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REVIEW ARTICLE

Systematic insights for educational sustainability: Principals' digital leadership and teacher professional performance

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ABSTRACT

Clarifying how leadership supports teacher performance within sustainability agendas is very important, as evidenced by the rapidly accelerating digital transformation of education and the global call for resilient, future-ready education. Improving teachers' digital proficiency and performance is a critical strategy for enhancing educational standards, particularly as global education systems undergo digital transformation. School principals play a central role in this process through their leadership styles. The necessity for a thorough synthesis is highlighted by the scattered evidence, despite increased attention, regarding the relationship between principals' digital leadership and teacher effectiveness as well as long-term institutional sustainability. This systematic literature review (SLR) examines how principals' leadership influences teachers' digital performance by synthesizing empirical studies published between 2015 and 2025. With the PRISMA framework as a guide and the addition of qualitative content analysis and bibliometric mapping, the review analyzes 21 peer-reviewed studies from diverse educational contexts, focusing on research trends, conceptual frameworks, and methodologies. Findings reveal key leadership practices—such as platformization, collaboration, systemic improvement, and fostering a digital culture—that significantly enhance teacher performance, particularly in digitally enriched classrooms. By incorporating these observations, the review shows how strategic digital leadership promotes institutional resilience and equity in addition to enhancing teachers' self-esteem and pedagogical efficacy. The review highlights how strategic digital leadership strengthens teachers' confidence and pedagogical effectiveness, providing valuable evidence-based insights for policy and practice aimed at creating digitally competent schools. This work contributes to advancing our understanding of leadership's role in driving successful digital transformation in education. The role of leadership in promoting sustainable digital transformation is better understood thanks to this synthesis, which also helps guide leadership development initiatives that support the UN 2030 Agenda for Sustainable Development.

Keywords: principal leadership; teaching performance; quality improvement; educational sustainability; systematic literature review; PRISMA

1. Introduction

Due to the quick spread of technology and the demand for more resilient, sustainable educational systems that can strike a balance between technological innovation, long-term equity, and institutional

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stability, the digital transformation of education has become a defining characteristic of modern education. As societies strive to meet the goals of the United Nations 2030 Agenda for Sustainable Development—particularly Goal 4: Quality Education—educational institutions are increasingly expected to adopt digital strategies that not only enhance learning outcomes but also promote inclusivity, innovation, and long-term systemic improvement. In this regard, school administrators are becoming more and more acknowledged as both instructional and digital leaders who influence the circumstances around the meaningful integration of technology into teaching and learning[1]. Particularly in areas like digital competency, pedagogical innovation, and technology-enhanced instruction, their leadership has a significant impact on teachers' professional performance[2]. Placing this transition within the sustainability discourse, which connects digital change to more general ecological, social, and institutional concerns, further enhances the relevance of current research.

Due to the quick spread of technology and the demand for more resilient, sustainable educational systems that can strike a balance between technological innovation, long-term equity, and institutional stability, the digital transformation of education has become a defining characteristic of modern education. Digital strategies that not only improve learning outcomes but also foster inclusivity, innovation, and long-term systemic improvement are becoming more and more expected of educational institutions as societies work to meet the goals of the United Nations 2030 Agenda for Sustainable Development, especially Goal 4: Quality Education. The significance of current research is strengthened by placing this shift within the sustainability discourse, which places digital change within broader ecological, social, and institutional concerns.

Many empirical studies have examined how principals' leadership styles and digital capabilities impact teachers' work in digitally mediated learning environments over the past decade. Effective digital leadership has been shown to improve student outcomes, elevate instructional practices, and better prepare teachers across diverse educational settings[3]. Additionally, research emphasizes the multifaceted nature of digital leadership, encompassing professional development facilitation, technology management, digital culture cultivation, and strategic vision[4,5].

The relevance of digital leadership extends beyond academic performance to include broader sustainability goals. This manner of framing leadership emphasises how long-term school viability and the attainment of SDG-aligned outcomes are inextricably linked to equal access to technology, the reduction of educational gaps, and the development of adaptive capability. As schools grapple with challenges such as technological equity, environmental responsibility, and the need for future-ready learners, principals' digital leadership plays a pivotal role in fostering institutional sustainability. This includes nurturing a digital culture that promotes continuous learning, supports inclusive access to digital tools, reduces educational disparities, and strengthens the adaptive capacity of schools. In this context, digital leadership becomes a catalyst for building resilient, future-oriented educational ecosystems that align with the principles of sustainable development.

Despite this expanding corpus of work, there is still a lack of a clear synthesis connecting the goal of educational sustainability, teacher professional performance, and principals' digital leadership. It is unclear how digital leadership tactics consistently transfer into better teacher practice, equity, and long-term institutional resilience because previous research frequently addresses technology integration or leadership style in isolation. Furthermore, not many evaluations synthesise data from elementary, secondary, and postsecondary education to elucidate common trends, mediating variables, and conceptual frameworks that

promote change with a sustainability focus. One significant knowledge gap is the absence of an integrated body of evidence.

This study concentrates on studies released between 2015 and 2025, a decade that saw significant advancements in policy and practice, to guarantee a strong and up-to-date body of data. Leadership expectations have changed since 2015 as a result of the UN 2030 Agenda's ratification and the quick acceleration of post-digital education changes, such as the COVID-19 era's heightened mandates for blended learning, cloud-based platforms, and broad one-to-one device efforts. Choosing this time frame highlights the technological, pedagogical, and structural changes influencing the present conversation about school leadership and documents the rise of digital policies that are in line with sustainability.

The current review treats teacher professional development, equity, and institutional resilience as mutually reinforcing goals in order to solve this, specifically integrating the analysis of digital leadership within the sustainability agenda. The current study specifically attempts to fill this gap by offering a systematic review of empirical research on the impact of principals' digital leadership on teachers' professional performance, paying special attention to the ways in which these relationships support or complement educational sustainability.

Even with this expanding literature, several gaps remain. First, the pathways through which digital leadership strategies translate into measurable improvements in teacher performance across various settings are not yet well synthesized. Although direct effects on teacher performance and technology integration have been studied by researchers like Saeed and Kang and Raman and Thannimalai, the underlying mechanisms and conceptual frameworks are not sufficiently explored[6,7]. Second, while there is growing discourse around educational sustainability, few studies explicitly link principals' digital leadership to systemic, long-term goals such as innovation, equity, and institutional resilience[8,9]. Third, there is a lack of comprehensive analysis that consolidates findings across elementary, secondary, and higher education to provide an integrated understanding of leadership for digital transformation and sustainability.

Within a single analytical framework, this study investigates the relationship between sustainability, teacher development, and digital leadership. The evaluation emphasises how leadership decisions relate to resource stewardship, inclusive growth, and systemic adaptability by integrating sustainability concepts. It offers useful implications for creating educational institutions that are not only technologically competent but also sustainable, inclusive, and prepared for the uncertainties of the future. By combining empirical data, this study aims to close the observed knowledge gap by elucidating mechanisms, highlighting effective practices, and guiding leadership development programs. This review thus contributes fresh perspectives on the evolving role of leadership in digital learning environments and its strategic alignment with sustainable development goals. By answering the following research questions, this study aims to foster a more holistic and nuanced understanding of leadership in the digital era:

RQ1: How does principals' digital leadership influence teachers' professional performance?

RQ2: In what ways does principals' digital leadership contribute to or align with the goals of educational sustainability in the reviewed literature?

RQ3: What research gaps and future directions are identified in the literature on principals' digital leadership, teachers' performance, and educational sustainability?

2. Theoretical perspective

A solid body of research on literature reviews in the field of educational leadership and administration serves as the foundation for this study[10-12]. Bellibaş and Gümüş (2019) point out that there are three basic types of scholarly evaluations in this field[10].

The first category includes bibliometric mapping, which examines frequently cited sources, influential authors, trending keywords, geographical research activity, and intellectual networks in order to find patterns and structures in the academic literature. For instance, Hallinger and Kovačević used descriptive statistical techniques, keyword clustering, and citation and co-citation analyses to do a thorough bibliometric analysis of 22 educational administration publications[12]. Key contributors, regional research concentrations, prevailing conceptual frameworks, and recurrent topics within the area were all identified by their work.

The second group consists of content analysis reviews, which look at academic papers in a methodical way to find important research subjects, theoretical stances, and methodological strategies. This strategy is demonstrated by Hammad et al.[13], who do a thorough thematic and methodological analysis of studies to track the development of research agendas and theoretical frameworks.

Integrative syntheses, which fall under the third category, are designed to emphasise overarching themes and draw broader conclusions by combining the results of several investigations. Examples include Oplatka & Arar and Gümüş et al.[14,15], whose syntheses combine empirical results from many contexts and approaches to offer a thorough understanding of the field.

Apart from these discrete methodologies, some researchers have embraced a mixed-methods review approach that combines content analysis with bibliometric approaches. The prevalence and development of leadership models in educational administration, as well as changes in research methodologies, academic leadership, and thematic goals across time, were all studied by Gumus et al.[11].

This mixed-methods approach is in line with the current study, which uses content analysis and bibliometric mapping to investigate changes in the literature. In particular, this study looks into trends in scholarly production, major discoveries, research design features, regional distribution of studies, journal publication patterns, and the overall course of academic inquiry in the field.

3. Materials and methods

3.1. Selection of papers

To gain a comprehensive understanding of the state of the area, the study started with a methodical review of the literature. The scholarly work that examines the connections between principals' digital leadership, teacher professional practices, and the more general objectives of educational sustainability was the focus of this review.

To reflect the post-2015 policy era shaped by the UN 2030 Agenda, the rapid post-digital education reforms, and the acceleration of blended-learning initiatives during and after COVID-19—factors that have redefined expectations for leadership, sustainability, and systemic equity—the review window was set to 2015–2025, in accordance with the Introduction.

To guarantee the quality and applicability of the chosen research, a clear set of inclusion criteria was used (**Table 1**). To find a broad range of peer-reviewed articles and relevant academic outputs, a literature search was carried out across major academic databases, such as Scopus, Web of Science (WoS), and Google Scholar.

Table 1. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Topic, Abstract, Keywords	Principal digital leadership & teacher professional performance & educational sustainability	
Population	Education-related	Non-education
Date	≥2015.1-2025.5	＜2015
Data collection source	Both original and secondary research were considered	
Language	English	Other languages
Publication Type	Peer-reviewed journal, bookchapter, conference papers, dissertations	Preprints, grey literature, and editorials
Study design	Qualitative, quantitative, mixed research	Theoretical research
Access Status	Open Access Content	

The exact search dates were 12–25 May 2025, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was adopted to guide screening and reporting. Full Boolean search strings are now presented in **Table 2**.

Table 2. Full search strings used in three databases (January 2015–April 2025).

Databases	Full Search Strings	No.
Scopus	ALL(("principal leadership" OR "principal digital leadership" OR "school digital leadership" OR "educational digital leadership") AND ("digital competence" OR "digital literacy" OR "technology integration") AND ("teacher professional performance" OR "teaching effectiveness" OR "instructional quality"))	**256**
WoS	TS=(("principal digital leadership" OR "school digital leadership" OR "educational digital leadership") AND ("teacher digital competence" OR "teacher digital literacy" OR "teacher technology integration") AND ("teaching performance" OR "teaching effectiveness" OR "instructional quality"))	**886**
Google Scholar	("principal digital leadership") AND ("teacher professional performance") AND ("educational sustainability")	**22**
	Total	**1164**

The terms "principal digital leadership," "teacher professional performance," and "educational sustainability" were used in a second manual Google Scholar search, which produced 22 pertinent studies. This was a component of a larger data collection procedure that used findings from WoS and Scopus to initially identify 1,142 papers. 1094 unique records remained in the dataset after duplicate entries were eliminated.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework served as a guide for the screening and selection procedure[16]. 62 studies were selected for additional quality evaluation after parallel screening of complete texts, abstracts, and titles was done by two separate reviewers. Discussions were held to settle differences, and in cases where disagreements remained, a third reviewer made a decision to reach an agreement. Additionally, the Mixed Methods Appraisal Tool (MMAT, 2018 version) was used to evaluate the methodological quality of the kept publications[17]. 42 articles were kept for full-text review after a thorough evaluation of methodological rigour and relevance. After evaluation, 39 papers were found; we looked through them to find key findings and suggest subjects.

Following this thorough review, 21 empirical studies were chosen for the final analysis in this research since they satisfied all inclusion requirements. With thorough counts at each inclusion and exclusion stage, **Figure 1** depicts the PRISMA selection procedure.

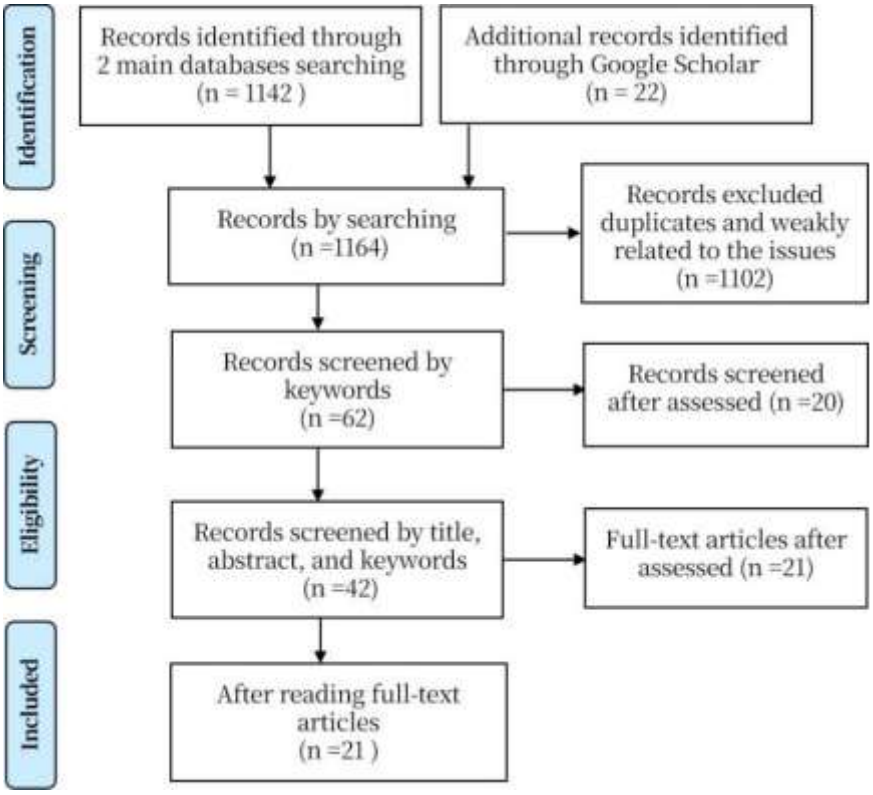

Figure 1. PRISMA flow diagram of the study.

3.2. Coding strategy and analytical approach

The research design (qualitative, quantitative, or mixed-methods), the type of data source used (e.g., survey instruments, case study, etc.), the main focus of findings, the key influencing factors, the mediating mechanisms (rational, emotional, organisational, etc.), and the identified mediators (e.g., teacher efficiency, job satisfaction, digital skill level, etc.) were all systematically recorded for each study that was part of the review.

The "supporting professional development through digital principal leadership" paper by Sterrett and Richardson[18], which offers information on how digital principals assist professional development in their schools, served as the basis for the coding framework. Three themes emerge from the way these principals operate: "1) Engaging teachers in purposeful professional development; 2) Engaging in digital professional learning networks; 3) Supporting teachers as professional leaders." Additionally, the coding framework takes into account the professional development lens provided by Blase, J., & Blase, J.[19], who contended that principals supported teachers' professional development by "(1) emphasising the study of teaching and learning; (2) supporting collaboration efforts among educators; (3) developing coaching relationships among educators; (4) encouraging and supporting redesign of programs; (5) applying the principles of adult learning, growth, and development to all phases of staff development; and (6) implementing action research to inform instructional decision making."

Microsoft Excel was used to code the data and do basic statistical processing. It also made it easier to visualise new patterns and theme trends. The coded data was then integrated and interpreted using content analysis, paying close attention to recurrent themes pertaining to the main outcome focus of the study, influential dimensions, mediating processes, and variables.

4. Results

4.1. General findings

After doing a literature search, 21 studies were found and categorised in a methodical manner. Based on the results, the distribution of studies across journals and years is fairly balanced (**Figure 2**).

	Journal	2019	2020	2021	2022	2023	2024	2025	Year
2019	SAGE Open	1							1
2019	International Journal of Innovative Technology and Exploring Engineering	1							1
2020	Systematic Reviews in Pharmacy		1						1
2020	Journal of Organizational & Educational Leadership		1						1
2021	Emerging science journal			1					1
2021	Journal of Education and E-Learning Research			1					1
2021	Sustainability			1					1
2022	International Journal of Educational Research				1				1
2022	Information & Management				1				1
2022	The Educational Review, USA				1				1
2022	International Journal of Multidisciplinary: Applied Business and Education Research				1				1
2023	Education and Information Technologies					1			1
2023	Pakistan Journal of Distance and Online Learning					1			1
2023	Enrichment: Journal of Multidisciplinary Research and Development					1			1
2023	Revista de Gestao Social e Ambiental					1			1
2024	Academy of Education and Social Sciences Review						1		1
2024	Education Sciences						1	1	2
2025	International Journal of Learning, Teaching and Educational Research							1	1
2025	International Journal of Leadership in Education							1	1
2025	Computers and Education							1	1
	Total	2	2	3	4	4	2	4	21

Figure 2. Number of publications per journal and year.

The methodological strategies used by the chosen publications were primarily quantitative, as shown in **Table 3**, with 13 research using this methodology. Just two studies used a mixed-methods design; the remaining six studies used qualitative methodologies. Readers are directed to Table B1 in Appendix B for a thorough summary of the chosen publications, including the precise methodology used and their related classifications.

Significant patterns about the approaches used in the chosen papers were found by the content analysis. The majority of the research (13 out of 21) used quantitative methodologies, as shown in Table 3, which is in line with the emphasis on quantifiable outcomes including student achievement, teacher performance, and the efficacy of technology integration. These research mostly employed questionnaires to gather information from educators and school administrators, enabling extensive, broadly applicable conclusions about how digital leadership affects teaching methods.

Two studies, or a lesser percentage, used mixed-methods research, which combines qualitative and quantitative techniques to offer a more complex picture of the effects of leadership practices. In order to gain a deeper understanding of the lived experiences of administrators and teachers in digitally altered school environments, the remaining six research used qualitative approaches, mostly in the form of case studies and interviews.

Table 3. Research methods of 21 empirical studies.

Qualitative		Quantitative		Mixed Methods		
Interview	3	Survey	13	Interview+Survey	2	
Survey	1					
Interview+observation+documentation	2					
Total	6		13		2	21

According to geography, the majority of the reviewed research were carried out in Asia (14 studies), followed by Europe (5 studies). North America (1 study) and Africa (1 study) were less represented (**Table 4**). According to this distribution, despite being a worldwide phenomenon, digital leadership in education may present different opportunities and difficulties based on the local situation. For example, European studies examined themes like as policy alignment, teacher autonomy, and digital citizenship, whereas Asian studies frequently concentrated on concerns pertaining to technological equity, accessibility, and capacity building in settings with limited resources.

Table 4. Number of the country of studies.

Region	Country	Count
Asia (14)	Indonesia (4), Malaysia (3), Philippines (2), Pakistan (2), Turkey (1), Kuwait (1), Arab (1)	**14**
Europe (5)	Greece (2), Switzerland (2), Spain and Bulgaria (1)	**5**
North America (1)	USA (1)	**1**
Africa (1)	Nigeria (1)	**1**
Total		**21**

4.2. Results of content analysis

4.2.1. Key findings focus

Across all reviewed articles, technology integration is a central theme, appearing in every study reviewed (100% of the literature), reflecting its crucial role in transforming education through digital leadership (**Table 5**). Other frequently recurring themes include digital leadership (appearing 19 times), visionary leadership (14 times), and digital culture (12 times), underscoring the multifaceted nature of leadership in the context of digital transformation. These themes emphasize how school principals are leveraging digital tools, platforms, and strategies to foster a culture of innovation, collaboration, and adaptive learning in schools.

Table 5. Findings focused in reviewed studies.

	Themes	Frequency
1	Technology integration	21
2	Digital leadership	19
3	Visionary leadership	14
4	Digital culture	12
5	School principals	11
6	Systemic improvement	8

	Themes	Frequency
7	Professional practice	7
8	Educational leadership	7
9	Professional development	7
10	Digital transformation	6
11	Strategic leadership	5
12	Strategic resource allocation	5
13	Transformational leadership	5
14	Digital citizenship	4

Table 5. (*Continued*)

In order to promote systemic change (11 mentions) and guarantee sustainable teaching methods, school principals play a critical role as change agents. In order to integrate school methods with more general educational sustainability goals—like encouraging inclusion, creativity, and long-term resilience in teaching and learning environments—their leadership styles are essential. Given the substantial influence that principals' digital leadership has on teacher competency and overall educational outcomes, professional practice (8 mentions) and professional development (7 mentions) are highlighted as crucial areas of concern in this context.

Notably, school leaders must oversee broader systemic processes to guarantee that digital technologies are successfully incorporated into curricula and pedagogical practices. These processes include strategic leadership (5 mentions), transformational leadership (5 mentions), and strategic resource allocation (5 mentions). Additionally, there are four mentions of the concept of digital citizenship, which highlights the significance of teachers and students using technology in an ethical, responsible, and productive manner within the school ecosystem.

According to these results, digital leadership involves more than just bringing new technology into classrooms; it also entails coordinating it with long-term objectives of educational sustainability, a topic covered in a number of studies, including innovation, equity, and institutional resilience. The durability of educational methods can be greatly enhanced by administrators' strategic vision for integrating a digital culture into schools and by providing teachers with ongoing professional development opportunities.

4.2.2. Key affecting dimensions

Sterrett and Richardson assert that their study offers crucial information about how digital principals affect the professional development of teachers in their institutions[18]. Three major themes that support successful digital leadership are identified by the study. Teachers' participation in professional learning communities that use digital resources and platforms is facilitated by digital principals, according to the first theme, Engaging in Digital Professional Learning Networks. These principals contribute to the creation of a culture of continuous learning by encouraging cooperation and knowledge sharing in virtual environments, which supports teachers' continual professional growth and instructional enhancement.

Principals' digital leadership is acknowledged for fostering teacher improvement through six crucial techniques, which are based on Blase and Blase's paradigm for teacher development[19]. The results of the 21 papers that were analysed here highlight how digital leadership significantly affects teacher effectiveness, with an emphasis on professional development and instructional techniques. In addition to improving

teachers' pedagogical skills, these tactics aid in the growth of a supportive school environment and digital culture.

The elements of digital leadership and their impact on teacher performance as found in the analysed research are categorised in **Table 6** below.

Table 6. How teacher performance is impacted by principals digital leadership **(From Blase, J., & Blase, J. , 2000)**[19]**)**.

	Dimension	Description
1	"Emphasizing the study of teaching and learning"	Research aimed at enhancing learning outcomes, teacher efficacy, and classroom instruction[20-23].
2	"Supporting collaboration efforts among educators"	Research highlighting the importance of teamwork in school improvement, teacher preparation, and leadership[6,8,24-26].
3	"Developing coaching relationships among educators"	Research highlighting the value of mentoring, coaching, and promoting teacher growth through leadership[5,18,27,28].
4	"Encouraging and supporting redesign of programs"	Research showing that software modifications are necessary to improve performance[9,29-31].
5	"Applying the principles of adult learning, growth, and development to all phases of staff development"	Research focussing on adult learning, digital competency, and professional development[7,21,32,33].
6	"Implementing action research to inform instructional decision making"	While some studies concentrate on how leadership affects performance and decision-making, many do not specifically address this strategy[22,34].

The studies in Table 6 show how digital leadership can improve teacher effectiveness in a variety of ways. Every one of the six tactics put out by Blase and Blase is essential to the development of teachers as professionals[19]. For example, Alajmi et al. and Nawaz et al. have shown that a strong emphasis on the study of teaching and learning is associated with notable enhancements in classroom instruction and student outcomes[20,22]. Additionally, encouraging educators to work together creates a strong feeling of community, and principals can help teachers improve by promoting partnerships and opportunities for knowledge sharing[6,24].

The importance of mentorship and individualised support in enhancing teaching methods is also emphasised by the strategy of developing coaching relationships among educators[18,27]. Accordingly, principals are essential in promoting and aiding program redesigns that better match professional development to new demands and difficulties[9,29].

It is clear that adult learning theories are crucial in improving the digital competencies of educators, as shown by Antonopoulou et al. and Raman & Thannimalai, as the application of the principles of adult learning, growth, and development continues to gain prominence in the literature[7,32]. Though less frequently highlighted, the idea of using action research to guide instructional decision-making is nevertheless crucial in determining choices about teaching methods and technology integration[22,34].

In summary, these results highlight the vital role that digital leadership plays in supporting teachers' continuous professional development. School administrators can enhance teacher performance and create a more productive and interesting learning environment for students by placing a strong emphasis on goal-setting, coaching, teamwork, and program reform. According to the research's findings, principals who embrace a thorough, multifaceted approach to digital leadership have a higher chance of creating a welcoming and flexible learning environment in their institutions.

4.2.3. Mediating / moderating variables path

We mapped the mediating paths in **Figure 3** and highlighted the most commonly reported mediating elements for each pathway in **Figure 4** to better show how principals' digital leadership impacts teacher professional performance. Organisational (31 instances), rational (21), emotional (21), student (7), community-family (7), cultural (6), and strategic resource (4) are among the paths.

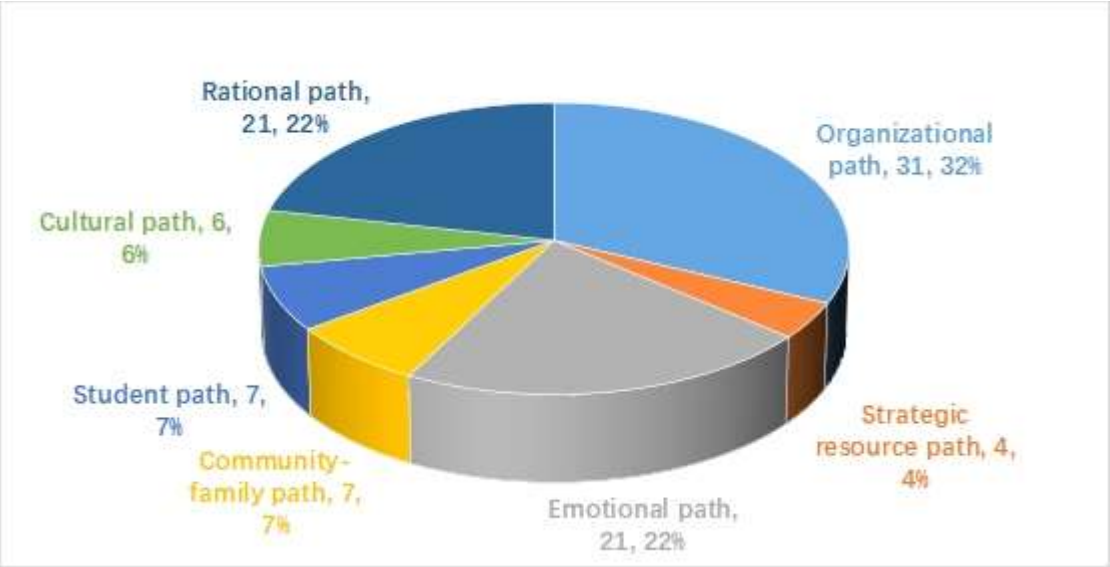

Figure 3. Mediating paths linking principals' digital leadership to teacher professional performance.

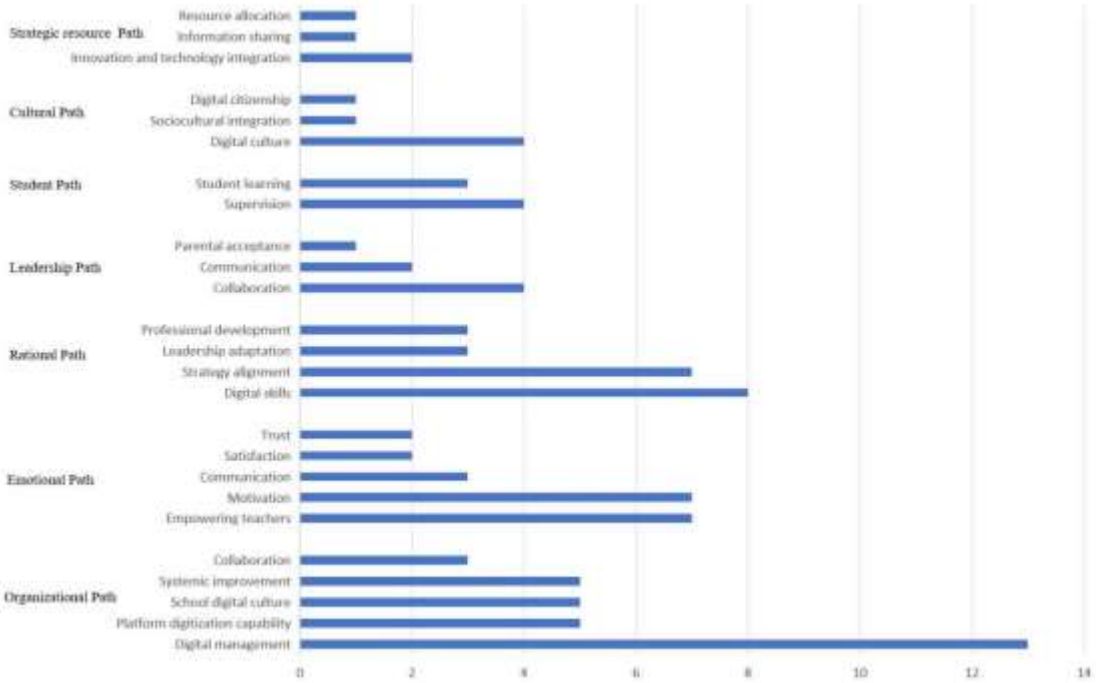

Figure 4. Frequency of mediating variables within each pathway.

Teacher professional performance is impacted by principals' digital leadership in a number of linked ways. Table A1 in Appendix A links each study to the coded categories.

Organizational Path (31 occurrences): The most frequently reported pathway, with the primary mediating variable being digital management practices (13 occurrences). These include establishing clear institutional visions for technology use, reorganizing professional development through digital platforms, and engaging in strategic planning. Other notable mediators include platform digitization capability (5), school digital culture (5), and systemic improvement initiatives (5), collectively contributing to enhanced collaboration (3) and institutional effectiveness.

Emotional Path (21 occurrences): This pathway centers on empowering teachers (7) and enhancing motivation (7), demonstrating how digital leadership fosters a supportive environment conducive to innovation and professional growth. Secondary mediators, such as communication (3), teacher satisfaction (2), and trust (2), further emphasize the relational and affective aspects of leadership.

Rational Path (21 occurrences): Key mediating factors include development of digital skills (8) and alignment of leadership with institutional strategies (7). Leadership adaptation (3) to technological shifts and support for targeted professional development (3) highlight the role of analytical, evidence-based decision-making in improving teacher competencies.

Community-Family Path (7 occurrences): Mediators in this pathway include community and stakeholder collaboration (4), effective communication strategies (2), and parental acceptance (1), emphasizing the role of external partnerships in sustaining school-wide digital transformation.

Student Path (7 occurrences): This pathway links leadership practices to student-centered outcomes, mediated by supervision of digital instruction (4) and enhancement of student learning (3), illustrating the influence of leadership on classroom-level changes and student engagement.

Cultural Path (6 occurrences): Primarily mediated by digital culture (4), with additional contributions from sociocultural integration (1) and promotion of digital citizenship (1), highlighting the role of cultural sensitivity and ethical digital practices in shaping professional behavior.

Strategic Resource Path (4 occurrences): Mediators include innovation and technology integration (2), information sharing (1), and resource allocation (1), showing how access to infrastructure and strategic resources supports effective digital leadership.

Principals' digital leadership, which functions through a variety of mediating mechanisms including organisational structures, emotional support, logical decision-making, cultural awareness, community engagement, and student-focused practices, greatly influences teachers' professional performance in schools that are undergoing digital transformation and sustainability.

4.2.4. Key contribution to educational sustainability

A number of leadership techniques were shown to be essential for improving the professional performance of teachers, especially when using digital resources. In order to guarantee that both instructors and students have access to reliable, flexible learning environments, platformization - the use of digital platforms for instruction, collaboration, and learning management - was emphasised as a successful strategy for raising teacher effectiveness.

The significance of collaboration between teachers and principals in establishing professional development plans was another important discovery. One strategy for improving teachers' digital competency and teaching methods was the establishment of professional learning networks (PLNs), which were led by principals. Principals can encourage peer-to-peer learning as they mentor teachers through these networks, fostering an environment of ongoing development that enhances teachers' digital competency and overall efficacy as educators.

Furthermore, the growth of a digital culture has been continuously identified as a key element supporting the uptake of educational innovations and digital tools. Principals support the transition to more collaborative, tech-integrated teaching methods by fostering an institutional culture that recognises and promotes digital literacy. The entire school community is becoming more involved and tech-savvy as a result of this shift, which goes beyond just the teachers and includes kids and even parents.

The formulation of long-term initiatives that not only enhance immediate educational achievements but also set the groundwork for future educational systems that are more flexible and adaptable is made possible by principals' digital leadership.

Key findings show that principals may help create schools that can prosper in a constantly changing digital ecosystem by integrating sustainability concepts into their leadership practices. These principles include equality, resource efficiency, and the scalability of educational technologies. In order to support future-proof educational ecosystems that can withstand obstacles like funding cuts, technological obsolescence, or changes in educational paradigms, principals strategically allocate resources and exercise leadership to ensure that technological advancements are not only integrated but maintained over time.

5. Discussion

5.1. Limitations

Although there are many methodological advantages to using databases, this review also identifies a number of noteworthy drawbacks. First, the diversity and representativeness of the evidence base may have been limited by the omission of grey literature and non-English publications. Second, the findings may not be as applicable to larger international contexts due to the prevalence of studies carried out in certain geographic areas. Additionally, the studied literature's lack of interdisciplinary integration limits the possibility of more creative or comprehensive interpretations of teacher performance and digital leadership. The focus of the research on Asian educational systems also casts doubt on claims of universal transferability and emphasises the necessity of culturally sensitive replication in other areas. Future studies should think about expanding the inclusion criteria to include non-traditional and multilingual sources, implementing measures to lessen regional concentration, encouraging methodological standardisation, and utilising a range of disciplinary viewpoints to improve the findings' robustness and applicability in order to allay these worries. By situating future research within sustainability standards (equity, resource efficiency, and institutional adaptability), it will become even more evident how leadership models might be scaled responsibly in a variety of settings.

5.2. Implications

The review's conclusions have significant ramifications for educational leaders who want to use digital leadership to improve teachers' professional performance. Principals play an increasingly important role in fostering collaboration, influencing digital culture, and assisting teacher development as schools continue to incorporate technology into their teaching methods. This entails making sure that, from the standpoint of sustainability, digital transformation enhances rather than diminishes long-term institutional capacity, fair access, and employee well-being.

Instead of just restating data statistics, this synthesis identifies three interrelated domains—systemic alignment, relational capacity, and strategic vision—that influence whether digital leadership results in long-term teacher development.

School administrators must, first and foremost, embrace a purposeful, empirically supported approach to digital leadership that aligns institutional vision with realistic goals. Schools can link short-term performance

gains with long-term advantages like decreased digital disparities, steady capacity growth, and resilient teaching cultures by integrating these goals into sustainability frameworks. Coherence across departments is promoted and fragmented adoption is decreased by integrating specific, quantifiable goals for digital transformation and connecting them to curriculum priorities. Clearly defining school-wide goals for digital transformation can help staff members feel more focused and purposeful. By promoting congruence between digital tools, teaching methods, and performance expectations, principals may create an environment where educators feel empowered and inspired to use technology in meaningful ways.

Furthermore, it is crucial to foster an organisational culture that values ongoing professional development. The evaluated research consistently demonstrate that teacher efficacy and innovation significantly increase when principals prioritise organised, iterative professional learning, which includes coaching cycles, peer observation, and feedback protocols. In addition to technical talents, professional development should cover leadership skills, digital citizenship, and pedagogical integration. A culture of responsible innovation is strengthened when professional development opportunities—like instruction in inclusive pedagogy, long-term planning, and ethical technology use—are connected to sustainability. It is possible to boost teacher efficacy and promote creativity by incorporating chances for educators to take part in peer mentoring, professional learning networks (PLNs), and leadership positions in digital projects. Recognising successful digital teaching strategies and providing regular, constructive feedback can help boost teacher motivation and foster an excellence culture.

Crucially, the emotional and relational aspects of leadership were found to be crucial. Increased adoption of digital tools is consistently associated with the development of trust, open communication, and awareness of the workload of educators. Even well-funded technology ventures fail in the absence of these prerequisites. Seeing this relational labour as a component of education's "social sustainability" emphasises how staff well-being, empathy, and openness support long-lasting transformation. Leaders are better equipped to overcome resistance and develop staff members' digital preparedness when they promote psychological safety and set an example of inclusive, flexible leadership techniques.

Lastly, human development plans need to be in line with systemic changes in school governance, resource allocation, and digital infrastructure. The long-term benefits of reforms are increased by policies that guarantee device fairness, lessen environmental impact (e.g., energy-efficient hardware), and incorporate sustainability indicators into digital strategy. Effective digital leadership is not just technical, as the evaluation emphasises; it calls for a comprehensive approach that strikes a balance between organisational change, emotional engagement, and logical planning. While school systems must continue to invest in both infrastructure and human resources, policymakers must incorporate digital leadership competencies into principal preparation criteria. By firmly establishing these competencies in sustainable development agendas, leaders can promote institutional resilience and equity in addition to instructional excellence. This comprehensive approach should be reflected in future leadership development programs, giving school administrators the tools they need to steer digital transformation in a way that promotes teacher development, teamwork, and, eventually, student learning results.

5.3. Future research directions

Future research should use longitudinal designs to monitor the long-term effects of principals' digital leadership on teacher performance, demonstrating resilience and sustainable effectiveness. Investigating contextual factors—such as institutional digital capacity, leadership structure, and socio-cultural context—can reveal conditions that shape the effectiveness of digital leadership strategies (eg.[35,36]). It becomes clear

which leadership pathways result in schools that are prepared for the future when these requirements are directly linked to sustainability measures like equity of access, resource durability, and stakeholder inclusion.

To further understand the mechanisms relating leadership to teacher outcomes, more research is advised on mediating factors such as teacher motivation, digital competency, and collaborative culture, such as Ahn and Bowers's research[37]. Karakose et al.'s research can also provide many insights[38]. To supplement quantitative trends and capture teachers' opinions on leadership initiatives and their evolution over time, mixed-methods and participatory approaches are advised.

In order to enhance solely quantitative trends, mixed-methods and participatory approaches can reveal how instructors view leadership initiatives and how these perspectives change over time. To improve generalisability, future research should also broaden to include non-English studies and under-represented regions. More in-depth, context-sensitive insights into these processes may be provided by mixed-methods approaches to research on sustainability in education[39-41]. The impact of cultural and policy environments can be made clearer by cross-national comparisons and meta-analytic techniques. Furthermore, the conceptual connection between digital transformation and educational sustainability will be reinforced by using interdisciplinary frameworks from environmental management, organisational behaviour, and educational policy.

Overall, these approaches provide a strong emphasis on practical advice for developing policies, educating leaders, and providing systemic support to advance sustainable, technologically advanced teaching methods.

6. Conclusion

In order to directly address the research concerns about how principals' digital leadership influences teacher effectiveness and promotes educational sustainability, this systematic review synthesises data from 21 empirical studies conducted between 2015 and 2025. The review makes it clear that principals' digital leadership—which is typified by strategic vision, digital culture building, and relational support—has a measurable positive impact on teachers' instructional quality, engagement, and adaptability by combining findings from elementary, secondary, and higher education.

This evaluation views principals' digital leadership as a lever for long-term educational sustainability as well as a driver of instructional excellence, with a foundation in the 2030 Agenda's vision of resilient, equitable, and future-ready education. The main finding is that when technology integration is purposefully coordinated with pedagogical objectives and sustainability priorities, digital leadership serves as a stimulus for teacher professional development. Higher-quality instruction and better student results result from boosting teachers' self-esteem, encouraging teamwork, and integrating digital practices into school culture (RQ1). Furthermore, by strengthening institutional resilience and minimising inequities, leadership initiatives that prioritise inclusivity, equitable access, and ongoing learning are in direct line with the tenets of sustainable education (RQ2).

The review emphasises through this synthesis that trust-building, acknowledging teacher competence, and adaptive planning are all components of good digital leadership that go beyond technical management. Such strategies protect long-term systemic progress while allowing schools to adapt to the rapid changes in technology.

The evaluation highlights several research gaps, including a lack of interdisciplinary frameworks that integrate organisational behaviour and educational leadership, a lack of longitudinal data, and an under-

representation of non-English and regionally diverse studies (RQ3). Filling up these gaps will improve theoretical coherence and increase future research's worldwide applicability.

The study emphasises the value of leadership development programs that integrate digital competency, relational acumen, and sustainability awareness by incorporating these ideas. In order to lead schools through digital transformation and foster inclusive, future-ready educational ecosystems, principals must be equipped with these well-rounded competencies.

Author contributions

Conceptualization, Yuexin Xin, Aida Hanim A. Hamid, and Azlin Norhaini Mansor; Methodology, Yuexin Xin; Software, Yuexin Xin; Validation, Yuexin Xin, Aida Hanim A. Hamid, and Azlin Norhaini Mansor; Formal Analysis, Yuexin Xin; Investigation, Yuexin Xin; Resources, Yuexin Xin; Data Curation, Yuexin Xin; Writing—Original Draft Preparation, Yuexin Xin; Writing—Review & Editing, Yuexin Xin; Visualization, Yuexin Xin; Supervision, Aida Hanim A. Hamid and Azlin Norhaini Mansor; Project Administration, Aida Hanim A. Hamid and Azlin Norhaini Mansor.

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Conflict of interest

The authors declare no conflicts of interest.

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Appendix A

Table A1. Coded categories of studies review.

	Categories	Paths	Occurrences	Total
1	Organizational path	Digital management	13	31
		Platform digitization capability	5	
		School digital culture	5	
		Systemic improvement	5	
		Collaboration	3	
		Empowering teachers	7	
2	Emotional path	Motivation	7	21
		Communication	3	
		Satisfaction	2	
		Trust	2	
3	Rational path	Digital skills	8	21
		Strategy alignment	7	
		Leadership adaptation	3	
		Professional development	3	
4	Community-family path	Collaboration	4	7
		Communication	2	
		Parental acceptance	1	
5	Student path	Supervision	4	7
		Student learning	3	
6	Cultural path	Digital culture	4	6
		Sociocultural integration	1	
		Digital citizenship	1	
7	Strategic resource path	Innovation and technology integration	2	4
		Information sharing	1	
		Resource allocation	1	
				97

Appendix B

Table B1. List of studies review.

Authors	Year	Title	Country of study	Data source	Research design
Alajmi et al.	2022	"The impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait"	Kuwait, Asia	Survey	Quantitative
Antonopoulou et al.	2021	"Transformational leadership and digital skills in higher education institutes: during the COVID-19 pandemic"	Greece, Europe	Survey	Quantitative
Antonopoulou et al.	2025	"Teachers' Digital Leadership and Competencies in Primary Education: A Cross-Sectional Behavioral Study"	Greece, Europe	Survey	Quantitative
Baldera et al.	2025	"Digital Leadership Pioneers: Navigating Outstanding School Principals' Successes in the Evolving Educational Landscape"	Philippines, Asia	Interview+ Observation+ Documentation	Qualitative
Benitez et al.	2022	"Impact of digital leadership capability on innovation performance: The role of platform digitization capability"	Spain and Bulgaria, Europe	Interview+ Survey	Mixed-methods
Ghamrawi & Tamim	2023	"A typology for digital leadership in higher education: The case of a large-scale mobile technology initiative (using tablets)"	Arab, Asia	Interview	Qualitative
Hamzah et al.	2021	"The Effects of Principals' Digital Leadership on Teachers' Digital Teaching during the COVID-19 Pandemic in Malaysia"	Malaysia, Asia	Survey	Quantitative
Karakose et al.	2021	"Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the COVID-19 pandemic"	Turkey, Asia	Survey	Qualitative
Nawaz et al.	2023	"Relationship between Digital Leadership Competencies and Teachers' Performance: Structural Equation Model Analysis"	Pakistan, Asia	Survey	Quantitative
Obadimeji & Oredein	2022	"Digital Leadership and Decision-Making Styles as Determinants of Public Primary School Teachers' Job Performance for Sustainable Education in Oyo State"	Nigeria, Africa	Interview+ Survey	Mixed-methods
Quddus et al.	2020	"Effect of ecological, servant dan digital leadership style influence university performance? evidence from indonesian universities"	Indonesia, Asia	Survey	Quantitative
Raman & Thannimalai	2019	"Importance of Technology Leadership for Technology Integration: Gender and Professional Development Perspective"	Malaysia, Asia	Survey	Quantitative
Retnowati & Santosa	2023	"Digital leadership, culture & employee capabilities: Sustainable organizational performance in education-a case study"	Indonesia, Asia	Survey	Quantitative
Rosa	2022	"Digital Leadership and Teachers' Performance: Basis for a Proposed Training Program"	Philippines, Asia	Survey	Quantitative
Ruloff & Petko	2025	"School principals' educational goals and leadership styles for digital transformation: results from case studies in upper secondary schools"	Switzerland, Europe	Interview	Qualitative

Authors	Year	Title	Country of study	Data source	Research design
Saeed & Kang	2024	"The impact of digital leadership on the performance of secondary teachers"	Pakistan, Asia	Survey	Quantitative
Schmitz et al.	2025	"Enhancing teacher collaboration for technology integration: The impact of transformational leadership"	Switzerland, Europe	Survey	Quantitative
Sterrett & Richardson	2020	"Supporting professional development through digital principal leadership"	USA, North America	Interview	Qualitative
Umah et al.	2023	"MADRASAH PRINCIPAL DIGITAL LEADERSHIP INNOVATION IN DIGITAL LEARNING TRANSFORMATION"	Indonesia, Asia	Interview+ Observation+ Documentation	Qualitative
Wiyono et al.	2024	"Elevating Teachers' Professional Digital Competence: Synergies of Principals' Instructional E-Supervision, Technology Leadership and Digital Culture for Educational Excellence in Digital-Savvy Era"	Indonesia, Asia	Survey	Quantitative
Yusof et al.	2019	"Digital leadership among school leaders in Malaysia"	Malaysia, Asia	Survey	Quantitative

Table B1. (*Continued*)