Pioneering educational frontiers: South Korea-ASEAN synergy in big data integration and future innovations

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Article Info

ABSTRACT

This study examines the evolving trends in publication collaboration and research topics related to big data and education in South Korea and the Association of Southeast Asian Nations (ASEAN) region, analyzed through the lens of international relations (IR). Using scientometric methods, the study analyzed 2,427 publications from Web of Science (WoS) through R Studio and VOSViewer, highlighting a marked increase in publication volume, citation, and collaboration in recent years. The research focuses on key areas such as the integration of big data in teaching and performance assessment, the intersection of big data with artificial intelligence (AI), and the varying implementation frameworks across different countries. The findings reveal that while significant progress has been made, there is a need for more structured collaborative efforts. To enhance future research output and collaboration, the study recommends establishing international research networks, organizing joint projects, facilitating exchange programs, and investing in necessary infrastructure. Additionally, it suggests developing policy frameworks and securing funding to support these initiatives. Engaging industry partners and expanding collaborative networks are crucial for advancing the field and optimizing the application of big data in education.

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1. INTRODUCTION

The exponential growth of data has led to predictions that it will become the new oil on a global scale, fueling various sectors and driving innovation [1]. Big data, characterized by its vast volume, high velocity, and diverse variety, surpasses traditional storage and analysis methods, necessitating advanced information technology systems and methods such as cluster analysis, natural language processing, predictive modeling, and social network analysis [2]. This burgeoning field has already begun to induce significant societal changes across multiple domains, including communication, government, banking, transportation, health, and education.

In the educational sector, the integration of information and communication technologies has resulted in nearly all student activities-ranging from coursework and assessments to interactions with learning materials-being digitized and stored as data [3]. Experts recognize the transformative potential of big data in education, predicting it will revolutionize educational processes and systems. Extensive research has demonstrated various applications of big data in education [4], [5], such as predicting student performance,

personalizing learning experiences [4], providing immediate feedback [6], evaluating graduates' employability [7], and informing the development, implementation, and monitoring of education policies [3].

However, the integration of big data into education has not yet been fully realized, presenting a critical problem that this research seeks to address [5]. Several factors hinder this integration, including ethical concerns, [8], [9], challenges in data collection and management, and a shortage of education experts skilled in big data analytics (BDA) [10]. Furthermore, the digital divide persists, creating a hierarchy between and within countries, distinguishing those with access to vast data resources ("big data-rich") from those without ("big data-poor") [11].

A study proposes to bridge these gaps by examining the role of universities as "engaged institutions" in the era of big data. The 1990s' rise of "academic capitalism" transformed universities into "entrepreneurial universities," focusing on economic growth and development through their "third mission" [12]. In today's educational landscape, universities, with their capacity to analyze big data, are uniquely positioned to drive innovation, community development, and economic progress [13]. By leveraging big data, universities can enhance educational strategies, contribute to socially relevant policy formulation, and serve as crucial actors in innovation policies [12].

South Korea's leadership in utilizing big data for societal progress, thanks to its advanced infrastructure and software capabilities, provides a valuable model for other countries, particularly within the Association of Southeast Asian Nations (ASEAN) region [14], [15]. This research seeks to explore the current trends in big data usage in education within South Korea and ASEAN, focusing on the concept of "institutional thickness" [16]. Countries with greater "institutional thickness"-marked by high levels of cooperation and knowledge-sharing among institutions-are better positioned to harness big data for innovative educational practices.

The innovative value of this research lies in its comprehensive analysis of big data integration in education across different countries, its identification of key factors that facilitate or hinder this integration, and its proposed strategies for enhancing collaboration and research output in the field. By doing so, the objective of this study is to provide actionable insights that can guide future policies and initiatives, ultimately advancing the role of big data in education and fostering regional development. The study primarily addresses the research question: What are the strategies that can help further improve the big data and education landscape between ASEAN countries and South Korea?

To ensure the recommendations are specific and applicable, the paper also explores the current landscape of big data and education publications from ASEAN countries and South Korea. Given the increasing interest in big data in different fields, the authors hypothesize that the landscape of big data in education publications from ASEAN countries and South Korea is growing. The authors also hypothesize that despite the increasing number of research publications, citations, and collaborations in ASEAN countries, a significant gap exists compared to the more advanced South Korea.

2.   METHOD

This research employed altimetric and scientometric techniques to analyze the current state of big data integration in education across ASEAN countries and South Korea. Inspired by the methodology of Gracio *et al.* [17], this study quantitatively analyzed the evolution of relevant publications, collaboration networks, and knowledge domains. It used keyword co-occurrence and frontier analysis alongside emerging trends identified through literature co-citation and cluster analysis [18]. These approaches provide a comprehensive macro-level overview that enhances understanding of scientific practices and offers valuable insights for shaping policies, guidelines, and research management strategies [19].

Data was extracted from the Web of Science (WoS) database, selected for its extensive coverage of scholarly literature, which includes essential information such as author details, publication data, citation records, and abstracts. WoS's interdisciplinary scope and the ability to filter results by geographic location made it particularly suitable for this study, as it ensured a focused analysis specific to South Korea and ASEAN countries [20]. The systematic search was conducted in June 2023 using the keywords "big data" and "education", following the precedent set by previous reviews on the subject. The search was restricted to publications from South Korea and ASEAN nations to maintain a region-specific focus [21], [22]. Full publication records were downloaded as plain text files, enabling detailed data analysis.

Data management was performed using the tidyverse and dplyr packages in R Studio, which facilitated the merging of datasets, removal of duplicates, and elimination of incomplete records, ensuring the dataset's integrity and reliability. For data analysis and visualization, R Studio and VOSviewer were employed [23]. The analysis comprised three key components: a trend analysis of publications per country, a network analysis of publications across all countries, and a text analysis using co-occurrence maps for the collective dataset and individual nations.

The study's findings were further analyzed through the lens of international relations (IR) theories, following the research agenda and global IR dimensions outlined by Acharya [24]. Practical recommendations were then proposed to enhance collaborations on big data and education initiatives between South Korea and ASEAN countries. Examples of past projects from other countries were also added to aid readers in identifying feasible and realistic strategies further.

3.   RESULTS AND DISCUSSION
3.1. Current landscape of big data integration in education in South Korea and ASEAN countries

A total of 2,427 publications about big data and education were extracted and analyzed for this study. South Korea emerged as a notable contributor, originating 46.19% of the publications, thereby highlighting its substantial involvement in the field. ASEAN countries also actively participated, with Malaysia (n=480), Singapore (n=387), Indonesia (n=255), Thailand (n=85), Philippines (n=74), Vietnam (n=12), Myanmar (n=10), Cambodia (n=5), and Laos (n=4) generating related publications, as presented in Figure 1. Among the extracted publications, articles constituted the majority, accounting for 65.57% of the dataset, followed by proceeding papers (26.76%) and reviews (6.56%). A noteworthy trend observed is the consistent increase in publications from 2013 to 2022, culminating in 498 publications in the most recent year. Furthermore, the rise in publications was accompanied by a substantial increase in citations, totaling 53,622 for all publications, resulting in an impressive overall h-index of 94.
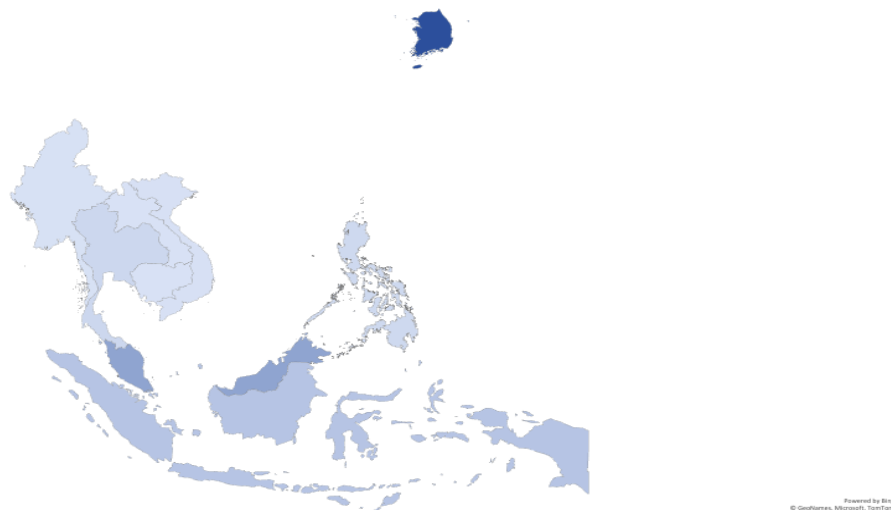

Figure 1. Big data and education publication distribution in ASEAN countries and South Korea

The top 10 institutions with the most publications on big data and education primarily comprised of universities from South Korea, Singapore, and Malaysia, such as Korea University, Kyung Hee University, Kyungpook National University, Nanyang Technological University, National University of Singapore, Seoul National University, Sungkyunkwan University, Universiti Malaya, Universiti Teknologi Malaysia, and the Universiti Teknologi MARA. These institutions have played a pivotal role in shaping the research landscape within the analyzed regions, showcasing their commitment to advancing knowledge in big data integration in education. This result also reflects the imperative for "engaged universities" as "entrepreneurial actors," as suggested by Brown within the context of academic capitalism in East Asia [12]. The diverse range of publication types, the upward trajectory of publications, and the contributions from influential institutions collectively signify the growing interest and engagement in advancing knowledge at the intersection of big data and education within the analyzed regions. Several factors may have contributed to this increase in publication output. Firstly, advancements in educational technology have provided educators with a wide range of commercial and free educational tools that facilitate various modes of learning. Moreover, the COVID-19 pandemic has expedited the adoption of online tools for distance learning, compelling educators and administrators to utilize platforms equipped with algorithms to structure and monitor teaching and learning activities [25].

The analysis revealed a pattern of collaboration where affiliations from ASEAN countries most frequently collaborated with those from the United States of America, China, and Australia. Furthermore, the analysis highlighted that Singapore, Malaysia, Indonesia, Thailand, and the Philippines were the primary

ASEAN countries collaborating with South Korea for big data and education publications. Interestingly, the analysis also revealed that in big data and education publications, Malaysia and Singapore have collaborated with South Korea and other ASEAN countries, such as Indonesia, Thailand, and Brunei. The investigation further showed that the distribution of publications varied depending on factors such as the presence of dedicated big data research centers, engineering and education departments offering big data courses or programs, advanced technology infrastructure, and the existence of relevant guidelines and policies on data management, analysis, and storage. Government support, a critical enabler for effective system integration, a research [26] was reported as a significant contributing factor in countries with high research funding, resulting in more publication outputs. Conversely, countries with limited publications were found to have limited collaborative experiences in big data and education. For instance, there remains a need to incorporate big data into the education sector in the Philippines despite its usage in other government agencies [27].

Examining the abstracts extracted from the publications facilitated the identification of the prevailing clusters of topics in the domain of big data integration in education. Keyword co-occurrence analysis uncovered three significant clusters of topics of these publications, which include: i) the utilization of big data in universities for teaching and performance assessment; ii) the intersection of big data and artificial intelligence (AI) components such as machine learning; and iii) the implementation framework of big data in education and other industries, as shown in Figure 2. The initial two clusters were consistent with the four themes identified in a previous systematic review on big data and education [28]. These themes encompass learner behavior and performance, modeling and educational data warehousing, educational system enhancement, and integrating big data into the curriculum. The third cluster, which revolves around the co-occurring keywords in the research on utilizing big data to connect education and industry, may be linked to recent endeavors to strengthen university-industry relationships. The advent of the Industrial Revolution has significantly amplified and diversified global knowledge, compelling higher education institutions to forge closer ties with relevant industries [29]. Keywords such as law, policy, guidelines, and recommendations could have been more frequent in the titles and abstracts of the analyzed studies. These documents play a crucial role in emphasizing the significance of big data in education and providing frameworks and practical strategies that assist educational institutions in effectively integrating big data into their respective systems.
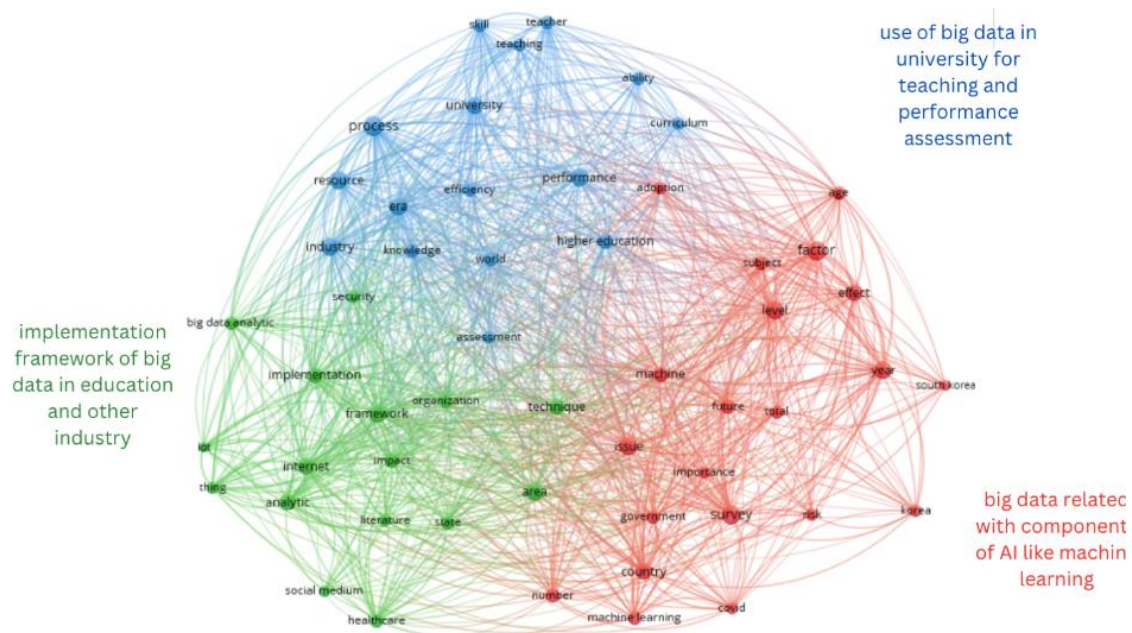

Figure 2. Network map of big data and education collaboration of South Korea and ASEAN countries

Further analysis per country revealed that publications from Malaysia, Singapore, and Indonesia predominantly revolved around integrating big data and various technologies in education, particularly emphasizing the role of teachers. In the case of Malaysia, the study on big data application in mathematics education highlighted the growing importance of big data as a pillar in the Ministry of Education's Digital Education Strategy 2020-2025 [30]. Malaysia's significant contribution of 480 publications within the

broader field of big data and education underscores its active role in exploring the potential of big data to enhance educational outcomes, especially in mathematics. While South Korea leads in global big data research with 46.19% of publications, Malaysia's efforts demonstrate robust engagement in the field. Moreover, the study emphasizes the use of diverse data sources, such as student records and learning management systems, which reflect global trends in data-driven educational practices. Importantly, big data is recognized for its potential to drive innovation in higher education and improve administrative and academic processes. The study further suggested that the integration of big data will continue to shape educational practices, particularly in the context of the fourth industrial revolution (IR 4.0), where automation and AI are becoming central to addressing emerging challenges.

In contrast, publications from Thailand, the Philippines, Vietnam, and Brunei were more inclined towards discussing the general features and potential applications of big data in education. In comparison, publications from South Korea exhibited a more advanced stage of research and implementation. South Korean publications focused on integrating big data with AI for learning environments and processes. Additionally, a notable emphasis was on using big data techniques and models for prediction and decision-making related to educational performance and challenges. These findings signify South Korea's progress in leveraging BDA and advanced technologies to enhance educational practices and outcomes.

The study on the application of big data in the Korean college education system identified several key findings that align with South Korea's broader advancements in educational technology. One of the primary areas of focus is the learning analytics environment, which explores how big data can be applied to enhance curricula and educational outcomes in Korean colleges [31]. This reflects South Korea's increasing integration of big data and AI to improve learning environments. Despite the growing availability of meaningful online data due to expanded ICT infrastructure, Kim and Ahn [31] highlighted that the actual utilization of this data for educational improvement remains limited, underscoring a gap that South Korea is actively addressing. However, they also noted challenges, such as mitigating negative impacts and ensuring data neutrality, as South Korea integrates advanced technologies like AI with big data in education. As evidenced by the analysis of keywords, the evolution of research topics across countries can be likened to the process of normalizing big data within a country [15]. Shin asserted that adopting and normalizing a complex and expansive technology like big data into a system necessitates a comprehensive understanding of its characteristics, strengths, limitations, and potential impact on human activities [15].

3.2. Analyzing the current landscape using IR distinct lenses

This section explores the significant roles of big data and education within the framework of non-traditional security issues, emphasizing their potential to foster regionalism and integration across East Asia. By utilizing various IR theories, the analysis aims to uncover how advancements and collaborations in these fields mirror and potentially influence the existing international system and order. Realism may interpret these collaborations as strategic efforts by states to enhance their security and power within the region, while liberalism might view them as opportunities for cooperation that promote peace and mutual benefits through interdependence. Constructivism would consider the shared values and norms that these cooperative efforts in big data and education help to construct, fostering a collective identity and regional cohesion that align with broader global norms and policies. Through this multifaceted analytical approach, the section seeks to demonstrate how the intersection of technology, education, and international policy shapes and is shaped by the dynamics of East Asian geopolitics.

Realism, a fundamental theory in IR, offers a lens to understand power dynamics between states and how they influence collaborations, particularly in big data and education. It emphasizes self-interest and power dynamics as critical drivers of state actions. From a realist perspective, analyzing big data and education publications within South Korea and ASEAN reflects power dynamics, strategic considerations, and regional competition shaping research collaborations and priorities. In this context, South Korea's substantial contribution (46.19% of publications) can be interpreted as its interest in securing a competitive edge and enhancing its regional influence. The research output is seen to gain relative advantages in the evolving field of educational technology. Collaboration patterns involving ASEAN countries, the United States, China, and Australia illustrate strategic alignment to maximize benefits. South Korea's collaboration with ASEAN countries can be seen as extending its influence and counterbalancing other major powers, such as China and the United States, in the region. The competition for influence and the quest for regional power play a central role in these collaborations.

Liberalism offers a lens through which to view the collaborative efforts between South Korea and ASEAN in big data and education research and integration as a reflection of both "low politics" of economic interdependence and "high politics" in the regional arena [32]. Liberalism, with its emphasis on cooperation, multilateralism, and shared interests, was evident in how arrangements like the ASEAN+3 and the East Asian Summit could serve as platforms for the implementation of the framework of big data in education and other industries. Identifying clusters of topics, such as utilizing big data in universities for teaching and

performance assessment, represents a collective dedication to enhancing educational processes. Furthermore, the acknowledgment of the impact of technological advancements in educational technology, significantly accelerated by the COVID-19 pandemic, resonates with liberalist beliefs suggested by Seton-Watson in terms of progress and adaptation [33]. Ko *et al.* [34] examined various aspects of higher education affected by the pandemic, such as remote learning, tuition refunds, the return of Chinese international students in South Korea, and the normalization of college operations. In the second phase, they identified key areas, including preparations for the college scholastic ability test (CSAT), the balance of in-person and online classes, early admissions, and job market support. The third phase focused on issues such as CSAT and college-specific exams, campus quarantine measures, social dynamics, and continued support for graduates entering the job market.

Liberalism also encourages economic interdependence, as suggested by the Kantian Triangle [35]. This has been shown in South Korea and ASEAN's efforts in big data and education through the adoption of technological innovations for the benefit of society and the facilitation of global connections. Moreover, the role of critical institutions, primarily universities from South Korea, Singapore, and Malaysia, in shaping the research landscape reflects the liberalist idea of institutions being drivers of progress and knowledge sharing. Ijab *et al.* [36] explored the readiness of higher education institutions in Malaysia to adopt BDA using the technology-organization-environment (TOE) framework. The study revealed that organizational, technological, and environmental factors play a significant role in influencing BDA readiness. Despite these influences, the level of readiness at the examined public university was deemed unsatisfactory, suggesting that while there are initiatives in place, more progress is required. The research utilized a qualitative approach, specifically in-depth interviews, to gather insights into staff members' beliefs and perceptions regarding BDA readiness, offering a deeper understanding of the underlying factors affecting adoption. However, the study's focus on a single institution limits its generalizability, and future research should consider a quantitative approach across multiple institutions to broaden its applicability. The study also contributed to Information Systems literature by proposing a conceptual framework that integrates readiness theories with the TOE framework, offering a foundation for further studies.

Within the constructivist framework, the intersection of big data and education in South Korea and ASEAN highlights the influential role of shared ideas, norms, and collaborative efforts in shaping this academic field. Constructivist theorists, such as Wendt [37] argue that shared beliefs and norms significantly shape the international system, challenging traditional realist and liberal perspectives that emphasize material capabilities. The co-occurrence analysis of keywords and the identification of topic clusters further underscore the socially constructed nature of the research domain. Collaborative engagements between ASEAN and South Korea have driven innovations in education through the application of big data, incorporating AI components like machine learning for teaching and performance assessments. The three clusters identified in this research also reflect the evolving norms and collective beliefs within the academic and professional communities regarding the applications and potential of big data in education. This aligns closely with Surbakti *et al.* [38] who emphasized the "effective use" of big data, particularly with regard to its seamless integration into educational systems. They identified essential factors such as data quality, privacy, security, and governance, along with perceived organizational benefits, process management, and the role of systems, tools, and technologies. Additionally, organizational culture and the human aspect were also emphasized as crucial to ensuring the successful implementation and advancement of big data in education. These factors are essential in shaping how big data is utilized to enhance educational outcomes and streamline institutional processes.

The prominence of certain institutions from South Korea, Singapore, and Malaysia in research contributions highlights the role of institutions in shaping the research landscape. These institutions act as norm carriers, facilitating collaboration and knowledge sharing in line with the normative framework of enhancing education through technology. The European Union (EU) emerged as a norm-entrepreneur in education policy, advocating concepts of social cohesion, employment, and productivity to bolster social citizenship and advance educational equality [39]. Similarly, ASEAN, a regional organization akin to the EU, has the potential to act as a norm-entrepreneur by championing big data and technological advancement through its collaborations, particularly with South Korea. This reflects the normative capacity of regional institutions to guide collective action and research endeavors that contribute to enhancing educational practices across the region.

Acknowledging the influence of ASEAN and its pivotal role in promoting technological advancement through the integration of big data with South Korea, diverse IR theories offer varied explanations for how relations within the East Asian region contribute to a collaborative and facilitating environment for the realization of a more integrated education system. Looking ahead, understanding the collaboration between various societal entities within the ASEAN-South Korean circles can be enhanced through the triple helix thesis. This framework broadens conventional conceptions of collaboration, extending them to a broader context of cross-border partnerships within East Asia.

3.3. Exploring the future collaborative landscape of South Korea and ASEAN Countries in advancing big data integration in education

Based on relevant publications, the authors have put forward seven approaches, as shown in Figure 3, that can be adopted by educators, policymakers, and stakeholders in South Korea and the ASEAN region to enhance their big data and education initiatives. Each suggestion is elaborately explained in subsequent sections, along with supporting theories to provide a comprehensive understanding of the proposals. Practical examples are also provided to help readers identify feasible and realistic strategies that they can adapt specific to their needs.
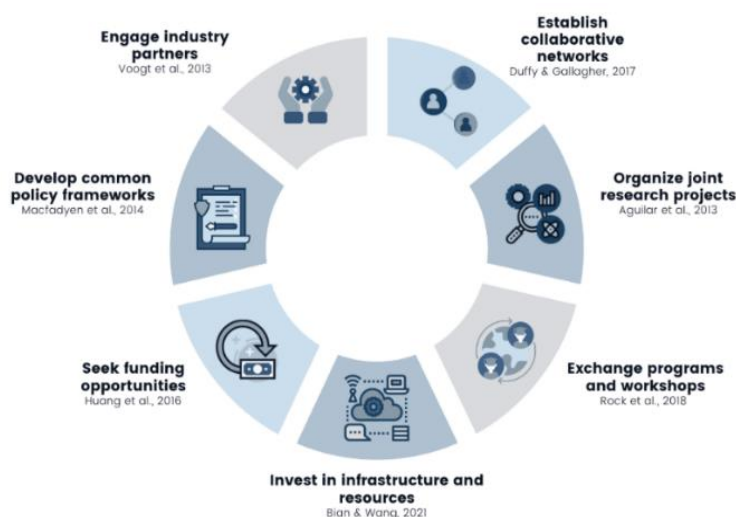

Figure 3. Recommendations for improving big data and education projects in ASEAN and South Korea

3.3.1. Recommendation #1: establish collaborative networks

Establishing international formal networks facilitates regular communication, knowledge sharing, and joint research initiatives, promoting discussions to address various issues. The effectiveness of collaborative networks in breaking boundaries and improving practices and research has been demonstrated in scholarly communities, schools, and healthcare facilities [40], [41]. Collaborations can lead to transformative advancements in educational practices, policies, and research methodologies, benefiting the participating institutions and the broader educational community [41].

3.3.2. Recommendation #2: organize joint research projects

Another recommendation is to encourage the initiation of joint research projects that specifically focus on integrating big data into education. By bringing together students, researchers, and experts from South Korea and ASEAN countries, these joint research projects can foster a collaborative environment. These collaborative environments can serve as opportunities where participants work towards common research goals, share resources and findings, and enhance the visibility of their work [42].

3.3.3. Recommendation #3: exchange programs and workshops

Another strategy is facilitating in-person, online, or hybrid exchange programs and workshops. These programs provide valuable opportunities for researchers, educators, and policymakers from both regions to immerse themselves in each other's processes and environments, fostering interaction and facilitating the exchange of relevant experiences, knowledge, and skills. Rock *et al.* [43] highlighted the positive impact of such activities in fostering regional collaboration, as early career professionals and students could connect with mentors who guided them on their professional journey. In addition, such activity may also help share and showcase best practices, success stories, and lessons learned in implementing big data integration in education [44].

3.3.4. Recommendation #4: invest in infrastructure and resources

Another crucial strategy is prioritizing allocating resources and investments toward developing essential educational big data infrastructure. This includes establishing BDA tools, robust cloud computing capabilities, and secure big data storage systems supporting collaborative research and initiatives in big data

and education. By investing in these technological foundations, researchers and educators can effectively and efficiently analyze and utilize large-scale educational data to make data-informed decisions and drive innovation. A notable example of this strategy is China's approach to integrating big data into education [45]. Li *et al.* [46] reported that China had introduced its national big data strategy as part of the 5-year national plan for economic and social development.

Furthermore, the government has approved approximately 250 colleges and universities to launch programs related to big data between 2016 and 2017. By following China's lead, South Korea and ASEAN countries can prioritize the development of their national strategies and plan to integrate big data into education. Kim and Ahn [31] stressed the importance of establishing data exchange systems and securing sufficient data to fully realize the benefits of learning analytics, aligning with South Korea's ongoing efforts to develop infrastructures supporting big data analysis in education.

3.3.5. Recommendation #5: seek funding opportunities

Interested parties must explore regional and international funding opportunities to enhance collaboration in big data and education. Huang *et al.* [47] reported that seeking such scientific funding may help improve future research investments, optimize peer review processes, and ensure equitable distribution of funds. Thus, it is recommended to actively seek partnerships with funding agencies, organizations, and foundations that promote educational innovation and research collaboration.

3.3.6. Recommendation #6: develop common policy frameworks

Collaboratively developing policy frameworks and institutional guidelines is crucial for successfully integrating big data into education. Policymakers, researchers, and educators should engage in discussions to identify shared challenges, opportunities, and ethical considerations to establish guidelines that promote responsible and effective use of big data in educational settings. Macfadyen *et al.* [48] emphasized the significance of policies and guidelines as driving forces behind sustainable solutions or strategies for complex institutional problems. Their study proposed two policy frameworks that can be explored for integrating big data in education. The first framework is the rapid outcome mapping approach model, which involves systematically mapping the institutional context, identifying key factors specific to the context that may influence the implementation process (such as people, political structures, policies, institutions, and processes), and using this information to design interventions and shape strategic planning [48]. The second framework is "cause-effect framework" (or driving force-pressure-state-exposure-effect-action (DPSEEA) framework), which helps determine the multiple linkages between the driving forces underpinning complex systems. This framework sheds light on the various points within a complex system of relationships where action may be required to bring about change [48]. By adopting these frameworks, policymakers, researchers, and educators can effectively address the challenges and complexities of integrating big data into education.

3.3.7. Recommendation #7: engage industry partners

It is also recommended that collaborative endeavors be made to facilitate the integration of big data in education and bridge the gap between academia and industry. The rapidly evolving nature of various industries presents significant challenges to educational systems, as educators must continuously adapt to changes in what and how students learn [49]. Therefore, establishing solid and formal partnerships between universities and industry becomes essential, as they can provide valuable real-world data, practical insights, and opportunities for applying big data techniques in educational contexts. These university-industry collaborations offer several benefits [50]. First, they enable educators to gain access to up-to-date information and real-time data directly from industry sources, enhancing the relevance and authenticity of educational experiences. Second, industry partners can provide valuable insights into the skills and competencies required in the current job market, helping academic institutions align their curriculum and teaching methods with industry needs. Finally, these collaborations foster a mutually beneficial exchange of knowledge and expertise, creating opportunities for joint research projects, internships, and professional development programs.

By following these practices, South Korea and ASEAN countries can create a robust and sustainable collaborative landscape for big data integration in education. These recommended strategies may also help further foster innovation and more efficient knowledge exchange. These collective and continuous efforts are necessary to handle educational challenges and ensure that systematic data-driven approaches and data-informed decision-making processes are utilized to address different problems of each country.

4. CONCLUSION

This study has provided a comprehensive analysis of the current and future potential of big data integration in education within South Korea and the ASEAN region. By examining publication trends, international collaborations, and critical research topics through the lens of IR, we have highlighted both the progress made and the challenges that persist in these regions. The results demonstrate a growing interest in leveraging big data for educational enhancement, yet significant work remains to optimize its application.

As anticipated in the introduction, the analysis confirms that tailored strategies, developed with a deep understanding of regional contexts, are essential for overcoming barriers and maximizing the benefits of big data in education. The study's findings suggest that future research should focus on refining these strategies, fostering stronger international collaborations, and addressing the unique challenges of each region. The ongoing development and application of big data in education present promising prospects for innovation, and the continued efforts of educators, policymakers, and stakeholders will be crucial in realizing its full potential. Looking ahead, further studies should explore the practical implementation of these strategies, ensuring that the educational landscape evolves in tandem with technological advancements.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

An informed consent was not necessary for this research.

ETHICAL APPROVAL

An ethics board review approval does not apply to this research.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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