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The Implementation of Technology in School Learning Over the Last 50 Years: A Bibliometric Analysis of the Scopus Database

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Abstract: This research aims to analyze research trends in the field of technology use in the school environment. Using predetermined keywords, researchers selected documents using the PRISMA method and obtained 599 final documents which were analyzed using the R Program Biblioshiny, Publish or Perish 8, and VOSviewer to map trends in research results with bibliometric analysis. From this analysis it can be concluded that research on the use of technology in the school environment began in 1974 until 2024 with peak publications in 2023 and peak citations in 2018. The United States is the most productive country in the field of most productive countries. Nanyang Technological University is the most productive affiliate, recording the highest number of publications. Journal Q1 "Computers and Education" is the most productive journal with the highest h-index. Hyuksoo Kwon from the Republic of Korea is the writer with the highest h-index. The publication with the highest citations. There are 11 keyword clusters, with the keywords "Artificial Intelligence", "Programming", "Digitization", "Online Learning", "Augmented Reality", and "Cloud Computing" being the next recommended keywords if you want to do research in the field of use technology in the school environment.

Keywords: Bibliometric; School; Scopus; Technology

Introduction

Over the past few centuries, technological advancements have affected every area of human life (Dipayana et al., 2024; Lestari et al., 2024; Rif et al., 2024). Technology has always been a key factor in the advancement of humanity, from the development of steam engines in the 18th century to the digital revolution in the 21st (Ananda et al., 2024; Anita et al., 2024; Sidiki et al., 2024). Technology is the application of science and engineering to the creation of new instruments, frameworks, and procedures that improve human capacity for problem-solving and task-solving (Brynjolfsson et al., 2014; Haryono et al., 2024; Ramadhani et al., 2024; Sitorus et al., 2024). Technology can define as a tool that increases productivity, streamlines workflow, broadens human potential, and expedites and facilitates daily chores (Autor, 2019; Moor, 2020). Technology is highly beneficial in many fields, including business, education, health, and communication (Laranjeiro, 2022; Minich et al., 2019; Rinkinen et al., 2024; Wahyuni et al., 2024). Telemedicine and health information systems are useful tools in the medical field that help with better access to care, quicker diagnosis, and more precise treatment (Topol, 2019). Business technology has a significant impact as well, mostly through process automation and a decrease in human error, which boost productivity and efficiency across a range of industries (Azoury et al., 2014). Technology has a significant impact on education as well since it gives students access to a wealth of knowledge, simulations, and visualisation tools that aid in the understanding of difficult subjects (Alika et al., 2021).

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Education is the process by which people learn the knowledge, skills, values, and attitudes needed to grow as people and make a positive contribution to society (Agriani, 2023; Reimers et al., 2020; Sulastri, 2023). Education moulds social character and values in addition to imparting knowledge and skills in individuals (Kamińska et al., 2019; UNESCO Division for Inclusion and sustainable development, education sector, 2017). The knowledge society recognizes that Education Institutions are a fundamental part of the globalization process, where the use of technologies improve students' ability towards learning (Lazar et al., 2018). Technology in education is transforming teaching and learning through online learning, blended learning, and the use of digital media (Davis, 2017; Zafrullah & Ramadhani, 2024). In the sphere of education, technology has made it possible to use more participatory teaching methods, distant learning, and faster and sustainability of education management system (Botto et al., 2023; Li et al., 2022; Suryanarayana et al., 2024). Technology can also enhance the quality of education through sophisticated learning tools and more effective evaluations (Selwyn, 2019).

Primary schools (SD), Secondary schools (SMP), and Senior high schools (SMA) are using technology more and more these days (Hashim et al., 2024; Rogne et al., 2024; Syahfitri, 2024). AI utilisation, digital assessment, virtual classrooms, and project-based learning are a few uses for this technology (Knoblauch, 2022; Sembiring et al., 2024). Educational technologies have the power to uplift students' motivation because they use simulation and visualisation to assist pupils learn difficult subjects (Jiang et al., 2024; Krasnova et al., 2023).

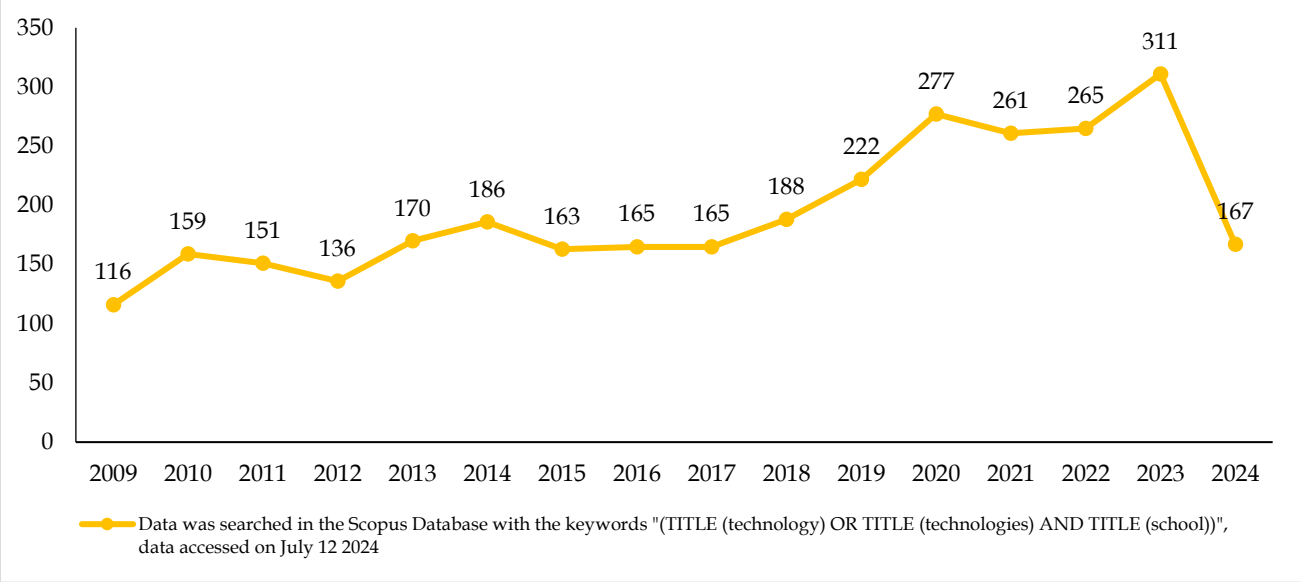

Figure 1. Publication Trends Regarding the Use of Technology in Schools in the Scopus Database in the Last 15 Years

The graphs in the aforementioned data demonstrate how the use of technology in education has grown in popularity as a research topic. Numerous studies have looked at how technology may improve teaching procedures, increase access to education, and improve learning experiences. Bibliometric analysis is a technique that measures and analyses scientific literature based on bibliographic data in order to discover areas to be studied and research trends (Aria et al., 2017; Zupic et al., 2015). Base on this analysis, it will obtain a thorough understanding of how technology has shaped education in the past and will continue to do so through this analysis, which will also aid in the advancement of research and provide insight into the structures and advancements in a particular scientific subject.

Method

This research aims to analyze trends in technology use across schools contained in the Scopus database using bibliometric methods. Bibliometrics is a quantitative approach used to measure, analyze and visualize various aspects of scientific literature (Otitolaiye et al., 2024; Tosun, 2024; Ülker et al., 2023; Zafrullah, Hardi, et al., 2024; Zafrullah, Ibrahim, et al., 2024). This method involves the use of statistical and mathematical tools to evaluate publication patterns, collaboration between authors, and the development of research trends in a particular field. By using bibliometrics, researchers can identify the most influential articles, understand the dynamics of research topic development, and determine the relationship between various themes that appear in the literature. This analysis provides deep insight into how technology

is being applied in educational contexts around the world, as well as helping to identify areas that require further attention or have potential for innovative development.

Before analyzing documents using the bibliometric method, the author first selected documents on the Scopus Database using PRISMA. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method is a framework used to compile and report systematic reviews and meta-analyses in a transparent and complete manner (McKenna, 2024; Mishra et al., 2023). PRISMA helps researchers in filtering and selecting relevant studies based on predetermined inclusion and exclusion criteria, ensuring that the results obtained have high validity and reliability.

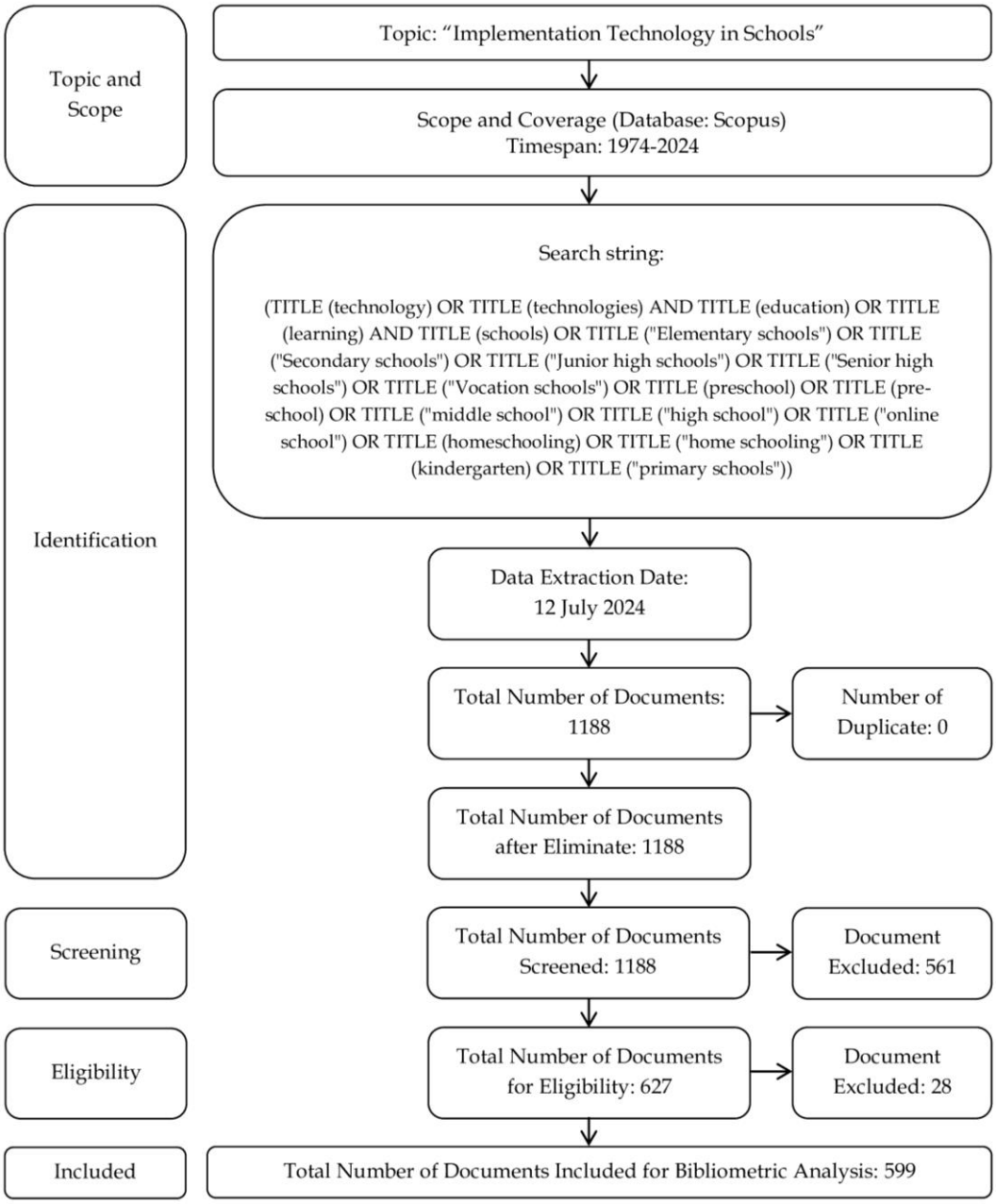

Figure 2. PRISMA Flow for Eliminating Documents in the Scopus Database in Research Regarding the Implementation of Technology Use in Schools. Flowchart by Page et al., (2021)

The researcher used the main keyword, namely "Technology" and used all school keywords starting from schools for small children, home schooling, to high schools, this was done so that all schools were included in this analysis stage. So the first search obtained 1188 documents. At the screening stage, the author limited it

to "Social Sciences" and document types namely "Article" and "Conference Paper", so that 561 documents were eliminated leaving 627 documents.

In the Eligibility stage, the author then looked at all the documents manually and eliminated 28 documents, leaving 599 documents that survived until the Included stage. Next, the author carried out an analysis using the Publish or Perish 8, R Program Biblioshiny and VOSviewer to map the results of publication trends in the field of technology use in schools. The author analyzes starting from main information, best authors, most influential sources, most productive countries, productive affiliates, documents with the highest citations, to novelty and keyword grouping. This analysis aims to provide in-depth insight into how technology is implemented at various school levels and identify emerging trends and patterns in the related literature.

Result and Discussion

Main Information

The author analyzes Main Information in one of the menus in the R Program Biblioshiny which aims to obtain a general overview of the characteristics of the documents studied. This analysis includes information such as the publication and citation trends, number of publications per year, distribution of authors, and journal sources used, thus providing a basic understanding of trends and patterns in the use of technology in schools.

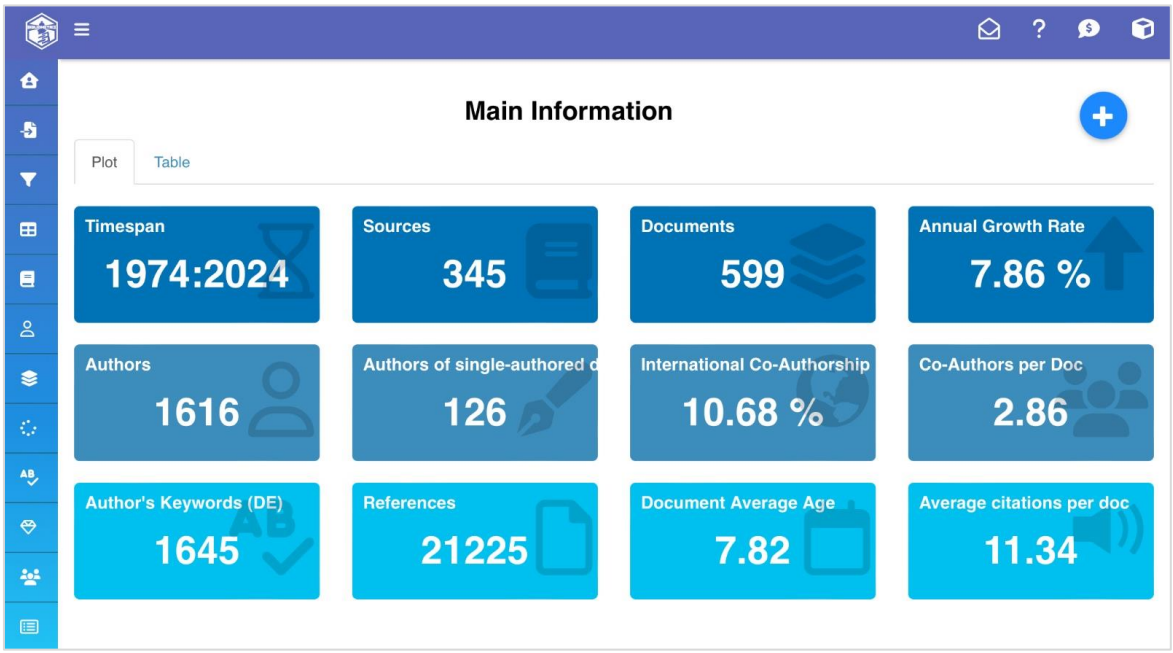

Figure 2. Main Information on Biblimetric Analysis on the Topic of Using Technology in the School Environment. Analysis Using R Program Biblioshiny

This research comes from 345 leading journals and proceedings in the world, with a total of 599 documents analyzed. In this study, the annual growth rate was 7.86%, indicating a steady increase in the number of publications related to the use of technology in schools. The number of authors involved in this research reached 1616, of which 126 were sole authors. Additionally, there was a significant contribution from international authors, accounting for 10.68%, indicating that this topic has global appeal and involves substantial cross-national collaboration. With the large number of documents analyzed, this research provides comprehensive insight into trends and developments in the use of technology in the school environment. Furthermore, the study identified 1645 keywords used by the authors, reflecting a wide range of topics and focus in research on educational technology. In addition, there were 21225 references used, demonstrating the depth and breadth of the literature on which this analysis is based.

Publication and Citation Trends

Researchers analyzed trends in the number of publications and citation trends from year to year, starting from 1974 to 2024, with the aim of understanding the development and dynamics of research on the use of technology in schools over the last five decades. This analysis also aims to identify key periods where there have been spikes in the number of publications and citations, which could indicate

increased interest and significant contributions in the field.

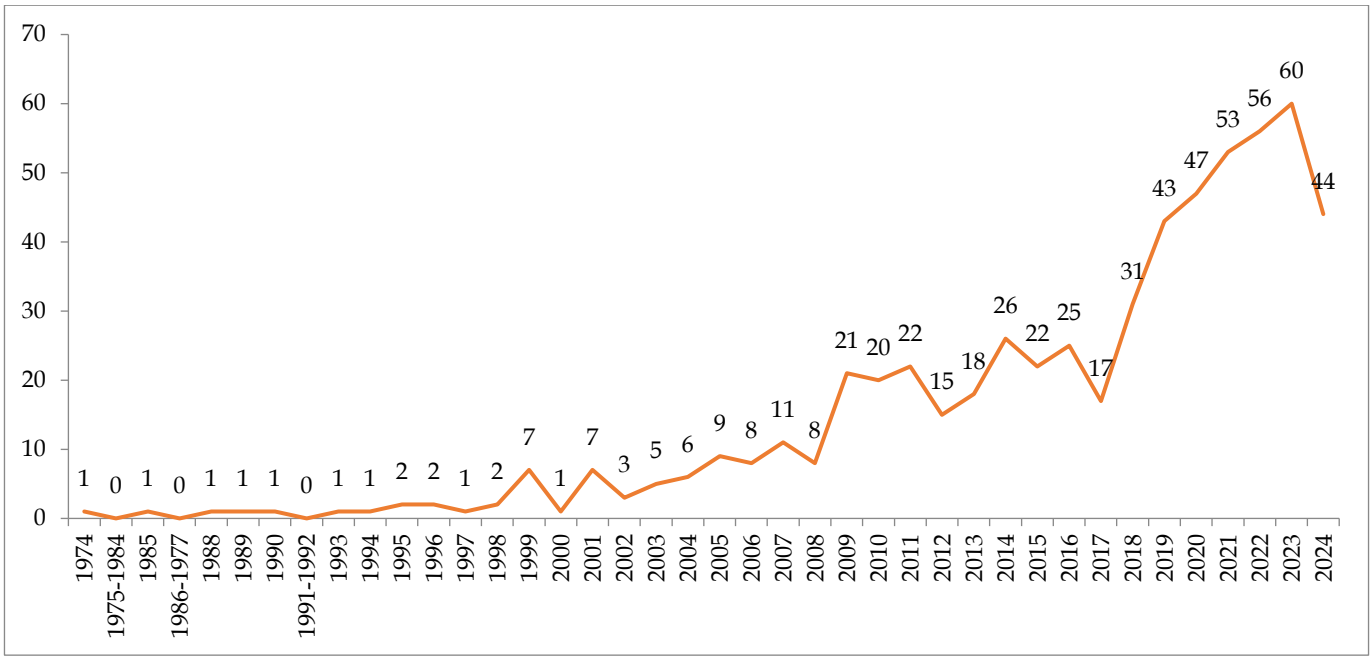

Figure 3. Number of Publications from Year to Year in the Field of Technology Use in the School Environment. Data analyzed on July 17, 2024

From Figure 3, the number of publications in the first 30 years was only 43(7.17%) publications. This is because technology has not yet developed very well in the education sector, so adoption and research related to its use in schools is still limited. Apart from that, limited access and technological infrastructure at that time was also a major inhibiting factor. However, in the last 20 years, the number of publications has increased drastically by 12%, reaching 556(92.82%) publications. The main cause of this increase is the rapid development of information and communications technology, which has significantly changed the way education is delivered. Advances in hardware and software, an increasingly faster and wider-reaching internet, and the integration of digital technology in school curricula have encouraged more research and implementation of technology in educational settings. This reflects how technology has become an integral part of the modern learning process, increasing the effectiveness of teaching, and opening up new opportunities for educational innovation.

There were blank periods in publication, namely 1975-1984, 1986-1987, and 1991-1992. This is natural considering that technology was not very developed at that time, so research and application of technology in the education sector was still very limited. However, the peak of publications regarding the use of technology in schools will occur in 2023 with a total of 60(10.01%) publications. The main cause of this surge is the transition from the Covid-19 pandemic situation, which has forced the global education system to adapt to distance and online learning. The pandemic accelerated the adoption of technology in education, encouraging schools and institutions to develop and implement digital solutions to ensure the continuity of the teaching and learning process. In addition, experiences during the pandemic have increased awareness of the importance of technology in creating flexible and inclusive learning environments, resulting in research in this area increasing significantly.

From Table 1, it can be seen that 463(77.29%) of the 599 documents were cited, indicating that the majority of publications have received recognition and references from other researchers. 2018 was the most productive with the highest h-index, reaching 15, because this year the number of publications produced and the number of citations received was very significant, reaching 31 publications and 481 citations. This shows an increase in interest and influence of research in the field of technology use in the school environment in that year.

In addition, from 2008 to 2016, the number of citations exceeded 200 indicating high research activity and significant impact of studies in the field of technology use in schools. This increase indicates a trend of increasing interest and broad research among academics and practitioners, which continues to contribute to the development and deeper understanding of technology integration in education. This reflects the importance of developing and

implementing technology in supporting the teaching and learning process at various levels of education.

Table 1. Number of Citations from Year to Year in the Field of Technology Use in the School Environment.

Year	Total of Publications	Number of Publications Cited in That Year	TC[a]	h[b]	TC/P[c]
1974	1(0.17%)	1(0.22%)	13(0.19%)	1	13
1975-1984	-	-	-	-	-
1985	1(0.17%)	1(0.22%)	-	1	0
1986-1977	-	-	-	-	-
1988	1(0.17%)	1(0.22%)	-	1	0
1989	1(0.17%)	1(0.22%)	1(0.01%)	1	1
1990	1(0.17%)	1(0.22%)	26(0.38%)	1	26
1991-1992	-	-	-	-	-
1993	1(0.17%)	1(0.22%)	11(0.16%)	1	11
1994	1(0.17%)	1(0.22%)	7(0.10%)	2	7
1995	2(0.33%)	1(0.22%)	10(0.15%)	2	5
1996	2(0.33%)	2(0.43%)	8(0.12%)	2	4
1997	1(0.17%)	1(0.22%)	35(0.52%)	1	35
1998	2(0.33%)	2(0.43%)	61(0.90%)	2	4.5
1999	7(1.17%)	7(1.51%)	80(1.18%)	4	11.57
2000	1(0.17%)	1(0.22%)	4(0.06%)	1	4
2001	7(1.17%)	7(1.51%)	155(2.28%)	6	22.14
2002	3(0.50%)	3(0.65%)	79(1.16%)	2	26.33
2003	5(0.83%)	5(1.08%)	128(1.88%)	3	25.6
2004	6(1.00%)	5(1.08%)	63(0.93%)	3	10.5
2005	9(1.50%)	8(1.73%)	110(1.62%)	5	12.22
2006	8(1.34%)	8(1.73%)	148(2.18%)	6	18.5
2007	11(1.84%)	9(1.94%)	131(1.93%)	5	11.91
2008	8(1.34%)	7(1.51%)	370(5.45%)	5	46.25
2009	21(3.51%)	19(4.10%)	216(3.18%)	9	10.29
2010	20(3.34%)	18(3.89%)	381(5.61%)	10	19.05
2011	22(3.67%)	14(3.02%)	515(7.58%)	9	23.41
2012	15(2.50%)	12(2.59%)	524(7.71%)	9	34.93
2013	18(3.01%)	14(3.02%)	210(3.09%)	7	11.67
2014	26(4.34%)	19(4.10%)	205(3.02%)	8	7.88
2015	22(3.67%)	17(3.67%)	591(8.70%)	10	26.86
2016	25(4.17%)	19(4.10%)	201(2.96%)	7	8.04
2017	17(2.84%)	15(3.24%)	185(2.72%)	9	10.88
2018	31(5.18%)	28(6.05%)	481(7.08%)	15	15.52
2019	43(7.18%)	33(7.13%)	367(5.40%)	10	8.53
2020	47(7.85%)	41(8.86%)	609(8.97%)	11	12.96
2021	53(8.85%)	44(9.50%)	514(7.57%)	10	9.7
2022	56(9.35%)	45(9.72%)	235(3.46%)	10	4.2
2023	60(10.02%)	35(7.56%)	126(1.86%)	5	2.1
2024	44(7.35%)	17(3.67%)	43(0.63%)	4	0.98
Total/Average	599(100%)	463(77.29%)	6792(100%)	38	135.84

a: Number of Citations per Year, b: h-index, c: Total Citations/Total of Publications
Data Analyzed on July 17, 2024

Most Productive Countries and Collaboration Between Countries

The most productive countries and collaboration between countries are analyzed with the aim of identifying the countries most active in research on the use of technology in schools. This analysis also aims to understand international collaboration patterns that can enrich and broaden the perspectives and approaches in this research.

Table 2. Top 15 Country Contributions in Terms of Highest Publications and Number of Citations in the Field of Technology Use in the School Environment

Rank	Country	Continent	Total of Publications	%	Total Citations	%
1st	United States	North America	62	10.35%	1038	15.28%
2nd	China	Asia	42	7.01%	584	8.60%
3rd	United Kingdom	Europe	24	4.01%	570	8.39%
4th	Turkey	Europe/Asia	21	3.51%	365	5.37%
5th	South Africa	Africa	14	2.34%	72	1.06%
6th	Sweden	Europe	13	2.17%	226	3.33%
7th	Australia	Oceania	12	2.00%	251	3.70%
8th	Hong Kong	Asia	12	2.00%	140	2.06%
9th	Indonesia	Asia	11	1.84%	35	0.52%
10th	Korea	Asia	10	1.67%	69	1.02%
11th	Finland	Europe	8	1.34%	105	1.55%
12th	Brazil	South America	7	1.17%	40	0.59%
13th	Canada	North America	7	1.17%	104	1.53%
14th	Kazakhstan	Asia	7	1.17%	7	0.10%
15th	Malaysia	Asia	7	1.17%	431	6.35%

Description: Data Analysis using R Program Biblioshiny, data analyzed on July 17, 2024

From Table 2, it can be seen that the United States is ranked first in the number of articles and total citations regarding the use of technology in schools. With 62(10.35%) publications and 1038(15.28%) citations, the United States shows significant dominance in research and contributions to the development of educational technology. Factors supporting the United States' leading position include a high level of technological innovation, government support, and strong collaboration between educational institutions and the technology industry. In addition, a strong research culture and large funding allocations for educational research also play a role in the high productivity and impact of research in the United States.

China ranks second with 42(7.01%) publications and 584(8.60%) citations, showing great contribution in the same field. The rapid development of technology and education in China, supported by large investments in infrastructure and human resources, has made the country one of the major players in educational technology research. Apart from China, other Asian countries such as Hong Kong, Indonesia, Korea, Kazakhstan and Malaysia also contributed significantly. Asia dominates this list, reflecting the continent's strong commitment to advancing educational technology.

Not only did Asian and North American countries contribute, but there was also representation from all continents. The United Kingdom and several other European countries such as Sweden and Finland also showed no less important contributions. Australia from Oceania, South Africa from Africa, and Brazil from South America show that attention to the use of technology in schools is a global phenomenon. Although the number of articles and citations from some countries is lower, their contributions remain important in providing a global perspective on this issue. This diversity of contributions indicates a global awareness of the importance of integrating technology in education to improve the quality of learning and teaching throughout the world.

Figure 4 shows a network map depicting collaborative relationships between countries in the use of technology in the school environment. There are eight clusters, each represented by a different color, indicating groups of countries that have a lot of interaction with each other in this context. The United States is at the

center of this network with the largest circle, indicating that this country has the greatest number of collaborations or connections with other countries in the use of technology in schools. The bigger the circle, the more collaboration is carried out by that country (Rusydiana et al., 2021).

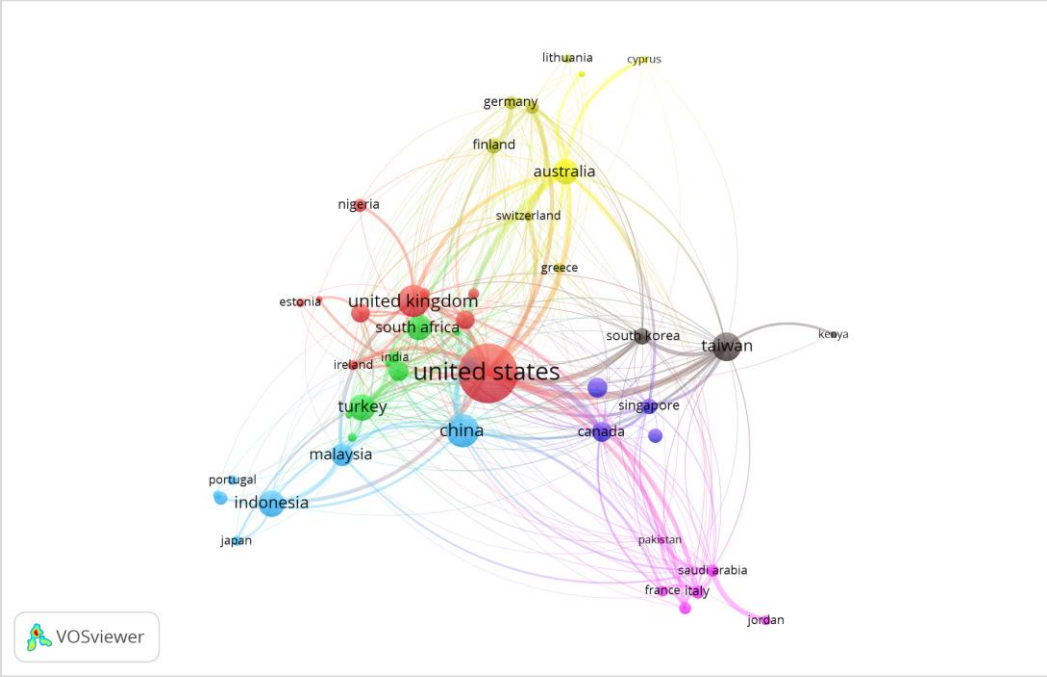

Figure 4. Inter-Country Collaboration on Studies Regarding the Use of Technology in the School Environment. Analysis with VOSviewer (At least 3 Papers)

These clusters show a global pattern of interaction in which certain countries act as hubs or centers in international collaboration networks in the use of technology in schools. For example, the United Kingdom, China, and Taiwan also have quite large circles, indicating their important role in this network. This network reflects the complexity and depth of relationships between countries in implementing and sharing educational technology in schools, which can include the adoption of educational hardware and software, teacher training in technology, and the development of technology-integrated curricula.

The Most Productive Affiliations

The author conducted an analysis of affiliations with the highest publications aimed at identifying the most productive institutions in research. This analysis also aims to understand the contribution of each institution to the development of science.

In Table 3, Nanyang Technological University from Singapore stands out as the affiliate with the highest number of publications in research on the use of technology in the school environment. With 22(3.67%) publications or approx. of the total, the university shows significant contribution in this field. Followed by Thaksin University from Thailand with 12(2.00%) publications, these two institutions confirmed Asia's dominance in contributing to this research. On the other hand, institutions from Europe also play an important role, as can be seen from the top three rankings filled by Lipetsk State Pedagogical P. Semenov-Tyan-Shansky University and Ataturk University, which are located in Russia and Turkey respectively. Even though these two universities are located on two continents, Europe and Asia, they remain in regions that have a significant influence on the development of knowledge about the use of technology in education.

Overall, this table provides a clear picture of the geographic diversity in the contribution of research on technology use in school settings. The dominance of Europe and Asia is striking, with institutions from these two continents making up most of the top rankings. But not only Europe and Asia are dominant, North America also plays a significant role with institutions such as the University of Maryland and the American Institutes for Research each contributing 7 publications. This shows that the technological educational context is not just a particular regional focus, but is an important subject of study throughout the world, with extensive contributions from leading educational institutions across multiple continents. The involvement of institutions from various countries and continents in this research reflects the importance of global collaboration to understand and improve the use of technology in education throughout the world.

Table 3. Top 15 Affiliates with the Highest Publications in the Use of Technology in the School Environment

Rank	Affiliation	City	Country	Continent	NP[a]	%
1st	Nanyang Technological University	Singapore	Singapore	Asia	22	3.67%
2nd	Thaksin University	Phatthalung	Thailand	Asia	12	2.00%
3rd	Lipetsk State Pedagogical P. Semenov-Tyan-Shansky University*	Lipetsk	Russia	Europe/Asia	12	2.00%
4th	Ataturk University*	Erzurum	Turkey	Europe/Asia	11	1.84%
5th	University of Trás-os-Montes and Alto Douro	Vila Real	Portugal	Europe	8	1.34%
6th	Université de Bordeaux	Bordeaux	France	Europe	8	1.34%
7th	Stockholm University	Stockholm	Sweden	Europe	7	1.17%
8th	University of Cambridge	Cambridge	United Kingdom	Europe	7	1.17%
9th	University of Maryland	College Park	United States	North America	7	1.17%
10th	University of Porto	Porto	Portugal	Europe	7	1.17%
11th	American Institutes for Research	Washington, D.C.	United States	North America	6	1.00%
12th	Aristotle University of Thessaloniki	Thessaloniki	Greece	Europe	6	1.00%
13th	Eindhoven University of Technology	Eindhoven	Netherlands	Europe	6	1.00%
14th	National Taiwan Normal University	Taipei	Taiwan	Asia	6	1.00%
15th	Russian State Social University	Moscow	Russia	Asia	6	1.00%

* : Located on two continents, namely Asia and Europe, a: Number of Publications Data analyzed on July 17, 2024

The Most Higher Source

The authors conducted an analysis of the most trusted sources, especially international journals and proceedings indexed by Scopus, with the aim of identifying the most relevant and influential references in supporting their research. This is important to ensure that the information used can be accounted for and provides a strong basis for the research results obtained.

Table 4. Top 15 Sources from Highest Scopus Indexed Journals or Proceedings in the h-index in the field of Technology Use in the School Environment

Rank	Source Name	Type	SQ[a]	Publisher	Country	h[b]	TC[c]	NP[d]
1st	Computers and Education	Journal	Q1	Elsevier Ltd	United Kingdom	13	1428 (21.02%)	15 (2.50%)
2nd	International Journal of Technology and Design Education	Journal	Q1	Springer Netherlands	Netherlands	11	366 (5.39%)	27 (4.51%)
3rd	Technology, Pedagogy and Education	Journal	Q1	Routledge	United Kingdom	8	296 (4.36%)	8 (1.34%)
4th	Education and Information Technologies	Journal	Q1	Kluwer Academic Publisher	United States	7	154 (2.27%)	19 (3.17%)
5th	Educational Technology Research and Development	Journal	Q1	Springer Boston	United States	7	144 (2.12%)	7 (1.17%)
6th	Eurasia Journal of Mathematics, Science and Technology Education	Journal	Q3	Modestum LTD	Turkey	5	118 (1.74%)	11 (1.84%)
7th	Education Sciences	Journal	Q2	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	4	70 (1.03%)	6 (1.00%)
8th	Journal of Computer Assisted Learning	Journal	Q1	Wiley-Blackwell Publishing Ltd	United Kingdom	4	101 (1.49%)	5 (0.83%)

Rank	Source Name	Type	SQ[a]	Publisher	Country	h[b]	TC[c]	NP[d]
9th	Journal of Educational Computing Research	Journal	Q1	SAGE Publications Inc.	United States	4	53 (0.78 %)	5 (0.8 3%)
10th	Procedia - Social and Behavioral Sciences	Conference	-	Elsevier B.V	United States	4	61 (0.90 %)	7 (1.1 7%)
11th	Sustainability	Journal	Q1	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	4	48 (0.71 %)	6 (1.0 0%)
12th	Technology, Knowledge and Learning	Journal	Q1	Springer Science + Business Media	United States	4	37 (0.54 %)	5 (0.8 3%)
13th	British Journal of Educational Technology	Journal	Q1	Wiley-Blackwell Publishing Ltd	United Kingdom	3	65 (0.96 %)	6 (1.0 0%)
14th	Journal of Information Technology for Teacher Education	Journal	Q1	Routledge	United Kingdom	3	23 (0.34 %)	4 (0.6 7%)
15th	Journal of Research on Technology in Education	Journal	Q1	Taylor and Francis Ltd.	United Kingdom	3	35 (0.52 %)	3 (0.5 0%)

a: Scopus Quartile, Search from scimagojr.com on July 17, 2024, b: h-index, c: Total of Citations, d: Number of Publications

The Most Productive and Trends in Number of Publications Authors

The author conducted an analysis of the most productive and trends in number of publications from authors with the aim of identifying the most productive authors and observing trends in the number of their publications over time. This analysis helps understand individual contributions to research as well as developments and directions of study in the field of technology in the school environment.

Table 5. Top 15 Authors with the Highest H-index in the Field of Technology Use in the School Environment

Rank	Author Name	Affiliation	Country	h-index	TC[a]	NP[b]
1st	Hyuksoo Kwon	Kongju National University	Republic of Korea	3	18 (0.27%)	3 (0.50%)
2nd	Dominik Petko	Schwyz University of Teacher Education	Switzerland	3	111 (1.63%)	3 (0.50%)
3rd	Rabia Meryem Yilmaz	Ataturk University	Turkey	3	252 (3.71%)	3 (0.50%)
4th	Brian A. Bottge	University of Kentucky	United States	2	17 (0.25%)	2 (0.33%)
5th	Irina Viktorovna Burmykina	Lipetsk State Pedagogical P. Semenov-Tyan-Shansky University	Russia	2	14 (0.21%)	2 (0.33%)
6th	Glenda Carter	North Carolina State University	United States	2	26 (0.38%)	2 (0.33%)
7th	Yuh-Ming Cheng	SHU-TE University	Taiwan	2	89 (1.31%)	2 (0.33%)
8th	Rosemary Deaney	University of Cambridge	United Kingdom	2	51 (0.75%)	2 (0.33%)
9th	Nina Vladimirovna Fedina	Lipetsk State Pedagogical P. Semenov-Tyan-Shansky University	Russia	2	14 (0.21%)	2 (0.33%)
10th	Vince Geiger	University of Queensland	Australia	2	115 (1.69%)	2 (0.33%)
11th	Simin Ghavifekr	University of Malaya	Malaysia	2	370 (5.45%)	2 (0.33%)
12th	Mercedes González-Sanmamed	University of A Coruña	Spain	2	21 (0.31%)	2 (0.33%)

Rank	Author Name	Affiliation	Country	h-index	TC[a]	NP[b]
13th	Merrilyn Goos	University of Queensland	Australia	2	115 (1.69%)	2 (0.33%)
14th	Sara Hennessy	University of Cambridge	United Kingdom	2	51 (0.75%)	2 (0.33%)
15th	Herwin	Universitas Negeri Yogyakarta	Indonesia	2	8 (0.12%)	3 (0.50%)

a: Total of Citation, b: Number of Publications, Data analyzed on July 17, 2024, Source: R Program & Google Scholar

In Table 5, Hyuksoo Kwon from Kongju National University in South Korea is ranked highest in research contribution with an h-index of 3, total citations of 18(0.27%), and number of publications of 3(0.50%). Dominik Petko from Schwyz University of Teacher Education in Switzerland is in second place with the same h-index, total citations of 111(1.63%), and the same number of publications of 3(0.50%). Rabia Meryem Yilmaz from Ataturk University in Turkey also has an h-index of 3 with the highest total citations among the big three, namely 252(3.71%), and the number of publications is 3(0.50%).

No single university dominates this list, indicating that research on the use of technology in school settings is conducted by a wide range of institutions from different countries. No country shows significantly higher productivity than any other country. All affiliates and countries on this list play an important role in contributing to the understanding and development of technology in schools, reflecting the diversity and international collaboration in this field.

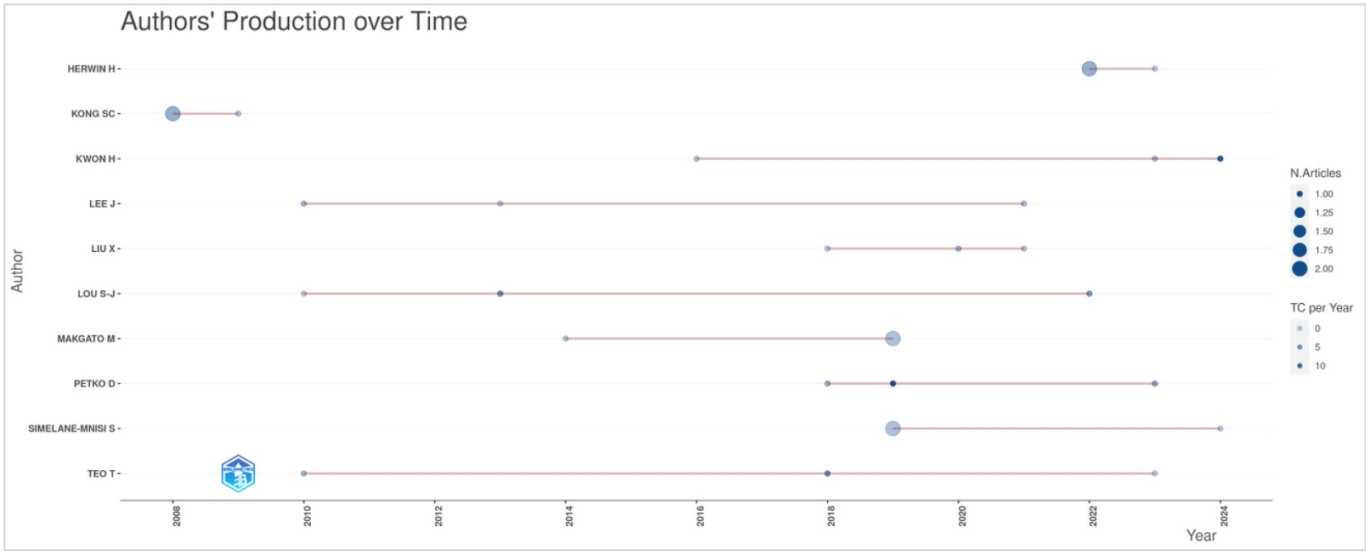

Figure 5. Authors Production Over Time in the Field of Technology Enablement in the School Environment. Analysis with R Program

In Figure 5, it can be seen that Siu-Cheung Kong from The Education University of Hong Kong and Sibongile Simelane-Mnisi from Tshwane University of Technology are the most productive authors in recent years in the field of technology use in schools Siu-Cheung Kong began to show its productivity since 2010 with a number of articles published consistently until 2022. Siu-Cheung Kong articles are not only numerous, but also have a significant impact in the field, as shown by the quite high number of citations per year. This shows that the research conducted by Siu-Cheung Kong has great relevance and influence in educational technology studies.

Sibongile Simelane-Mnisi is also prominent in this field, especially after 2016. This author continues to produce articles through 2024, demonstrating ongoing commitment and contribution to research on technology use in schools. His articles have varying but still significant annual citation counts, indicating that his work is recognized and used by many other researchers. With consistent and recognized contributions, Sibongile Simelane-Mnisi has played an important role in the development and understanding of educational technology in recent years.

However, according to Table 5, Siu-Cheung Kong is not included in the list of authors with the highest h-index in this field, which may indicate that although prolific, the citations and impact of his articles have not yet reached the highest levels. In contrast, authors such as Hyuksoo Kwon, Dominik Petko, and Rabia Meryem Yilmaz, who lead the list with an h-index of 3, show that although their number of articles is not as high as that of Siu-Cheung Kong, their research has received widespread recognition and has had a significant impact

in the academic community, as indicated by high total citations.

Documents with the Higher Citation

The author conducted an analysis by looking at the documents with the highest citations to identify the most influential contributions to research on the use of technology in schools. The results of this analysis provide insight into the trends and impact of research in the field.

Table 6. Highest Documents and Evolution of the Number of Citations in the Last 5 Years in the Field of Technology Use in the School Environment.

Rank	Citation	Title	Total Citations	Citation Evolution in last 5 years (2020-2024)				
				20	21	22	23	24
1st	(Ghavifekr et al., 2015)	Teaching and learning with technology: Effectiveness of ICT integration in schools	352 (5.18%)	65	51	66	89	33
2nd	(Chai et al., 2011)	Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) …	278 (4.09%)	22	17	20	28	20
3rd	(Sahin et al., 2020)	The effect of Augmented Reality Technology on middle school …	212 (3.12%)	13	40	50	71	36
4th	(Rau et al., 2008)	Using mobile communication technology in high school education: ….	209 (3.08%)	13	13	13	11	5
5th	(Plowman et al., 2012)	Preschool children's learning with technology at home	187 (2.75%)	17	24	24	9	8
6th	(Yates et al., 2021)	High school students' experience of online learning during Covid-19: …	157 (2.31%)	-	17	57	57	26
7th	(De Smet et al., 2012)	Researching instructional use and the technology acceptation …	108 (1.59%)	13	12	7	11	7
8th	(Bergdahl et al., 2020)	Engagement, disengagement and performance when …	97 (1.43%)	4	13	34	27	19
9th	(Schmid et al., 2019)	Does the use of educational technology in personalized learning …	83 (1.22%)	12	17	23	17	11
10th	(Shapley et al., 2011)	Effects of technology immersion on middle school students' …	83 (1.22%)	17	5	10	11	7
11th	(Plowman et al., 2010)	Supporting young children's learning with technology at home and in preschool	80 (1.18%)	10	2	6	8	2
12th	(Sailer et al., 2021)	Digital learning in schools: What does it take beyond digital technology?	79 (1.16%)	-	3	18	34	25
13th	(Goos et al., 2003)	Perspectives on technology mediated learning in secondary school …	77 (1.13%)	6	2	4	3	1
14th	(Cheng et al., 2013)	Investigating elementary school students' technology acceptance …	73 (1.07%)	8	9	10	8	7
15th	(Kim et al., 2008)	Pocket school: Exploring mobile technology as a sustainable literacy …	70 (1.03%)	4	3	2	-	1

Source: R Program Biblioshiny, Data analyzed on July 17, 2024

In Table 6, citation analysis shows that the document with the highest citations is the work of Ghavifekr et al. (2015) which focuses on the effectiveness of the integration of information and communication technology (ICT) in the teaching and learning process in schools with a title that has a total of 352 citations. The article by Chai et al. (2011), which is in second place with 278 citations, explored the technological pedagogy knowledge possessed by prospective elementary school teachers for meaningful learning using information and communication. The article by Sahin et al. (2020) with 212 citations in third place, discusses the effects of augmented reality technology on secondary school students' achievement and attitudes towards science education.

The dominant year range in this top 15 includes articles published between 2003-2021, with the majority of research conducted in the last decade. The reason for the dominance of articles from the last decade is due to rapid developments in educational technology and increasing interest in the application of technology in the school environment. Continuously developing technology provides new opportunities for research, and increasing access to technology in schools is a major driver of higher publications and citations

The evolution of citations in the last five years shows significant variation among the articles. Some articles, such as the work by Ghavifekr et al. (2015) and Sahin et al. (2020), experiences dozens of citations each year, reflecting its continued relevance and influence in educational research. On the other hand, some articles only receive a unit number of additional citations each year, indicating that their impact may be more limited or related to very specific topics. In general, of the 15 documents analyzed, the topics discussed include the integration of technology in teaching, online learning experiences during the COVID-19 pandemic, acceptance of technology by teachers and students, and the impact of technology on learning at various school levels, from primary to secondary education. All of these documents contribute significantly to the field of technology use in the school environment, providing insight and guidance for educational practitioners and researchers in optimizing the use of technology to improve learning outcomes.

Group Keywords and Novelty Keywords

In addition to the analysis using the R Program, researchers also analyzed keywords to identify groups and novelties using VOSviewer. Group and novelty analysis of keywords aims to group related topics and find the latest trends. This helps researchers understand the relationship between various concepts and see the developments and innovations that emerge in this field.

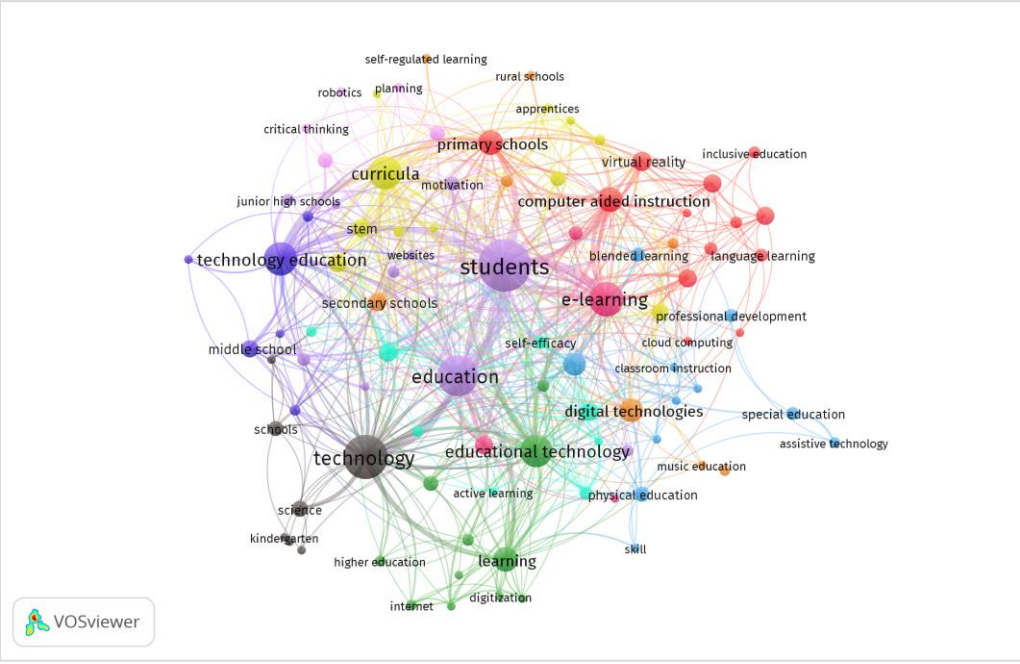

Figure 6. Keyword Grouping Analysis on the Topic of Technology Use in the School Environment with VOSviewer on the Network Visualization Menu (Keyword Occurance ≤ 3)

With Keyword Occurrence ≤ 3, we get 94 keywords with 11 clusters. Next, the author interpreted 11 clusters and named the clusters. This is done so that the analysis can be more structured and make it easier to understand the relationship between various topics that appear in the research.

Table 7. Grouping of 11 Clusters in the Field of Technology Use in the School Environment

No	Color	Groups Name	Keywords
1	Red (13 items/13.82%)	Inclusive Digital Education	Augmented Reality, Children, Cloud Computing, Computer Aided Instruction, Distance Learning, Elementary Schools, Inclusive Education, Language Learning, Preschool Education, Primary Schools, Technology Acceptance, Virtual Reality, Young Children
2	Green (11 items/11.70%)	Digital Learning Innovation	Computer System, Digitalization, Educational Technology, Higher Education, Internet, Learning, Literacy, Mathematics Education, Software, Teacher Education, TPACK
3	Blue (11 items/11.70%)	Modern Integrated Learning	Assistive Technology, Blended Learning, Classroom Instruction, Computer Science, Physical Education, Professional Development, Science Technology, Skill, Special Education, Technology Integration, Ubiquitous Learning

4	Yellow (11 items/11.70%)	Collaborative Learning Innovations	Apprentices, Collaborative Learning, Curricula, Interactive Technology, Mobile Learning, Pedagogical Issues, Project Management, Societies and Institution, STEM, Student Motivation, Vocational Education
5	Purple (10 items/10.63%)	Online Innovative Learning	Academic Achievement, Education, Formative Assessment, Innovation, Junior High Schools, Motivation, Social Media, Social Networking (Online), Students, Websites
6	Cyan (8 items/8.51%)	Active Self-Learning	Active Learning, Artificial Intelligence, Early Childhood Education, ICT, Learning Abilities, Problem Solving, Self-Directed Learning, Self-Efficacy
7	Orange (8 items/8.51%)	Digital Integrated Learning	Digital Technologies, Game-Based Learning, Music Education, Out-of-School Learning, Rural Schools, Secondary Schools, Self-Regulated Learning, Technology Enhanced Learning
8	Black (7 items/7.44%)	Digital Learning Leadership	Communication Technologies, Kindergarten, Qualitative Research, Schools, Science, Technology, Technology Leadership
9	Medium Blue (6 items/6.38%)	Creative Problem-Based Learning	Creativity, Learning Disabilities, Middle School, Problem-Based Learning, Programming, Technology Education
10	Pink (5 items/5.31%)	Critical Integration in Project Learning	Critical Thinking, Integration, Planning, Project-based Learning, Robotics
11	Light Pink (4 items/4.25%)	Web-Based Teaching and Learning	E-learning, Online Learning, Teaching and Learning, Web 2.0

Source: VOSviewer, data analyzed on July 17, 2024

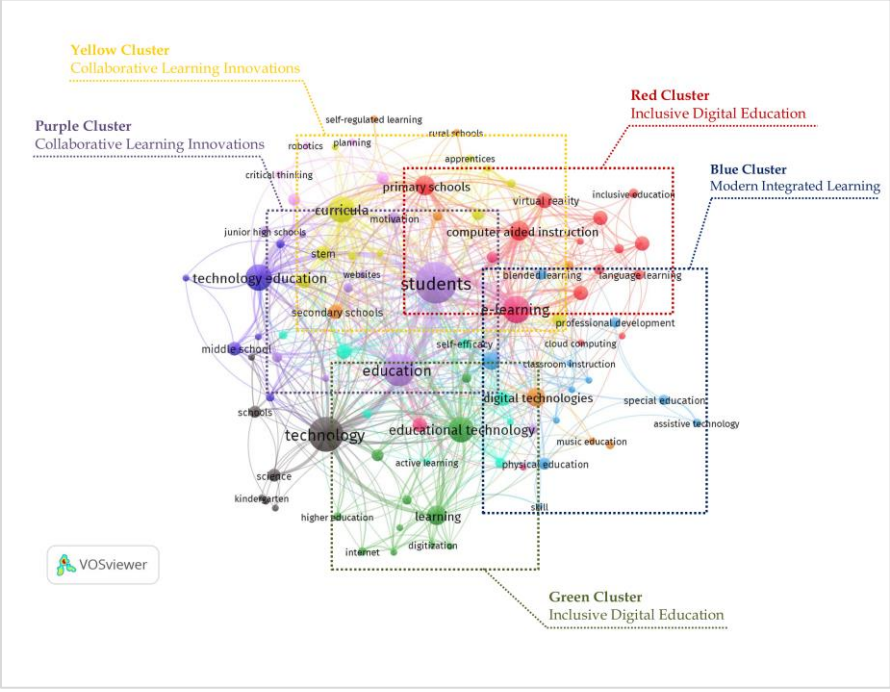

Figure 7. Giving Cluster Names in Red, Green, Blue, Yellow, and Purple in Network Visualization Images in VOSviewer

The red cluster titled "Inclusive Digital Education" covers various important aspects of the application of technology in educational environments, especially for children and primary schools. Augmented Reality (AR) and Virtual Reality (VR) provide immersive learning experiences, which can enhance the understanding of materials for children in primary and preschool (Cheng, 2024; Muhammad et al., 2021). Cloud Computing enables flexible and efficient access to data and learning materials, supporting Distance Learning and Computer Aided Instruction, which is particularly important in situations where face-to-face education is not possible (Bervell et al., 2020; Onofrei et al., 2020). In the context of inclusive education, technology can accommodate the various needs of students with different backgrounds, including in Language Learning programs that target the improvement of young children's language skills (Peruzzo et al., 2024; Shadiev et al., 2020). Primary Schools and Elementary Schools can implement this method to ensure all children get equal learning opportunities, namely AR, VR, Cloud Computing, Distance Learning, Computer Aided Instruction, and

Language Learning programs. Technology acceptance by teachers, students and parents is the key to successful adaptation, ensuring the teaching and learning process runs smoothly and effectively in this digital era.

The green cluster titled "Digital Learning Innovation" covers various important aspects of the application of technology in education, from primary to higher education. Digitalization and the use of Computer Systems have changed the way we access and deliver information, making the Internet a very important tool in the teaching and learning process (Alenezi, 2020; Schmidt et al., 2020). Educational Technology provides new tools and methods to improve math literacy and education, enabling more interactive and engaging learning (Tuma, 2021). Educational software assists in the provision of more varied and customizable learning materials (Cheng et al., 2020). Teacher Education and the TPACK (Technological Pedagogical Content Knowledge) framework play an important role in ensuring teachers are able to integrate technology into their curriculum effectively (Rodrigues, 2020; Tondeur et al., 2020). All of this is aimed at improving the quality of learning and ensuring every student gets equal and high-quality learning opportunities.

The blue cluster titled "Modern Integrated Learning" covers various important aspects of the application of technology across the education spectrum. Assistive Technology helps students with special needs to learn more effectively, while Blended Learning combines online and face-to-face learning to create a more flexible learning experience (Singh et al., 2021; Tekerek et al., 2024). Classroom Instruction in the digital age now involves the use of advanced technology in teaching subjects such as Computer Science and Physical Education, enriching traditional teaching methods (Javaid et al., 2021; Krause et al., 2020; Rahmat et al., 2021). Professional Development for teachers ensures they have the necessary skills to effectively integrate technology into the curriculum (Hennessy et al., 2022; Yurtseven Avci et al., 2020). Science technology is advancing learning in STEM fields, while the skills required for the 21st century continue to be enhanced through learning that involves technology integration (Al Hamad et al., 2024; Ismail et al., 2023). Special Education also benefits greatly from these technologies, ensuring all students can learn according to their abilities (Marino et al., 2023). Ubiquitous Learning allows learning to happen anywhere and anytime, supporting the concept of lifelong learning and ensuring inclusive and equitable education (Aithal et al., 2023).

The yellow cluster entitled "Collaborative Learning Innovations" covers various important aspects of the application of technology across educational environments. Apprenticeships and Vocational Education utilize interactive technologies to provide immersive practical experiences (Kim et al., 2020; Mulders et al., 2024). Collaborative Learning is supported by mobile technology and interactive devices, allowing students to work together on projects despite being in different locations (Ansari et al., 2020; Criollo-C et al., 2021). Curricula in societies and institutions are designed to integrate project-based STEM learning to enhance students' technical and managerial skills (Baran et al., 2021; Owens et al., 2022). Pedagogical Issues in this digital era include adapting teaching methods that support student motivation and utilizing Mobile Learning to provide learning materials that can be accessed anytime and anywhere (Alam et al., 2023). All of this aims to create a learning environment that is dynamic, flexible, and relevant to the needs of the modern workforce.

The purple cluster titled "Online Innovative Learning" covers various important aspects of applying technology in educational settings to improve academic achievement and student motivation. Innovation in education is applied in Junior High Schools through the use of technology-based Formative Assessment to provide faster and more precise feedback to students (Nsabayezu et al., 2023; Wiyaka et al., 2020). Social media and online social networking are becoming important tools for students and teachers to share information, collaborate and support interactive learning (Ansari et al., 2020; Rabbanee et al., 2020; Yeung et al., 2023). The use of educational websites provides extensive and diverse resources that students can access to deepen their understanding (Castro et al., 2023). All these efforts aim to create a dynamic learning environment and support students' academic development in this digital era.

The cyan cluster titled "Active Self-Learning" covers various important aspects in the application of technology in educational environments to improve students' learning abilities from Early Childhood Education to higher levels. The application of Artificial Intelligence in education helps identify and support each student's Learning Abilities, enabling a more personalized and effective approach (Akgun et al., 2022). The use of Information and Communication Technology (ICT) supports problem-based learning that prepares students to face real challenges (Bedregal-Alpaca et al., 2020; Kardipah et al., 2020). Active Learning encourages students' direct involvement in the learning process, while students' Self-Directed Learning and Self-Efficacy are enhanced through access to digital resources that allow them to manage and direct their own learning process (Cardullo et al., 2021; Silamut et al., 2020). All of

this aims to create a proactive learning environment and empower students to become lifelong learners.

The orange cluster titled "Digital Integrated Learning" covers various important aspects of applying technology to enhance students' learning experience in various educational contexts. Digital Technologies are used to enrich learning in Secondary Schools and Rural Schools, ensuring wider and more equitable access to educational resources (Bergdahl et al., 2020; Syvyi et al., 2022). Game-Based Learning and Music Education utilize technology to make learning more engaging and interactive, encouraging maximum student engagement (Adipat et al., 2021; Camlin et al., 2021). Out-of-School Learning provides opportunities for students to learn outside the traditional school environment, expanding their scope of learning (Berg et al., 2021; Uludag, 2021). Self-Regulated Learning is enhanced through digital tools and platforms that allow students to manage and direct their own learning (Anthonysamy et al., 2020; Broadbent et al., 2020). Technology-enhanced learning ensures that all aspects of education are effectively integrated to create a dynamic and sustainable learning environment (Downie et al., 2021; Rudinger, 2020).

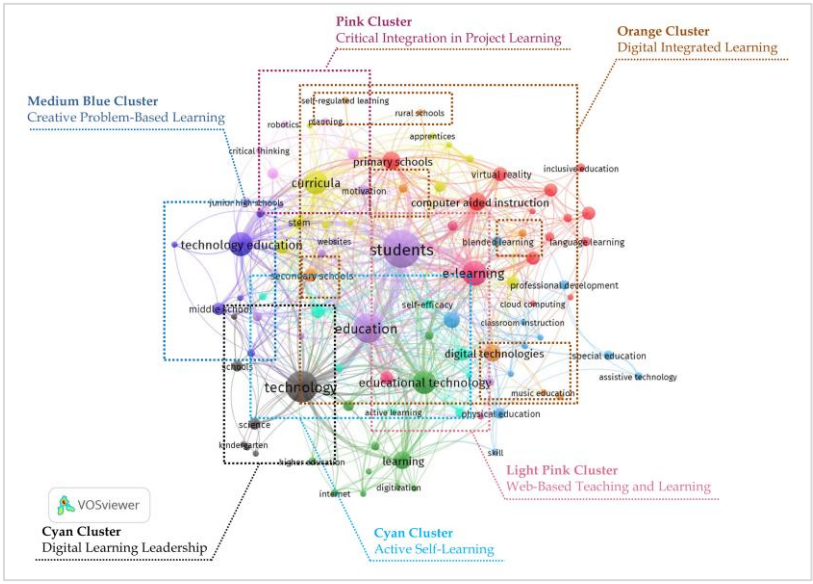

Figure 8. Giving Cluster Names in Cyan, Orange, Black, Medium Blue, Pink, and Light Pink in Network Visualization Images in VOSviewer

The black cluster titled "Digital Learning Leadership" covers various important aspects of the application of technology in educational settings, from Kindergarten to high school. Communication technologies are used to strengthen connections between students, teachers and parents and support more collaborative and interactive learning (Blau et al., 2020; Hutchison et al., 2020). Qualitative research plays an important role in understanding the impact and effectiveness of technology use at different levels of education (Alalwan et al., 2020; Hermino et al., 2020; Winarto et al., 2020). In science, the use of technology enables more immersive and engaging experimentation and learning (Liu et al., 2020). Technology leadership is essential to ensure that all technology initiatives in schools are well managed and provide maximum benefit to all stakeholders (AlAjmi, 2022). With this approach, the result can be a dynamic, inclusive and effective learning environment across all levels of education.

The medium blue cluster titled "Creative Problem-Based Learning" highlights the use of technology to improve education across all levels of education, especially in Middle School. Creativity is sparked through a Problem-Based Learning approach supported by technology, allowing students to develop problem-solving and innovation skills (Bozkurt Altan et al., 2021; Suradika et al., 2023). Learning Disabilities are addressed with an inclusive approach, where technology is used to provide better accessibility to curriculum and learning materials (Atanga et al., 2020; Petretto et al., 2021). Programming and Technology Education is strengthened by the use of digital tools that allow students to learn and develop technical skills independently (Pinto et al., 2020; Scherer et al., 2020). This approach aims to create a learning environment that stimulates creativity and innovation, while providing the necessary support for all students, including those with learning challenges.

The pink cluster titled "Critical Integration in Project Learning" discusses ways in which education can combine key elements such as Critical Thinking, Planning, and Project-based Learning to provide a holistic and immersive learning experience. Through

this approach, students are not only given the opportunity to develop technical skills such as in Robotics, but are also invited to utilize critical thinking abilities in dealing with complex problems and projects (Shanta et al., 2022; Zadok, 2020). The integration between Critical Thinking, Planning, and Project-based Learning aims to prepare students with the necessary skills to succeed in the ever-changing modern world, where the ability to think critically and work in teams is essential (Sofya et al., 2021). With a focus on Project-based Learning, it offers contextualized and relevant learning experiences, allowing students to apply their knowledge in real-world situations and build deeper understanding.

The light pink cluster entitled "Web-Based Teaching and Learning" explores the use of technology in education, particularly in the context of E-learning and Online Learning. This approach involves the use of Web 2.0 platforms to effectively support Teaching and Learning, facilitate interaction between teachers and students and enable access to diverse educational resources online (Lim et al., 2020). This approach not only enables flexible and adaptive learning according to individual needs, but also encourages the development of innovative and collaborative learning methods. Web-Based Teaching and Learning brings new possibilities in online education, integrating technology thoroughly to improve the quality of teaching and learning in this digital age (Gupta et al., 2024).

Apart from grouping keywords, the author also analyzes the novelty of keywords using an overlay visualization menu. This step aims to identify the latest trends so that it can provide recommendations for further research in the field of technology use in the school environment.

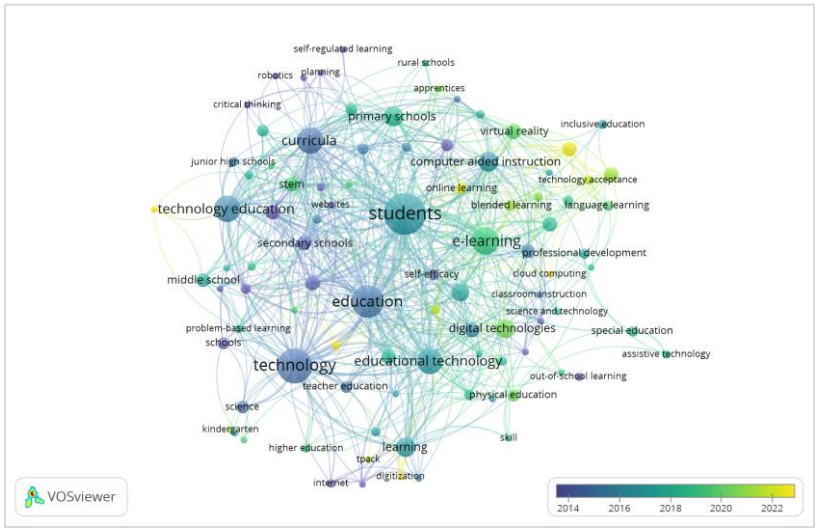

Figure 9. Keyword Novelty Analysis in the Overlay Visualization Menu in VOSviewer

In the overlay visualization menu, a brighter color indicates that the keyword was used in the most recent year. Figure 9 shows that 2022 is the most recent year with prominent keywords. One of the keywords that emerged was Artificial Intelligence (AI). In the context of technology in the school environment, AI has great potential to change the way teaching and learning are done. With AI, teaching can be tailored individually to each student, assisting teachers in assessing student performance, and providing more targeted guidance.

Another keyword is Programming, which is also gaining significant attention in 2022. Incorporating programming into the school curriculum not only helps students understand the basics of programming, but also develops critical thinking and problem-solving skills. With increasingly sophisticated technology, programming skills have become very important and relevant in preparing students for a future dominated by technology.

Digitization, Online Learning, Augmented Reality, and Cloud Computing are other keywords that are yellow and newest. Digitization allows easier and more efficient access to teaching materials, while Online Learning has become the main solution during the Covid-19 pandemic, enabling educational continuity in times of crisis. Augmented Reality brings an interactive and immersive learning experience, making learning more interesting for students. Cloud Computing, on the other hand, offers flexible data storage and access solutions, making collaboration between teachers and students easier. All of these keywords indicate recent trends in the use of technology in the school environment and constitute important recommendations for further research.

Conclusion

This research aims to analyze research trends in the field of technology use in the school environment. Using predetermined keywords, researchers selected documents using the PRISMA method and obtained 599 final documents which were analyzed using the R Program Biblioshiny, Publish or Perish 8, and VOSviewer to map trends in research results with bibliometric analysis. From this analysis it can be concluded that research on the use of technology in the school environment began in 1974 until 2024 with peak publications in 2023 and peak citations in 2018. The United States is the most productive country in the field of most productive countries. Nanyang Technological University is the most productive affiliate, recording the highest number of publications. Journal Q1 "Computers and Education" is the most productive journal with the highest h-index. Hyuksoo Kwon from the Republic of Korea is the writer with the highest h-index. The publication with the highest citations. There are 11 keyword clusters, with the keywords "Artificial Intelligence", "Programming", "Digitization", "Online Learning", "Augmented Reality", and "Cloud Computing" being the next recommended keywords if you want to do research in the field of use technology in the school environment.

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Author Contributions

Article writing was done by Y.I. Data collection and data analysis were done by Y.K.S, and Z.Z. Direction, guidance, review of ideas, concepts, methodology, analysis were done by S.H.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Adipat, S., Laksana, K., Busayanon, K., Asawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. *International Journal of Technology in Education*, *4*(3), 542–552. https://doi.org/10.46328/ijte.169

Agriani, F. (2023). Counseling Guidance Teacher Services in Increasing Student Learning Motivation from Broken Home Families. *Elementaria: Journal of Educational Research*, *1*(1), 1–13. https://doi.org/10.61166/elm.v1i1.1

Aithal, P. S., & Aithal, S. (2023). Stakeholders' Analysis of the Effect of Ubiquitous Education Technologies on Higher Education. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 102–133. Retrieved from https://ssrn.com/abstract=4453569

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, *2*(3), 431–440. https://doi.org/10.1007/s43681-021-00096-7

Al Hamad, N. M., Adewusi, O. E., Unachukwu, C. C., Osawaru, B., & Chisom, O. N. (2024). A review on the innovative approaches to STEM education. *International Journal of Science and Research Archive*, *11*(1), 244–252. https://doi.org/10.30574/ijsra.2024.11.1.0026

AlAjmi, M. K. (2022). The impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait. *International Journal of Educational Research*, *112*, 101928. https://doi.org/10.1016/j.ijer.2022.101928

Alalwan, N., Cheng, L., Al-Samarraie, H., Yousef, R., Alzahrani, A. I., & Sarsam, S. M. (2020). Challenges and prospects of virtual reality and augmented reality utilization among primary school teachers: A developing country perspective. *Studies in Educational Evaluation*, *66*, 100876. https://doi.org/10.1016/j.stueduc.2020.100876

Alam, A., & Mohanty, A. (2023). Learning on the Move: A Pedagogical Framework for State-of-the-Art Mobile Learning. *International Conference on Data Management, Analytics & Innovation*, 735–748. https://doi.org/10.1007/978-981-99-1414-2_52

Alenezi, A. (2020). The role of e-learning materials in enhancing teaching and learning behaviors. *International Journal of Information and Education Technology*, *10*(1), 48–56. Retrieved from https://www.ijiet.org/vol10/1338-JR373.pdf

Alika, O., & Radia, E. H. (2021). Development of Learning Media Based on Cross Puzzle Game in Science Learning to Improve Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 173–177. https://doi.org/10.29303/jppipa.v7i2.667

Ananda, D. P., Qurbaniah, M., & Rahayu, H. M. (2024). Implementation of the Environmental Exploration Learning Model (JAS) Assisted by Google Lens on the Scientific Literacy of Taman Mulia High School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4480–4485. https://doi.org/10.29303/jppipa.v10i8.8156

Anita, Y., Kenedi, A. K., Putera, R. F., Ladiva, H. B.,

Qolbi, N., & Akmal, A. U. (2024). A Flipped Classroom Learning Model Based on Social and Emotional Learning to Improve the Pancasila Student Profile Values in Science and Environment Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4510–4518. https://doi.org/10.29303/jppipa.v10i8.8357

Ansari, J. A. N., & Khan, N. A. (2020). Exploring the role of social media in collaborative learning the new domain of learning. *Smart Learning Environments*, *7*(1), 9. https://doi.org/10.1186/s40561-020-00118-7

Anthonysamy, L., Koo, A. C., & Hew, S. H. (2020). Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning. *Education and Information Technologies*, *25*(4), 2393–2414. https://doi.org/10.1007/s10639-020-10201-8

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Atanga, C., Jones, B. A., Krueger, L. E., & Lu, S. (2020). Teachers of students with learning disabilities: Assistive technology knowledge, perceptions, interests, and barriers. *Journal of Special Education Technology*, *35*(4), 236–248. https://doi.org/10.1177/0162643419864858

Autor, D. H. (2019). Work of the Past, Work of the Future. *AEA Papers and Proceedings*, *109*, 1–32. https://doi.org/10.1257/pandp.20191110

Azoury, N., & Abu-Ghazaleh, T. (2014). The Impact of Technological Development on Business and Education. *Business and Education in the Middle East*, 87–98. https://doi.org/10.1057/9781137396969_8

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills. *Journal of Turkish Science Education*, *18*(4), 798–815. Retrieved from https://www.tused.org/index.php/tused/article/view/1287/732

Bedregal-Alpaca, N., Sharhorodska, O., Tupacyupanqui-Jaen, D., & Corneko-Aparicio, V. (2020). Problem based learning with information and communications technology support: An experience in the teaching-learning of matrix algebra. *International Journal of Advanced Computer Science and Applications (IJACSA)*, *11*(3). Retrieved from https://www.academia.edu/download/85177772/Paper_15-Problem_based_Learning_with_Information.pdf

Berg, T. B., Achiam, M., Poulsen, K. M., Sanderhoff, L. B., & Tøttrup, A. P. (2021). The role and value of out-of-school environments in science education for 21st century skills. *Frontiers in Education*, *6*, 674541. https://doi.org/10.3389/feduc.2021.674541

Bergdahl, N., Nouri, J., Fors, U., & Knutsson, O. (2020). Engagement, disengagement and performance when learning with technologies in upper secondary school. *Computers & Education*, *149*, 103783. https://doi.org/10.1016/j.compedu.2019.103783

Bervell, B., & Umar, I. N. (2020). Blended learning or face-to-face? Does Tutor anxiety prevent the adoption of Learning Management Systems for distance education in Ghana? *Open Learning: The Journal of Open, Distance and e-Learning*, *35*(2), 159–177. https://doi.org/10.1080/02680513.2018.1548964

Blau, I., Shamir-Inbal, T., & Hadad, S. (2020). Digital collaborative learning in elementary and middle schools as a function of individualistic and collectivistic culture: The role of ICT coordinators' leadership experience, students' collaboration skills, and sustainability. *Journal of Computer Assisted Learning*, *36*(5), 672–687. https://doi.org/10.1111/jcal.12436

Botto, M., Federici, B., Ferrando, I., Gagliolo, S., & Sguerso, D. (2023). Innovations in geomatics teaching during the COVID-19 emergency. *Applied Geomatics*, *15*(3), 551–564. https://doi.org/10.1007/s12518-022-00416-4

Bozkurt Altan, E., & Tan, S. (2021). Concepts of creativity in design based learning in STEM education. *International Journal of Technology and Design Education*, *31*(3), 503–529. https://doi.org/10.1007/s10798-020-09569-y

Broadbent, J., Panadero, E., Lodge, J. M., & de Barba, P. (2020). Technologies to enhance self-regulated learning in online and computer-mediated learning environments. *Handbook of Research in Educational Communications and Technology: Learning Design*, 37–52. https://doi.org/10.1007/978-3-030-36119-8_3

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Camlin, D. A., & Lisboa, T. (2021). The digital 'turn'in music education. In *Music Education Research* (Vol. 23, Issue 2, pp. 129–138). Taylor & Francis. https://doi.org/10.1080/14613808.2021.1908792

Cardullo, V., Wang, C., Burton, M., & Dong, J. (2021). K-12 teachers' remote teaching self-efficacy during the pandemic. *Journal of Research in Innovative Teaching & Learning*, *14*(1), 32–45. https://doi.org/10.1108/JRIT-10-2020-0055

Castro, F. R., & da Cruz, F. M. (2023). Search strategies and information sources on the web used by students of an integrated technical course. *Seven Editora*. https://doi.org/10.56238/tfisdwv1-004

Chai, C. S., Koh, J. H. L., Tsai, C.-C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, *57*(1), 1184–1193. https://doi.org/10.1016/j.compedu.2011.01.007

Cheng, K.-H. (2024). Development of an immersive virtual reality system for learning about plants in primary education: evaluation of teachers' perceptions and learners' flow experiences and learning attitudes. *Educational Technology Research and Development*, *72*(2), 845–867. https://doi.org/10.1007/s11423-023-10300-6

Cheng, S.-C., & Lai, C.-L. (2020). Facilitating learning for students with special needs: a review of technology-supported special education studies. *Journal of Computers in Education*, *7*(2), 131–153. https://doi.org/10.1007/s40692-019-00150-8

Cheng, Y.-M., Lou, S.-J., Kuo, S.-H., & Shih, R.-C. (2013). Investigating elementary school students' technology acceptance by applying digital game-based learning to environmental education. *Australasian Journal of Educational Technology*, *29*(1). https://doi.org/10.14742/ajet.65

Criollo-C, S., Guerrero-Arias, A., Jaramillo-Alcázar, Á., & Luján-Mora, S. (2021). Mobile learning technologies for education: Benefits and pending issues. *Applied Sciences*, *11*(9), 4111. https://doi.org/10.3390/app11094111

Davis, N. (2017). *Digital technologies and change in education: The arena framework*. Routledge.

De Smet, C., Bourgonjon, J., De Wever, B., Schellens, T., & Valcke, M. (2012). Researching instructional use and the technology acceptation of learning management systems by secondary school teachers. *Computers & Education*, *58*(2), 688–696. https://doi.org/10.1016/j.compedu.2011.09.013

Dipayana, I. M., Dewi, N. P., Tandi, J., Wirawan, W., Rachmawati, M., & Azizah, N. (2024). Sub-Chronic Toxicity Test of Purple Leaf Extract on the Kidney Histopathology of Male White Rats. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4572–4578. https://doi.org/10.29303/jppipa.v10i8.8312

Downie, S., Gao, X., Bedford, S., Bell, K., & Kuit, T. (2021). Technology enhanced learning environments in higher education: A cross-discipline study on teacher and student perceptions. *Journal of University Teaching and Learning Practice*, *18*(4). https://doi.org/10.53761/1.18.4.12

Ghavifekr, S., & Rosdy, W. A. W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science*, *1*(2), 175–191. https://doi.org/10.21890/ijres.23596

Goos, M., Galbraith, P., Renshaw, P., & Geiger, V. (2003). Perspectives on technology mediated learning in secondary school mathematics classrooms. *The Journal of Mathematical Behavior*, *22*(1), 73–89. https://doi.org/10.1016/S0732-3123(03)00005-1

Gupta, A. K., Aggarwal, V., Sharma, V., & Naved, M. (2024). Education 4.0 and Web 3.0 Technologies Application for enhancement of distance learning management Systems in the Post–COVID-19 ERa. In *The Role of Sustainability and Artificial Intelligence in Education Improvement* (pp. 66–86). Chapman and Hall/CRC. https://doi.org/10.1201/9781003425779-4

Haryono, H. E., Zayyadi, M., Marzuqi, I., & Kaniawati, I. (2024). The Effectiveness of Collaborative E-Learning-Based Learning in Reducing Student Misconceptions on Heat in East Java High Schools During Merdeka Belajar. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4543–4550. https://doi.org/10.29303/jppipa.v10i8.8179

Hashim, N. H., Ariffin, N. A., Abdullah, N. A. C., & Harun, N. O. (2024). Using BioBoard-G: A Board Game for Enhancing Understanding of Cell Division for Secondary School. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *38*(2), 83–94. https://doi.org/10.37934/araset.38.2.8394

Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology use for teacher professional development in low-and middle-income countries: A systematic review. *Computers and Education Open*, *3*, 100080. https://doi.org/10.1016/j.caeo.2022.100080

Hermino, A., & Arifin, I. (2020). Contextual character education for students in the senior high school. *European Journal of Educational Research*, *9*(3), 1009–1023. https://doi.org/10.12973/eu-jer.9.3.1009

Hutchison, K., Paatsch, L., & Cloonan, A. (2020). Reshaping home–school connections in the digital age: Challenges for teachers and parents. *E-Learning and Digital Media*, *17*(2), 167–182. https://doi.org/10.1177/2042753019899527

Ismail, M., Zubair, M., Alqadri, B., & Basariah, B. (2023). Integration of technological pedagogical and content knowledge in 21st Century learning. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2363–2367. https://doi.org/10.29303/jppipa.v9i5.3732

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Substantial capabilities of robotics in enhancing industry 4.0 implementation. *Cognitive Robotics*, *1*, 58–75. https://doi.org/10.1016/j.cogr.2021.06.001

Jiang, J., & Fryer, L. K. (2024). The effect of virtual reality learning on students' motivation: A scoping review. *Journal of Computer Assisted Learning*, *40*(1), 360–373. https://doi.org/10.1111/jcal.12885

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual reality and its applications in education: Survey. *Information*, *10*(10), 318. https://doi.org/10.3390/info10100318

Kardipah, S., & Wibawa, B. (2020). A flipped-blended learning model with augmented problem based learning to enhance students' computer skills. *TechTrends*, *64*(3), 507–513. https://doi.org/10.1007/s11528-020-00506-3

Kim, K. G., Oertel, C., Dobricki, M., Olsen, J. K., Coppi, A. E., Cattaneo, A., & Dillenbourg, P. (2020). Using immersive virtual reality to support designing skills in vocational education. *British Journal of Educational Technology*, *51*(6), 2199–2213. https://doi.org/10.1111/bjet.13026

Kim, P., Miranda, T., & Olaciregui, C. (2008). Pocket school: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America. *International Journal of Educational Development*, *28*(4), 435–445. https://doi.org/10.1016/j.ijedudev.2007.11.002

Knoblauch, C. (2022). Digital project-based learning in the higher education sector. *Innovations in Learning and Technology for the Workplace and Higher Education: Proceedings of 'The Learning Ideas Conference'2021*, 170–179. https://doi.org/10.1007/978-3-030-90677-1_17

Krasnova, E., Masalova, M., & Shelkovnikova, S. (2023). Motivation as a necessary condition for learning in the age of digitalization. *E3S Web of Conferences*, *371*, 5076. https://doi.org/10.1051/e3sconf/202337105076

Krause, J. M., O'Neil, K., & Jones, E. (2020). Technology in physical education teacher education: A call to action. *Quest*, *72*(3), 241–259. https://doi.org/10.1080/00336297.2019.1685553

Laranjeiro, D. (2022). Open Education Smart Campus–technological development of an educational platform. *2022 International Symposium on Computers in Education (SIIE)*, 1–4. https://doi.org/10.1109/SIIE56031.2022.9982359

Lazar, I., & Panisoara, I. O. (2018). Understanding the role of modern technologies in education: A scoping review protocol. *Psychreg J. Psychol*, *2*(2), 74–86. Retrieved from https://www.pjp.psychreg.org/wp-content/uploads/2018/12/74-86.pdf

Lestari, Y., & Sunarso, A. (2024). Development of Interactive Media Based on GIPAS Application Assisted by Self-Directed Learning Model to Improve Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4461–4469. https://doi.org/10.29303/jppipa.v10i8.7462

Li, D., & Begalieva, S. (2022). Using Video Materials for Teaching Chinese Students the Russian Language in Distance Learning During the Period of the COVID-19Pandemic. *Eurasian Journal of Educational Research*, *98*(98), 302–317. Retrieved from https://ejer.com.tr/using-video-materials-for-teaching-chinese-students-the-russian-language-in-distance-learning-during-the-period-of-the-covid-19pandemic-2/

Lim, J., & Newby, T. J. (2020). Preservice teachers' Web 2.0 experiences and perceptions on Web 2.0 as a personal learning environment. *Journal of Computing in Higher Education*, *32*(2), 234–260. https://doi.org/10.1007/s12528-019-09227-w

Liu, R., Wang, L., Lei, J., Wang, Q., & Ren, Y. (2020). Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons. *British Journal of Educational Technology*, *51*(6), 2034–2049. https://doi.org/10.1111/bjet.13028

Marino, M. T., Vasquez, E., Dieker, L., Basham, J., & Blackorby, J. (2023). The future of artificial intelligence in special education technology. *Journal of Special Education Technology*, *38*(3), 404–416. https://doi.org/10.1177/01626434231165977

McKenna, J. W. (2024). Systematic Literature Reviews. In *Research Methods in Special Education* (pp. 89–111). Routledge.

Minich, A., Berezovski, Y., Metelkin, D., Timirgalin, A., Volkov, G., & Mukminov, I. (2019). Technological development to enhance the value of a exploration business case. *Progress' 19*, *2019*(1), 1–5. https://doi.org/10.3997/2214-4609.201953013

Mishra, V., & Mishra, M. P. (2023). PRISMA for Review of Management Literature–Method, Merits, and Limitations–An Academic Review. *Advancing Methodologies of Conducting Literature Review in Management Domain*, 125–136. https://doi.org/10.1108/s2754-586520230000002007

Moor, J. H. (2020). What is computer ethics? In *The Ethics of Information Technologies* (pp. 15–24). Routledge.

Muhammad, K., Khan, N., Lee, M.-Y., Imran, A. S., & Sajjad, M. (2021). School of the future: A comprehensive study on the effectiveness of

augmented reality as a tool for primary school children's education. *Applied Sciences*, *11*(11), 5277. https://doi.org/10.3390/app11115277

Mulders, M., Buchner, J., & Kerres, M. (2024). Virtual reality in vocational training: A study demonstrating the potential of a VR-based vehicle painting simulator for skills acquisition in apprenticeship training. *Technology, Knowledge and Learning*, *29*(2), 697–712. https://doi.org/10.1007/s10758-022-09630-w

Nsabayezu, E., Iyamuremye, A., Mbonyiryivuze, A., Niyonzima, F. N., & Mukiza, J. (2023). Digital-based formative assessment to support students' learning of organic chemistry in selected secondary schools of Nyarugenge District in Rwanda. *Education and Information Technologies*, 1–31. https://doi.org/10.1007/s10639-023-11599-7

Onofrei, G., & Ferry, P. (2020). Reusable learning objects: a blended learning tool in teaching computer-aided design to engineering undergraduates. *International Journal of Educational Management*, *34*(10), 1559–1575. https://doi.org/10.1108/IJEM-12-2019-0418

Otitolaiye, V. O., & Abd Aziz, F. S. (2024). Bibliometric analysis of safety management system research (2001–2021). *Journal of Safety Research*, *88*, 111–124. https://doi.org/10.1016/j.jsr.2023.10.014

Owens, A. D., & Hite, R. L. (2022). Enhancing student communication competencies in STEM using virtual global collaboration project based learning. *Research in Science & Technological Education*, *40*(1), 76–102. https://doi.org/10.1080/02635143.2020.1778663

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., & Moher, D. (2021). Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. *Journal of Clinical Epidemiology*, *134*, 103–112. https://doi.org/10.1016/j.jclinepi.2021.02.003

Peruzzo, F., & Allan, J. (2024). Rethinking inclusive (digital) education: Lessons from the pandemic to reconceptualise inclusion through convivial technologies. *Learning, Media and Technology*, *49*(2), 244–258. https://doi.org/10.1080/17439884.2022.2131817

Petretto, D. R., Carta, S. M., Cataudella, S., Masala, I., Mascia, M. L., Penna, M. P., Piras, P., Pistis, I., & Masala, C. (2021). The Use of Distance Learning and E-learning in Students with Learning Disabilities: A Review on the Effects and some Hint of Analysis on the Use during COVID-19 Outbreak. *Clinical Practice and Epidemiology in Mental Health: CP & EMH*, *17*, 92. https://doi.org/10.2174%2F1745017902117010092

Pinto, M., & Leite, C. (2020). Digital technologies in support of students learning in Higher Education: literature review. *Digital Education Review*, *37*, 343–360. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=7615204

Plowman, L., Stephen, C., & McPake, J. (2010). Supporting young children's learning with technology at home and in preschool. *Research Papers in Education*, *25*(1), 93–113. https://doi.org/10.1016/j.compedu.2011.11.014

Plowman, L., Stevenson, O., Stephen, C., & McPake, J. (2012). Preschool children's learning with technology at home. *Computers & Education*, *59*(1), 30–37. https://doi.org/10.1080/02671520802584061

Rabbanee, F. K., Roy, R., & Spence, M. T. (2020). Factors affecting consumer engagement on online social networks: self-congruity, brand attachment, and self-extension tendency. *European Journal of Marketing*, *54*(6), 1407–1431. https://doi.org/10.1108/EJM-03-2018-0221

Rahmat, A., Syakhrani, A. W., & Satria, E. (2021). Promising online learning and teaching in digital age: Systematic review analysis. *International Research Journal of Engineering, IT and Scientific Research*, *7*(4), 126–135. https://doi.org/10.21744/irjeis.v7n4.1578

Ramadhani, A. M., & Retnawati, H. (2024). Computational Thinking and its Application in School: A Bibliometric Analysis (2008-2023). *International Conference on Current Issues in Education (ICCIE 2023)*, 329–338. https://doi.org/10.2991/978-2-38476-245-3_35

Rau, P.-L. P., Gao, Q., & Wu, L.-M. (2008). Using mobile communication technology in high school education: Motivation, pressure, and learning performance. *Computers & Education*, *50*(1), 1–22. https://doi.org/10.1016/j.compedu.2006.03.008

Reimers, F. M., & Schleicher, A. (2020). *A framework to guide an education response to the COVID-19 Pandemic of 2020* (Vol. 14, Issue 04). Oecd Paris.

Rif, D., & Wilujeng, I. (2024). Physics Learning Media Based on Mobile Learning on the Android Platform to Increase Student's HOTS. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4470–4479. https://doi.org/10.29303/jppipa.v10i8.7261

Rinkinen, T., Kinnula, M., & Nordquist, H. (2024). Technological development roles and needs in pre-hospital emergency care from the advanced level paramedics' perspective. *International Emergency Nursing*, *73*, 101406. https://doi.org/10.1016/j.ienj.2024.101406

Rodrigues, A. L. (2020). Digital technologies integration

in teacher education: the active teacher training model. *Journal of E-Learning and Knowledge Society*, *16*(3), 24–33. https://doi.org/10.20368/1971-8829/1135273

Rogne, W. M., Rønneberg, V., Gamlem, S. M., Spilling, E. F., & Uppstad, P. H. (2024). Effects of digitalisation on learning to write–A naturalistic experiment. *Learning and Instruction*, *93*, 101970. https://doi.org/10.1016/j.learninstruc.2024.101970

Rudinger, B. J. (2020). Technology-Enhanced Learning. In *Quality Education* (pp. 876–884). Springer. https://doi.org/10.1007/978-3-319-95870-5_62

Rusydiana, A. S., Rahardjo, S., & Soeparno, W. S. (2021). Mapping research on halal logistics using VOSviewer. *Library Philosophy and Practice*, *2021*, 1–14. Retrieved from https://core.ac.uk/download/pdf/478907998.pdf

Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, *144*, 103710. https://doi.org/10.1016/j.compedu.2019.103710

Sailer, M., Murböck, J., & Fischer, F. (2021). Digital learning in schools: What does it take beyond digital technology? *Teaching and Teacher Education*, *103*, 103346. https://doi.org/10.1016/j.tate.2021.103346

Scherer, R., Siddiq, F., & Viveros, B. S. (2020). A meta-analysis of teaching and learning computer programming: Effective instructional approaches and conditions. *Computers in Human Behavior*, *109*, 106349. https://doi.org/10.1016/j.chb.2020.106349

Schmid, R., & Petko, D. (2019). Does the use of educational technology in personalized learning environments correlate with self-reported digital skills and beliefs of secondary-school students? *Computers & Education*, *136*, 75–86. https://doi.org/10.1016/j.compedu.2019.03.006

Schmidt, J. T., & Tang, M. (2020). Digitalization in education: challenges, trends and transformative potential. *Führen Und Managen in Der Digitalen Transformation: Trends, Best Practices Und Herausforderungen*, 287–312. https://doi.org/10.1007/978-3-658-28670-5_16

Selwyn, N. (2019). *Should robots replace teachers?: AI and the future of education*. John Wiley & Sons.

Sembiring, Y. K., Purbani, W., Damsi, M., & Salimah, Z. (2024). A Bibliometric Analysis: The Use of Artificial Intelligence in Foreign Language Learning. *International Conference on Current Issues in Education (ICCIE 2023)*, 444–454. https://doi.org/10.2991/978-2-38476-245-3

Shadiev, R., & Yang, M. (2020). Review of studies on technology-enhanced language learning and teaching. *Sustainability*, *12*(2), 524. https://doi.org/10.3390/su12020524

Shanta, S., & Wells, J. G. (2022). T/E design based learning: assessing student critical thinking and problem solving abilities. *International Journal of Technology and Design Education*, *32*(1), 267–285. https://doi.org/10.1007/s10798-020-09608-8

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2011). Effects of technology immersion on middle school students' learning opportunities and achievement. *The Journal of Educational Research*, *104*(5), 299–315. https://doi.org/10.1080/00220671003767615

Sidiki, S. A. A., Abdjul, T., Lamangantjo, C. J., Buhungo, T. J., Yusuf, F. M., & Hermanto, I. M. (2024). The Implementation of PBL Model on Student Learning Outcomes in the Concept of Life Organizational Systems. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4486–4497. https://doi.org/10.29303/jppipa.v10i8.8100

Silamut, A., & Petsangsri, S. (2020). Self-directed learning with knowledge management model to enhance digital literacy abilities. *Education and Information Technologies*, *25*(6), 4797–4815. https://doi.org/10.1007/s10639-020-10187-3

Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. *Journal of Educational Technology Systems*, *50*(2), 140–171. https://doi.org/10.1177/00472395211047865

Sitorus, E., Sihombing, P., Panataria, L. R., & Saragih, M. K. (2024). The Effect of NASA Liquid Organic Fertilizer and Chicken Manure on the Growth of Sweet Corn Plants (Zea mays saccharata Sturt). *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4551–4560. https://doi.org/10.29303/jppipa.v10i8.7530

Sofya, R., & Ritonga, M. (2021). Analysis and Development of Learning Plans Using Project Based Learning Model in Fostering 4 Cs Skills of Economics Education Students. *Sixth Padang International Conference On Economics Education, Economics, Business and Management, Accounting and Entrepreneurship (PICEEBA 2020)*, 294–301. https://doi.org/10.2991/aebmr.k.210616.044

Sulastri, S. (2023). Application of the Assignment Method in Enhancing Student Learning Enthusiasm in the Subject of Jurisprudence. *Elementaria: Journal of Educational Research*, *1*(1 SE-Articles), 54–64.

https://doi.org/10.61166/elm.v1i1.5

Suradika, A., Dewi, H. I., & Nasution, M. I. (2023). Project-based learning and problem-based learning models in critical and creative students. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 153–167. https://doi.org/10.15294/jpii.v12i1.39713

Suryanarayana, K. S., Kandi, V. S. P., Pavani, G., Rao, A. S., Rout, S., & Krishna, T. S. R. (2024). Artificial Intelligence Enhanced Digital Learning for the Sustainability of Education Management System. *The Journal of High Technology Management Research*, *35*(2), 100495. https://doi.org/10.1016/j.hitech.2024.100495

Syahfitri, J. (2024). The utilization of local wisdom-based interactive digital module to improve students' critical thinking skills. *International Journal of STEM Education for Sustainability*, *4*(1), 110–119. https://doi.org/10.53889/ijses.v4i1.305

Syvyi, M., Mazbayev, O., Varakuta, O., Panteleeva, N., & Bondarenko, O. (2022). Distance learning as innovation technology of school geographical education. *ArXiv Preprint ArXiv:2202.08697*. https://doi.org/10.48550/arXiv.2202.08697

Tekerek, A., Fırat, S., Bingöl, A. S., Güzel, A., & Elbasan, B. (2024). Assistive Technologies in Higher Education for Special Education. In *Applied Assistive Technologies and Informatics for Students with Disabilities* (pp. 135–152). Springer. https://doi.org/10.1007/978-981-97-0914-4_8

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): A mixed-method study. *Educational Technology Research and Development*, *68*(1), 319–343. https://doi.org/10.1007/s11423-019-09692-1

Topol, E. (2019). *Deep medicine: how artificial intelligence can make healthcare human again*. Hachette UK.

Tosun, C. (2024). Analysis of the last 40 years of science education research via bibliometric methods. *Science & Education*, *33*(2), 451–480. https://doi.org/10.1007/s11191-022-00400-9

Tuma, F. (2021). The use of educational technology for interactive teaching in lectures. *Annals of Medicine and Surgery*, *62*, 231–235. https://doi.org/10.1016/j.amsu.2021.01.051

Ülker, P., Ülker, M., & Karamustafa, K. (2023). Bibliometric analysis of bibliometric studies in the field of tourism and hospitality. *Journal of Hospitality and Tourism Insights*, *6*(2), 797–818. https://doi.org/10.1108/JHTI-10-2021-0291

Uludag, G. (2021). Views of Preschool Teachers on Using Out-of-School Learning Environments in Preschool Education. *International Online Journal of Education and Teaching*, *8*(2), 1225–1249. Retrieved from https://eric.ed.gov/?id=EJ1294339

UNESCO Division for Inclusion and sustainable development, education sector, P. (2017). *Education for Sustainable Development Goals: Learning Objectives*. United Nations Educational Scientific and Cultural Organization.

Wahyuni, A., Kusumah, Y. S., Martadiputra, B. A. P., & Zafrullah, Z. (2024). Tren penelitian kemampuan pemecahan masalah pada pendidikan matematika: Analisis bibliometrik. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *7*(2), 337–356. https://doi.org/10.22460/jpmi.v7i2.22329

Winarto, W., Syahid, A., & Saguni, F. (2020). Effectiveness the use of audio visual media in teaching islamic religious education. *International Journal of Contemporary Islamic Education*, *2*(1), 81–107. https://doi.org/10.24239/ijcied.Vol2.Iss1.14

Wiyaka, W., & Fani Prastikawati, E. (2020). Plickers as an online formative assessment to improve secondary school students' English learning. *Proceedings of the the 3rd International Conference on Education & Social Science Research (ICESRE)*. https://dx.doi.org/10.2139/ssrn.3864809

Yates, A., Starkey, L., Egerton, B., & Flueggen, F. (2021). High school students' experience of online learning during Covid-19: the influence of technology and pedagogy. *Technology, Pedagogy and Education*, *30*(1), 59–73. https://doi.org/10.1080/1475939X.2020.1854337

Yeung, C. A., Liccardi, I., Lu, K., Seneviratne, O., & Berners-Lee, T. (2023). Decentralization: The future of online social networking. In *Linking the World's Information: Essays on Tim Berners-Lee's Invention of the World Wide Web* (pp. 187–199). https://doi.org/10.1145/3591366.3591383

Yurtseven Avci, Z., O'Dwyer, L. M., & Lawson, J. (2020). Designing effective professional development for technology integration in schools. *Journal of Computer Assisted Learning*, *36*(2), 160–177. https://doi.org/10.1111/jcal.12394

Zadok, Y. (2020). Project-based learning in robotics meets junior high school. *Journal of Engineering, Design and Technology*, *18*(5), 941–958. https://doi.org/10.1108/JEDT-01-2019-0023

Zafrullah, Z., Hardi, V. A., Nabilah, N., & Fitriani, A. (2024). Transforming the Utilization of ChatGPT in Education: A Bibliometric Analysis. *Innovative: Journal Of Social Science Research*, *4*(1), 5316–5329. https://doi.org/10.31004/innovative.v4i1.5578

Zafrullah, Z., Ibrahim, Z. S., Ariawan, R., Ulwiyah, S., & Ayuni, R. T. (2024). Research on Madrasas in International Publications: Bibliometric Analysis with Vosviewer. *COMPETITIVE: Journal of Education*, *3*(2), 116–127. https://doi.org/10.58355/competitive.v3i2.93

Zafrullah, Z., & Ramadhani, A. M. (2024). The Use of Mobile Learning in Schools as A Learning Media: Bibliometric Analysis. *Indonesian Journal of Educational Research and Technology*, *4*(2), 187–202. https://doi.org/10.17509/ijert.v4i2.65586

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. https://doi.org/10.1177/1094428114562629