

Deep Learning Integration in Curriculum: A Digital Leadership Strategy for Effective School Management

Maria Vatmawaty Bety¹, Sururi²
Educational Administration
Universitas Pendidikan Indonesia
Bandung
betymaria@upi.edu

Abstract

Deep Learning Approach emphasizes a transformational learning environment. This learning approach focuses on the meaningful, joyful and mindful learning, critical thinking development, problem solving skills, and the 21st century competencies which prepare the students to globally navigate the challenges and readiness of the digital era. Otherwise, the successful implementation of the deep learning approach in schools should be supported by the digital leadership strategy in order to manage effective school administration. In case of that, a better sustainable education could be enhanced and ensured effectively. This study is aimed at figuring out (1) the effective strategies of digital leadership used by the principals to succeed the implementation of deep learning integration in curriculum, and (2) the impacts of digital leadership strategies for effective school management. A Systematic Literature Review using PRISMA Protocol is conducted to reveal how deep learning integration in curriculum could be one of the strategies used in the era of digital education implemented by principals to develop a sustainable education. This method systematically identifies, evaluates and synthesizes various studies taken from relevant peer-reviewed articles taken from Scopus in the published year of 2018 – 2025. The result found that there was a conceptual framework that maps the implementation of deep learning integration in school curriculum as one strategy of digital leadership applied by the school principals in order to develop effective school managements towards sustainable education.

Keywords: Deep learning, Digital leadership, School management, Sustainable education

Introduction

Digital leadership is becoming popular in the era of industrial revolution 4.0 which is crucial for guiding organizations through transformation and ensuring alignment with the use of technology in the vision and goals of organization (Grobman et al., 2022; Netaniel et al., 2024). Moreover, in educational organizations, it is inevitably challenging rather than neglecting it. Several studies have proven that the success of technology integration in educational organization is strongly affected by the quality of leadership and the internal of conditions of the organization dealing with school management (Juni et al., 2025; Permana et al., 2025).

The supporting curriculum for digital leadership implementation in school is deep learning curriculum which fostering twenty-first-century competencies indicating learning transformation with collaboration, communication, and problem-solving, while continuous assessment helps students to check progress and make necessary improvements for knowledge application beyond the classroom (Adnyana, 2024; Arif et al., 2025; Halimah et al., 2025; Oviedo et al., 2024; Al Akhyar, 2024).

However, many challenges come to appear as the implementation of deep learning integration in curriculum such as technological infrastructures and lacks of school sources such as teacher's readiness to technology advancement into learning process, the most significant is the schools in remote area (Okoye et al., 2023). In case of that, research has shown that principals in accordance with digital leadership could

significantly occupy the teacher’s ability and readiness to integrate technology into classroom learning which could impact to students better learning outcomes (Alias et al., 2023; Ghavifekr et al., 2021; Omar et al., 2020; Rasdiana et al.,2024). However, another research by (Musaigwa, 2023) emphasizes on the findings that the role of leadership could shape vision, manage resistance, and foster a culture of innovation. Thus, a leader must adopt any strategy approach for integrating technologies into learning (Permana et al., 2025; Wibowo et al., 2024).

Nevertheless, the technology integration into curriculum needs a deep pedagogical approach, one of these is a deep learning framework that focuses on the six global competencies which are character, citizenship, collaboration, communication, creativity and critical thinking. On the other hand, deep learning also contributes to sustainable education for developing long- term competencies such as critical thinking, global awareness and social responsibility which are crucial for the resilience of future communities’ development and individuals (Rieckmann, 2012). Otherwise, the success of deep learning integration leans on two basic pillars, both are visionary digital leadership and effective school management for a transformational management. In fact, most research conducted separately about deep learning and digital leadership. It indicates that there is some lack of synthesized academic evidence connecting these three essential elements of a sustainable education which are digital leadership, deep learning integration and school management as a transformational strategy for a sustainable education especially Sustainable Development Goal 4, Quality in Education.

This gap shows that there is a need to identify and synthesize conceptual model to guide the school administrators for managing effective transition of deep learning integration as digital approach. This raises a critical question: (1) What effective strategies of digital leadership could facilitate the integration of deep learning into the school environment, (2) What are the impacts of digital leadership strategies for effective school management to achieve success of deep learning integration into curriculum towards sustainable education. However, this research aims to figure out and synthesize the strategies of digital leadership that could facilitate the integration of a deep learning approach into the school environment and describing the school management practice could support and prevent the achievement of sustainable development goal 4 through deep learning integration.

The conceptual framework of this study illustrates that there is a relationship between digital leadership and effective school management as strategy and support for achieving the success of deep learning integration in curriculum for sustainable education through a deep Systematic Literature Review approach.

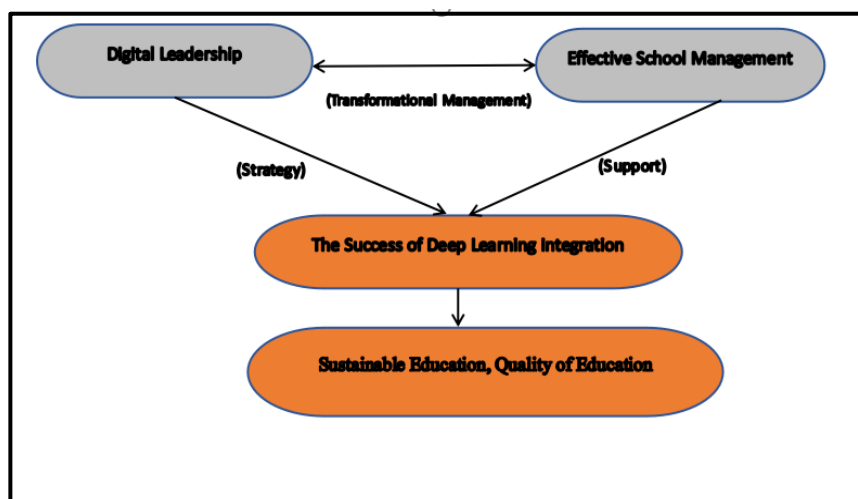


Figure.1. A research Framework

Through a systematic approach, this study is expected to create a comprehensive conceptual map illustrating how digital leadership strategies are applied to successfully implement deep learning integration into curriculum by the support of effective school management which aims to contribute for sustainable education, quality of education. The findings will not only enrich the academic literature but also provide a practical foundation for education stakeholders to design more effective and contextually relevant digital leadership strategies for transformational management.

Methodology

This study employs a qualitative research design using the Systematic Literature Review (SLR) method to figure out, synthesize, identify and describe various studies discussing the deep learning integration into curriculum focusing on the digital leadership strategy of implementing it and the supporting school management to succeed it. The literature review process follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, which consists of four main stages: identification, screening, eligibility, and inclusion (Permana et al., 2025; Varsha et al., 2024). This comprehensive literature research ensures transparency and data validity conducted across Scopus academic databases covering publications from 2018 to 2025.

The Scopus-indexed articles were used as data of the study. Because of its powerful and convenience searching feature provided, Scopus has also been utilized as reliable publications of many literature reviews by global researchers (Hong et al., 2024; Nguyen et al., 2023; Nguyen Thi et al., 2024; Zainal Abidin et al., 2023). Furthermore, the Scopus-indexed journals are also included in the Web of Science for almost 99.11 % (Nguyen Thi et al., 2024; Singh et al., 2021). Moreover, this research steps are described as follows: (a) Inclusive and exclusive criteria analysis consisting of publication years from 2018 - 2025, publication type as peer-reviewed articles and proceedings of international conference, academic database indexed Scopus.

Then, topics focused on digital leadership, deep learning integration (6 C's), school management and sustainable education goal 4, the last, English language used articles. (b) The selected articles are chosen using Boolean string keywords as (“Digital Leadership” OR “School Management” OR “Educational Administration”) AND (“Deep Learning” OR “21st Century Skills” OR “6 C’s”) AND (“SDGs” OR “Sustainable Education”).

Table 1. The Search String used for Systematic Review Process

Data Base	Search String	Documents Found
Scopus	TITLE-ABS-KEY (“digital leadership” OR “deep learning” OR “21st century skills” OR “6 C’s”) AND (“school management” OR “educational administration”) AND (“digital leadership” OR “sustainable education” OR “SDGs”) AND (“deep learning” OR “21st Century skills” OR “6 C’s” OR “school management” OR “sustainable education” OR “SDGs”)) AND PUBYEAR > 2017	83 documents

AND PUBYEAR <2026

(c) Screening and selection were done by removing duplicates, reviewing titles and abstracts and conducting a full- text assessment to ensure alignment with the focus of this study. The irrelevant topics of selected articles discussing only about digital leadership and strategies but not strategies to implement deep learning integration were excluded from final selection. Adjusting the screening process, a total of 8 articles were identified as relevant to the objectives of the study.

The selected articles then were subjected to data extraction and thematic coding. The elements examined included: strategy of digital leadership used to implement deep learning integration in curriculum, figured out the impacts of digital leadership to school management, the support of effective school management to implementation of deep learning integration in curriculum and the impacts to sustainable education. All data were collected then analyzed using a descriptive -qualitative approach, focusing on mapping key themes and the patterns of relationship between strategy of digital leadership and effective school management to achieve success in deep learning integration to curriculum towards sustainable education. The synthesis is expected to provide a new comprehensive conceptual overview that mapping digital leadership strategies to manage deep learning integration into curriculum effectively and to give policy recommendation for global educational administrators.

Result and Discussion

This part of the study presents the findings and analysis on the (8) selected research articles found. Fundamentally, it focuses on research questions which are (1) the effective strategies of digital leadership could facilitate the integration of deep learning approaches into the school environment, (2) What are the impacts of digital leadership strategies for effective school management to achieve success of deep learning integration into curriculum towards sustainable education.

Table 2. The Findings of Systematic Literature Review

Title, Authors, Years Publication	Research Method	Main Results	Conclusion
<i>The Crucial Role of High School Management in Facilitating e-Portfolio Implementation in Classrooms</i> Modise, M.-E.P.; Majola, X.M.; Kotoka, J.K. (2025)	A qualitative research approach and the Technology Adoption Model (TAM).	This study investigated e-portofolio implementation as the support of digital learning with a particular focus on the role of school management. Findings of the study indicate that members of school management can be catalysators for teachers and	The integration of technology into classroom learning i.e e-portofolio needs support of school principal with digital leadership. In the other hand, some issues may appear such as insufficient support system, inadequate infrastructures, limited access to relevant ICT resources, and lack of training development. Therefore, the researchers recommend that the successful integration technology into school management could be

		<p>learners to integrate technology in the classroom, thereby facilitating and supporting the implementation of this approach in schools. It means that the school management plays a crucial but often overlooked role as catalysts for technology integration yet they are systematically excluded from training and professional development specially training for technology implementation.</p>	<p>achieved by training and preparation and stakeholder involvement in which e-portofolio could hold significant educational potential for a sustainable education.</p>
<p><i>Principals' Digital Leadership Competencies in the Fourth Industrial Revolution: Teachers' Perspectives</i> Okunlola, J.O.; Naicker, S.R. (2025)</p>	<p>A quantitative, descriptive research design.</p>	<p>The findings of this study described that high school leaders are perceived by teachers as meeting ISTE-A digital leadership standards in school management in which the female leaders exhibited slightly higher digital skills than males, though gender was insignificant in meeting the ISTE-A standards overall. However, the practical implications and recommendations for the school principals and administrators are</p>	<p>The study mainly underscores the importance of digital leadership in school management, offering practical implications for leadership practices, policy decisions, and future research. Although the ISTE-A standards are met, the emphasis on systemic improvement highlights how Nigerian principals adapt strategies to local resource constraints, differing from high-tech education systems. Recommendations for leadership include promoting the ISTE-A standards among school leaders, which can be the investment of digital leadership training, fostering digital literacy, and supporting adaptability to technological changes to advance digital transformation in education</p>

		<p>investment in digital leadership skills, fostering digital innovation culture, Promoting ISTE-A standards and addressing gender discrepancy.</p>	<p>for supporting a sustainable educational which adaptable with technology.</p>
<p><i>Evolution and Future Directions in School Leadership Development Research: A global Bibliometric Perspective (2015-2025)</i> Hariyanti, R.A.M.; Pahrudin, A.; Akmansyah, M.; Fauzan, A. (2025)</p>	<p>A Bibliometric Analysis</p>	<p>The study examines public trends, citation dynamics, collaboration networks, thematic evolution and potential future research directions in school leadership development from 2015-2025. Based on the results found, the emerging themes for future research include leadership strategies for curriculum adaptation in response to global challenges and digital transformation, leadership models that could support educator well-being and motivation, inclusive and equity-focused leadership that addresses diversity social identities and leadership practices across educational levels, particularly within higher and</p>	<p>It can be concluded that emerging research trends highlight a growing focus on sustainability, well-being, and digital transformation. This study provides a comprehensive overview of the scholarly landscape in school leadership development, identifying key trends, influential contributors, and future research directions. It highlights the field's evolution towards more complex, human-centered, and digitally integrated leadership models, emphasizing the need for adaptive strategies in a global educational context. So that, it is essential for policymakers and practitioners in formulating effective leadership development strategies amid global educational challenges. Indeed, digital leadership could leverage adaptive sustainable education.</p>

<p><i>A Review of the Conceptual Structure and Evolution of Digital Leadership Research in Education</i> Karaköse, T.; Polat, H.; Tülübaş, T.; Demirkol, M. (2024)</p>	<p>Science mapping methodology and used SciMAT software (version 1.1.04)</p>	<p>professional education contexts.</p> <p>The results highlight that cultivating technology or e-leadership, considering the developments in the world of computers and the internet, research into digital leadership has gained momentum in recent years, particularly following the COVID-19 pandemic. Based on the findings found on publications and citation trends in period 1 (1991-2016), period 2 (2017-2021), and period 3 (2022-2024), it states that technology leadership was the most persistent motor theme across all 3 periods. The study defines that digital leadership is regarded as a broader concept for application in investigating the knowledge, skills, competencies, and perspectives of school leaders to facilitate the healthy integration of digital technologies into education, school</p>	<p>Research examines that digital leadership has evolved from focusing on technology leadership and e-leadership toward a broader concept of digital leadership, which includes skills, knowledge, and vision for integrating rapidly evolving digital technologies for school administration and student learning. Therefore, it requires further investigations in many aspects of digitalization in education to build a more solid and insightful knowledge base to guide the effective practice of digital leadership in schools.</p>
--	--	---	--

<p><i>From Participatory Leadership to Digital Transformation under the interpretation of Political Philosophy: Types of Leadership in Education and School Administration</i></p>	<p>A Literature Review</p>	<p>administration, and student learning.</p>	<p>This study examines three big skills to be analyzed as the digital transformation which are (1) the concept management and leadership types, (2) change of transformational leadership to distributed and participative one and (3) support of digital leadership for transformation learning and school management. The modern school leader must combine a variety of those skills in order to adequately cope with his role. So that, the learning system and school management could be aligned with one another to digital leadership.</p>	<p>Technology is an instrument of power and influence, but the goals for human integration remain the same, emphasizing the need not to confuse means with ends. The influence of political philosophy is necessary to determine human value and qualitatively separate modes of leadership, preventing a slide into relativism where the education of a leader and a criminal are considered equal. School leadership is a critical field where the leader is responsible for daily decision-making, establishing school culture, and adapting to new conditions as school units operate as open systems interacting with the wider social environment.</p>
<p>Vavouras, E.; Koliopoulou, M.; Manolis, K. (2024)</p>				
<p><i>School Leadership and Management in the Age of Artificial Intelligence (AI): Recent Developments and Future Prospects</i></p>	<p>A Literature Review</p>	<p>This study explores how Artificial Intelligence (AI) is transforming school leadership and management. By analyzing future trends and recent advancements, it underscores the opportunities and challenges AI possesses for educators, students</p>	<p>AI is a transformative force in education which contributes to school leadership by offering opportunities for improved management, decision making, customization of educational experiences and increased stakeholder engagement. However, it also presents challenges to its implementations relating to lack of infrastructure, culture and skills. Then, the digital</p>	
<p>Karaköse, T.; Tülübaş, T. (2024)</p>				

and school leaders. This study reviews the integration of AI-based digital technologies in educational settings and highlights their implications for effective and collaborative school leadership. This finding explains the AI in education, typology of AI technologies, implications for school leadership and management which contributes to digital leadership emphasizing on using technology not only for administrative efficiency but also for transparency, collaboration and open communication. It may enable open government models, distributed leadership, and data-driven decisions.

Reinventing School Health Service Management in Nigeria: Literature Review, Best Practices for Digital Upgrade

Ukpabio, G.E.; Mbon, U.F.; Ekanem, E.E.; Ukpang, N.N.; Okon, E.E.; Aniah, S.A.; Omini, E.E.; Ngaji, M.I.; Egwuonwu, C.O.K.; Egwu, S.O. (2023)

Integrative Literature Review

This study examines the challenges facing the management of School Health Service (SHS) in Nigerian Primary and Secondary schools and proposes digital best practices as solutions for collaborative leadership not only promotes technological adoption but also pedagogical innovations to truly harness AI's potentials. Based on the conclusion that a digitalized management input will solve the problems of SHS in Nigerian schools, it was suggested among other things that the Ministry of Education should insist on digital literacy for teachers and school heads, redefine conditions for stakeholders' participation in SHS and review its policy. The

effective improvement. The problems identified were: lack of awareness of SHS, lack of personnel, underfunding, poor facilities, poor inter sectoral networking, lack of critical leadership input, poor data management among others. The solution proffered to the problems was digitalized management input in form of: engaging in internet-based awareness campaign on SHS; utilizing social media to host School/Community collaboration on SHS; creating school health help/donation platform using digital technology; providing digital leadership in school management, creating digital data mining system and others.

Ministries of Education and Health should set up a joint monitoring team to supervise operations of SHS in Nigerian schools. This studies also indicates that digital leadership should embrace and actively promote the use of digital tools and also the mindset of it.

Analysis of Digital Leadership in School Management and Accessibility of Animation-Designed Game-Based Learning for Sustainability of Education for Children with Special Needs

Baglama, B.; Evcimen, E.; Altinay, F.; Sharma, R.C.; Tlili, A.; Altinay, Z.; Dağlı, G.; Jemni,

A Qualitative Research Method

This study finds that digital leadership in school management and the use of accessible animation-based game learning significantly

The study concludes that animation-based, technology-supported learning environments positively affect the development, motivation, and skill acquisition of children with special needs, and that ensuring accessibility of these tools for teachers and families

M.; Shadiev, R.; Yücesoy, Y.;
Çelebi, M. (2022)

support the is essential, particularly in
sustainability of crisis conditions like COVID-
education 19. It also concludes that
especially for digital leadership is now an
children with inevitable requirement in
special needs school management: leaders
incidentally the must integrate digital
condition after the platforms and emerging
Covid 19 technologies, foster
pandemic. This innovation and collaboration,
study specifically and guide schools through
explains that (1) digital transformation so that
visual animation educational goals and societal
designs improve expectations can be met,
learning and skills, especially in special
(2) accessibility of education settings.
animation and
technology
education is
crucial, (3)
perceptions of
digital leadership in
school and (4) the
need for digital
leadership in
schools. In this
context, this study
provides
information on the
use and
accessibility of
animation
technology in
special education,
offers suggestions
for the benefit of
visual design and
animation, which
are among the
assistive
technologies, and
gives insights into
how school
management is
ready for digital
education.

Based on the results presented on the systematic literature review table above, the eight articles studied about the digital leadership strategy to implement deep learning and how effective school management done to succeed it which contributes to sustainable education. Each article contributes to diverse insights and perspective to strategies can be used for implementing deep learning as a digital leadership strategy for effective school management. The study by (Modise et al., 2025) highlights that technology integration into school could enhance the school administration process which could impact best practice of learning in which the use of e-portofolio as digital collection for tracking student progress and learning materials. It is inevitably conducted in deep learning integration into school curriculum.

Supporting this the research by (Wen Jiang, 2025) reveals that deep learning approach into curriculum can effectively facilitate the students' learning modalities and final academic outcomes and successfully identify key performance indicators in physics study while maintaining high prediction accuracy. Meanwhile, in the study by (Wen Jiang, 2025) it is stated that the integration of deep learning into curriculum needs support of technology by utilizing of multi-modal data (e.g class participation, homework completion, lab performance, online learning duration and discussion frequency). So, in order to implement successful deep learning integration into curriculum it needs ICT competence mastered by school leaders to cultivate teaching, learning and school administration based on technology.

The implementation of deep learning is better supported by training and preparation for school administrators and stakeholder involvement. Research by (Okunlola et al., 2025) explains more about the school leaders' focus on digital leadership's competence based on ISTE-A standards by examining data of teacher's perceptions on it. It finds out the (1) lowest mean score (2.83) describing the challenges of digital learning culture implementation faced by the digital school leadership and (2) the gender leaders do not significantly impact overall digital leadership standards compliance.

It indicates that digital learning culture could be enhanced by the implementation of deep learning integration into curriculum as supported by the research by (Nofirman, 2025) promoting the embedding of deep learning in STEM could impact student engagement practising the 21st century skills with integration of digital learning which could increase students learning motivation (82.5%), programming skills (20-35%) and collaboration skills (27.5%). Meanwhile, the study by (Hariyanti et al., 2025) employing a global bibliometric perspective highlights digitally integrated leaderships model and the need for adaptive strategies in global education context could be best strategies for implementing deep learning into curriculum developing the 21st century skills in learning which brings digital transformation for leadership and school management towards sustainable education globally.

The strategies needed based on research by (Sutikno, 2025) are the strategic leadership, building a school culture that is open to innovation and utilizes available facilities to support the implementation of deep learning which could meet the competencies of 21st century. More explanation about strategy of digital leadership investigated by researcher (Karaköse et al., 2024) reveals that digital leadership has evolved from focusing on technology leadership and e- leadership toward a broader concept of digital leadership, which includes skills, knowledge, and vision for integrating rapidly evolving digital technologies for school administration on data-driven decision making and student learning for integrating AI and STEM in deep learning approach.

It is clearly defined by (Xie et al., 2023) as stated in (Netaniel et al., 2024) that digital leadership conveys the ability and wisdom of school leader or the school management team plan and develop a vision for the

integration of technology and to influence and guide all the school parties including teachers, students and staffs to work together achieving the goals and visions facilitated by the technological advancement in the educational organization. However, researcher (Vavouras et al., 2024) explains that digital leadership is the transformation of school leadership which compared to participatory leadership redefining leadership styles in educational organizations requiring digital leaders to possess and adopt digital knowledge and skills, introducing digital visions and foster team spirit in school management. While researcher (Karaköse et al., 2024) explicitly explains AI integration in school leadership could be a transformative force in education brings efficiency and effective school management for improved management, decision making, customization of educational experiences and increased stakeholder management.

Moreover, the study by (Ukpabio et al., 2023) that implementation of best practice digitalization in management, data mining and ICT in education can enhance awareness, coordination, fundraising, leadership and data management. In the end, the last study by (Baglama et al., 2022) specifically investigates the learning method in deep learning pedagogy employing technology integration with animation-based. It positively affects the development, motivation and skill acquisition of children with special needs. This study highlights the need of digital leadership to achieve school goals, follow new technologies, reach the desired level of societal development, support students learning and ensure education continuity of any disruption face-to-face learning.

The results of the studies then are analyzed into two main points of this research objectives. Firstly, the effective digital leadership to facilitate deep learning integration can be achieved by building and communicating to educators and school staffs about a clear digital-deep learning vision as supporting a shared vision that links technology and deep learning outcomes i.e critical thinking, collaboration, creativity and problem solving rather than just using ICT in learning (Munirah, 2022). The supporting written policies, school development plans, and regular communication can maximize teachers' understanding vision to see deep learning as the core purpose of digitalization. (2) Strengthening teacher digital and pedagogical competence by providing caching, PLCs, peer-mentoring, an value-based digital literacy programs that help teacher designs project based and inquiry-oriented task (Syarip, 2025). (3) Providing robust digital infrastructure and support by ensuring reliable devices, connectivity, platforms and technical support so teachers can implement deep learning projects without constant technical obstacles (Munirah, 2022).

Next, by modeling and data-driven decision making that can be applied in digital tools as LMS, data dashboards and collaborative platforms to model effective practice and make data-based decisions of teaching quality and student progress in deep learning tasks (Karakose, 2023) so that e-communication, digital collaboration and the use of analytics could create digital culture in school towards a successful deep learning integration. The last, by creating a supportive and innovative school culture indicating a digital school leader that fosters collaboration, experimentation and risk taking by recognizing innovative school practice, tolerating failures, and involving teachers and students in decision-making about digital projects (Netaniel et al., 2024).

Secondly, the impacts of digital leadership strategies on school management and deep learning integration towards sustainable education needs to be understood by the school leaders in order to reshape the school management process and in turn strengthen deep learning integration and sustainable education outcomes provided by (1) improved effectiveness and coherence of school management. This effectively impacts on strategic school management, data driven based school programs and participatory decision making so that planning, budgeting, human resources, and evaluation are aligned with technology-supported deep learning

goals supporting the consistent implementation of deep learning pedagogy (Teguh et al., 2025). Next (2), It also affects higher level of teacher technology integration and deep learning practice. The empirical study by (Ilyas et al, 2025) shows that digital leadership positively and significantly influences teacher's technology integration, shifting practice towards more-student centered, high order learning activities in which inquiry teaching design, project based and collaborative tasks of deep learning competencies are appraised clearly.

Then (3), it impacts on sustainable digital transformation and continuous improvement indicating that digital leadership strategies help institutionalize change by embedding digital tools and deep learning pedagogy into policies, culture and routines of organizations system (Netaniel et al., 2024) for ensuring sustainable education in long-term adaptability, equity of access and an organizational culture of ongoing learning process (Ronghuai et al., 2024). The last (4), contribution to sustainable education outcomes in students enables deep learning approaches powered by digital pedagogy reflecting students' sustainability-related competencies i.e systems thinking, critical reflection, collaborative problem-solving digital literacy, and a sustainability mindset (Jan et al., 2018). It comes to a conclusion of the findings that digital leadership strategies act through more effective, technology-enabled school management to strengthen deep learning integration in the curriculum, which then drives sustainable education by building both resilient schools and sustainability- oriented student capabilities.

Conclusion

This study concludes that the integration of deep learning into curriculum significantly and positively affect the digital leadership strategies and enhances transformational effective school management. The effective strategies of digital leadership can employ building and communicating for a clear digital-deep learning vision, providing professional development for enhancing teachers' digital and pedagogy competence, improving digital infrastructure and support, applying data-driven decision making and creating supportive innovative school culture. These strategies may bring impact on improved effective school management, level development of teacher technology integration and deep learning practice, sustainable digital transformation and sustainable students and sustainable education outcomes for students.

Based on the findings, it is recommended that school leaders strengthen their digital leadership competencies particularly in integrating successful deep learning into school curriculum supported by the effective school management by collaborating with all school stakeholders and improving digital innovation for 21st century competencies. The future research may be empirically tested by quantitative research in schools applied deep learning integration and digital leadership in any country.

References

- Adnyana, I. B. (2024). "Deep learning-based critical thinking development in high school students". *Jurnal Pendidikan Inovatif*, 12(1), pp. 55–67.
- Al Akhyar, M. (2024). "Continuous assessment in deep learning: Building 21st-century competencies". *Jurnal Evaluasi Pendidikan*, 18(2), pp. 112–128.
- Alias, B. S., Nawawi, W., Nor, M. Y. M. (2023). "Technology Integration among Teachers: The Role of Principal's Technology Leadership Practices". *Tuijin Jishu/Journal of Propulsion Technology*, 44(2). <https://doi.org/10.52783/tjjpt.v44.i2.1055>.

- Arif, M., Rahman, T., & Lestari, D. (2025). "Teacher evaluation in deep learning implementation: From design to practice". *Jurnal Ilmu Pendidikan*, 21(1), pp. 75–89.
- Baglama, B., Evcimen, E., Altinay, F., Sharma, R.C., Tlili, A., Altinay, Z., Dağlı, G., Jemni, M., Shadiev, R., Yücesoy, Y. & Çelebi, M. (2022). Analysis of Digital Leadership in School Management and Accessibility of Animation-Designed Game-Based Learning for Sustainability of Education for Children with Special Needs. *Sustainability* (Switzerland), Volume 14 Issue 13, DOI: 10.3390/su14137730.10.3390/educsci15060656
- Ghavifekr, S., & Wong, S. Y. (2021). "Technology Leadership in Malaysian Schools". *International Journal of Asian Business and Information Management*, 13(2), 1–18. <https://doi.org/10.4018/ijabim.20220701.oa3>.
- Grobman, M., & Joia, L. A. (2022). "Digital Transformation of Leadership in the Post-Pandemic Era: A Literature Review on E-Leadership and E-Competencies". *XLVI Encontro Da Anpad - EnAnpad*, 2177–2576
- Halimah Siti, Imran Rido, VeraWati, Laela Hamidah, Aini Qolbiyah. (2025). Integrating Artificial Intelligence and Deep Learning for Enhancing Educational Quality. *International Journal Of Humanities Education And Social Sciences (IJHESS)* E-ISSN: 2808-1765, Volume 5, Number 2, October 2025, Page. 1143 – 1151.
- Hariyanti, R. A. Mustika. Pahrudin, A., Akmansyah Muhammad, Fauzan Ahmad. (2025). Evolution and future directions in school leadership development research: A global bibliometric perspective (2015-2025). *European Journal of Sustainable Development Research*, Vol. 9 Issue 4, DOI: 10.29333/ejosdr/16753.
- Hong, C. N. T., Thu, H. L. T., Huy, V. N., & Le Thi, B. (2024). A systematic review of research on gender diversity in STEM education. *International Journal of Learning, Teaching and Educational Research*, 23(4). <https://doi.org/10.26803/ijlter.23.4.12>
- Ilyas, Wahab, Imran, Mahluddin, Asmawati. (2025). Digital Transformation In Educational Management For School Quality In The Digital Era. Scaffolding: *Jurnal Pendidikan Islam dan Multikulturalisme*, Volume 7 Number 3 (2025) September-December 2025 Page: 78-90 E-ISSN: 2656-4491 P-ISSN: 2656-4548 DOI: 10.37680/scaffolding.v7i3.7735
- Jan, Hermes & Isabel Rimanoczy. (2018). Deep Learning for a Sustainability Mindset. *The International Journal of Management Education*, 16 (2018) 460-467. <https://doi.org/10.1016/j.ijme.2018.08.001>
- Juni, N. V., S. T. Teoritis, I. J. Tengker, & N. Pali. (2025). "Strategi Pengembangan Lembaga Pendidikan Melalui Analisis SWOT: Program Studi S3 Manajemen Pendidikan, PPs, Universitas Negeri Manado". Khatulistiwa: *Jurnal Pendidikan dan Sosial Humaniora*, Volume. 5 Nomor. 2 Juni 2025.
- Karaköse, T. & Tülübaş, T. (2024). School Leadership and Management in the Age of Artificial Intelligence (AI): *Recent Developments and Future Prospects. Educational Process: International Journal*, Volume 13 Issue 1 pp 7-14, DOI: 10.22521/edupij.2024.131.1.
- Karaköse, T., & Tülübaş, T. (2023). Digital Leadership and Sustainable School Improvement—A Conceptual Analysis and Implications for Future Research. *Educational Process: International Journal*, 12(1): 7-18.
- Karaköse, T., Polat, H., Tülübaş, T., & Demirkol, M. (2024). A Review of the Conceptual Structure and Evolution of Digital Leadership Research in Education. *Education Sciences*, Vol. 14 Issue 11, DOI: 10.3390/educsci14111166
- Modise, Mphoentle Puleng, Majola, Xolani Moffat, Kotoka, Jonas Kwadzo. (2025). The crucial role of high school management in facilitating e-portfolio implementation in classrooms. *Journal of Education and e-Learning Research* Vol. 12 Issue 4 pp. 573-580, DOI:10.20448/jeelr.v12i4.756

- Munirah Khalid Al Ajmi. (2022). The Impact of Digital Leadership on Teacher's technology Integration During the COVID-19 Pandemic in Kuwait. *International Journal of Educational Research*, 9, 112:101928. doi: [10.1016/j.ijer.2022.101928](https://doi.org/10.1016/j.ijer.2022.101928)
- Musaigwa, M. (2023). "The Role of Leadership in Managing Change". *Int. Rev. Manag. Mark.*, vol. 13, no. 6, pp. 1–9, 2023, doi: 10.32479/irmm.13526.
- Netaniel Giovanni, Hapzi Ali, Ida Nurhaida. (2024). "Fostering Sustainable Digital Leadership in Educational Organization, Systematic Literature Review using NVIVO and PRISMA". *Dinasti International Journal of Economics, Finance and Accounting (DIJEFA)*, Vol. 5, No. 3, July 2024, DOI: <https://doi.org/10.38035/dijefa.v5i3>
- Nguyen Thi Thanh Huyen, Duong Thi Nga and Dang Thi Phuong Thao. (2024). A Comprehensive Analysis of Teacher Professional Learning Communities: A Scopus-Based Review (2019–2024), *International Journal of Learning, Teaching and Educational Research* Vol. 23, No. 8, pp. 158-179, August 2024 <https://doi.org/10.26803/ijlter.23.8.9>
- Nguyen, G. T. C., & Thai, D. T. (2023). Integrated teaching in primary schools: A systematic review of current practices, barriers, and future developments. *International Journal of Evaluation and Research in Education*, 12(4).
- Nofirman. (2025). Implementation of Deep Learning Curriculum in STEM Education: A Case Study in Secondary Schools in Bengkulu. *International Journal Education and Computer Studies (IJECS)*, 5(2), 61-73. <https://doi.org/10.35870/ijeecs.v5i2.4615>.
- Okoye, K., Hussein, H., Arrona-Palacios, A., Quintero, H. N., Ortega, L. O. P., Sanchez, A. L., Ortiz, E. A., Escamilla, J., & Hosseini, S. (2023). "Impact of digital technologies upon teaching and learning in higher education in Latin America: an outlook on the reach, barriers, and bottlenecks". *Education and Information Technologies*, 28(2), pp. 2291–2360
- Okunlola, John Olayemi & Naicker, Suraiya R. (2025). Principals' Digital Leadership Competencies in the Fourth Industrial Revolution: Teachers' Perspectives. *Education Sciences*, Vol. 15 Issue 6,
- Omar, M. N., & Ismail, S. N. (2020). "Mobile Technology Integration in the 2020s: The Impact of Technology Leadership in the Malaysian Context". *Universal Journal of Educational Research*, 8(5), 1874–1883. <https://doi.org/10.13189/ujer.2020.080524>.
- Oviedo Bayas, D., Robalino, M., & Armas, D. (2024). "Deep learning strategies to enhance collaborative problem-solving in secondary education". *Education and Information Technologies*, 29(2), 1637–1655. <https://doi.org/10.1007/s10639-023-11847-8>.
- Permana Johar, Sururi, Anisa Isti Yuslimah. (2025). "AI Integration in School Management: A Systematic Review of Leadership Approaches and Organizational Readiness". *Proceedings of the 1st International Conference on Educational Science and Teacher Education (ICESTE 2025)*, Advances in Social Science, Education and Humanities Research 960, https://doi.org/10.2991/978-2-38476-489-1_6.
- Rasdiana, Tami Nurhadi, Muh. Ilham Akbar B., Fitrah Amalia Salim, Anindita Trinura Novitasari, Restu Nur Cholidah, Nining Sahara H. A. Rawe et.al. (2024). "The Effect of Digital Leadership in Nurturing Teachers' Innovation Skills for Sustainable Technology Integration Mediated by Professional Learning Communities". *Journal of Infrastructure, Policy and Development 2024*, 8(10), 8480. <https://doi.org/10.24294/jipd.v8i10.8480>
- Rieckmann, M. (2012). "Future-oriented higher education: Which key competencies should be fostered through university teaching and learning?" *Futures*, 44(2), 127–135. <https://doi.org/10.1016/j.futures.2011.09.005>
- Ronghuai Huang, Michael Agyemang Adarkwah, Mengyu Liu, Ying Hu, Rongxia Zhuang, Tingwen Chang. Digital Pedagogy for Sustainable Education Transformation: Enhancing Learner-Centred Learning in

- the Digital Era. *Frontiers of Digital Education*, 2024, 1(4): 279-294 DOI:10.1007/s44366-024-0031-x
- Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics*, 126, 5113–5142. <https://doi.org/10.1007/s11192-021-03948-5>
- Sutikno. (2025). Optimizing Principal Management for Deep Learning Curriculum Implementation in Vocational High Schools. Scaffolding: *Jurnal Pendidikan Islam dan Multikulturalisme*, Volume 7 Number 3 (2025) Page: 37-55 E-ISSN: 2656-4491 P-ISSN: 2656-4548 DOI: 10.37680/scaffolding.v7i3.7780.
- Syarip, Dadang. (2025). Digital Leadership in Educational Institutions: Media Management Strategies for 21st Century Science Education. *Jurnal Penelitian Pendidikan IPA*, 11(9), 100–106. <https://doi.org/10.29303/jppipa.v11i9.12567>.
- Teguh Trianung D.S1, Winda Sundari, Andi Kurniawan, Nugraha Adhi Setiawan, Jihan Aisyah. (2024). Education Management: Decision-Making Strategies in Technology Integration in the Digital Age. *Al-Ishlah: Jurnal Pendidikan* Vol.16, 2 (June, 2024), pp. 2032-2044 ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.V.16i2.5141
- Ukpabio, G.E.; Mbon, U.F.; Ekanem, E.E.; Ukpong, N.N.; Okon, E.E.; Aniah, S.A.; Omini, E.E.; Ngaji, M.I.; Egwuonwu, C.O.K.; Egwu, S.O. (2023). Reinventing School Health Service Management in Nigeria: Literature Review, Best Practices for Digital Upgrade. *Journal of Educational and Social Research*, Volume Volume 13 Issue 4 pp. 311 - 320, DOI: 10.36941/jesr-2023-0111
- Varsha P S, A. Chakraborty & A. K. Kar. (2024). “How to Undertake an Impactful Literature Review: Understanding Review Approaches and Guidelines for High-impact Systematic Literature Reviews”. *South Asian J. Bus. Manag. Cases*, vol. 13, no. 1, pp. 18–35, 2024, doi: 10.1177/22779779241227654
- Vavouras, E., Koliopoulou, M., & Manolis, K. (2024). From Participatory Leadership to Digital Transformation under the interpretation of Political Philosophy: Types of Leadership in Education and School Administration. *Dia-noesis Journal*, Volume 16 pp. 153 - 170, DOI: 10.12681/dia.38171
- Wen Jiang. (2025). Wen, Jiang. (2025) Deep Learning-Based Prediction of Student Performance in Physics Education Using Multimodal Data. *ICBDIE* 2025, Suzhou, China. <https://doi.org/10.1145/3729605.3729627>.
- Wibowo, B. S., R. P. Bendriyanti, & I. Maja. (2024) “Leadership Strategies in Digital Education: Enhancing Teacher Development and Student Outcomes through Technology Integration”. vol. 01, no. 3, pp. 271–277, 2024.
- Xie, Y., & Wang, N. (2023). The Connotation Evolution and Enhancement Strategies of Digital Leadership in China’s Universities in the Context of Digital Transformation. *Advances in Education, Humanities and Social Science Research*, 8(1), 221. <https://doi.org/10.56028/aehtsr.8.1.221.2023>
- Zainal Abidin, N. B., Mat Jan, N. A., Othman, A. Z., Thiruchelvam, L., Jinn, L. S., Sani, S. A. S., Haris, N. I., & Aziz, N. A. (2023). A five-year bibliometric analysis of Education 4.0 and direction for Education 5.0 future research. *International Journal of Learning, Teaching and Educational Research*, 22(9), 382–400. <https://doi.org/10.26803/ijlter.22.9.21>