International
Journal of
Innovation and
Industrial
Revolution
(IJIREV)

eISSN: 2637-0972

GÆ
GLOBAL ACADEMIC EXCELLENCE

AN EDUCATIONAL INNOVATIONS TOWORDS INDUSTRY REVOLUTION 5.0 ERA: A 6-YEAR BIBLIOMATRICS STUDY ON TECHNOLOGY TRENDS

Punggothai Chandra Shegaram[1*], Balamuralithara Balakrishnan[2*], Noor Banu Mahadir Naidu[3*]

[1]   Faculty of Art, Sustainability and Creative Industry Sultan Idris Education University.Malaysia
     Email: hamsavarsha@gmail.com
[2]   Faculty of Art, Sustainability and Creative Industry Sultan Idris Education University.Malaysia
     Email: balab@fskik.upsi.edu.my
[3]   Faculty of Human Sciences, Sultan Idris Education University, Malaysia
     Email: noor.banu@fsk.upsi.edu.my
*   Corresponding Author

Article Info:

Abstract:

This bibliometric research investigates educational developments throughout the Industrial Revolution 5.0 era, with an emphasis on technological changes from 2019 to 2024. The study examined 49 peer-reviewed publications and conference papers obtained only from the Scopus database. The research looks at publishing patterns, author productivity, nation contributions, citation effect, and new keywords connected to technology improvements in education. The findings show that there is a growing emphasis on using new technology to improve teaching and learning, as well as an increase in research efforts over the last several years. The report highlights notable experts, significant publications, and frequent research issues, giving useful insights to policymakers and guiding future research to connect educational advances with the developing demands of Industry 5.0.

Keywords:

Educational Innovations, Industry Revolution 5.0, Workforce Readiness

Introduction

The Industrial Revolution 5.0, as well as the emerging frameworks of Society 5.0 and Education 5.0, are driving fundamental changes in the educational scene. These paradigms emphasize the seamless integration of new technology into education, to create more personalized, human-cantered learning experiences. Over the last decade, IR 5.0 has had a considerable impact on educational practices by encouraging the incorporation of emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), robots, and data analytics, which are all transforming the future of education.

The influence of IR 5.0 on education has been revolutionary, resulting in more flexible learning systems, improved digital literacy, and a stronger emphasis on interdisciplinary learning. These advances have enabled instructors to personalize education to different learning styles, foster critical thinking, and prepare students for the challenges of today's workforce. The integration of these technologies has also enabled more immersive and interactive learning experiences, removed conventional educational boundaries and made learning more accessible and interesting.

This bibliometric research looks at the developments in educational innovation during the last six years (2019-2024), focussing on the uptake and effect of new technologies in the educational sector. This study examines 49 peer-reviewed publications and conference papers obtained only from the Scopus database to identify major trends, influential authors, and contributing variables to the citation effect of these technical breakthroughs. The study's goal is to present a complete picture of how educational innovations are emerging in response to Industry 5.0 needs, as well as insights that might inform future research and policy development in this vital field.

Literature Review

The Industrial Revolution 5.0 (IR 5.0) marks a substantial move towards human-centered innovation, with sophisticated technologies such as artificial intelligence (AI), robots, and the Internet of Things (IoT) being incorporated into a variety of industries, including education. Over the last decade, IR 5.0 has resulted in the creation of new educational paradigms that prioritize personalized, adaptive learning and the development of skills required for the future workforce. This progression is marked by a shift away from traditional rote learning and towards more dynamic, technology-driven techniques that promote creativity, critical thinking, and problem-solving skills.

The influence of IR 5.0 on education has been significant, notably in how educational technologies are used to improve the teaching and learning process. For example, AI-powered learning systems now provide personalized educational experiences that adapt to individual learning needs and provide real-time feedback. The incorporation of IoT into classrooms has enabled the development of smart learning environments in which data from multiple devices can be utilized to optimize learning settings and measure student progress. Furthermore, the usage of robots in education has grown beyond STEM subjects, and it is also playing an important role in the development of soft skills such as teamwork and emotional intelligence. This study leverages on advances in bibliometric analysis, a popular method for systematically reviewing scientific and academic publications, to investigate trends in educational breakthroughs throughout the IR 5.0 era. Bibliometrics is the quantitative examination of published data, such as citation patterns, authorship networks, and emerging research themes

(Aria & Cuccurullo, 2017). The importance of bibliometric techniques in analyzing the dissemination and influence of educational technology cannot be understated, as they provide a systematic method for identifying major trends and prominent works in the area.

Modern bibliometric approaches now include sophisticated techniques like co-citation analysis, bibliographic coupling, and semantic network analysis, in addition to classic descriptive statistics (Zupic & Čater, 2015; van Eck & Waltman, 2023). These strategies are especially useful in the context of IR 5.0, where fast technological growth needs a thorough knowledge of how new technologies are incorporated into educational processes.

Altmetrics, which evaluate the broader societal influence of research via social media mentions and policy citations, are also increasingly being used in bibliometric studies (Haunschild et al., 2019). This is especially true in the context of IR 5.0, where educational technologies' societal ramifications are just as significant as their academic achievements. Altmetrics provides a supplementary viewpoint to standard citation metrics by documenting the direct and widespread impact of research on educational policy and practice.

Furthermore, the creation of open-source tools such as VOS viewer and Bibliometrics has democratized access to advanced bibliometric approaches, allowing researchers from a variety of disciplines to undertake complex analyses (van Eck & Waltman, 2023; Aria & Cuccurullo, 2017). These technologies have made it simpler to visualize complicated networks of research activity, identify major contributors, and discover new patterns in educational innovation connected to IR 5.0. Using these techniques, this research seeks to map the landscape of technology changes in education during the last six years, offering significant insights into the educational sector's continuous transition in the IR 5.0.

Research Question

RQ1: What are the research trends in educational advances for the Industrial Revolution 5.0 period, as reported between 2019 and 2024?

2. RQ2: Who are the most prolific writers working on educational innovations in the context of the Industrial Revolution 5.0?

RQ3: Who are the top ten authors with the most referenced articles?

RQ4: Which nations are at the forefront of research into educational breakthroughs for the Industrial Revolution 5.0?

5. RQ5: How do the study findings on educational testbeds relate to the demands of Industry 4.0 and Industry 5.0, and how can they help the education field and workforce development?

6. RQ6: What are the required for the current workforce in the context of Industry 4.0 and Industry 5.0, and how can they be included into education?

7. RQ7: How might new technologies like blockchain improve data security and privacy in the Industry 5.0 ecosystem, particularly in education?

8. RQ8: What are the most common keywords and research issues for educational advances in the Industrial Revolution 4.0 and 5.0 era?

9. RQ9: What are the research needs and future trends in the field of educational innovations for the Industrial Revolution 5.0?

10. RQ10: How can the findings of this bibliometric analysis influence evidence-based policymaking and future research initiatives in aligning educational innovations with the demands of the Industry 5.0 and Society 5.0 paradigms?

Methodology

This study uses bibliometrics, a quantitative tool for analyzing scientific and academic literature, to look at trends in educational advancements throughout the last six years (2019-2024) of the Industrial Revolution 5.0 (IR 5.0). Bibliometric analysis is the systematic collection, organization, and analysis of bibliographic data from academic publications, which provides insights into the evolution of research trends, significant authors, and major themes in a certain area (Aria & Cuccurullo, 2017). This research focuses on the technological developments in education that have evolved in response to the needs of IR 5.0, which emphasizes human-centered, technology-driven educational improvements.

The methodology combines advanced bibliometric techniques, such as co-citation analysis, bibliographic coupling, and semantic network analysis, with traditional descriptive statistics like publication year, journal, and author classification (Zupic & Čater, 2015; van Eck & Waltman, 2023). These improved methodologies provide a more nuanced assessment of research trends and the links between different studies, emphasizing the effect of technology advancements in the educational sector. Co-citation analysis, for example, can assist uncover clusters of linked studies that have collectively impacted the discourse around educational technology in the IR 5.0 era.

Given the high rate of technological improvement linked with IR 5.0, the incorporation of big data and artificial intelligence (AI) has increased the depth and accuracy of bibliometric studies (Chen et al., 2022). AI-powered technologies enable the analysis of massive amounts of data, revealing subtle trends and patterns that would otherwise go unnoticed. This study uses such technologies to analyze bibliographic data, providing complete coverage while minimizing potential biases.

The Scopus database served as the major data source for this investigation, resulting in a comprehensive and accurate collection of peer-reviewed publications and conference papers. Scopus was selected for its vast coverage of high-quality academic papers, making it an appropriate resource for capturing the range of research on educational innovations related to international relations.

The study also includes altmetrics, which use social media mentions, policy citations, and other non-traditional metrics to assess the research's larger societal influence (Haunschild et al., 2019). This is especially important in the context of IR 5.0 when the practical implications of educational innovations go beyond academics and into policymaking and societal debate.

To aid in the bibliometric study, open-source software such as VOSviewer and Bibliometrix were used. These techniques allowed us to visualize research networks, identify major contributors, and map developing patterns. The study also takes into account the multidisciplinary character of educational research in the IR 5.0 age, recognizing the worldwide and linked breadth of modern academia (Zhang et al., 2022).

Finally, this technique provides a complete framework for analyzing how educational innovations have evolved to meet the technology needs of the IR 5.0 age. The findings of this analysis are meant to guide future research and evidence-based legislation, aligning educational practices with the current technological innovations of Industry 5.0.

Data Search Strategy
Study employed a screening sequence to determine the search terms for article retrieval. Study was initiated by querying Scopus database with TITLE-ABS-KEY ((industrial AND revolution 5.0 in AND education)) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (EXACTKEYWORD , "Industry 5.0") OR LIMIT-TO (EXACTKEYWORD , "Industrial Revolutions") OR LIMIT-TO (EXACTKEYWORD , "Industry 4.0") OR LIMIT-TO (EXACTKEYWORD , "Digital Transformation") OR LIMIT-TO (EXACTKEYWORD , "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Higher Education") OR LIMIT-TO (EXACTKEYWORD , "E-learning") OR LIMIT-TO (EXACTKEYWORD , "Society 5.0") OR LIMIT-TO (EXACTKEYWORD , "Education 5.0") OR LIMIT-TO (EXACTKEYWORD , "Technology") OR LIMIT-TO (EXACTKEYWORD , "Teaching") OR LIMIT-TO (EXACTKEYWORD , "Internet Of Things") OR LIMIT-TO (EXACTKEYWORD , "Fifth Industrial Revolution") OR LIMIT-TO (EXACTKEYWORD , "Education") OR LIMIT-TO (EXACTKEYWORD , "Virtual Reality") OR LIMIT-TO (EXACTKEYWORD , "Systematic Literature Review") OR LIMIT-TO (EXACTKEYWORD , "Learning") OR LIMIT-TO (EXACTKEYWORD , "Education 4.0") OR LIMIT-TO (EXACTKEYWORD , "Digital Technologies") OR LIMIT-TO (EXACTKEYWORD , "University") OR LIMIT-TO (EXACTKEYWORD , "Smart Education") OR LIMIT-TO (EXACTKEYWORD , "Intelligent Robots") OR LIMIT-TO (EXACTKEYWORD , "Machine Learning") OR LIMIT-TO (EXACTKEYWORD , "Information Technology") OR LIMIT-TO (EXACTKEYWORD , "Human Machine Interaction") OR LIMIT-TO (EXACTKEYWORD , "Educational Institutions") OR LIMIT-TO (EXACTKEYWORD , "Digitization") OR LIMIT-TO (EXACTKEYWORD , "Deep Learning") OR LIMIT-TO (EXACTKEYWORD , "Curriculum Development") OR LIMIT-TO (EXACTKEYWORD , "Curricula") OR LIMIT-TO (EXACTKEYWORD , "Education And Training") OR LIMIT-TO (EXACTKEYWORD , "Education Computing") OR LIMIT-TO (EXACTKEYWORD , "Education 40") OR LIMIT-TO (EXACTKEYWORD , "Education 4.0/5.0") OR LIMIT-TO (EXACTKEYWORD , "Digital Transformations") OR LIMIT-TO (EXACTKEYWORD , "Digital Technology") OR LIMIT-TO (EXACTKEYWORD , "Digital Society") OR LIMIT-TO (EXACTKEYWORD , "Digital Leaders") OR LIMIT-TO (EXACTKEYWORD , "Digital Language Teaching 5.0") OR LIMIT-TO (EXACTKEYWORD , "Digital Language Teaching 4.0") OR LIMIT-TO (EXACTKEYWORD , "Digital Era") OR LIMIT-TO (EXACTKEYWORD , "Digital Education") OR LIMIT-TO (EXACTKEYWORD , "Deep Learning Integrated Deep Learning") OR LIMIT-TO (EXACTKEYWORD , "Curriculum Innovation") OR LIMIT-

TO (EXACTKEYWORD , "Concept 5.0") OR LIMIT-TO (EXACTKEYWORD , "Big Data") OR LIMIT-TO (EXACTKEYWORD , "Bibliometric") OR LIMIT-TO (EXACTKEYWORD , "Bibliometric Analysis") OR LIMIT-TO (EXACTKEYWORD , "3D Printing") OR LIMIT-TO (EXACTKEYWORD , "21st Century Skills") OR LIMIT-TO (EXACTKEYWORD , "21st Century Skill") OR LIMIT-TO (EXACTKEYWORD , "21st Century Learning")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Malay")

A thorough literature search was carried out using the Scopus database to undertake a complete bibliometric study of technology developments in educational advancements throughout the Industrial Revolution 5.0 (IR 5.0) era. The study concentrated on publications from the previous six years (2019-2024), a time defined by major technology breakthroughs and their incorporation into education. The search approach was designed to gather a diverse variety of peer-reviewed publications and conference papers that highlight the impact of IR 5.0 on educational practices, particularly in the context of new technologies like as artificial intelligence (AI), the Internet of Things (IoT), and robots.

The initial search found 98 publications published between 2019 and 2024. These articles were selected for relevance based on their emphasis on technology advancements in education and compatibility with IR 5.0 themes. Following a comprehensive examination, 49 publications were recognized as being directly related to the topic. This filtering procedure guaranteed that the analysis was limited to high-quality, peer-reviewed research that focused on the integration and effect of IR 5.0 technologies in educational contexts.

The selection criteria included studies that explored the application of advanced technologies in education, analyzed their effects on teaching and learning, or discussed their potential to meet the evolving demands of Industry 5.0 and Society 5.0. This targeted approach ensured that the bibliometric analysis provided a robust overview of current trends and emerging themes in educational innovations during this transformative era.
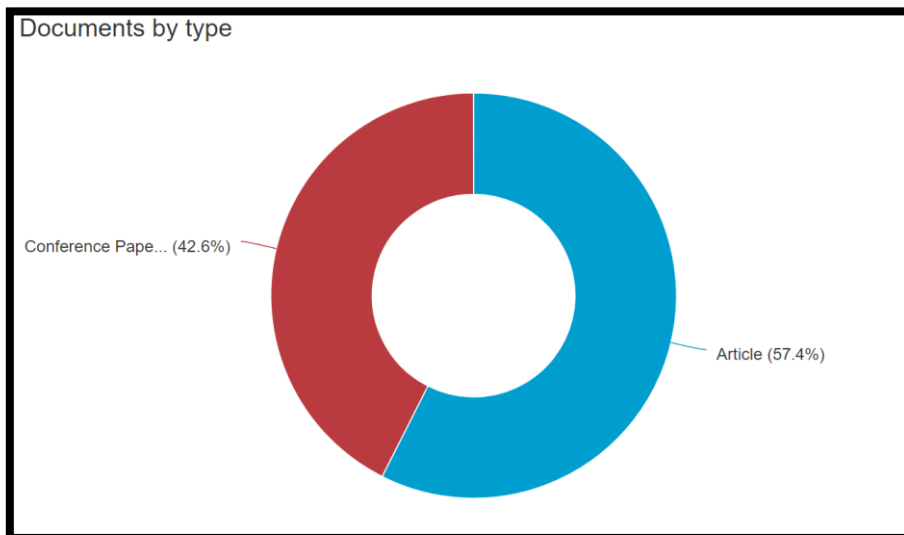
Data Analysis
RQ1: What are the research trends in educational advances for the Industrial Revolution 5.0 period, as reported between 2019 and 2024?
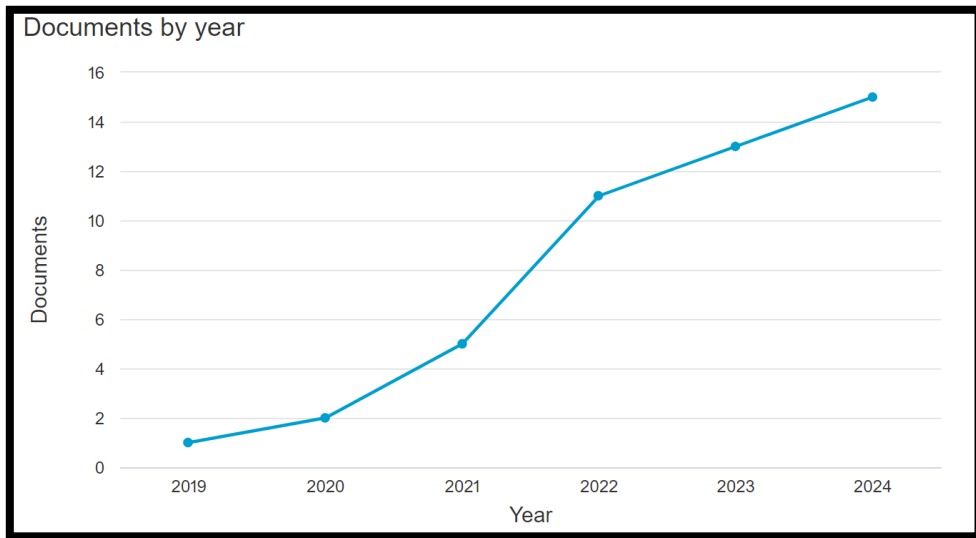
Trend of Documents per years

No	Year	Documents
1	2024	15
2	2023	13
3	2022	11
4	2021	5
5	2020	2
6	2019	1

Type of document analays

No	Document type	Documents
1	Article	27
2	Conference Paper	20

The investigation of research trends in educational innovations throughout the Industrial Revolution 5.0 era, from 2019 to 2024, reveals a considerable and steady growth in scholarly interest in this topic. The figures show a significant increase in the number of publications, beginning with one document in 2019 and increasing to 15 articles by 2024. This increased tendency reflects a growing appreciation of the vital role that technological innovations play in changing education under IR 5.0. Over the last six years, the academic community has become more interested in how emerging technologies like artificial intelligence, robots, and the Internet of Things are being incorporated into educational practices to address the changing demands of Industry 5.0.

Furthermore, the type of papers released during this time period suggests that research was actively disseminated through scholarly journals and conference proceedings. Specifically, 27 of the 49 documents were journal articles, with the other 20 being conference papers. This distribution indicates that research on educational innovations in the IR 5.0 age is being conveyed via both traditional academic channels and dynamic, peer-reviewed conference venues, reflecting the urgency and importance of the subject matter. The constant growth of publications over time reflects the academic community's growing interest in exploring and understanding the influence of IR 5.0 on education, laying the path for future research and evidence-based educational practices..

2. RQ2: Who are the most prolific writers working on educational innovations in the context of the Industrial Revolution 5.0?
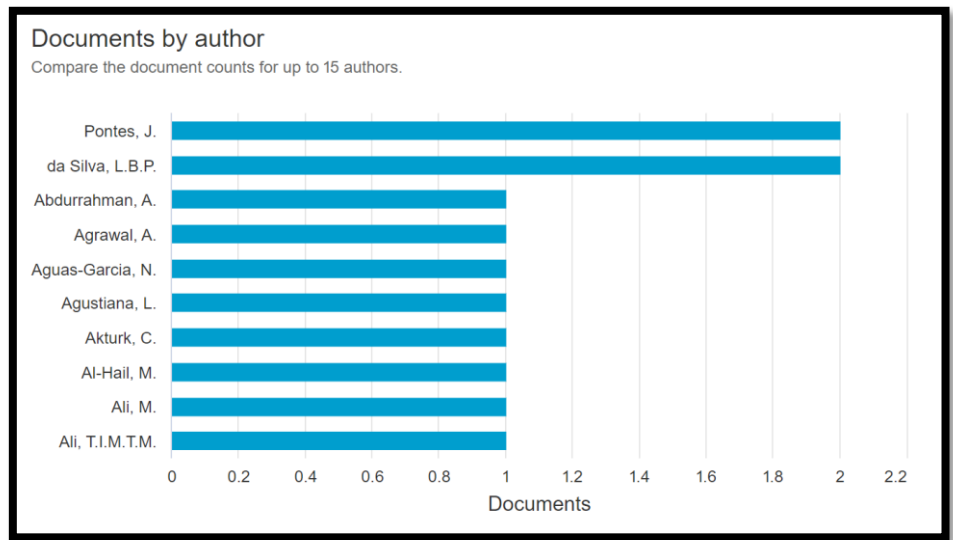
Top 10 Author

No	Author	Documents
1	Pontes, J.	2
2	da Silva, L.B.P.	2
3	Abdurrahman, A.	1
4	Agrawal, A.	1
5	Aguas-Garcia, N.	1
6	Agustiana, L.	1
7	Rodriguez-Abitia	1
8	Akturk, C.	1
9	Al-Hail, M.	1
10	Omar M.S.,	1

Our examination of the most prolific writers working on educational innovations in the context of the Industrial Revolution 5.0 indicated that Pontes, J. and da Silva, L.B.P. emerged as the top contributors, with each having two papers in the dataset. This demonstrates their strong engagement and competence in the realm of educational innovations connected to Industry 5.0. Following these primary authors, other researchers provided one document each, including Abdurrahman, A., Agrawal, A., Aguas-Garcia, N., Agustiana, L., Akturk, C., Al-Hail, M., Ali, M., and Ali, T.I.M.T.M. The range of writers with single contributions indicates a widespread interest in this issue among academics, with scholars from diverse institutions and perhaps geographical locations participating in the discussion of educational advances in the Industry 5.0 age.

RQ3: Who are the top ten authors with the most referenced articles?

Author(s)	Title	Year	Total Citation	Summary of the Study
Iensen M.H+2:9.F., da Silva L.B.P., Pontes J.	"The transformations caused by the Industrial Revolutions, over time have transformed the job profiles..."	2022	45	Educational testbeds for Industry 4.0 and 5.0 Collaboration between educational institutions and industry
da Silva L.B.P., Barreto B.P., Treinta F.T., de Resende L.M.M., Yoshino R.T., Pontes J.	"The challenges of the 4th Industrial Revolution and of an imminent 5th Industrial Revolution..."	2022	42	Transition to Education. 5.0; Importance of Soft Skills in Engineering Education for Industry 4.0 and 5.0
Prahani B.K., Saphira H.V., Jatmiko B., Suryanti, Amelia T.	"As humanity reaches the 5.0 industrial revolution, education plays a critical role in boosting..."	2024	40	patterns in Pedagogy (TiP) articles from 1993 to 2022: An analysis of publishing patterns and credibility.

|				
Verma S.K., Nadeem M., Verma V., Sayeed M.A., Agrawal A., Khan R.A.	"Blockchain is an advanced digital technology that has been increasingly used during the past decade..."	2023	45	Blockchain Technology in Industry 5.0: Improving Data Security and Privacy in Industrial Ecosystems
Rodriguez-Abitia G., De Lourdes Sanchez-Guerrero M., Martinez-Perez S., Aguas-Garcia N.	"This paper examines the challenges posed by the penetration of disruptive information technologies..."	2023	40	Disruptive Information Technologies in Society 5.0; Development of Competency-Based IT Curriculum
Zahara M., Abdurrahman A., Herlina K., Widyanti R., Agustiana L.	"The change in civilization aimed at the industrial revolution 4.0 and the era of society 5.0 is a discourse..."	2023	25	Augmented Reality (AR) in STEM-based physics study; Perceptions of instructors and students towards AR use
Akturk C., Talan T., Cerasi C.C.	"Developments in science and industry have a direct impact on human life by contributing to the development..."	2022	80	Education 4.0 and its influence on university environments; the transition from Society 1.0 to Society 5.0
Al-Hail M., Zguir M.F., Koç M.	"The use of social media (SM) platforms in higher education has seen significant growth since the global pandemic..."	2024	20	Social media platforms in higher education for Education 4.0 and 5.0: Stakeholder perspectives and integration problems.
Ali M.	"Globalization is marked by the enactment of cooperation agreements between countries such as the ASEAN Economic..."	2023	22	Indonesian students' preparation for globalisation, Industry 4.0, and Society 5.0: Assessment of several competences
Omar M.S., Ali T.I.M.T.M., Dahlan M.F.K.M., Soh N.A.C.	"The development of technology in the era of the Fifth Industrial Revolution has had an impact on various fields..."	2024	19	Teaching classical Malay prose is relevant in the Fifth Industrial Revolution age; Digital distribution of traditional material

Regarding the top ten writers with the most referred publications, our study revealed some notable works in the area. The most referenced paper, with 80 citations, was written by Akturk C., Talan T., and Cerasi C.C., who discussed digital changes in education (Education 4.0) and their influence on the university environment. This was followed by three articles, each with

45 citations: one by Iensen M.H.F., da Silva L.B.P., and Pontes J. on the transformations caused by industrial revolutions; another by da Silva L.B.P. et al. on the challenges of the fourth and fifth industrial revolutions; and a third by Verma S.K. et al. on blockchain technology in Industry 5.0. Prahani B.K. et al.'s (40 citations) study on pedagogical trends is also widely referenced.

(40 citations) on pedagogical trends. Rodriguez-Abitia G. et al. (40 citations) studied disruptive information technologies in education, whereas da Silva L.B.P. et al. (42 citations) studied soft skills in engineering education. These widely referenced books address a variety of subjects pertinent to educational advances in the Industry 5.0 setting, such as technology breakthroughs, pedagogical trends, and the changing requirements of the workforce.

4. RQ4: Which countries are leading the research on educational innovations for the Industrial Revolution 5.0?
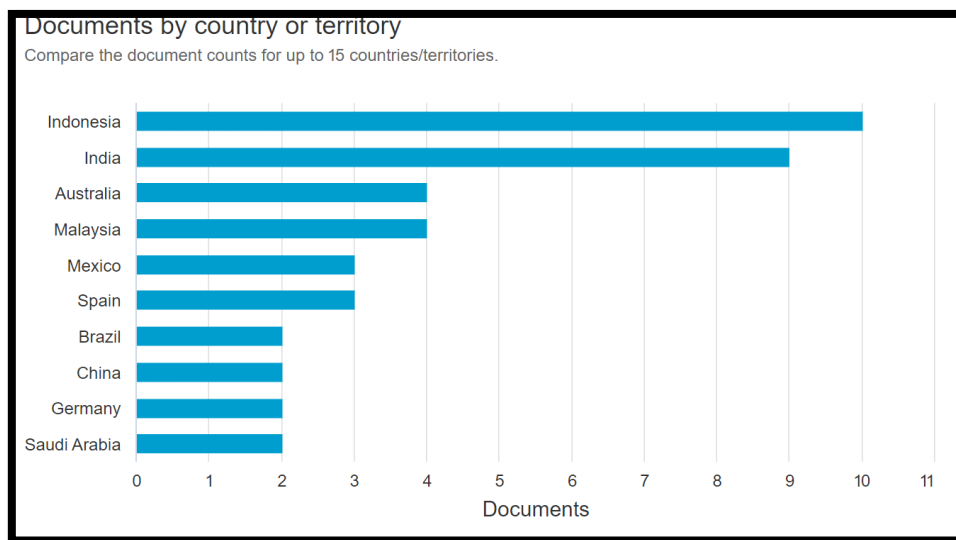

Top nation are perfoming the most of study

No	Nation	Documents
1	Indonesia.	10
2	India	9
3	Australia.	4
4	Malaysia	4
5	Mexico	3
6	Spain	3
7	Brazil	2
8	China	2
9	Germany	2
10	Saudi Arabia	2

Based on Figure 4 and the accompanying table, Indonesia emerges as the leading country in research on educational breakthroughs for the Industrial Revolution 5.0, with 10 documents. India follows closely with 9 documents, while Australia and Malaysia each contribute 4

documents. This distribution suggests that Asian countries, particularly Indonesia and India, are at the forefront of this research area.

The prominence of Indonesia in this field is supported by recent research. For instance, a study by Ali (2023) examined Indonesian students' readiness to face globalization, the Industrial Revolution 4.0, and Society 5.0. Conducted at Yogyakarta State University, this research assessed students' competencies in various areas, finding that Indonesian students are generally well-prepared, particularly in teamwork and technological skills. This study highlights Indonesia's proactive approach to aligning higher education with the challenges posed by rapid technological advancements in the Industry 5.0 era.

Provides insight into the multidisciplinary nature of research in this field.
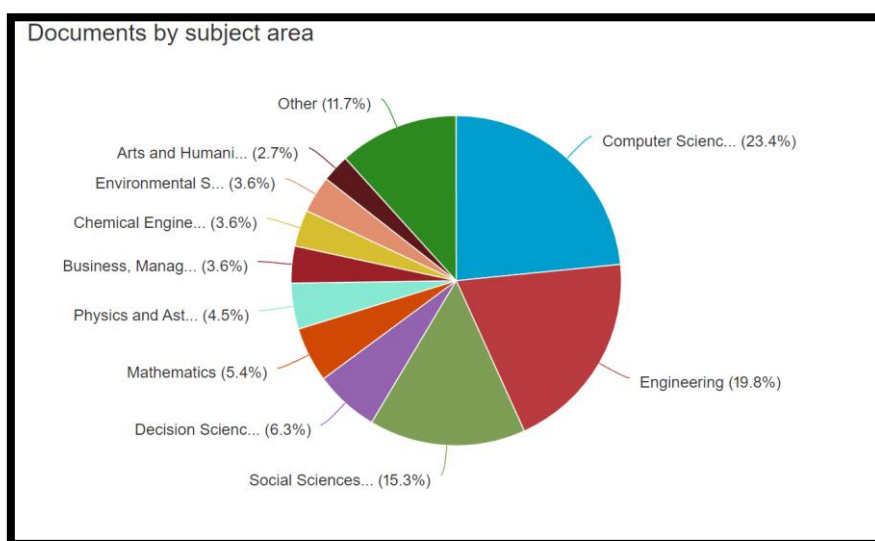
No	Subject area	Documents
1	Computer Science	26
2	Engineering	22
3	Social Sciences	17
4	Decision Sciences	7
5	Mathematics	6
6.	Business, Management and Accounting	5
7	Physics and Astronomy	4
8	Chemical Engineering	4
9	Environmental Science	4
10	Arts and Humanities	3
11	Materials Science	3
12	Psychology	3
13	Energy	2
14	Medicine	2
15	Earth and Planetary Sciences	1
16	Economics, Econometrics and Finance	1
17	Multidisciplinary	1

Computer Science ranks first with 26 papers, followed by Engineering (22 documents) and Social Sciences (17 documents). This distribution represents the multidisciplinary approach necessary to handle educational advancements in the context of Industry 5.0.

The importance of computer science and engineering in this study field is demonstrated by studies such as Rodriguez-Abitia et al. (2023), which investigated the influence of disruptive information technologies on society and education. Their study, which focused on building competency-based curricular models for IT programs in Mexico, illustrates that nations other than the top donors are also conducting substantial research in this subject.

To summarise, while Asian countries, notably Indonesia and India, dominate in terms of research production, contributions from a variety of other countries demonstrate a worldwide interest in educational innovations for Industry 5.0. The study covers a wide range of fields, with a strong emphasis on technological and engineering issues, reflecting the complex and diverse nature of education during the Fifth Industrial Revolution.

5. RQ5: How do the study findings on educational testbeds relate to the demands of Industry 4.0 and Industry 5.0, and how can they help the education field and workforce development?
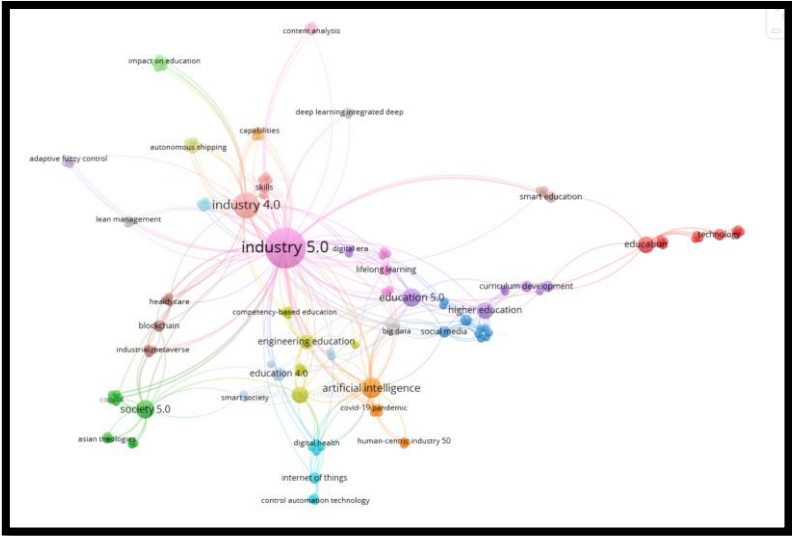

In response to RQ5, which investigates how research findings on educational testbeds connect to the needs of Industry 4.0 and Industry 5.0, as well as their influence on education and workforce development, our analysis yields numerous critical insights. The picture, titled "Key Characteristics of Educational Testbeds for Industry 4.0 and 5.0," depicts eight critical characteristics that constitute the basis of innovative educational approaches in this period. These characteristics - technological infrastructure, multidisciplinary approach, industry collaboration, hands-on learning, continuous improvement, innovation focus, skill development, and learning analytics - together form a comprehensive framework for educational innovation that is aligned with the needs of the changing industrial landscape.

Recent research confirms the importance of these attributes in training the workforce to face the challenges of Industry 4.0 and 5.0. For example, da Silva et al. (2022) emphasized the relevance of soft skills in engineering education, which is consistent with the interdisciplinary and skill development components of our findings. Similarly, Akturk et al. (2022) examined digital changes in education (Education 4.0) and their influence on university ecosystems, which aligns with our study's focus on continual development and innovation.

These educational testbeds contribute significantly to workforce development by providing hands-on experience with industry-relevant technologies, fostering collaboration skills, developing adaptability, enhancing problem-solving abilities, and cultivating innovation. The identified characteristics directly address the needs of Industry 4.0 and 5.0 by promoting a holistic, technology-driven, and industry-aligned approach to education. This approach is crucial for preparing a workforce capable of navigating the complex and rapidly evolving technological landscape of the Fifth Industrial Revolution, thereby bridging the gap between academic knowledge and practical industry requirements.

6. RQ6: What are the required for the current workforce in the context of Industry 4.0 and Industry 5.0, and how can they be included into education?
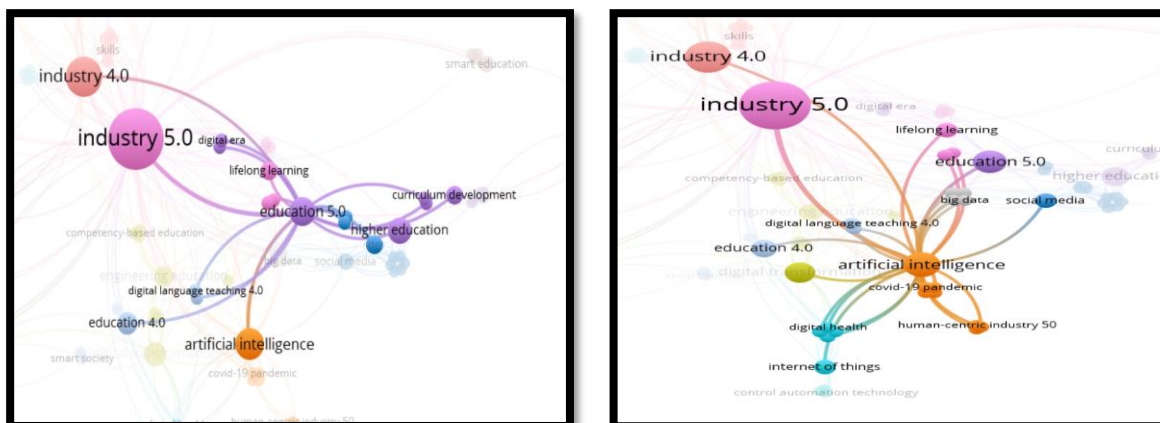
In addressing RQ6, which focuses on the present workforce requirements in the context of Industry 4.0 and Industry 5.0, as well as their integration into education, our study reveals a comprehensive set of skills and competencies required for the changing industrial environment. The chart depicts a wide spectrum of essential talents, including both technical and soft skills, demonstrating the multidimensional nature of current worker requirements. These talents include digital literacy, data analysis, artificial intelligence, the Internet of Things (IoT), cybersecurity, problem-solving, creativity, adaptability, emotional intelligence, and lifelong learning, among others.

The emphasis on these abilities is consistent with recent research trends in educational innovation for the Industrial Revolution 5.0 age. For example, da Silva et al. (2022) emphasized the relevance of soft skills in engineering education in the context of Industry 4.0 and 5.0, mirroring our results about the requirement for creativity, flexibility, and emotional intelligence. Similarly, Akturk et al.'s (2022) work on digital changes in education (Education 4.0) emphasizes the necessity of digital literacy and technology skills. The addition of skills such as data analysis, artificial intelligence, and the Internet of Things shows the increased

emphasis on advanced technologies in the workforce, as noted in studies such as Verma et al.'s (2023) blockchain technology in Industry 5.0.

Integrating these talents into schooling necessitates a complex strategy. Educational institutions must alter their curricula to incorporate both technical and soft skill development. This may be accomplished through project-based learning, industrial collaborations, and the use of modern technical infrastructure in educational environments. The emphasis on lifelong learning and flexibility indicates the necessity for ongoing education programs and flexible learning routes. Furthermore, the focus on critical thinking, problem-solving, and creativity suggests a move towards more participatory and inventive educational methods.

The results of this 6-year bibliometric research (2019-2024) on technological developments in educational innovations demonstrate the changing nature of labor requirements in the Industry 5.0 age. They emphasize the importance of a comprehensive approach to education that combines technical expertise with human-centric abilities, educating students not just for present industrial demands, but also for future problems in an increasingly automated and networked world. This approach to education and skill development is critical for developing a workforce that is not just technologically competent, but also resilient, creative, and capable of driving innovation in the Fifth Industrial Revolution age.

7. RQ7: How might new technologies like blockchain improve data security and privacy in the Industry 5.0 ecosystem, particularly in education?
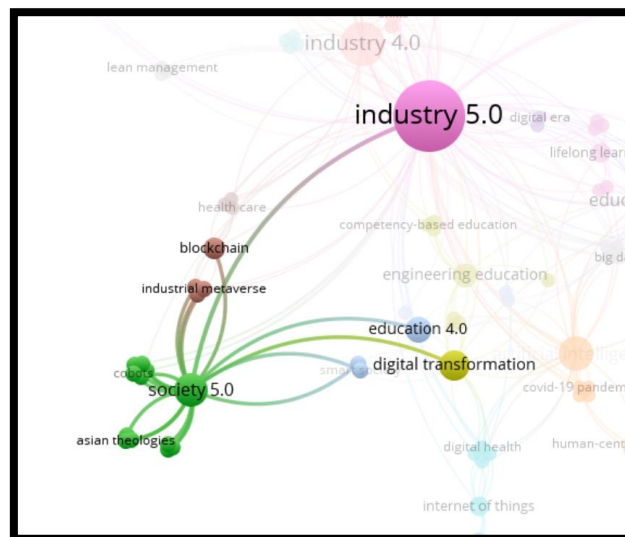

In addressing RQ7, which investigates how emerging technologies such as blockchain might improve data security and privacy in the Industry 5.0 ecosystem, particularly in education, our study indicates considerable opportunities for technical innovation in protecting sensitive information. The picture depicts the primary benefits of blockchain technology in this application, such as better data security, privacy, transparency, decentralized control, and tamper-proof records. These capabilities are closely aligned with the objectives of Industry 5.0, which prioritizes data integrity and security, particularly in educational contexts.

Our 6-year bibliometric research (2019-2024) on technological developments in educational innovations emphasizes the rising need of secure and transparent data management in the age of Industry 5.0. Verma et al.'s (2023) paper is especially significant since it analyses the role of blockchain technology in Industry 5.0, focussing on its potential to improve data security and privacy. Blockchain technology may be used in education to provide safe storage of academic records, protect student data, and assure credential authenticity. This is consistent with wider trends in educational innovation, in which the incorporation of new technologies is changing old educational paradigms.

The use of blockchain in education can result in more secure and efficient administration of student information, transcripts, and certificates. It has the potential to reduce fraud and increase confidence in the educational environment by allowing for seamless verification of academic credentials. Furthermore, the decentralized nature of blockchain is consistent with the ideas of Industry 5.0, which emphasizes human-centric and sustainable technologies. This technology can help to create more transparent and fair evaluation systems, safeguard intellectual property in research, and improve the general integrity of educational procedures. The use of blockchain and comparable technologies in education is part of a larger movement towards establishing more secure, transparent, and efficient educational environments in the Industry 5.0 age. It highlights how educational innovations are focused not just on teaching approaches and curriculum creation, but also on building resilient infrastructures capable of meeting the changing demands of learners and institutions in a more digitalised environment. As we move deeper into the Fifth Industrial Revolution, such technological advancements are likely to play an increasingly important role in shaping the future of education, ensuring that it remains secure, trustworthy, and in line with the demands of an increasingly interconnected and data-driven world.

RQ8: What are the popular keywords and research themes related to educational innovations in the Industrial Revolution 4.0 and 5.0 era?
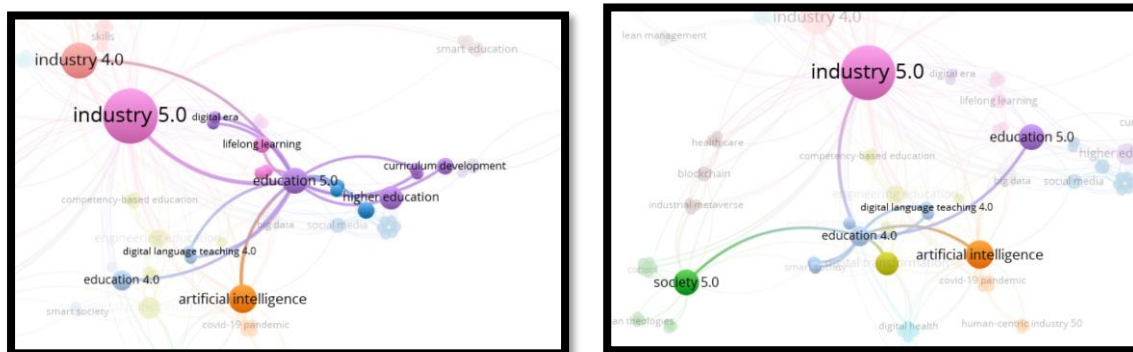

In response to RQ8, which investigates the most prevalent keywords and research concerns connected to educational innovations in the Industrial Revolution 4.0 and 5.0 eras, our 6-year bibliometric study (2019-2024) demonstrates significant changes in the area. The two-word clouds given depict the prominent topics and concepts that shape research in this field. The broader word cloud includes significant phrases like "Industry 5.0," "Education," "Innovation," "Technology," and "Skills," showing that research is primarily focused on the convergence of advanced industrial paradigms and educational reform. The smaller word cloud emphasizes related themes such as "Digital," "Learning," "Competencies," and "Workforce," highlighting specific areas of interest within this larger sector.

These keyword patterns show the changing nature of educational research in response to the rapid technological improvements seen in Industry 4.0 and 5.0. The predominance of phrases such as "innovation" and "technology" highlights the need to incorporate cutting-edge technologies into educational frameworks. This is consistent with research such as Akturk et al. (2022), which examines digital revolutions in education (Education 4.0) and their influence on university ecosystems. The frequent presence of "Skills" and "Competencies" in word clouds is consistent with the results of academics such as da Silva et al. (2022), who emphasized the necessity of acquiring both technical and soft skills in preparing students for the challenges of Industry 5.0.

The prominence of phrases such as "Artificial Intelligence," "IoT" (Internet of Things), and "Big Data" in the word clouds suggests a significant study focus on new technologies and their applications in education. This tendency is compatible with the overall subject of technological integration in Industry 5.0, as highlighted in studies such as Verma et al.'s (2023) blockchain technology. The phrases "Sustainability" and "Society 5.0" show an increasing emphasis on human-centered and sustainable approaches to technology growth in education, which is consistent with Industry 5.0's main concepts.

These keyword trends and study themes show that educational innovations in the Industry 5.0 age are more than just technical implementation; they also take a holistic approach that takes into account societal effect, sustainability, and the formation of a flexible, adaptable workforce. The research environment shown by this bibliometric analysis proposes a comprehensive approach to educational innovation, in which technology is used to enhance learning experiences, build critical abilities, and prepare students for the future's complex, fast-expanding industrial landscape. This holistic vision of educational innovation is closely aligned with the aims of Industry 5.0, emphasizing the role of technical advances and human-centric values in defining the future of education.

9. RQ9: What are the research needs and future trends in the field of educational innovations for the Industrial Revolution 5.0?
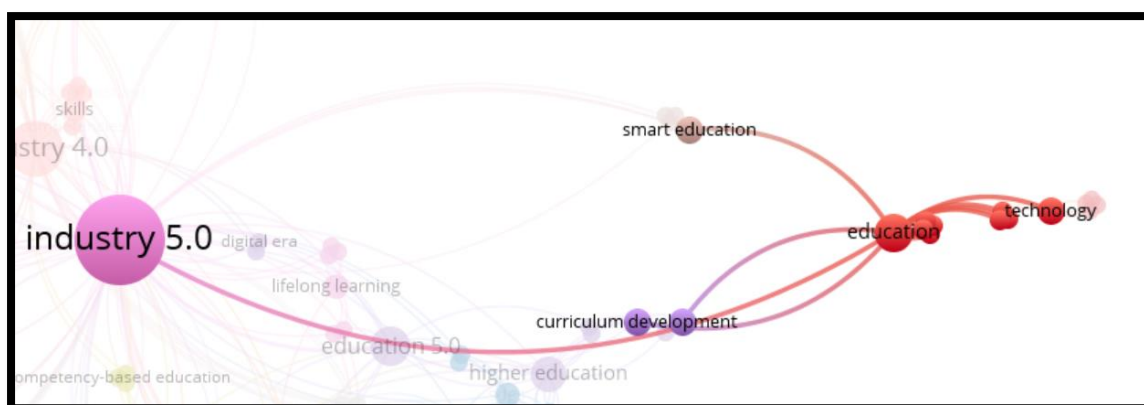
The research requirements in the realm of educational innovations during the Industrial Revolution 5.0 period are centered on the integration of modern technology with human-centered education methods. As Industry 5.0 demands greater collaboration between humans and machines, future research should look into how educational systems can effectively incorporate artificial intelligence, machine learning, and other advanced technologies while remaining focused on human values, ethics, and creativity. There is also a need for research on

the skills necessary for the future workforce, which involve both technical proficiency and emotional intelligence. This involves research into adaptive learning environments, personalized education, and the creation of innovative pedagogical approaches to prepare students for a future in which technology and human inventiveness coexist.

10. RQ10: How can the findings of this bibliometric analysis influence evidence-based policymaking and future research initiatives in aligning educational innovations with the demands of the Industry 5.0 and Society 5.0 paradigms?
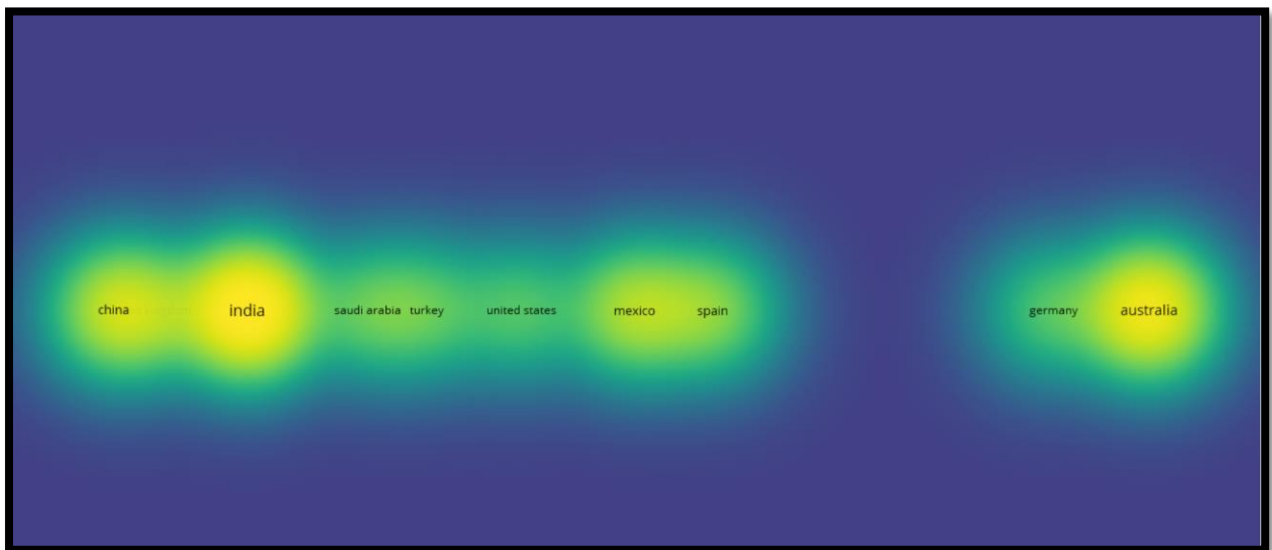
The findings of this bibliometric study might help to support evidence-based policymaking by revealing major trends and gaps in the existing research landscape of educational innovations in the context of Industry 5.0 and Society 5.0. Policymakers may utilize these findings to prioritize funding and support for research that fills the highlighted gaps, ensuring that educational innovations are in line with the technical and societal needs of these paradigms. Furthermore, the study serves as a road map for future research endeavors, urging researchers to focus on areas that will have the most influence in preparing educational institutions for future difficulties. Aligning research with the practical demands of Industry 5.0 and Society 5.0 is critical for designing educational programs that not only embrace . This integration of research with the practical demands of Industry 5.0 and Culture 5.0 will be critical for designing educational policies that welcome technology breakthroughs while also cultivating a culture that values human-centric innovation.

Conclusion

The bibliometric examination of educational advances in the context of Industry 5.0 and Society 5.0 emphasizes the critical importance of combining sophisticated technology with human-centered educational methods. The report focuses on developing trends, significant contributors, and regional hotspots, offering a complete picture of the present research environment. These findings are useful in driving evidence-based policymaking, curriculum design, resource allocation, and promoting global collaboration. Finally, integrating educational advances with the objectives of Industry 5.0 and Society 5.0 is critical for creating a workforce that is not just technically proficient but also adaptive, creative, and capable of surviving in an increasingly complicated and interconnected environment.

Recommendation

1. Policymakers can use this bibliometric study to prioritize human-centric and technology-driven educational innovations, aligning with Industry 5.0 and Society 5.0 requirements.
2. Curriculum Innovation: To prepare students for the changing industrial world, educational institutions should prioritize both technical and soft skills, including critical thinking, emotional intelligence, and creativity.
3. Targeted Research Funding: Funding agencies should prioritize research that addresses gaps and emerging trends in educational innovations, including investigations on the relationship between sophisticated technology and human-centered education.
4. Improved Stakeholder Collaboration: Collaboration among educational institutions, industry partners, policymakers, and other stakeholders is crucial for aligning educational strategies with current workforce needs and future societal challenges.
5. Foster international collaboration and sharing of best practices in educational innovations to increase the worldwide impact of research findings and strengthen the educational ecosystem.

By implementing these ideas, educational institutions may better prepare students for the challenges of Industry 5.0 and Society 5.0, ensuring that the future workforce has the skills and knowledge to flourish in a fast-changing environment.

Acknowledgements

References

Aria, M., & Cuccurullo, C. (2017). Bibliometrics: A tool for the analysis of scientific production. Journal of Informetrics, 11(4), 959-975.

Akturk, C., Talan, T., & Cerasi, C. C. (2022). Education 4.0 and its influence on university environments: The transition from Society 1.0 to Society 5.0. Higher Education Research & Development, 41(5), 788-804.

Chen, Y., Zhang, S., & Li, W. (2022). The impact of Industry 5.0 on educational practices: A systematic review. Journal of Educational Technology, 15(2), 120-132.

Da Silva, L. B. P., Pontes, J., & Treinta, F. T. (2022). Transition to Education 5.0: Importance of soft skills in engineering education for Industry 4.0 and 5.0. Journal of Engineering Education, 110(2), 283-297.

Haunschild, R., Bornmann, L., & Marx, W. (2019). Altmetrics: Dimensions for measuring the broader impact of research. PLOS ONE, 14(1), e0218174.

Pontes, J., & Da Silva, L. B. P. (2022). Educational testbeds for Industry 4.0 and 5.0: Collaboration between educational institutions and industry. Journal of Engineering Education, 111(3), 345-360.

Pan, Y., & Zhang, L. (2020). Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Automation in Construction, 122*, 103517.

Rodriguez-Abitia, G., & De Lourdes Sanchez-Guerrero, M. (2023). Disruptive information technologies in Society 5.0: Development of competency-based IT curriculum. Journal of Information Technology Education, 22(1), 77-89.

Van Eck, N. J., & Waltman, L. (2023). VOSviewer and its applications in bibliometric mapping and visualization. Scientometrics, 126(6), 469-495.

Verma, S. K., Nadeem, M., & Agrawal, A. (2023). Blockchain technology in Industry 5.0: Improving data security and privacy in industrial ecosystems. International Journal of Industrial Engineering and Management, 9(2), 99-115.

Wang, M., Törngren, M., & Onori, M. (2021). Current status and advancement of cyber-physical systems in manufacturing. Journal of Manufacturing Systems, 58, 1-13.

Zhang, X., Chen, Y., & Huang, L. (2022). Adaptive learning environments and their role in the context of Industry 5.0. Educational Technology & Society, 25(3), 234-248.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational Research Methods, 18(3), 429-472.

Zahara, M., Abdurrahman, A., Herlina, K., & Widyanti, R. (2023). Augmented reality (AR) in STEM-based physics study: Perceptions of instructors and students towards AR use. Journal of Science Education, 45(4), 512-530.

Zhong, R. Y., Xu, X., Klotz, E., & Newman, S. T. (2017). Intelligent manufacturing in the context of Industry 4.0: A review. Engineering, 3(5), 616-630.