A Bibliometric Review of the Impact of Technology on Student Learning Facilities: Current Trends and Future Directions

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Abstract. This bibliometric review investigates the impact of technology on student learning facilities, focusing on understanding current trends and identifying potential future directions. The study analyses various scholarly articles, books, and conference papers to provide an overview of the research landscape. With the rapid advancements in information technologies, new learning paradigms like e-learning and mobile learning have emerged, utilising the Internet and multimedia systems to enhance educational quality. These innovative learning approaches aim to increase accessibility to educational resources and training services, thereby improving learning experiences. Notably, visualisation tools in advanced educational curricula have been shown to enhance students' proficiency in mastering technological procedures. This approach aids students in comprehending the industrial processes relevant to their future professional endeavours. The review's findings highlight key themes and methodologies within the existing literature, identifying gaps that offer opportunities for future research. The review emphasises the significant influence of technology integration on the teaching and learning process, marking the shift from traditional book-based methods to the digital era. Despite certain challenges, this transition extends knowledge access through digital devices and enhances the classroom experience. The review concludes by proposing future research paths, emphasising the need to explore integrating artificial intelligence and technology-enhanced learning in student learning facilities. The potential benefits of these technologies present a promising avenue in education.

Keywords: Artificial Intelligence, Technology-enhanced learning, student learning facilities

1 Introduction and Background

In the past few years, notable progress has been made in information technologies, leading to the widespread adoption of modern communication technologies. This has given rise to new terms like e-learning and mobile learning. These various approaches to e-learning leverage information technologies such as the Internet and multimedia systems to enhance the quality of education. Their purpose is to make resources and training services more easily accessible, thereby facilitating improved learning experiences[1]. Visualisation tools in the advanced educational curriculum have been shown to enhance students' proficiency in mastering technological procedures[2]. Engaging in

these activities allows students to understand industrial processes in the fields they will encounter in their future professional endeavours [3].

Technology integration in the teaching and learning process has had a profound influence. With the ubiquitous presence of the Internet, education has transitioned from traditional book-based methods to a digital era, eliminating the reliance on paper. Knowledge is no longer confined and can be expanded using diverse devices, including digital technology. Despite certain challenges, technology has proven effective in enhancing the classroom experience[4].

Technology has transformed classrooms into interactive and collaborative spaces. With the availability of digital tools, such as interactive whiteboards, educational apps, and virtual reality simulations, teachers can create engaging and immersive learning experiences[5]. Interactive multimedia content, including videos, animations, and simulations, enables students to visualise complex concepts and actively engage with the subject. Moreover, technology facilitates collaborative learning by enabling students to collaborate on projects, share ideas, and engage in online discussions. These collaborative activities foster critical thinking, problem-solving, and communication skills, which are essential for success in the digital age[6]. However, issues such as the digital divide, privacy and security concerns, information overload, and the need for digital literacy skills have arisen. This makes educators, policymakers, and stakeholders collaborate in implementing equitable and sustainable technology integration strategies, ensuring that all students have access to the necessary resources and support[7], [8].

Previous studies have looked at various aspects of the impact of technology on student learning facilities. These studies have explored the effects of technology integration on student engagement, academic performance, and learning outcomes[9]–[11]. They have investigated the effectiveness of specific technologies, such as interactive whiteboards, educational software, and online learning platforms(Dhillon and Murray, 2021; Jin & Bridges, 2014; Mohamed Al-Faki & Hassan Adam Khamis, 2014). Furthermore, research has examined the role of technology in promoting collaborative learning, personalised instruction, and student-centred approaches[15]–[17]. Additionally, some studies have examined the challenges and barriers associated with implementing technology in learning facilities, including access, infrastructure, and teacher training[18]–[20]. Overall, these studies have provided valuable insights into the effects of technology on student learning experiences.

While previous studies have provided valuable insights, several gaps in the existing research are apparent. There is a need for long-term studies to examine the lasting effects of technology integration on student learning outcomes. Research should address equity and accessibility issues, exploring how technology access and digital literacy impact students from diverse backgrounds. Further investigation is required to understand the most effective pedagogical approaches that leverage technology in learning environments. The impact of technology-related professional development for teachers also warrants more attention. Moreover, studies should employ multidimensional assessment methods to understand technology's impact on student learning comprehensively. Lastly, research on emerging technologies like AI, VR, AR, and blockchain can shed light on their potential benefits and challenges in educational settings. Addressing

these gaps will enhance our understanding of technology's influence on student learning facilities, guiding stakeholders in making informed decisions.

This study aims to conduct a bibliometric review of the existing literature on the impact of technology on student learning facilities. By analysing and synthesising the findings of previous studies, the study aims to identify current trends in research related to technology's influence on student learning. Additionally, it seeks to identify the gaps and limitations in the existing literature, thereby providing insights into the future directions for research in this field. Through this bibliometric review, the study aims to contribute to understanding the overall impact of technology on student learning facilities and guide future research endeavours. The bibliometric review will be conducted systematically, including literature search, study selection, data extraction, and analysis. The review aims to identify current trends in research on the impact of technology on student learning facilities and highlight gaps in the existing literature. By employing this rigorous methodology, the review will provide valuable insights for future research in this field.

2   Methodology

This study employed a bibliometric technique as a research method. This entails gathering publication data that has been published. According to Oladinrin et al. [21], the bibliometric method is useful since it enables one to extract the core of a study area from a massive body of data. It makes it possible to investigate information structure, generate new study subjects, and record the interdisciplinarity of research topics.

Bibliometric analysis can support researchers in examining the content and citations of scholarly works, such as articles published in journals and other scientific writings. Bibliographic data used in bibliometric analysis includes elements such as publication type, research topic area, researcher's country of origin, journal of publication, and language used in the article. Bibliometric analysis can be considered a quantitative approach to analysing the bibliographic information presented in the articles. This method utilises statistical techniques to measure scholarly literature. The effectiveness of bibliometric analysis lies in its ability to provide datasets that can be utilised to enhance research quality[22]. The figure below shows the systematic approach to selecting publications from [23].
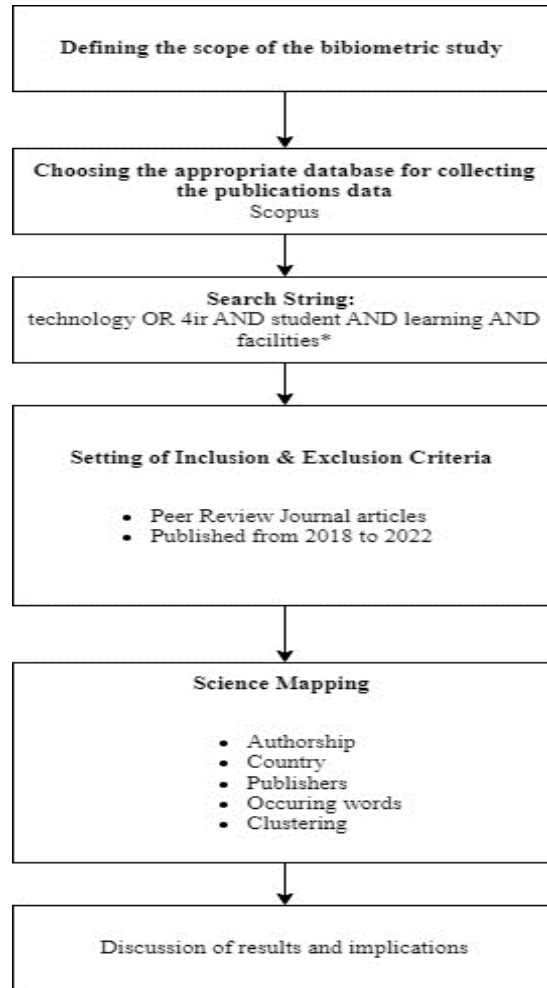
Fig. 1. Research Method

The publication data was sourced from the Scopus index. This is mainly because research articles have indicated that the Scopus database is well-suited for bibliometric analysis. Scopus offers greater convenience when exporting data than the Web of Science (WOS) database [24]. Exporting more than 500 papers from WOS often requires manual operations, whereas Scopus provides a smoother process. Additionally, the Scopus database encompasses a broader range of papers in business and management, further enhancing its suitability for bibliometric analysis [25].

The data from Scopus was then carried out through a search string of linking words that address the impact of students in learning facilities. This was to find suitable publications based on their titles, abstracts, and keywords. The Boolean operator AND

ensured that every publication containing the keywords was extracted from Scopus. While the Boolean operator OR avoid overlaps and asterisks is used as a wildcard character to represent variations of a word or to truncate a word stem[26].

Inclusion and exclusion criteria were set for the study. According to [27], developing inclusion and exclusion criteria is essential in designing rigorous research protocols. These criteria serve as guidelines to determine which participants or studies will be included or excluded from the research. By establishing clear and specific criteria, researchers can ensure that the study population or relevant literature aligns with the research objectives, thereby enhancing the quality and validity of the findings. Inclusion and exclusion criteria help researchers create a focused and well-defined study population, leading to more reliable and meaningful results. For this, the inclusion and exclusion criteria for this study were set as follows:

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Published between 2018 and 2022	Excludes year < 2018, year > 2022
Should be journal articles	Excluded if its conference proceedings, book series
Must be written in English	Excluded in not written in any other language other than English

From the initial search, 1459 documents were found; however, 276 publications were retrieved after addressing the criteria. The resultant data was then subjected to analysis on VOSviewer. VOSviewer is a free software designed to facilitate the creation and visualisation of bibliometric maps in a user-friendly manner. Its primary goal is to assist researchers in generating easily interpretable maps based on bibliographic data. The software efficiently collects relevant literature and identifies similarities among selected publications based on specified parameters. It also helps identify significant themes or patterns within the publications, allowing researchers to gain valuable insights from the bibliometric analysis[28]. With the aid of VOSviewer, researchers may examine a variety of bibliometric networks made up of publications, journals, authors, organisations, or countries[29].
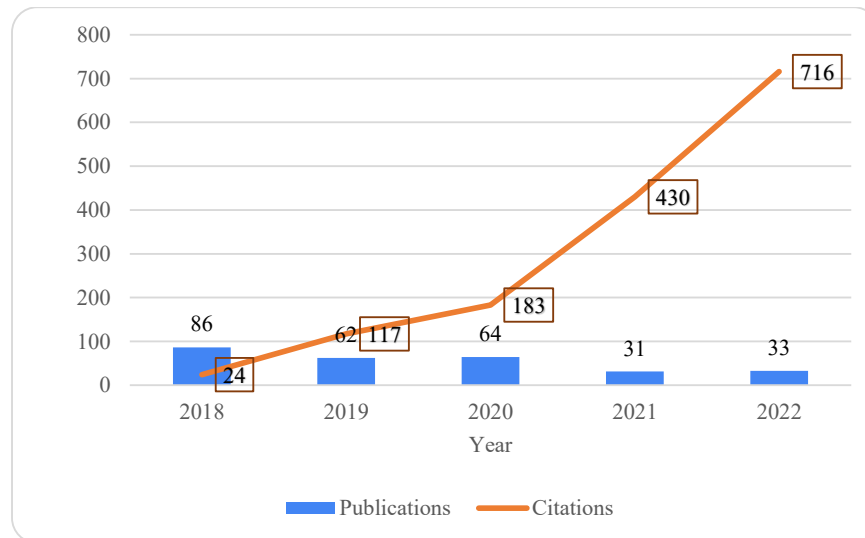
3   Results
3.1   Research Output

Fig. 2. Publication and Citations vs. Time

The bibliometric review of the impact of technology on student learning facilities reveals intriguing trends in terms of publications and citations. The analysis of publications over the years demonstrates some fluctuations. In 2018, 86 publications indicated a significant interest in the topic. However, this number experienced a slight decline to 62 publications in 2019, suggesting a potential shift in research focus or a temporary dip in interest. The subsequent year, 2020, witnessed a modest increase to 64 publications, indicating a renewed interest in exploring the influence of technology on student learning facilities. However, a noteworthy drop occurred in 2021, with only 31 publications, which may reflect various factors such as emerging research areas or changes in research priorities.

On the other hand, the cumulative analysis of citations provides valuable insights into the impact and visibility of the research in this field. While the number of publications fluctuated, the number of citations consistently increased, underscoring the significance of the research conducted. In 2018, the publications received 24 citations, which more than quadrupled to 117 citations in 2019. This upward trend continued in 2020, with citations rising to 183. The most remarkable development was observed in 2021, when citations skyrocketed to 430, signifying a growing recognition and influence of the research on the impact of technology on student learning facilities. This trend persisted in 2022, with citations reaching an impressive 716, further affirming the substantial impact of the research in this domain. The consistent increase in citations indicates the influence of this research on the scholarly community and the potential implications for educational practices. It suggests that the studies have been impactful

and contributed significantly to understanding how technology can enhance student learning facilities.

3.2   Countries

The top contributing countries in terms of research on the impact of technology on student learning facilities are the United States, Indonesia, Malaysia, India, and Iran. The United States has 31 publications and 200 citations, indicating a strong research output and impact. Indonesia follows closely with 51 publications and 186 citations, demonstrating a significant interest in this area. Malaysia, India, and Iran also show active research efforts with varying numbers of publications and citations.

On the other hand, Finland, Israel, Sweden, Tanzania, and Zambia are the least contributing countries, each having only 1 or 2 publications and no recorded citations. These countries may have relatively lower research output or visibility in this field. Countries' research contributions vary based on expertise, research focus, funding, collaboration networks, and infrastructure. The data suggests countries like Iran and the US have higher research outputs in a particular topic, while countries like Finland and Israel have fewer. However, lower output doesn't indicate lesser importance or quality, as many factors influence these numbers. These factors include collaboration efforts, the research community's size and priorities.

Table 2. Contributing Countries

Top Contributing Countries			Least contributing Countries		
Country	Doc	Citations	Country	Doc	Citations
Iran	11	244	Finland	1	0
United States	31	200	Israel	1	0
Indonesia	51	186	Sweden	1	0
India	19	164	Tanzania	2	0
Malaysia	27	144	Zambia	1	0

3.3   Authorship

Among the top-cited studies, Hamidi and Chavoshi's [1] 2018 research stands out for analysing essential factors for adopting mobile learning in higher education. Focusing on students at the University of Technology, their study gained significant attention, accumulating 208 citations. Another notable study by Joshi, Vinay, and Bhaskar in 2020 explored the impact of the coronavirus pandemic on the Indian education sector, specifically investigating teachers' perspectives on online teaching and assessments. This timely research garnered 118 citations, reflecting its relevance during a critical time. Additionally, Mian's [30] study investigated adapting universities for sustainability education in the context of Industry 4.0, highlighting challenges and opportunities. With fifty-six citations, their research contributes to understanding how higher education institutions can align with sustainable practices in the evolving technological landscape.

Table 3. Key contributing authors

Rank	Author	Title	Year	Citations
1	Hamidi H., Chavoshi A.	Analysis of the essential factors for the adoption of mobile learning in higher education: A case study of students of the University of Technology	2018	208
2	Joshi A., Vinay M., Bhaskar P.	Impact of coronavirus pandemic on the Indian education sector: perspectives of teachers on online teaching and assessments	2020	118
3	Mian S.H., Salah B., Ameen W., Moiduddin K., Alkhalefah H.	Adapting Universities for sustainability education in Industry 4.0: Channel of Challenges and Opportunities	2020	56
4	Yang A.-M., Li S.-S., Ren C.H., Liu H.-X., Han Y., Liu L.	Situational Awareness System in the Smart Campus	2018	51
5	Husnaini S.J., Chen S.	Effects of guided inquiry virtual and physical laboratories on conceptual understanding, inquiry performance, scientific inquiry self-efficacy, and enjoyment	2019	49
6	Petrov P.D., Atanasova T.V.	The Effect of augmented reality on Students' learning performance in stem education	2020	36
7	Zhu B., Feng M., Lowe H., Kesselman J., Harrison L., Dempski R.E.	Increasing Enthusiasm and Enhancing Learning for Biochemistry-Laboratory Safety with an Augmented-Reality Program	2018	36
8	Bucea-Manea-Tonis R., Simion V.E., Ilic D., Braicu C., Manea N.	Sustainability in higher education: The relationship between work-life balance and XR e-learning facilities	2020	35
9	Leontyeva I.A.	Modern distance learning technologies in higher education: Introduction problems	2018	35
10	Pramana E.	Determinants of the Adoption of mobile learning systems among university students in Indonesia	2018	35

3.4   Occurring Keywords and Clustering

In the research on the impact of technology on student learning facilities, the most frequently occurring keywords provide insights into the primary areas of focus. With the minimum occurrence of words set at seven (7), "E-learning" and "students" appear 48 times each, highlighting the significance placed on electronic learning methods and understanding the impact of technology on student experiences. The term "teaching" appears twenty-eight times, indicating a strong interest in investigating instructional practices and pedagogy in the context of technology integration. Additionally, "engineering education" and "higher education" 24 times each underscores the specific attention given to these domains. The recurring keyword "human" with 28 occurrences suggests a focus on understanding human perceptions and behaviours about technology and learning. These keywords collectively represent the core themes in the research,

emphasising the importance of technology in enhancing student learning experiences and informing educational practices.

Table 4. Keyword analysis

Cluster	Keyword	Occurrences	Total Link Strength
1	Artificial intelligence	7	15
	Curricula	13	42
	e-learning	48	140
	Educational computing	11	55
	Educational technology	10	31
	Engineering education	24	95
	Information and communication	7	39
	Learning systems	12	47
	students	48	181
	surveys	7	44
	sustainability	7	23
	Teaching	28	114
	Teaching and learning	12	33
2	adult	7	64
	Article	22	132
	Controlled study	7	50
	curriculum	9	36
	female	7	68
	Human	28	162
	Human experiment	12	88
	Humans	17	117
	Learning	24	99
	Male	7	68
	perception	7	50
	student	14	85
3	Blended learning	8	7
	Distance education	7	28
	Distance learning	9	21
	Higher education	24	72
	ICT	8	25
	Mobile learning	11	19
	Online learning	19	58
4	Covid-19	25	67
	Education	21	101
	Pandemic	7	32
	Technology	8	6

4   Cluster Analysis and Critical Review

The analysis of keyword clusters provides insights into the main themes and topics within the research on the impact of technology on student learning facilities. These clusters highlight the recurring concepts and areas of focus in the field.
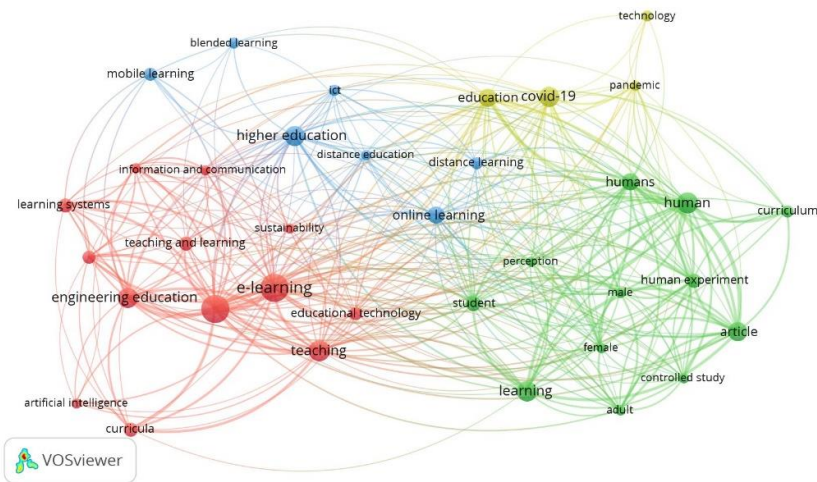

Fig 3. Cluster Analysis

4.1   Cluster one

This includes keywords related to educational technology, such as e-learning, curricula, educational computing, and learning systems. This cluster underscores the significance of technology integration in education, with a particular emphasis on designing curricula and implementing effective learning systems.

The prominence of the keyword "e-learning" suggests a shift towards digital and remote learning methods. With the advent of technology, educators are increasingly exploring the potential of e-learning to provide flexible, personalised, and accessible education to students. Researchers within this cluster are likely investigating the effectiveness of e-learning approaches, the development of online courses, and the impact of virtual classrooms on student engagement and academic outcomes.

Curricula focus on aligning technology integration with educational objectives and curriculum design. Researchers recognise the need to adapt curricula to incorporate technology effectively and enhance learning experiences. This involves developing strategies to integrate digital tools, interactive content, and online resources into the curriculum, ensuring they complement the overall educational goals and cater to the diverse needs of students.

The keyword "educational computing" highlights the role of technology in supporting teaching and learning processes. Researchers will likely explore using educational software, simulations, and data analysis tools to facilitate interactive and engaging learning experiences. This cluster suggests a growing interest in investigating how educational computing can enhance instructional methods, promote active learning, and improve student outcomes.

Furthermore, including "learning systems" in this cluster indicates a focus on designing and implementing technology-based platforms and systems that support student learning. Researchers are likely exploring adaptive learning systems, intelligent tutoring systems, and other innovative approaches to tailor instruction and provide personalised learning experiences. This area of research aims to leverage technology to create dynamic and responsive learning environments that cater to individual student needs and preferences.

4.2 Cluster two

The cluster revolves around human-related aspects of education, featuring keywords such as perception, gender, human experiment, and humans. This cluster suggests a focus on understanding human experiences, behaviours, and perspectives about technology and learning. It also includes keywords associated with research methodologies, such as articles and controlled studies, indicating the importance of rigorous investigation.

The presence of "perception" suggests a research interest in investigating how individuals perceive and interpret technology in educational settings. Researchers within this cluster may be exploring factors that influence perceptions of technology, such as usability, accessibility, and user experience. Understanding these perceptions can inform the design and implementation of technology-enhanced learning environments to ensure they align with learners' expectations and preferences.

The keyword "gender" indicates a specific focus on exploring gender-related issues in the context of technology and education. Researchers may investigate gender differences in technology adoption, participation, and outcomes. This could include examining gender disparities in access to technology, gender stereotypes in technology-related fields, and strategies to promote gender equity in educational technology.

The presence of "human experiment" suggests a focus on empirical studies that involve human participants. Researchers within this cluster may be conducting experiments to assess the impact of specific technological interventions on learning outcomes, engagement, or other relevant factors. These experiments can provide valuable insights into the effectiveness of educational technology and guide evidence-based practices.

The keyword "humans" reflects a broad focus on human-centred research within the context of technology and education. This cluster may encompass studies that explore various aspects of the human experience, such as motivation, cognition, emotions, and social interactions, concerning the use of technology in educational settings. Understanding the human dimension is essential for designing technology-enhanced learning environments that effectively meet the needs and preferences of learners.

4.3   Cluster three

This cluster encompasses keywords associated with different learning modes, such as blended learning, distance education, and online learning. This cluster highlights exploring various learning environments and technology integration to facilitate learning experiences. Additionally, it includes keywords related to higher education and information and communication technology (ICT), emphasising the role of technology in higher education settings. The keyword "blended learning" suggests focusing on instructional approaches that combine online and traditional face-to-face learning methods. Researchers within this cluster may explore the benefits, challenges, and effectiveness of blending online and in-person instruction to create a more flexible and engaging learning environment. This could involve investigating different models of blended learning, strategies for integrating technology into classroom settings and evaluating the impact on student learning outcomes.

The keywords "distance education" and "distance learning" emphasise education research delivered remotely, often through online platforms. Researchers within this cluster may explore distance education programs' design, delivery, and effectiveness. This could include investigating online course design, student engagement and interaction in virtual classrooms, and distance learning challenges and opportunities.

Including "higher education" suggests a focus on exploring online and distance learning within the context of higher educational institutions. Researchers may be investigating the adoption of online learning in universities, the impact on teaching and learning practices, and the implications for student success and retention in higher education settings.

The keyword "ICT" highlights the role of information and communication technology in supporting online and distance learning. Researchers within this cluster may be examining the use of digital tools, software applications, and communication platforms to facilitate online learning experiences. This could involve exploring the effectiveness of ICT in enhancing student engagement, collaboration, and access to educational resources.

The keywords "mobile learning" and "online learning" focus on using mobile devices and online platforms for educational purposes. Researchers within this cluster may investigate the potential of mobile learning applications, online course platforms, and virtual learning environments to support learning anytime, anywhere. This research may involve evaluating the impact of mobile and online learning on student engagement, learning outcomes, and accessibility.

4.4   Cluster four

This cluster focuses on the impact of the COVID-19 pandemic on education. Keywords such as COVID-19, pandemic, and education reflect the urgent need to adapt and innovate in response to the challenges posed by the pandemic. This cluster underscores the exploration of technology as a solution to mitigate the effects of the pandemic on student learning.

The keyword "Covid-19" reflects the central focus of this cluster, highlighting the specific context of the ongoing pandemic. Researchers within this cluster are likely

investigating the implications of the pandemic on various aspects of education, including teaching and learning practices, educational policies, and student experiences. This could involve studying the sudden shift to remote or online learning, the challenges educators and students face during this transition, and the effectiveness of different instructional approaches in the pandemic.

The keyword "Education" suggests a broad exploration of educational practices, policies, and systems affected by the pandemic. Researchers within this cluster may examine the disruptions caused by the pandemic and seek to understand the short-term and long-term consequences for education at different levels, from primary to higher education. This could involve investigating issues such as learning loss, inequities in access to education, digital divide challenges, and the role of technology in supporting remote learning.

The inclusion of "Pandemic" emphasises the broader context of the global health crisis and its impact on education. Researchers within this cluster may be exploring the interplay between public health considerations and educational practices, examining the strategies employed by educational institutions to ensure the safety and well-being of students and staff, and analysing the effects of prolonged disruptions to traditional educational settings.

5 Conclusion

The bibliometric review conducted in this study provides valuable insights into the impact of technology on student learning facilities. By analysing and synthesising the findings of previous studies, the review identifies current trends in research and highlights gaps and limitations in the existing literature. The analysis of publications and citations over the years indicates a growing interest in exploring the influence of technology on student learning facilities. While there were some fluctuations in the number of publications, the consistent increase in citations reflects the impact and visibility of the research conducted in this field. The studies have contributed significantly to understanding how technology can enhance student learning experiences.

The distribution of publications across research disciplines reveals the multidisciplinary nature of this field. The prominent disciplines include Social Sciences, Computer Science, and Engineering, emphasising the social, technical, and engineering aspects of technology's impact on student learning. Other disciplines, such as Medicine, Arts and Humanities, and Psychology, explore specific intersections between technology and student learning.

The analysis of the top contributing countries highlights the research efforts of the United States, Indonesia, Malaysia, India, and Iran. These countries have shown active engagement in studying the impact of technology on student learning facilities. However, there is still a need for more research representation from countries such as Finland, Israel, Sweden, Tanzania, and Zambia. The review also identifies notable studies based on their citation counts. These studies have addressed various aspects of technology integration in student learning facilities, including mobile learning adoption, the impact of the pandemic on online teaching, sustainability education in Industry 4.0, and the use of augmented reality in STEM education. These studies have contributed

significantly to the existing knowledge body and gained recognition within the scholarly community.

In conclusion, while progress has been made in understanding the impact of technology on student learning facilities, there are still gaps and limitations in the existing literature. Future research should focus on long-term studies to examine the lasting effects of technology integration, address equity and accessibility issues, explore effective pedagogical approaches, provide technology-related professional development for teachers, employ multi-dimensional assessment methods, and investigate emerging technologies' potential benefits and challenges. Researchers, educators, policymakers, and stakeholders can make informed decisions and enhance student learning experiences in the digital age by addressing these gaps.

Future studies should examine the long-term effects of technology integration in student learning facilities. This will help understand the sustained impact on student outcomes, academic performance, and skill development over an extended period. By addressing these future research areas, researchers can advance the understanding of technology's impact on student learning facilities and contribute to evidence-based practices that optimise student learning experiences in the digital age.

References

[1]   H. Hamidi and A. Chavoshi, 'Analysis of the essential factors for the adoption of mobile learning in higher education: A case study of students of the University of Technology', *Telematics and Informatics*, vol. 35, no. 4, pp. 1053–1070, Jul. 2018, doi: 10.1016/j.tele.2017.09.016.

[2]   D. Russell, Y. K. Cho, and E. Cylwik, 'Learning Opportunities and Career Implications of Experience with BIM/VDC', *Practice Periodical on Structural Design and Construction*, vol. 19, no. 1, pp. 111–121, Feb. 2014, doi: 10.1061/(asce)sc.1943-5576.0000191.

[3]   M. Torres-Ramírez, B. García-Domingo, J. Aguilera, and J. De La Casa, 'Video-sharing educational tool applied to the teaching in renewable energy subjects', *Comput Educ*, vol. 73, pp. 160–177, Apr. 2014, doi: 10.1016/j.compedu.2013.12.014.

[4]   B. Waluyo, U. Negeri, S. Pratiwi, R. Universitas, N. Surabaya, and A. Mustofa, 'EFL Teaching Experience With Technology: Portraying Higher Education Institutions in Suburban During the Post-Pandemic'.

[5]   X. Shu and X. Gu, 'An Empirical Study of A Smart Education Model Enabled by the Edu-Metaverse to Enhance Better Learning Outcomes for Students', *Systems*, vol. 11, no. 2, Feb. 2023, doi: 10.3390/systems11020075.

[6]   P. Häkkinen, S. Järvelä, K. Mäkitalo-Siegl, A. Ahonen, P. Näykki, and T. Valtonen, 'Preparing teacher-students for twenty-first-century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills', *Teachers and Teaching: Theory and Practice*, vol. 23, no. 1, pp. 25–41, Jan. 2017, doi: 10.1080/13540602.2016.1203772.

[7]   A. Imran, 'Why addressing digital inequality should be a priority', *Electronic Journal of Information Systems in Developing Countries*, May 2022, doi: 10.1002/isd2.12255.

[8]   R. Marcella and G. Chowdhury, 'Eradicating information poverty: an agenda for research', *Journal of librarianship and information science*, vol. 52, no. 2, pp. 366–381, 2020, doi: https://doi.org/10.1177/0961000618804589.

[9]   P. Argyriou, K. Benamar, and M. Nikolajeva, 'What to Blend? Exploring the Relationship Between Student Engagement and Academic Achievement via a Blended Learning Approach', *Psychology Learning and Teaching*, vol. 21, no. 2, pp. 126–137, Jul. 2022, doi: 10.1177/14757257221091512.

[10]   Z. Yu, M. Gao, and L. Wang, 'The Effect of Educational Games on Learning Outcomes, Student Motivation, Engagement and Satisfaction', *Journal of Educational Computing Research*, vol. 59, no. 3, pp. 522–546, Jun. 2021, doi: 10.1177/0735633120969214.

[11]   M. Sher, B. Ali, and R. Yasmeen, 'The Impact of Technology Integration on Student Engagement and Achievement in Mathematics Education: A Systematic Review https://journals.researchparks.org/index.php/IJIE', 2023. [Online]. Available: https://www.researchgate.net/publication/370446167

[12]   I. Mohamed Al-Faki and A. Hassan Adam Khamis, 'Difficulties Facing Teachers in Using Interactive Whiteboards in Their Classes', 2014. [Online]. Available: www.aijssnet.com

[13]   J. Jin and S. M. Bridges, 'Educational technologies in problem-based learning in health sciences education: A systematic review', *Journal of Medical Internet Research*, vol. 16, no. 12. JMIR Publications Inc., Dec. 01, 2014. doi: 10.2196/jmir.3240.

[14]   S. Dhillon and N. Murray, 'An investigation of EAP teachers' views and experiences of E-learning technology', *Educ Sci (Basel)*, vol. 11, no. 2, pp. 1–16, Feb. 2021, doi: 10.3390/educsci11020054.

[15]   E. Lee and M. J. Hannafin, 'A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it', *Educational Technology Research and Development*, vol. 64, no. 4, pp. 707–734, Aug. 2016, doi: 10.1007/s11423-015-9422-5.

[16]   T. J. Lund and M. Stains, 'The importance of context: an exploration of factors influencing the adoption of student-centered teaching among chemistry, biology, and physics faculty', *Int J STEM Educ*, vol. 2, no. 1, Dec. 2015, doi: 10.1186/s40594-015-0026-8.

[17]   C. H. Chen and C. C. Tsai, 'In-service teachers' conceptions of mobile technology-integrated instruction: Tendency towards student-centered learning', *Comput Educ*, vol. 170, Sep. 2021, doi: 10.1016/j.compedu.2021.104224.

[18]   A. A. Barakabitze *et al.*, 'Transforming African Education Systems in Science, Technology, Engineering, and Mathematics (STEM) Using ICTs: Challenges and Opportunities', *Education Research International*, vol. 2019. Hindawi Limited, 2019. doi: 10.1155/2019/6946809.

[19]   A. Alenezi, 'Barriers to Participation in Learning Management Systems in Saudi Arabian Universities', *Educ Res Int*, vol. 2018, 2018, doi: 10.1155/2018/9085914.

[20]   A. Al Natsheh, S. A. Gbadegeshin, A. Rimpiläinen, I. Imamovic-Tokalic, and A. Zambrano, 'Technology Innovation Management Review Identifying the Challenges in Commercializing High Technology: A Case Study of Quantum Key Distribution Technology', 2015. [Online]. Available: www.timreview.ca

[21]   O. T. Oladinrin, M. Arif, M. Q. Rana, and L. Gyoh, 'Interrelations between construction ethics and innovation: a bibliometric analysis using VOSviewer', *Construction Innovation*. Emerald Group Holdings Ltd., Apr. 14, 2022. doi: 10.1108/CI-07-2021-0130.

[22]   A. Bayu, D. Nandiyanto, D. Fitria, A. L. Husaeni, A. B. D. Nandiyanto, and D. F. A. Husaeni, 'BIBLIOMETRIC ANALYSIS OF ENGINEERING RESEARCH USING VOSVIEWER INDEXED BY GOOGLE SCHOLAR', 2022.

[23]   N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, 'How to conduct a bibliometric analysis: An overview and guidelines', *J Bus Res*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/J.JBUSRES.2021.04.070.

[24]   W. Chansanam and C. Li, 'Scientometrics of Poverty Research for Sustainability Development: Trend Analysis of the 1964–2022 Data through Scopus', *Sustainability (Switzerland)*, vol. 14, no. 9, May 2022, doi: 10.3390/su14095339.

[25]   S. Gao, F. Meng, Z. Gu, Z. Liu, and M. Farrukh, 'Mapping and clustering analysis on environmental, social and governance field a bibliometric analysis using scopus', *Sustainability (Switzerland)*, vol. 13, no. 13, Jul. 2021, doi: 10.3390/su13137304.

[26]   M. M. Tjebane, I. Musonda, C. Okoro, and A. Onososen, 'Artificial Intelligence (AI) in Sustainable Construction Management: A Scientometric Review', in *Lecture Notes in Civil Engineering*, Springer Science and Business Media Deutschland GmbH, 2023, pp. 137–150. doi: 10.1007/978-3-030-97748-1_12.

[27]   C. M. Patino and J. C. Ferreira, 'Inclusion and exclusion criteria in research studies: Definitions and why they matter', *Jornal Brasileiro de Pneumologia*, vol. 44, no. 2. Sociedade Brasileira de Pneumologia e Tisiologia, p. 84, Mar. 01, 2018. doi: 10.1590/s1806-37562018000000088.

[28]   J. K. Tamala, E. I. Maramag, K. A. Simeon, and J. J. Ignacio, 'A bibliometric analysis of sustainable oil and gas production research using VOSviewer', *Clean Eng Technol*, vol. 7, Apr. 2022, doi: 10.1016/j.clet.2022.100437.

[29]   S. H. H. Shah, S. Lei, M. Ali, D. Doronin, and S. T. Hussain, 'Prosumption: bibliometric analysis using HistCite and VOSviewer', *Kybernetes*, vol. 49, no. 3, pp. 1020–1045, Feb. 2020, doi: 10.1108/K-12-2018-0696.

[30]   S. H. Mian, B. Salah, W. Ameen, K. Moiduddin, and H. Alkhalefah, 'Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities', *Sustainability (Switzerland)*, vol. 12, no. 15, Aug. 2020, doi: 10.3390/su12156100.