpretation: What the Findings Reveal About Digital Synergy

Integrating the document, interview, and questionnaire findings reveals three overarching insights:

a) Schools are digitally active but not digitally strategic: Tools exist, but their use is limited to basic administration. Strategic use—analytics, dashboards, data-driven supervision—is still emerging.

b) Collaboration is conceptually embraced but structurally weak: High need scores and interview testimonies show enthusiasm, but institutional mechanisms are missing.

c) Digital synergy is present, but only in embryonic form: There are signs of synergy—communication improvements, faster feedback—but the deeper features (shared accountability, joint data interpretation,

evidence-based decision-making) require further development.

The integrated findings reveal that while digital tools are widely used and collaborative supervision is highly valued, both domains remain underdeveloped in practice. Schools demonstrate readiness—high need scores, positive attitudes, and clear conceptual understanding—but face structural, infrastructural, and capacity barriers preventing the actualization of digital synergy. These findings indicate that the transition from administrative digitization to transformative digital collaboration is underway but requires strategic system development, capacity building, and policy alignment to be fully realized.

Table 3. Integrated Qualitative and Quantitative Findings on Digital Synergy in Supervision

Theme (Qualitative)	Supporting Evidence (Quotes & Documents)	Quantitative Indicator (Mean ± SD)	Integrated Interpretation
1. Technology-Enabled Communication	"We use SIM and Google Workspace, but mainly for uploading reports."	Tech utilization need: 4,5 ± 0,38	High perceived need aligns with limited operational use; schools are digitally active but not digitally strategic.
2. Collaborative Supervisory Practices	"Collaborative supervision involves teachers in planning and evaluating learning."	Collaborative supervision need: 4,3 ± 0,41	Leaders value collaboration conceptually but lack formal structures → digital tools could institutionalize collaboration.
3. Data-Driven Decision Making	"We have the supervision reports, but they rarely become a reference for planning."	RKJM integration need: 3,6 ± 0,52; SIM use: 3,7 ± 0,44	Documents exist but data cycles are weak → indicates fragmented digital synergy and absence of feedback loops.
4. Institutional Challenges	"Some teachers still prefer manual forms even if digital is faster."	Evaluation need: 3,8 ± 0,47	Infrastructure + literacy gaps limit deeper digital integration despite moderate readiness across schools.
5. Emerging Digital Synergy Patterns	Cross-case evidence: tools used for communication, not analytics or supervision	All indicators cluster high (3,6-4,5)	Digital synergy is emerging but partial—schools ready conceptually, weak structurally; synergy exists in communication but not decision-making.

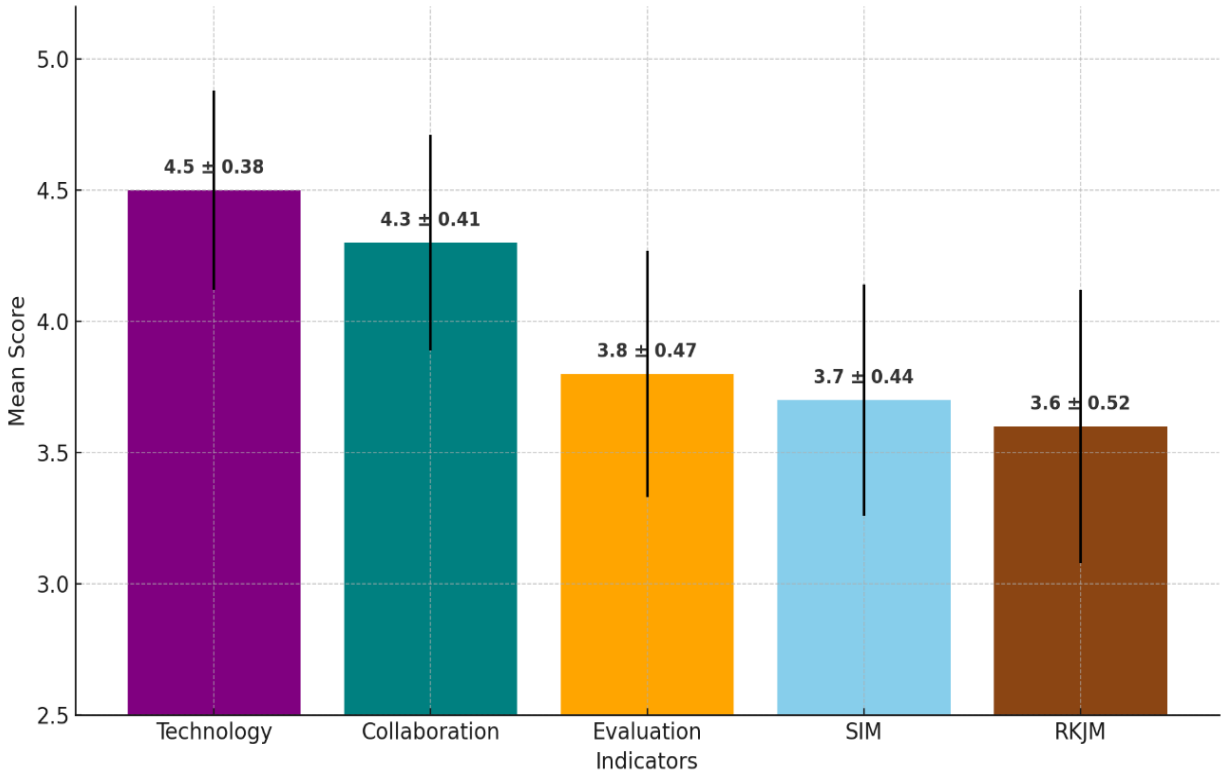

Figure 1. Principals' Supervisory Needs Related to Digital Synergy

The bar chart figure 1 illustrates the mean scores and standard deviations for five key supervisory indicators: Technology Utilization, Collaborative Supervision, Evaluation Indicators, SIM-Based Decision Making, and the Integration of Supervision into RKJM. Technology Utilization shows the highest mean score (M = 4,5, SD = 0,38), indicating that school leaders expressed the strongest perceived need in this domain. This is followed by Collaborative Supervision (M = 4,3, SD = 0,41), reflecting the high priority placed on strengthening collaborative processes within the supervisory system. The remaining indicators—Evaluation Indicators (M = 3,8, SD = 0,47), SIM usage for decision making (M = 3,7, SD = 0,44), and RKJM integration (M = 3,6, SD = 0,52)—display moderately high mean scores, showing that these areas are also considered important, though not to the same degree as technology and collaboration.

The varying heights of the bars, combined with the error bars for each indicator, reflect differences in both average need levels and variability across respondents. Evaluation Indicators and RKJM display the largest standard deviations, suggesting greater variation in how school leaders perceive their needs in these areas. In contrast, Technology Utilization and Collaborative Supervision exhibit relatively smaller standard deviations, indicating more consistent views across participants. Overall, the chart reveals a clear pattern in which technology-enabled supervision and collaborative approaches represent the most prominent needs, while other supervisory domains show consistent but slightly lower levels of priority.

DISCUSSION

The findings of this study indicate that digital synergy within supervisory practices is emerging unevenly across schools, with technology widely adopted for administrative purposes but not yet fully embedded in reflective or instructional supervision. This uneven development suggests that schools are digitally active but not digitally strategic, a distinction that extends earlier scholarship on distributed leadership which emphasizes shared interactions and distributed authority among educators. As highlighted by Phillips et al.[7] and Sharland et al.[12], the results reveal that digital synergy introduces an additional layer to these frameworks by redistributing informational resources, enabling data-mediated collaboration, and strengthening relational ties among supervisors and teachers. In this sense, the study supports and expands prior work on technology-enabled leadership by demonstrating that meaningful distribution of supervisory influence requires not only role sharing but also coherent digital ecosystems that connect actors through shared information flows.

A second key finding relates to the gap between high awareness of digital tools and the limited capacity for their operational use in supervision. Although principals reported strong needs for technology integration (M = 4,5, SD = 0,38), interviews showed that digital platforms such as SIM and Google Workspace were used primarily for uploading reports rather than for performance monitoring or data analytics. This finding aligns with earlier studies showing that digital proficiency is a prerequisite for effective leadership in technology-rich environments. This aligns with the distributed and collaborative models of supervision discussed by Harris and Hulpia et al.[1,4] by revealing that digital competence shapes the extent to which leadership can be distributed, the study introduces an important nuance to distributed leadership theory: leadership distribution is constrained when actors lack the digital fluency needed to engage in shared inquiry, data interpretation, and joint decision-making. This reinforces the idea that digital capacity is not peripheral but central to enacting collaborative, evidence-informed supervision.

The findings also show that collaboration is highly valued conceptually, as reflected in the very high need score for collaborative supervision (M = 4,3, SD = 0,41), yet remains structurally unsupported in practice. This disparity mirrors research indicating that collaboration flourishes when supported by routines, structures, and shared tools rather than informal interpersonal efforts alone. As noted by Börü and Statti,[13,14] the present study extends this literature by showing that digital platforms can operationalize and stabilize collaborative supervision, offering shared access to supervision data, enabling joint reflection, and facilitating collective planning cycles. These digitally mediated routines contribute to what scholars describe as “collaborative professionalism” and “collective instructional capacity,” offering new pathways through which distributed leadership can elevate instructional quality.

In addition, the study finds that data-driven decision-making remains fragmented, with supervision data often collected but not actively used to inform strategic planning, as indicated by moderate scores for RKJM integration (M = 3,6, SD = 0,52) and SIM-based decision-making (M = 3,7, SD = 0,44). This pattern highlights a missing link in the feedback cycle between supervision, planning, and evaluation—an issue noted in earlier work that distinguishes between data abundance and data use. In line with Phillips et al. and Heck & Hallinger,[7,8] While Distributed Leadership theory acknowledges the importance of shared information for collective decision-making, it seldom addresses the digital infrastructures required to sustain such circulation. The present findings clarify this gap by showing that data must be organized, shared, and interpreted through digital systems for leadership to truly function as a distributed phenomenon. Thus, the results both affirm and extend existing theoretical frameworks by identifying data circulation as a core mechanism of digital-era distributed leadership.

An important tension revealed by the findings concerns the dual nature of technology: while digital platforms

enhance transparency, efficiency, and documentation, they can also generate concerns about surveillance, workload intensification, and punitive uses of data. Similar tensions have been noted in prior research where digitalization increased visibility but also heightened apprehension among teachers. As Ho and Ng and Yan et al.[3,20] Participants in this study expressed discomfort with digital monitoring and skepticism about how data might be used, illustrating that technological enhancement does not automatically lead to greater trust or collaboration. These findings underscore that digital synergy must balance transparency with professional trust, aligning technological systems with cultures that prioritize developmental rather than punitive uses of data.

Taken together, these findings culminate in a conceptual contribution to the field: the development of a Digital Synergy Model for technology-mediated collaborative supervision. The model consists of four interdependent components: (1) technology platforms that support communication and data circulation; (2) data literacy and analytical capacity that enable supervisors and teachers to interpret and use evidence meaningfully; (3) collaborative routines that structure joint planning, shared reflection, and follow-up processes; and (4) leadership support and ethical governance that cultivate trust, regulate data use, and reinforce shared accountability. The dynamic interaction of these components reflects the central argument emerging from this study—that distributed leadership in the digital age requires not only shared roles but also digitally mediated relationships, shared evidence systems, and collaborative learning cultures. As such, the Digital Synergy Model expands existing theoretical perspectives by illustrating how technology transforms both the structure and the practice of supervision in contemporary schools.

Implication

The findings of this study offer several practical and theoretical implications for strengthening technology-mediated supervision within distributed leadership environments. For practitioners, the results underscore the need for schools to invest not only in digital platforms but also in building data literacy and collaborative routines that allow supervision data to be interpreted and acted upon collectively. This highlights the importance of instructional leadership training that integrates technology use, ethical data practices, and collaborative decision-making structures to reinforce digital synergy. For policymakers, the study suggests that regulatory frameworks should move beyond administrative compliance and instead promote digital ecosystems that enable transparency, shared accountability, and sustainable professional learning. Theoretically, the proposed Digital Synergy Model contributes to leadership scholarship by illustrating how digital infrastructures reshape the mechanisms through which leadership is distributed, thereby expanding the conceptual boundaries of Distributed Leadership theory in the digital era.

Limitations and future research

This study is limited by its focus on a small number of schools within a single regional context, which may constrain the generalizability of its findings to other educational settings with different digital capacities or policy environments. In addition, the qualitative emphasis of the research, while providing rich insights, limits the extent to which causal relationships between digital synergy and supervisory outcomes can be established. Future research should consider employing mixed-methods or longitudinal designs to examine how digital synergy evolves over time and whether the implementation of technology-mediated supervision leads to measurable improvements in instructional quality and school performance. Further studies may also validate and refine the Digital Synergy Model by testing its components across diverse school systems, exploring variables such as teacher digital readiness, organizational culture, and technological infrastructure. Such research would deepen understanding of how digital environments shape distributed leadership practices and how digital synergy can be optimized to support sustainable school improvement.

CONCLUSION

This study concludes that technology-mediated collaborative supervision can enhance school managerial quality and instructional development when the key components of digital synergy—technology platforms, data literacy, collaborative routines, and leadership support—are intentionally integrated into supervisory practice. The findings show that effective supervision is achieved not merely through the availability of digital tools, but through structured collaborative processes that enable principals and teachers to jointly interpret supervisory evidence, exchange feedback, and engage in shared decision-making. In line with the research objective, the study identifies that digital synergy fosters stronger communication flows, increases transparency in supervisory activities, and supports more consistent professional interactions, thereby contributing to improvements in teacher performance, job satisfaction, and institutional effectiveness. Furthermore, the study highlights that the most impactful technological tools are those that support accessible data sharing, routine collaborative reflection, and distributed leadership practices, indicating that meaningful educational transformation requires both digital capacity and supportive leadership cultures that sustain ethical, participatory, and evidence-informed supervision.

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FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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