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SUSTAINABILITY AND EFFICIENCY IN SMART SCHOOL MANAGEMENT: MAPPING RESEARCH TRENDS AND IMPLICATIONS FOR EDUCATIONAL DEVELOPMENT

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Abstract : *The increasing complexity of education management in the digital era poses challenges to achieving sustainability, efficiency, and effective school leadership. The implementation of the smart school concept remains fragmented due to insufficient integration among technological innovation, sustainability, managerial effectiveness, and human resource readiness to support educational transformation. This study aims to map and synthesize research trends in smart school management, with a focus on sustainability and efficiency, during the period 2010–2025. Data obtained from the Scopus database using the keywords "smart school," "sustainability," and "efficiency," resulting in 295 publications analyzed using bibliometric methods using VOSviewer. The results show increased scientific attention since 2018, along with the acceleration of global digitalization in education, with Malaysia, China, India, and Iran as major contributors. Thematic mapping indicates a shift from a technology-based approach to an integrated framework that emphasizes sustainability, efficiency, adaptive leadership, systemic collaboration, learning and innovation, and continuous professional development.*

Keywords : *Smart School; Sustainability; Efficiency; School Management.*

Abstrak : *Meningkatnya kompleksitas manajemen pendidikan di era digital menghadirkan tantangan dalam mewujudkan keberlanjutan, efisiensi, dan kepemimpinan yang efektif di sekolah. Implementasi konsep sekolah cerdas masih sering terfragmentasi karena belum adanya integrasi optimal antara inovasi teknologi, keberlanjutan, efektivitas manajerial, dan kesiapan sumber daya manusia dalam mendukung transformasi pendidikan. Studi ini bertujuan memetakan dan mensintesis tren penelitian mengenai manajemen sekolah cerdas dengan fokus pada keberlanjutan dan efisiensi selama periode 2010–2025. Data diperoleh dari basis data Scopus menggunakan kata kunci "smart school," "sustainability," dan "efficiency," menghasilkan 295 publikasi yang dianalisis melalui metode bibliometrik menggunakan VOSviewer. Hasil penelitian menunjukkan peningkatan perhatian ilmiah sejak 2018 seiring percepatan digitalisasi pendidikan global, dengan Malaysia, China, India, dan Iran sebagai kontributor utama. Pemetaan tematik menunjukkan pergeseran dari pendekatan berbasis teknologi menuju kerangka terintegrasi yang menekankan keberlanjutan, efisiensi, kepemimpinan adaptif, kolaborasi sistemik, inovasi pembelajaran, dan pengembangan profesional berkelanjutan.*

Kata Kunci : *Smart-School; Keberlanjutan; Efisiensi; Manajemen Sekolah.*

INTRODUCTION

The concept of a smart school represents an educational ecosystem that integrates digital technologies, data analytics, and sustainable management practices to enhance learning efficiency and institutional governance (Yusufu & Nathan, 2020). In contemporary discourse, the pursuit of sustainability and efficiency in school management has emerged as a strategic imperative for achieving long-term educational resilience and resource optimization. This topic is particularly critical as global educational systems face increasing demands for digital transformation and environmental accountability, requiring institutions to balance technological innovation with sustainable pedagogical design (Liu & Li, 2025; Saad et al., 2025; Trihantoyo et al., 2024). Within the broader research landscape, smart schools are increasingly positioned within smart governance and data-driven management frameworks, highlighting their role in enhancing institutional adaptability and transparency (Vasudavan & Abdul Hamed, 2025). However, despite growing scholarly attention, empirical studies that systematically portray the intellectual structure and evolution of smart school research, particularly from the lens of sustainability and managerial efficiency remain limited. This absence of comprehensive bibliometric mapping indicates an urgent need to consolidate fragmented findings and reveal the conceptual trajectory of smart school scholarship to inform future educational policies and management innovations (Singh et al., 2024).

Despite the increasing discourse on smart schools as a solution to modern educational challenges, several critical problems persist in achieving sustainable and efficient management practices. Empirical studies have reported that many smart school initiatives remain focused on technological adoption rather than on systemic integration that ensures sustainability, leadership alignment, and data-driven governance (Mardin & Haning, 2024; Pillai et al., 2024; Sneesl et al., 2022). The lack of coherent management frameworks, uneven technological readiness, and limited evaluation metrics have created disparities in institutional performance, particularly in developing countries where policy implementation is fragmented (Shah, 2024). These challenges indicate that, although smart school initiatives are expanding, their implementation often fails to translate into improved learning outcomes and organizational effectiveness. Evidence from recent evaluations indicates that many schools labeled as "smart" still operate under traditional administrative models, resulting in inefficiencies and limited impact on learning outcomes (Bhutoria & Aljabri, 2022). These conditions suggest that the sustainability and efficiency dimensions of smart school management remain underexplored and unresolved, thereby necessitating a

systematic bibliometric investigation to map research trends, conceptual gaps, and strategic priorities for advancing sustainable school management frameworks.

From a theoretical perspective, smart school management is grounded in transformational leadership and sustainable management theory, which emphasize adaptability, innovation, and long-term systemic improvement (Bass & Riggio, 2006; Fullan, 2007). Sustainability within smart schools is not merely defined as technological continuity but as the institutional capacity to sustain innovation through data-driven decision-making, efficient resource allocation, and resilient leadership models (Riansyah & Bethany, 2024). Efficiency refers to the optimization of administrative and pedagogical processes through digital ecosystems to achieve measurable outcomes with minimal resource waste (Pardo-Baldoví et al., 2023). Leadership transformation functions as a catalytic dimension that aligns managerial vision with digital culture and organizational change (Almonawer et al., 2023; Shin et al., 2023; West-Burnham, 2009). Thus, smart schools can be conceptualized as socio-technical systems in which sustainability, efficiency, and leadership transformation operate as interdependent dimensions shaping educational effectiveness.

However, the current body of research reveals several critical limitations. First, prior studies tend to examine smart schools from fragmented perspectives, primarily focusing on technological aspects while overlooking the integrated relationship between sustainability, efficiency, and leadership transformation (Chandra et al., 2025). Second, the literature is dominated by case-based and descriptive approaches, with limited use of systematic methods capable of mapping the intellectual structure and evolution of the field (Al-Badi et al., 2020). Third, while bibliometric analyses have been conducted in related domains such as smart education and smart universities, very few studies have simultaneously analyzed sustainability and efficiency within the specific context of smart school management (Mardin & Haning, 2024). These limitations indicate a clear research gap: the absence of an integrative bibliometric analysis that captures the conceptual and thematic interconnections between sustainability and efficiency in smart school research.

Addressing this gap, the novelty of this study lies in its integrative approach that simultaneously maps sustainability and efficiency within the smart school research landscape, while positioning leadership transformation as a connecting dimension. Unlike previous studies that focus on isolated themes, this study offers a comprehensive synthesis that links technological, managerial, and pedagogical perspectives into a unified analytical framework. This study aims to provide a comprehensive bibliometric analysis of research on smart schools in relation to sustainability, efficiency, and leadership transformation. The objectives are; 1) To examine the trends of productivity, publication growth, and citation

impact from 2010 to 2024, 2) to identify the most influential countries, institutions, document types, and subject areas contributing to this field, 3) to explore the predominant thematic clusters and conceptual structures that illustrate the intellectual evolution of this research domain. Through these objectives, this study contributes to advancing a more integrated understanding of smart school management and provides evidence-based insights for policymakers, educational leaders, and practitioners to enhance sustainability, efficiency, and leadership transformation in educational systems.

METHOD

This study adopted a bibliometric approach to systematically explore the intellectual landscape and research development of smart school studies within the context of sustainability, efficiency, and school management. The bibliometric method enables an objective and reproducible evaluation of the structure, dynamics, and evolution of scientific literature (Sillet, 2013; Zupic & Čater, 2015). Data were retrieved from the Scopus database due to its broad coverage of peer-reviewed international publications and its compatibility with bibliometric tools. However, this study acknowledges that relying solely on Scopus may exclude relevant studies indexed in other databases such as Web of Science or Dimensions, which represents a limitation of the dataset.

Data collection was conducted in October 2025 using a structured search strategy applied to the Title-ABS-Key fields in Scopus. To improve coverage and reduce bias, keyword expansion and query refinement were applied. The search string combined core terms and their variants, as follows: *Title-ABS-Key ("smart school" or "digital school"* or "*intelligent school*") and ("*sustainable"* or "*sustainable education*") and ("*efficiency*" or "*performance*" or "*resource optimization*") and ("*school management*" or "*leadership"* or "*governance"*). This strategy ensures broader retrieval of relevant studies and avoids over-reliance on a single keyword expression.

The inclusion criteria were: 1) publications between 2010–2025, 2) peer-reviewed journal articles and review papers, 3) English-language documents, and 4) studies directly related to smart school, sustainability, or efficiency in educational contexts. Exclusion criteria included conference notes, editorials, book reviews, and documents not directly relevant to educational management. After screening and validation, a total of 295 documents were retained for analysis.

Bibliographic records were exported in CSV format, including metadata such as authors, affiliations, publication year, keywords, and citation counts. Data cleaning was conducted to remove duplicates and standardize keyword variations. The dataset was

analyzed using VOSviewer (version 1.6.20) to perform co-occurrence and co-authorship analysis (Karakaş & Kartal, 2025). The following parameters were applied: minimum keyword occurrence threshold: 5; counting method: full counting; normalization method: association strength; clustering resolution: default (1.00); visualization type: network and overlay visualization. These parameters were selected to ensure consistency, interpretability, and replicability of the analysis. The analysis addressed three research questions: 1) How has the scientific production and citation impact of smart school research evolved between 2010 and 2025?, 2) Which countries, institutions, and disciplinary domains have played dominant roles in shaping the development of smart school research?, and 3) What are the dominant thematic clusters and how do they reflect the conceptual evolution of sustainability and efficiency in smart school research?

Descriptive indicators (publication trends and citation counts) were combined with network visualization to analyze structural relationships and thematic evolution within the dataset. This integrative approach enables a more comprehensive understanding of how sustainability, efficiency, and leadership dimensions are interconnected within smart school research.

RESULT AND DISCUSSION

1. Results

a) Productivity Trends, Publication Growth, and Citation Impact

The bibliometric analysis retrieved 295 documents indexed in the Scopus database using the search term "smart school" for the period 2010-2025. As presented in Figure 1, the annual publication trend shows a non-linear but overall increasing pattern across the study period. The trajectory can be grouped into three broad phases: an early exploratory phase (2010-2015), a consolidation phase (2016-2020), and a maturity or diffusion phase (2021-2025).

During the early period, publication output remained relatively limited, ranging from 6 to 17 documents per year. The lowest number of publications was recorded in 2013, with only 6 documents. From 2016 onward, the number of publications began to increase more steadily. Between 2019 and 2021, annual output more than doubled, reaching 27 documents in 2021. A sharper increase was recorded in 2023, when the number of publications peaked at 40 documents. After this peak, the annual output declined to 26 documents in 2024 and 17 documents in 2025. Overall, the annual trend indicates a sustained expansion of smart school research over time, despite some fluctuations in the later years.

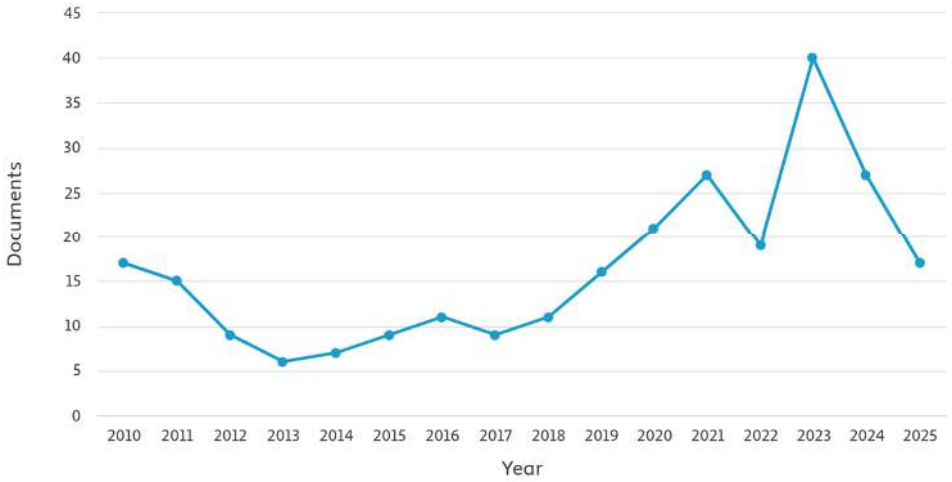

Figure 1: Documents by Year (Sources: Scopus Database 2010-2025)

Citation analysis across major publication venues further illustrates the distribution of scholarly influence within the smart school literature, as shown in Table 1. The most prominent sources include Procedia - Social and Behavioral Sciences (PSBC), Lecture Notes in Educational Technology (LNET), Journal of the Architectural Institute of Korea (JAIK), ACM International Conference Proceeding Series (ACM), and Smart Innovation, Systems and Technologies (SIST). Among these sources, ACM recorded the highest citation counts throughout the period. Its citations increased from 6,874 in 2010 to 78,969 in 2024, before decreasing to 51,618 in 2025. PSBC also showed substantial citation accumulation, rising from 271 citations in 2010 to 5,366 in 2024, followed by a decline to 3,635 in 2025. SIST demonstrated continuous growth, from 31 citations in 2010 to 7,828 in 2024, before declining to 5,574 in 2025.

More specialized sources appeared later in the period. LNET began to accumulate citations from 2014, increasing from 2 citations to 965 citations in 2024, then decreasing slightly to 767 in 2025. Similarly, JAIK emerged from 2020 onward, growing from 12 citations in 2020 to 338 citations in 2024, followed by 285 citations in 2025. The SCImago Journal Rank (SJR) data show variation in source impact across the period. ACM maintained relatively stable SJR values, ranging from 0.159 to 0.253. LNET reached its highest recorded SJR value at 0.397 in 2020, while SIST remained within a moderate range of 0.119 to 0.224. In contrast, PSBC recorded SJR values only up to 2016, after which no further SJR values were listed in the dataset. Overall, the citation and SJR data indicate that smart school research has been disseminated across a combination of conference proceedings, technology-oriented publication series, and interdisciplinary sources.

Table 1: Data Source Citations and SCImago Journal Rank by Year

Source citations by year																
Source	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
PSBC	271	839	1.559	2.145	2.661	3.168	3.421	3.749	4.405	5.560	6.173	5.999	5.724	5.669	5.366	3.635
LNET	-	-	-	-	2	31	153	175	249	323	391	487	634	646	965	767
JAIK	-	-	-	-	-	-	-	-	-	-	12	82	189	241	338	285
ACM	6.874	7.698	9.475	12.439	15.574	18.014	22.197	26.786	32.613	40.871	48.627	57.510	66.120	74.530	78.969	51.618
SIST	31	85	148	272	373	477	802	1.107	1.748	2.806	4.005	5.211	6.325	7.916	7.828	5.574
SCImago journal rank by year																
Source	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
PSBC	0.142	0.164	0.222	0.151	0.156	0.158	0	0	0	0	0	0	0	0	0	0
LNET	0	0	0	0	0	0	0.202	0.257	0.186	0.202	0.397	0	0	0	0	0
JAIK	0	0	0	0	0	0	0	0	0	0	0	0.187	0.19	0.204	0.208	0
ACM	0.25	0.184	0.181	0.222	0.25	0.253	0.213	0.159	0.169	0.2	0.182	0.232	0.209	0.253	0.191	0
SIST	0	0.119	0.141	0.153	0.143	0.159	0.166	0.173	0.156	0.18	0.172	0.224	0.17	0.174	0.163	0

Note: PSBS: Procedia - Social and Behavioral Sciences; LNET: Lecture Notes in Educational Technology; JAIK: Journal of the Architectural Institute of Korea; ACM: ACM International Conference Proceeding Series; SIST: Smart Innovation, Systems and Technologies

PSBC maintained a central role during the formative years of the field, with steady growth from 271 citations (2010) to 5,366 citations (2024), followed by a minor reduction in 2025 (3,635 citations). This pattern reflects the early scholarly discussions centered on behavioral, social, and pedagogical implications of smart schooling, which have since been overshadowed by more technically driven research streams. SIST represents a significant interdisciplinary platform bridging technology and educational management. Its citations grew consistently, from 31 in 2010 to 7,828 in 2024. It was indicating increasing integration of smart technologies in systemic and managerial contexts of schooling.

Meanwhile, newer sources such as LNET and JAIK have emerged as specialized contributors since 2015 and 2020, respectively. LNET's citations rose sharply from 2 (2014) to 965 (2024), underscoring the growing intersection between educational technology and digital pedagogy. Similarly, JAIK advanced from 12 citations (2020) to 338 (2024), reflecting architectural and spatial perspectives in the design of smart learning environments. The SCImago Journal Rank (SJR) analysis reinforces these observations. ACM and LNET hold the highest SJR values (ranging between 0.20–0.40), indicating both high impact and international visibility. In contrast, PSBC's SJR values decline after 2016, mirroring its reduced role in current technological discourses. SIST remains stable (0.14–0.22), suggesting a balanced contribution between technical innovation and applied educational research.

b) Influential Sources

The geographical distribution of smart school research shows that publication output is concentrated mainly in Asian countries, with Malaysia emerging as the leading contributor at approximately 34 documents, followed by India, China, and Iran (Figure 2). These countries represent the most visible national contributors within

the dataset. Indonesia also appears as an emerging contributor, indicating growing research activity in the smart school domain within Southeast Asia.

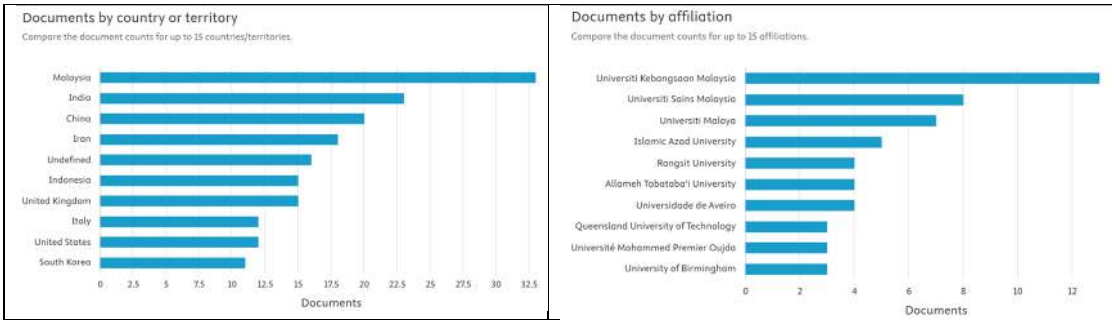

Figure 2: Most Influence Country and Institution

At the institutional level, Universiti Kebangsaan Malaysia (UKM) was identified as the most productive affiliation, contributing approximately 13 publications. It was followed by Universiti Sains Malaysia (USM) and Universiti Malaya (UM). Other productive institutions include Islamic Azad University and Rangsit University. These results indicate that institutional contributions are also concentrated within a relatively limited number of universities, particularly in Malaysia and other parts of Asia.

The distribution of document types further describes the publication profile of smart school research. As shown in Figure 3, journal articles account for the largest share of the dataset, representing 44.4% of total publications. Conference papers constitute the second-largest category at 38.3%. Book chapters contribute 8.8%, while reviews (1.5%), books (1.1%), and other document types such as editorials, errata, notes, and retracted papers each account for less than 1%. This pattern indicates that smart school research has been disseminated primarily through journal and conference publications.

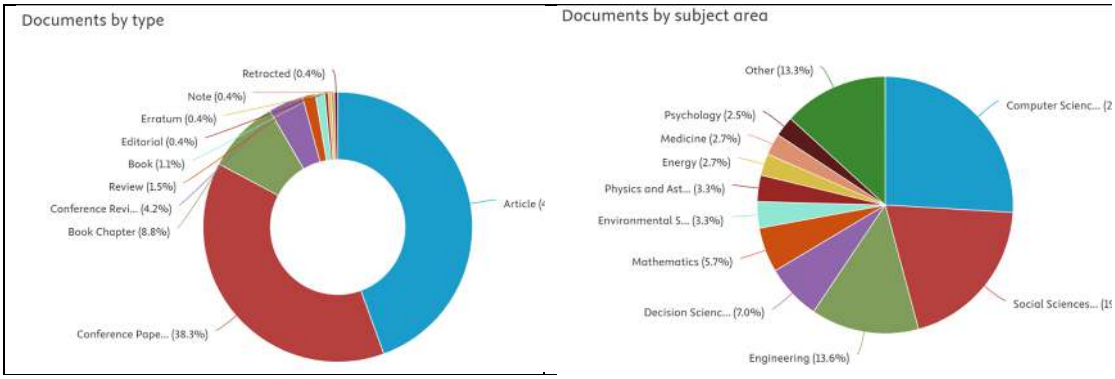

Figure 3: Distribution of Documents by Type and Subject Area

The subject-area distribution confirms the multidisciplinary nature of the field. Computer Science represents the largest subject area at 25.9%, followed by Social Sciences (19.9%), Engineering (13.6%), and Decision Sciences (7.0%). Additional subject areas include Mathematics (5.7%), Environmental Science (3.3%), Physics and Astronomy (3.3%), Energy (2.7%), Medicine (2.7%), and Psychology (2.5%). These findings show that smart school research spans both technology-oriented and human-centered disciplinary domains.

c) Thematic clusters and conceptual evolution

The keyword co-occurrence network reveals the main thematic structure of smart school research during 2010-2025 (Figure 4). The visualization shows a dense and interconnected network, indicating that the field has developed through multiple related themes rather than through isolated lines of inquiry. The most frequently connected terms include smart schools, teaching, ICT, e-learning, education, and smart classrooms, suggesting that the literature is strongly centered on the integration of digital technologies into teaching and learning processes.

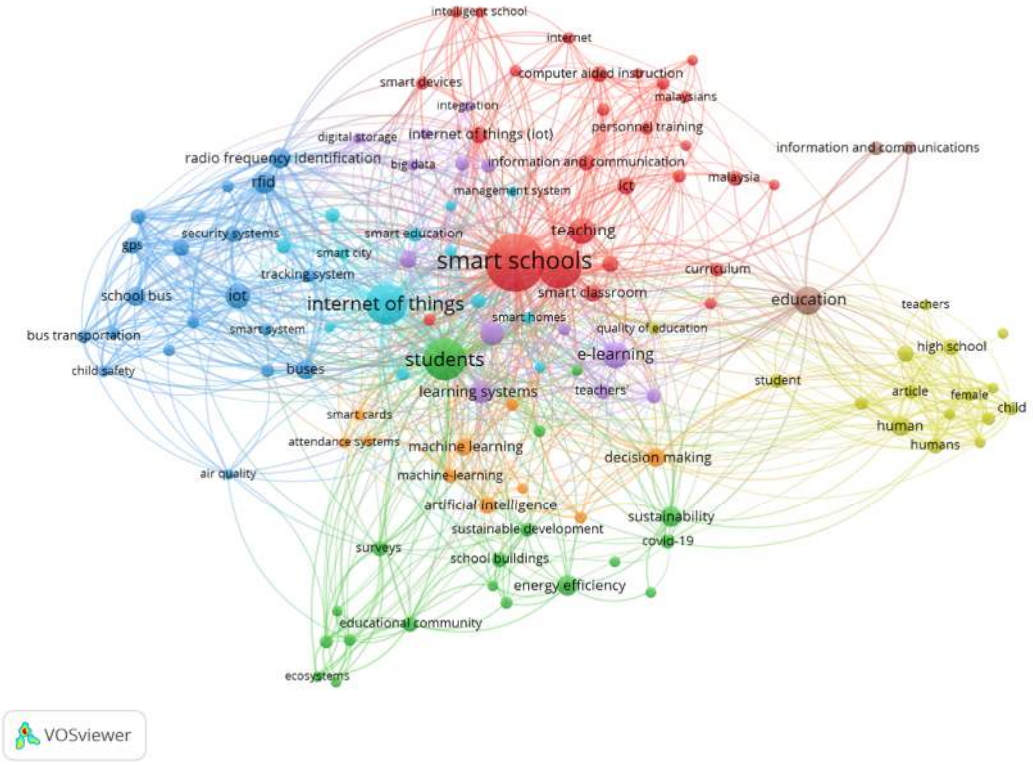

Figure 4: Network Visualization (Source: VOSviewer, 2025)

A second prominent cluster is associated with technological infrastructure and operational systems. This cluster includes terms such as internet of things (IoT), RFID,

security systems, tracking system, GPS, and school bus. The presence of these keywords indicates that a substantial part of the literature addresses monitoring systems, connected devices, and technology-supported school operations. Another thematic strand is related to sustainability and efficiency, reflected in keywords such as sustainability, energy efficiency, ecosystems, and school buildings. These terms show that the literature also includes work on environmentally oriented school infrastructure and resource-efficient educational environments. In addition, the appearance of COVID-19 suggests that the dataset includes studies related to digital and institutional responses during the pandemic period.

The network also highlights a human-centered cluster linking terms such as humans, teachers, students, decision making, and quality of education. This cluster indicates continued attention to the roles of educational actors, user engagement, and institutional processes within smart school research. At the more recent end of the thematic map, keywords such as machine learning, artificial intelligence, and learning systems indicate the growing presence of data-driven and intelligent approaches in the field. Taken together, the co-occurrence analysis suggests that smart school research has evolved from an initial emphasis on ICT integration and digital infrastructure toward broader themes involving connected systems, sustainability, and intelligent learning environments. The overall structure of the field is therefore both diverse and interconnected, combining pedagogical, technological, environmental, and human-centered dimensions within the smart school literature.

2. Discussion

The results indicate that research on smart schools has expanded substantially over the 2010-2025 period, although the growth pattern was not linear. The relatively limited number of publications in the early years suggests that smart school research initially developed as a niche area within broader discussions of educational technology and digital literacy (Mhlongo et al., 2023). The stronger increase after 2016 and the peak observed in 2023 suggest that the topic has moved into a more established phase of scholarly attention. This pattern may reflect the growing centrality of digital transformation in educational systems and the increasing relevance of technology-supported school management, learning environments, and institutional innovation (Siufong & Bin, 2026).

The citation patterns also show that the smart school field has been shaped strongly by technology-oriented publication outlets, especially ACM and other interdisciplinary sources. This suggests that the development of the field has been driven not only by pedagogical concerns but also by advances in computing, digital

infrastructure, and intelligent systems. At the same time, the continued presence of sources such as PSBC and SIST indicates that smart school research has not evolved as a purely technical domain. Rather, it has remained connected to broader educational, social, and managerial questions. This combination supports the view that smart school scholarship is inherently interdisciplinary, positioned at the intersection of education, technology, institutional management, and, increasingly, sustainability (Siufong & Bin, 2026).

The country and institutional distribution further reinforces this interpretation. The dominance of Asian countries, particularly Malaysia, India, China, and Iran, suggests that the smart school agenda has developed most visibly in regions where educational modernization and digitalization have become important policy priorities. Malaysia's leading position, along with the prominence of its universities, indicates the importance of institutional capacity and sustained policy support in shaping publication output. Indonesia's emerging presence is also noteworthy, as it suggests that smart school research is gaining momentum in contexts where digital transformation is being pursued alongside concerns related to equity, infrastructure readiness, and local educational needs. In this sense, the geographical distribution reflects not only productivity differences but also varying stages of educational digital transformation across national contexts (Wang et al., 2024).

The document-type distribution reveals another important characteristic of the field. The dominance of journal articles indicates that smart school research has achieved a degree of academic consolidation, while the large proportion of conference papers suggests that the topic also remains dynamic and innovation-oriented (Ni et al., 2026). This dual pattern implies that the field is both mature enough to sustain peer-reviewed theoretical and empirical work and flexible enough to accommodate emerging technological models, prototypes, and practical applications. In other words, smart school research appears to be a field that is simultaneously consolidating and evolving.

The subject-area analysis confirms that this field cannot be understood from a single disciplinary perspective. The strong representation of Computer Science highlights the importance of technological systems, digital platforms, and data-driven solutions in smart school development. However, the substantial contribution of Social Sciences shows that technological integration in education is also shaped by human behavior, institutional culture, pedagogy, and social context (Panakaje et al., 2024). Contributions from Engineering, Decision Sciences, Mathematics, and other fields further suggest that smart school research increasingly depends on collaboration across technical and human-centered domains. This interdisciplinary profile is one of the field's key strengths because it enables researchers to address educational problems from multiple analytical angles.

The thematic clusters provide a more detailed picture of the field's conceptual evolution. The centrality of terms such as smart schools, ICT, e-learning, teaching, and smart classrooms shows that the literature has been anchored primarily in teaching and learning transformation (Mahawar et al., 2025). This indicates that, at its core, the smart school concept is still closely associated with the redesign of educational processes through digital technologies (Mogas et al., 2022). However, the prominence of terms related to IoT, tracking systems, security systems, and school transport shows that the field has gradually expanded beyond classroom technology toward broader school-wide infrastructures and operational intelligence. This marks an important shift from technology use in instruction alone to technology integration across the entire educational ecosystem.

The emergence of sustainability-related terms such as energy efficiency, ecosystems, and school buildings suggests a further expansion of the smart school concept. In this more recent phase, smart schools are not only seen as digitally enhanced institutions but also as environments that should be efficient, resilient, and environmentally responsive (Mhlongo et al., 2023). This broadening of the concept is significant because it shows that smartness in education is increasingly linked with long-term institutional sustainability rather than short-term technological adoption (Al-Emran & Griffy-Brown, 2023). The appearance of COVID-19 in the network is also meaningful, as it indicates that the pandemic served as an accelerator for debates on resilience, remote learning, and the need for adaptable digital infrastructures in schooling (Huda, 2024).

Equally important is the human-centered cluster connecting teachers, students, decision making, and quality of education. This suggests that the literature does not treat technology as an autonomous driver of change. Instead, the effectiveness of smart school systems is still understood to depend on human agency, digital competence, and institutional decision-making processes (Timotheou et al., 2023). This is a crucial point for the field because it implies that technological advancement alone is insufficient without corresponding attention to leadership, user readiness, and educational quality. The recent emergence of artificial intelligence, machine learning, and learning systems strengthens this observation, as these themes point toward the next phase of development in which smart schools may become more adaptive, predictive, and personalized.

Overall, the findings suggest that smart school research has evolved from a relatively narrow focus on ICT integration toward a broader and more complex framework that includes infrastructure, governance, sustainability, and intelligent systems. The field now appears to conceptualize smart schools not simply as technology-rich institutions, but as integrated educational ecosystems designed to support efficient management, adaptive learning, and sustainable development (Alfoudari et al., 2023;

Mogas et al., 2022). This conceptual shift indicates a maturing body of scholarship with increasing relevance for both educational research and policy.

CONCLUSION

This bibliometric study shows that smart school research has developed into an increasingly established and multidisciplinary field over the 2010-2025 period. The publication trend demonstrates overall growth despite yearly fluctuations, while the citation pattern indicates that the field has been shaped primarily by technology-oriented and interdisciplinary publication venues. The results also reveal that scholarly contributions are concentrated in several Asian countries, particularly Malaysia, with institutional productivity driven by a relatively small group of universities. In addition, the dominance of journal articles and conference papers, together with the broad subject-area distribution, confirms that smart school research has evolved through the interaction of educational, technological, managerial, and social science perspectives.

The thematic analysis further indicates a clear conceptual shift from an initial emphasis on ICT adoption and digital infrastructure toward a broader understanding of smart schools as integrated educational ecosystems. Recent research increasingly incorporates sustainability, intelligent systems, institutional management, and human-centered learning, suggesting that the meaning of smartness in education now extends beyond technological deployment alone. Overall, the findings demonstrate that smart school research has reached a more mature stage in which innovation is increasingly framed in relation to adaptability, efficiency, inclusion, and long-term educational development.

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