

Revisiting the literature on smart education: A bibliometric and content analysis

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Abstract

Smart education is growing rapidly globally, thrusting on improved education and learning. The disruption caused by COVID in physical classes further highlighted the importance of digitally enabled education. Governments globally have also launched initiatives to promote ICT-enabled learning. However, this transition has not been without challenges, as evidenced by the digital divide highlighted during the pandemic, emphasizing the importance of inclusive smart education policies. This study aims to shed light on the conceptual framework of smart education through bibliometric and content analysis and highlights the problems pertaining to adopting in the learning environment. The findings of the study indicate the prominent authors, journals, countries, and documents. The study delves into the subject through content analysis. Moreover, the study also provides future directions for upcoming scholars.

Keywords

Smart education, E-learning, Artificial intelligence, Internet of things, Literature review

1. Introduction

Smart education is the adoption of new-age technology in various dimensions of education, like teaching, training, and research [1]. The benefits of smart education were most visible during the COVID lockdown period across the globe, where academic classes were taken by instructors on online platforms like Zoom, MS Teams, and Google Meet, to name a few. Further, academic research collaborations have increased post-COVID, and researchers have become more comfortable discussing online with their global counterparts.

Education is an essential pillar for human development and economic growth for a country, and many governments across the world are also focusing on and promoting technological advancements for better education and learning. The Republic of Korea introduced the SMART initiative to adopt and effectively learn from ICT (Information Communication Technology) tools [2]. The Indian government launched the "Samagra Shiksha Scheme," which aims for ICT-enabled learning via smart classrooms, ICT labs, digital books, virtual labs, and e-content to all government schools for classes 6th to 12th[3].

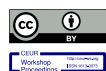
The COVID pandemic disruption also exposed the large-scale inequality in education access, with almost 33% of the students not having access to digital tools to get an education in distance mode, prompting the United Nations Educational, Scientific and Cultural Organization (UNESCO) to come out with a book titled "Guidelines for ICT in education policies and masterplans (2022)"[4]. These guidelines can help policymakers and educational institutions impart education using smart tech tools in a better manner and increase adoptions amongst learners.

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A study by [5] established that there is a significant increase in the adoption of the Internet of Things (IoT) in digital learning across various educational institutions worldwide. In a study on education in the engineering field, evidence was found suggesting that technological adoption plays an important role in preparing smart and skilled engineers [6]. Along similar lines, a positive impact on education due to smart tech was found in Vietnamese schools [7]. In a review study by [8], the five major attributes influencing the adoption of smart education were “technological aspects, data aspects, H.R. aspects, organizational aspects, and cost aspects”.

The upcoming decade is expected to see explosive growth in the smart education sector, with industry size growing from \$260 billion to around \$1.4 trillion in 2022 and 2032, respectively, clocking an average growth of 18.4% per annum [9]. This study aims to provide a comprehensive bibliographic literature review to identify the latest trends and intellectual structure of smart education themes. In particular, this study addresses the following research questions (RQs):

RQ 1 What is the general description (trend, countries, institutions, journals, and influential articles) of the scholarly landscape of smart education?

RQ 2 What is the knowledge structure of smart education research field?

The rest of this article is organized as follows: Section 2 outlines the methodology and data collection approach. Section 3 presents the bibliometric results and discussion, followed by the content analysis in the same section. The study concludes in Section 4.

2. Methodology and data collection

This section outlines the methodology used in this study. Literature reviews are increasingly used to synthesize existing knowledge, define current themes, and provide evidence-based insights (10,11,12). Researchers have employed various qualitative and quantitative methods, with systematic and bibliometric reviews widely popular (13, 14). Systematic reviews use qualitative approaches to analyze existing knowledge and advance the field, while bibliometric analysis is a quantitative and objective approach to reviewing the literature (15). In this study focusing on smart education, both qualitative and quantitative techniques are applied. Bibliometric analysis objectively assesses knowledge performance and mapping, while content analysis delves deep into the field of smart education. These approaches have been used in previous studies by various researchers (16,17).

In review studies, researchers commonly rely on Scopus and Web of Science databases for data collection. In the present study, the Scopus database is chosen for its extensive coverage of peer-reviewed scholarly literature adhering to stringent indexing standards (18,19). Employing a comprehensive search query, "Smart Education," restricted to article titles, abstracts, and keywords, the authors retrieved a dataset of 303 documents. Figure 1 presents the structure of the current study

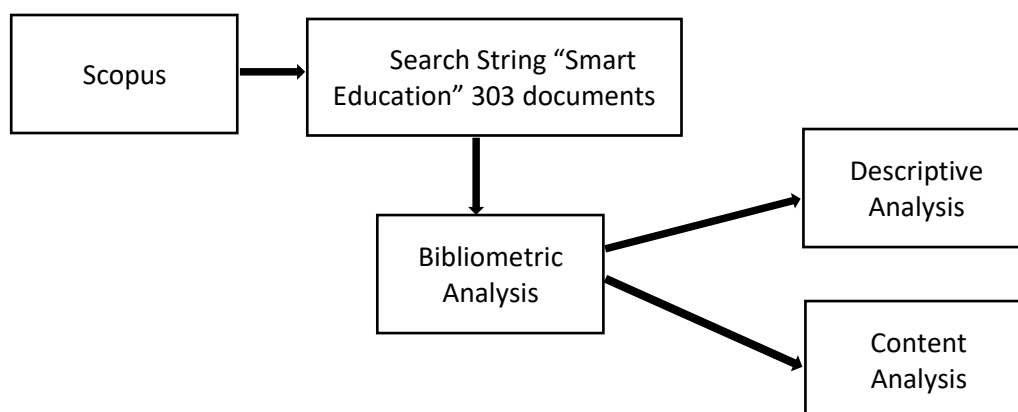


Figure 1: Structure of the study

3. Bibliometric results and discussion

3.1. General description

3.1.1. Annual publication pattern

Figure 2 displays the yearly publication pattern on smart education from 2003 to 2023. It indicates that initially, the subject has very slow growth. There are no publications even in some years. The subject has gained momentum since 2011, possibly due to the advancement of internet facilities and technology developments. The highest number of articles was published in 2023. It suggests that this topic has greater potential in the near future.

3.1.2. Leading institutions

Figure 3 demonstrates the most prolific institutions on the basis of the total number of publications in the smart education domain. It shows that the “Beijing Normal University” and “Hassan II University” are the most prominent institutions with equal publications. This is followed by the “Higher College of Technology” and “Gifu College” with 7 and 6 articles, respectively. These ten affiliations have contributed 17.82 % of sample articles in the studied domain.

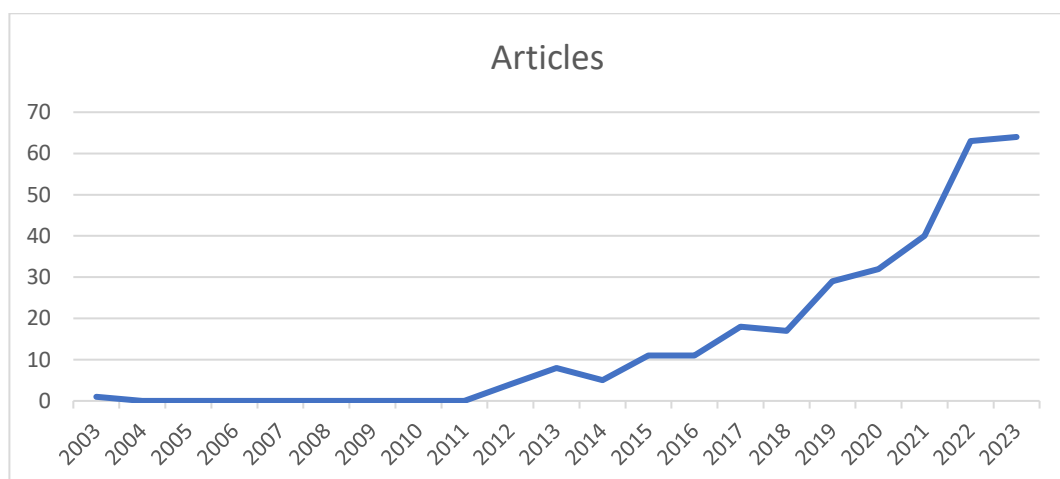


Figure 2: Yearly publication growth

3.1.3. Leading countries and their collaboration network

This section discusses the leading countries in the smart education research area. The complete set of documents was produced by 60 varied nations. It indicates that these countries have a keen interest in this realm. Table 1 depicts the top contributed countries in terms of producing the articles. It reflects that China has the highest number of publications (88 articles) on this subject. The Russian Federation is ranked second with 28 articles, followed by India on position third with 26 articles. When we look around the number of citations in Table 1, it reflects that the United States, having 11 articles, is on the top list with 249 total citations. The numbers indicate that this country's authors might focus on impactful work rather than quantity work. While the United Arab Emirates and Indonesia, listed in the top ten, must do more quality work in this research field.

Figure 4 demonstrates a collaboration map within the nations. The collaboration work is necessary for advancing the specific field [18]. The nodes' color and density of the interrelation between nodes highlighted the strength of the research relationship between these countries. Figure 4 illustrates that China has the highest research connection with other nations (8 links) followed by the United States and the United Kingdom, having seven links with other countries.

However, countries such as Greece and the United Arab Emirates have limited research links with other countries, requiring more collaboration from these nations.

3.1.4. Prominent Journals

It is crucial to be aware of the prestigious journals in order to understand the current state and possible future scope of the specific subject [20, 21]. Table 2 shows the top productive journals in the smart education search. The Smart Innovation, Systems, and Technologies is ranked at one published 29 articles. This is followed by Lecture Notes in Educational Technology and ACM International Conference Proceeding Series with 15 and 11 published articles, respectively. It also indicates that the most influential articles are published in Sustainability (Switzerland) Journals, having the highest number of total citations (124).

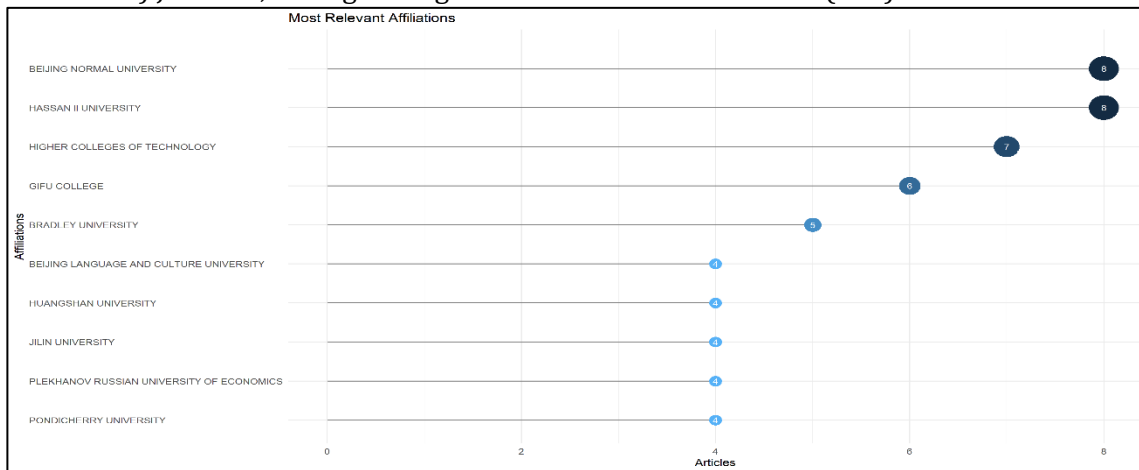


Figure 3: Top most organisations

Table 1
Top most countries

Country	Articles	Citations
China	88	653
Russian Federation	28	208
India	26	159
South Korea	25	197
United States	16	249
Japan	11	47
United Arab Emirates	11	32
Indonesia	10	21
Ukraine	8	50
Australia	6	98

3.1.5. Most influential articles

Table 3 shows the most impactful studies on the basis of the total number of citations. Citation analysis counts the number of times a study is cited by other works to determine its academic impact within a scientific field [22]. Table 3 indicates that an article titled “A research framework of smart education” is the most influential article, having 324 total citations. Other studies, such as “Internet of Things in smart education environment: Supportive framework in the decision-making process” and “Smart Education with artificial intelligence-based determination of learning styles also have significant impacts in the smart education literature, having 182 and 106 total citations, respectively. Interestingly, a recent study by [28] in 2020 was also listed in

the top ten influential articles, which indicates the significant impact of this study in the smart education literature. [23] highlighted the four-tiered structure of smart pedagogies and essential elements of smart educational environments for nurturing small learners. [24] stated the role of the Internet of Things in education and how it affects the students' learning.

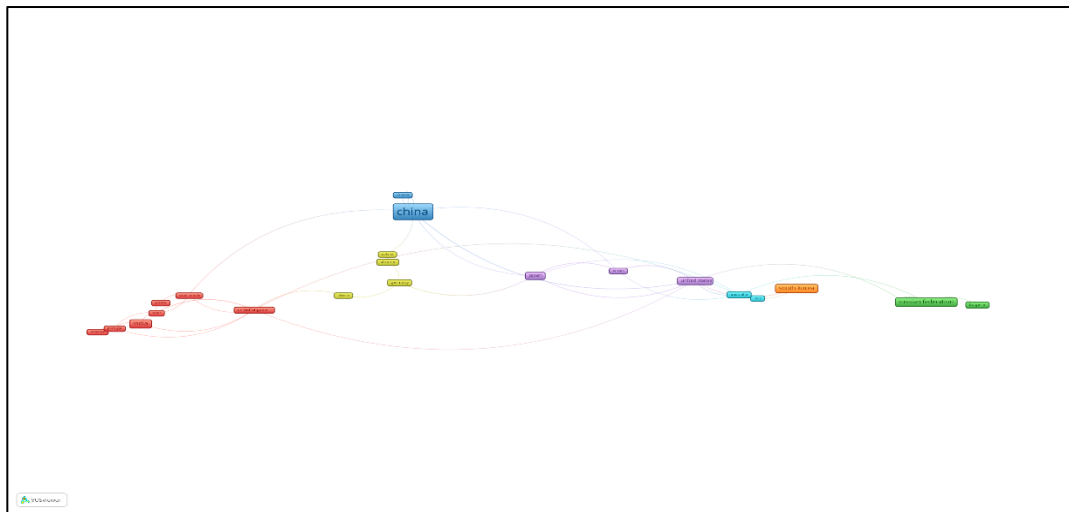


Figure 4: Country collaboration map

Table 2
Top most journals

Source	Articles	Citations
Smart Innovation, Systems and Technologies	29	106
Lecture Notes in Educational Technology	15	2
ACM International Conference Proceeding Series	11	8
Lecture Notes in Networks and Systems	9	21
Advances in Intelligent Systems and Computing	8	19
Sustainability (Switzerland)	7	124
Journal of Physics: Conference Series	5	17
Communications in Computer and Information Science	4	8
Education and Information Technologies	4	63
International Journal of Emerging Technologies in Learning	4	2

3.2 Content analysis

A lot of attention has been paid to the concept of a “smart education environment,” or a learning environment that makes use of information and communication technology (ICT). To further develop this environment and lessen the significant burden on educators, we need a system that can efficiently set up the learning environment [33]. In this context, literature heavily emphasizes cloud computing in the smart education system [34,32]. Cloud computing grabbed the attention for use in the education system due to its potential to provide affordable, safe, credible, and transferable educational services. [32] documented a content-focused smart education platform that combines a number of features necessary for setting up a cloud-based educational media service environment. [33] proposed a smart education system framework using mobile technology and cloud computing systems. Because of cloud computing, real education practices are unaffected by the use of smart educational technology. Similarly, [35] discussed a mobile Software-as-a-Service style Smart Education Support System enabling teaching staff to use the original digital learning materials and ICT environment without interfering. The smart education system significantly changes the education system. [36]

provided evidence of how university students and educators support this system. Furthermore, [37] demonstrated smart educational methods are adaptable and allow the instructional strategy to be changed to better meet the demands of specific learners.

Table 3
Top cited articles

Authors	Title	Year	TC
[23]	A research framework of smart education	2016	324
[24]	Internet of things in smart education environment: Supportive framework in the decision-making process	2019	182
[25]	Smart Education with artificial intelligence based determination of learning styles	2018	106
[26]	Social Networks Research for Sustainable Smart Education	2018	61
[27]	Intelligent Recommendation System for Course Selection in Smart Education	2018	56
[28]	Smart education literature: A theoretical analysis	2020	54
[29]	Teachers' beliefs and technology acceptance concerning smart mobile devices for SMART education in South Korea	2019	54
[30]	The potential of Augmented Reality to Transform Education into Smart Education	2018	51
[31]	Three Dimensions of Smart Education	2015	48
[32]	A Content Oriented Smart Education System based on Cloud Computing	2013	46

Note: TC is total citation

The goal of modern culture is to make a smart world. The objective of education is to meet the demands of an ever-changing globe and prepare students to become totally integrated members of society [30]. Smart education system based on digital technology is used to enhance the standard of the education system for the better quality of education [38]. It aids in developing competencies for critical thinking and assessing decision-making choices. Multiple tools, such as the Internet of Things, artificial intelligence, and wearable technology, drive this smart education system [30]. In line with this, [39] discussed the 5-G technology beneficial for developing the educational sector. Moreover, [40] documented the algorithm for smart learning. Modern trends for advancing smart education in Europe and Asia are also explored by [41].

The pandemic era and cities' transition to smart status necessitated e-learning, remote learning systems, and hybrid models. Personalized education is imperative to overcome distance learning challenges and maintain high achievement levels. While education systems have progressed, personalization to meet students' cognitive needs during non-face-to-face instruction remains a frontier. Various technologies are revolutionizing education in smart cities, enabling personalized learning and customized content based on individual preferences [42,43]. Leveraging technologies such as the Internet of Things in educational settings not only accelerates students' learning but also significantly enhances instructors' effectiveness (3,9066). Utilizing advanced technologies, smart education streamlines the processes of teaching, learning, communication, and collaboration, leading to increased efficiency due to timely notifications [44]. [42, 43] proposes a transformative paradigm for smart education based on the integration of XAI (Explainable Artificial Intelligence) and IoB (Internet of Behavior) technologies (IoT and IoB) to collect and analyze student behavior data. XAI further refines aspects for students to monitor their performance, ensuring tailored aid from the educational system [43]. [45] used neutrosophic sets to highlight critical aspects of IoT, showcasing its potential for informed

decision-making and enhancing smart education. [46] emphasizes the need for robust IoT security in the IoB and sustainable IoT ecosystems in smart education, stressing the importance of IoT security and ethical considerations for staff well-being and equipment use.

Advancements in AI and IoT technologies are reshaping education, transitioning from traditional to digital learning methods [5]. [47] found evidence that smart education effectively met distance learning objectives during the COVID-19 pandemic and military events in Ukraine. At the same time, the widespread adoption of IoT in education presents unique opportunities and challenges. Leveraging big data from IoT applications can address challenges, as seen in a literature survey identifying diverse IoT applications in education [5]. [23] outlined a comprehensive smart education framework, including a four-tier smart pedagogy approach, incorporating class-based differentiated instruction, collaborative learning, personalized learning, and mass-based generative learning. In addition, ten key features of smart learning environments are identified to nurture 21st-century skills. The paper also presents a technological architecture emphasizing smart computing and discusses associated challenges in smart education implantation. [48] introduces a Smart Education Framework, including New or improved teaching methods at the core layer. He categorizes technologies into essential, enriching, and supportive layers. The research provides a systematic approach, validating the framework through literature analysis. Additionally, [28] proposed a new innovative solution framework called SCAS Students Career Assistance System, aiding students in managing their learning and career development for a better future. Furthermore, rooted in ecological theory, integrating various information technologies leads to developing a Metaverse-based smart education ecosystem. This dynamic ecosystem emphasizes students-centered integrated learning experiences. However, the journey is not without its challenges; meticulous navigation is essential to address issues such as data security, privacy concerns, and potential social implications in virtual environments [49].

Utilizing technology and innovative teaching tools, contemporary smart education aims to improve skills and learning outcomes, generating Educational Big Data (EBD) from student interactions [50,51]. EBD holds potential for educational institutions and governments, yet challenges like data security persist. While EBD offers valuable insights and teaching enhancements, overcoming these challenges requires tailored, innovative approaches [50]. [52] proposes leveraging management systems and big data analytics to enhance teaching methods. They explore the implementation of Data Mining and Data Analytics to enhance learning and teaching experiences. Their research further employs an exploratory approach to uncover the intricacies and necessities of big data in the realm of education.

4. Conclusion

The development of new technologies has revolutionized learning, making it more effective, efficient, flexible, and comfortable. Learners utilize smart devices to access digital resources through wireless networks and immerse in personalized and seamless learning. Smart education, a concept that describes learning in the digital age, has gained increased attention. This is further accelerated by the urgent need for online education during the COVID-19 pandemic. Governments globally have also launched initiatives to promote ICT enabled learning. However, this transition has not been without challenges, as evidenced by the digital divide highlighted during the pandemic, emphasizing the importance of inclusive smart education policies.

The present study provides a comprehensive overview of the scholarly landscape of smart education. The growth in publications post-2011 reflects the increasing interest and research efforts in this field. Collaborative networks among countries, especially between research powerhouses like China and the United States, signify global cooperation in advancing smart education. While the proliferation of cloud computing has revolutionized smart education environments, challenges such as data security and privacy, as well as ethical considerations, underscore the need for continuous innovation and regulations. Smart education's evolution into personalized and student-centric learning experiences, fueled by technologies like XAI and the

IoB, showcases its potential to revolutionize teaching and learning approaches. EBD has emerged as a valuable resource, offering insights into student interactions, although challenges related to data security and privacy persist.

Based on the content analysis, future research endeavors could advance features or explore cutting-edge artificial intelligence algorithms or neurotechnology to better understand and cater to individual student's cognitive needs during remote learning. In addition, researchers could focus on developing frameworks and guidelines that ensure the ethical use of technologies in educational settings. Thus, the journey toward smart education is marked by immense potential and challenges. Embracing innovation, fostering global collaboration, and prioritizing ethics are important in navigating these challenges and unlocking the full transformative power of smart education for the benefit of learners worldwide.

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