Trends and research patterns of blended learning in science education: A VOSviewer-based bibliometric analysis

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Abstract
Blended learning combines online and face-to-face, creating a dynamic and interactive learning environment. This article aims to provide a comprehensive bibliometric literature review on "blended learning in science learning". Articles found with the Scopus database. There are 100 out of 449 articles found in the Scopus database from 2020 to 2024 analyzed in this study. The selected references were then managed using reference management software, namely Mendeley. After managing the database, these studies classified and visualized them using VOSviewer software. The results of this study are that the distribution of authors who research topics related to blended learning in science learning is still dominated by the United States and Indonesia. The gap in this study shows the future agenda's direction: blended learning in science learning is very important to study. Overall, teaching and learning activities using blended learning in science learning tend to increase yearly. This is also needed for more inter-regional research collaborations involving researchers from Asia and other developing countries in certain areas. Overall, this review provides a good reference point for further research on "blended learning in science learning".

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1. Introduction

Blended learning, as integration between learning look at face to face and online learning, has gotten significant attention in education literature, especially in the context of education science. In the era of continuous technological development. This creates an environment supportive of learning, where students can experience learning more dynamically and interactively (Redhana, 2024). By merging elements of learning conventional and digital, blended learning is not only renewing the teaching method but also revolutionizing the method students interact with the material lessons (Chastanti et al., 2024; Marni et al., 2024). Blended learning utilizes progressive technology such as online learning platforms, interactive applications, and multimedia tools. Students can access content flexibly (Muttaqin, 2024; Wahyudi & Jatun, 2024). For example, students can watch explanatory videos, participate in discussion forums, and finish online quizzes to strengthen their understanding. Flexibility This ensures students can Study in accordance with the rhythm they want, giving they more control of the learning process (Putro et al., 2023). This is very important in educational science because it allows students to experiment virtually. No available in the class physique.

Latest research underlines the value of blended learning in increasing the involvement of students and facilitating effective learning through pleasant interaction with concepts, scientific (Fahma et al., 2023; Janah & Ristianah, 2024; Kurniawati et al., 2024). Blended learning has many advantages in its application in the learning process. Therefore, it is important to study this blended learning.

Blended learning utilizes technology to increase the experience of students and makes learning more interesting (Khasanah et al., 2023; Rizkiyah, 2015). The essence of blended learning is the integration of strategic mechanisms of technology in content education, producing an experience that is significant and can increase the motivation and interest of students (Handayani et al., 2025; Lase, 2022; Sodikin et al., 2025). Blended learning

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fosters skills in thinking critically, analytically, and problem-solving (Awaliyah et al., 2023; Lestari et al., 2016; Suharyat et al., 2022; Sulistiyoningsih et al., 2015). Review systematic literature shows that blended learning has proven to grow an environment where students are more actively involved in a way that deepens their understanding of principles of scientific (Kasingku & Lotulung, 2024)

Gap Analysis: However, even though interest and existing literature about blended learning are increasing, there is still a real gap in its consistent implementation in education science. As research shows, a framework for effective blended learning design has started to emerge, but practical implementation in diverse educational contexts remains inconsistent and lacks a comprehensive pedagogical strategy (Yelia et al., 2024; Rasheed et al., 2020; Bervell & Arkorful, 2020). Furthermore, variations in teachers' understanding and acceptance of blended learning as a pedagogical tool present major obstacle to its widespread and effective application (Kurniawan, 2023; Bond et al., 2021; Bao, 2020). Research on blended learning has been widely discussed in health (Putra & Sofyan, 2019; Rohendi et al., 2020), sports (Masgumelar & Mustafa, 2021; Rodriquez et al., 2020), arts and culture (Istiqomah & Azizah, 2013), civic education (Hasan, 2022; Marlina, 2022), mathematics (Anggraini, 2018; Aritonang & Safitri, 2021), and English (Susanti & Prameswari, 2020; Suwarti et al., 2022). However, its application in science subjects such as physics, chemistry, or biology is rarely explored (Singh et al., 2021; López-Pérez et al., 2022).

A bibliometric analysis will reveal a comprehensive outlook on how blended learning has been applied and understood within science. This analysis provides educators with a better understanding of trends, best practices, and research gaps in blended learning, potentially guiding future pedagogical strategies. The bibliometric method identifies major research themes and scientific discourse, encouraging an evidence-based framework for future blended learning interventions. Furthermore, the insights gained from such analysis can inform curriculum developers and policymakers in designing educational strategies that effectively leverage blended learning as a critical engagement tool in science education.

Purpose or Hypotheses of the Study: This research aims to identify and visualize related publications with blended learning in education, especially in Science Education. In detail, the research aims to know the trend of writing blended learning articles in education science from the publication amount every year, country, influential authors in the field, and the development of publication maps. This is based on keywords.

2. Method

Review library bibliometrics This is based on the method of systematic and explicit (Garza-Reyes, 2015) or method mapping the mind that emphasizes boundaries knowledge (Tranfield et al., 2003). Research methods This adopts a five-step method (Hudha et al., 2020; Rukmana et al., 2023; Setyaningsih et al., 2018; Tranfield et al., 2003; Zupic & Čater, 2014) as in Figure 1.

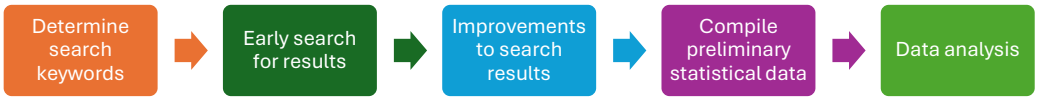


Figure 1. Analysis bibliometrics five step method

2.1. Define keywords search

Search literature done in December 2024 with the keywords "Blended Learning" and "Science Education." Scopus was selected because it is the largest database. Search first with the keywords “Blended Learning” and “Science Education.”

2.2. Search results beginning

Search This special for “journal”, “article”, “final publication stage”, “in English”, and the year “2019-2024”. A total of 449 articles were found on search beginning. The result was compiled in Comma-Separated Values (CSV) format to include all important information article, such as Name, author, author, ID, title, article, year, article, source title, volume, issue, and Art. No., page start, page end, page count, cited by, DOI, article link, affiliate, abstract, keywords, keyword index, publisher, ISSN, ISBN, CODEN, Abbreviated Source Title, Document Type, and Source.

2.3. Improvement results search

Relevant and indexed articles in the Scopus database were filtered. Discussions outside of learning science Are Not included in this data. It is just a discussion related to learning selected science. Then, for appropriate fixes, the file is saved in CSV file format. CSV data is imported to the device soft bibliography Delay. The generated CSV file is used for more data analysis.

2.4. Compiling initial data statistics

The data collected is saved in CSV format. At this stage, components complete the article journal (year published, volume, number, page, etc.), check and add required information if the data is not complete, and carry out data analysis so that the article can be classified based on year, source published, number of citations, and publisher.

2.5. Data analysis

Analysis of bibliometrics in study This using filter from Scopus. However, to analyze and visualize network bibliometrics used device soft Vosviewer (Martínez-López et al., 2020; Shukla et al., 2020). VOSviewer is used Because of his ability to work in a way efficient with large data sets and provides various interesting visuals, analyses, and investigations (Hakim, 2020; Hamidah et al., 2020; Machmuda et al., 2022; Van Eck & Waltman, 2010; Zakiyyah et al., 2022). Vosviewer can also create map publications, map authors, or map journals based on a co-citation network or build a keyword map based on a network together.

This study has several unique features compared to previous studies on blended learning in Science Education. First, the method used is a systematic five step bibliometric method, which describes the findings and visually maps the trends and relationships of the literature using VOSviewer. Second, this study specifically focuses on the analysis of blended learning in the context of science learning (physics, chemistry, biology), which is still rarely discussed in the literature. Third, the data is taken exclusively from the Scopus database with strict filters, ensuring the quality and relevance of the articles. Fourth, the analysis is quantitatively and visually represented through citation networks and keywords. Finally, the time coverage is the current period (2019–2024), thus presenting the most up-to-date picture of the trends and directions of blended learning research in science education.

3. Results and Discussion

3.1. Publication

After the refinement, 100 articles were obtained from the Scopus database. This data has been properly verified in the Scopus database for 2020-2024 with the keywords "Blended Learning" and "Science Education". Figure 2 presents the number of publications from 2020-2024 on blended learning in science learning.

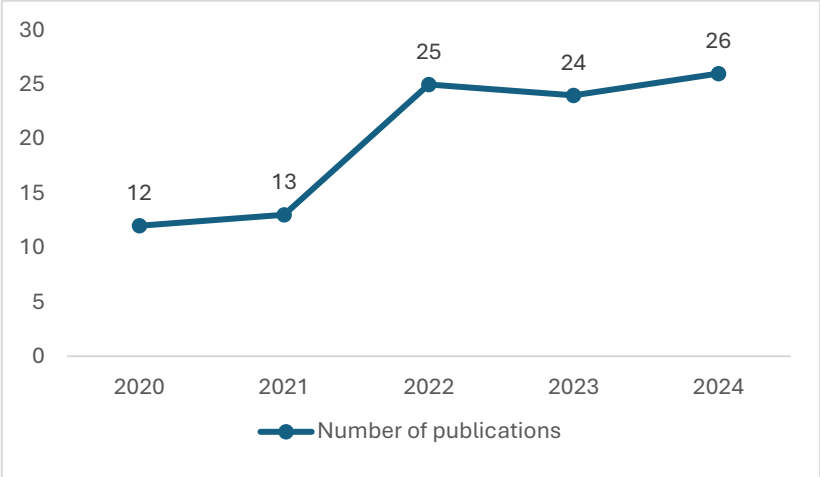


Figure 2. Number of Publications Each Year

Based on Figure 2, the Scopus database search results produced 100 documents on Blended Learning in Science Learning from 2020 to 2024. The number of documents published showed a decline in 2023. Data for 2024 is still being updated, and the number of publications in that year is expected to increase compared to 2020, 2021, 2022, and 2023. This is due to the influence of the impact of the industrial revolution 4.0 with increasingly rapid technological advances (Febrianti et al., 2021; Sari & Priatna, 2020). These technological advances affect the world of education, such as learning media that are integrated with technology (Handiyani & Abidin, 2023; Saputra et al., 2023).

The researcher tried to present the most relevant contribution to this study. The steps taken were to take 100 articles with the keyword "blended learning in science learning" that had the highest citation score (the top 10 cited articles). The results are obtained in Table 1.

Table 1. Top 10 cited articles

No	Writer	Findings	Publisher	Citation	SJR/ Quartile
1	(Rajabalee & Santally, 2021)	Implications for institutional e-learning policymaking to enhance student experience. Important factors related to the policy object, learning design models, student support and counseling, and learning analytics.	Kluwer Academic Publishers	183	1 .3/Q1
2	(Chirikov et al., 2020)	Online and blended instruction produces similar student learning outcomes as traditional face-to-face instruction at a much lower cost. Adopting these models at scale reduces faculty compensation costs that can fund increased STEM enrollment.	American Association for the Advancement of Science	94	4.48/Q1
3	(Seage & Turgen, 2020)	The teaching method had a statistically significant effect on the linear combination of science, technology, mathematics, and engineering scores ($F(4,124) = 80.27$, $p < .0001$, Pillai's Trace = .721, partial $\eta 2 = .721$), which supports the blended learning approach.	Ismail Sahin	64	
4	(Halasa et al., 2020)	Statistically significant improvement in student grades in the experimental group. Predictability calculations also indicate better learning outcomes if blended learning with flipped classroom design continues to be used in the future.	Wiley-Blackwell Publishing Ltd	56	0.78/Q1
5	(Iqbal et al., 2022)	The current literature is reviewed, challenges are explored, future research areas are identified, and finally, two case studies are reported that highlight the first steps needed to address these research areas. The results of this study ultimately detail the research gaps needed to facilitate real-time touchless hand-held interaction, kinesthetic learning, and machine learning agents with distance learning pedagogy.	Multidisciplinary Digital Publishing Institute (MDPI)	48	0.54/Q2
6	(Delgado, 2021)	The analysis yielded meaningful evidence that the course's skills-based development was well supported by digital delivery during the lockdown. Furthermore, differences in student performance across different sections of the course content were statistically significant and are discussed in this paper.	Multidisciplinary Digital Publishing Institute (MDPI)	31	0.81/Q2
7	(Bhutoria & Aljabri, 2022)	Positive impacts of ICT engagement on students' test scores across all subjects. However, ICT use outcomes tend to decline once students' engagement levels cross a moderate threshold of using ICT several times a week. Furthermore, heterogeneity analysis supports a marked decline in ICT use regardless of students' economic status. Cross-country comparisons suggest that declining ICT use outcomes are more pronounced in countries with well-developed ICT infrastructure than in less developed countries. If declining outcomes occur, excessive use of ICT in education is not an optimal choice, and significant cognitive gains can be achieved by using complementarities between traditional and ICT-based learning techniques in a variety of blended settings.	Elsevier Ltd	21	3.65/Q1
8	(Yilmaz & Malone, 2020)	Data analysis from the post-test survey research design alone indicated that students' perceptions were positive toward the use of blended learning in their science education methods course. However, the analysis determined that students felt that certain technical aspects of the blended learning environment hindered their learning.	SpringerOpen	20	1.57/Q1
9	(Nielsen et al., 2020)	A more detailed review of artifacts from three different science learning contexts illustrates that students based their design decisions on the content knowledge they represented, their technical ability to produce it, and how to engage an audience. Students enjoyed this form of assessment and felt that the tasks allowed them to demonstrate a wide range of abilities typically assessed in their courses. Recommendations for instructors provide guidance	Springer Netherlands	20	1.05/Q1

No	Writer	Findings	Publisher	Citation	SJR/ Quartile
		for considering these types of tasks in higher-level science contexts.			
10	(Sáiz - Manzanares et al., 2021)	Differences were found for the use of some learning objects as a function of gender and degree attained by students. Improved technology training for teachers and students is proposed, especially in Non-STEM qualifications, to reduce the impact of the technology gap and its collateral relationship with the gender gap and the digital divide.	Multidisciplinary Digital Publishing Institute (MDPI)	20	0.67/Q1

The most relevant contribution of this study is the number of citations. Based on the findings of the various studies described in Table 1, it can be concluded that implementing blended learning methods and using technology in education has a significant positive impact on student learning outcomes. The study by (Rajabalee & Santally, 2021) demonstrated the importance of institutional e-learning policies to improve the student experience. Furthermore, (Chirikov et al., 2020) underline that online and blended instruction can achieve learning outcomes equivalent to traditional face-to-face methods at a lower cost, thus supporting accessibility in STEM programs. Seage & Türegün (2020) emphasized the influence of teaching methods on student performance in STEM fields, while (Halasa et al., 2020) found that blended learning approaches can improve academic grades with better sustainability potential. (Iqbal et al., 2022) showed the challenges of distance learning, as well as the need to further explore the use of technology to improve interaction and learning effectiveness.

Delgado (2021) also showed that the use of digital delivery supports the development of skills in the curriculum. However, (Bhutoria & Aljabri, 2022) it cautions that excessive use of ICT can lead to decreased effectiveness. Yılmaz & Malone (2020) and Nielsen (2020) concludes that although students value blended learning, there are technical challenges that need to be addressed. The findings (Sáiz-Manzanares et al., 2021) demographic factors, such as gender and degree, can influence the use of learning objects and highlight existing technology gaps. Overall, the study's results support the importance of developing inclusive and adaptive education policies, improving technology training for educators and students, and applying diverse methods to create more effective and responsive learning environments in the digital age.

Blended learning has been proven to have a significant impact on learning in the science fields, especially Physics, Chemistry, and Biology, as shown by several studies in the selected bibliography. In Physics learning, research by Halasa et al. (2020) shows that the blended learning approach with a flipped classroom design can significantly improve students' academic scores. This approach allows students to understand physics concepts through a combination of interactive online and face-to-face learning, which is very useful in explaining abstract concepts such as force, motion, and energy. In addition, Chirikov et al. (2020) also confirmed that online and blended instruction provides learning outcomes equivalent to traditional face-to-face learning at a lower cost, and opens up opportunities for increased participation in STEM fields including physics. In the context of Chemistry, the findings Seage & Turgen (2020) reinforce that blended learning-based teaching methods have a significant effect on scores in STEM fields, including chemistry. They show that chemistry learning can be enhanced through the use of interactive simulations and virtual experiments that combine conceptual knowledge and practical skills in a balanced way. Meanwhile, Nielsen et al. (2020) added that in the context of higher-level science learning, students are able to design learning products based on chemical content by considering aspects of knowledge and audience appeal, which provides more exploration space in blended settings.

As for Biology, although it is not explicitly separated in these studies, biology is widely discussed as part of general science education. Yilmaz & Malone (2020) examined students' perceptions of blended learning in a science learning methods course and stated that students responded positively to the learning experience in a combined online and offline environment. However, technical barriers are a concern that needs to be addressed. In addition, Delgado (2021) found that delivering skills-based content in the context of lockdown showed significant differences in student performance across different sections of the material, which is also relevant in biology learning that requires observation skills and analysis of experimental data. In general, these articles underline that blended learning is not only relevant but also effective in supporting the learning of Physics, Chemistry, and Biology, especially in the context of active learning, mastery of 21st century skills, and flexibility in mastering complex content. However, special attention is needed on technological readiness and teacher training to optimize its implementation in science classes.

Figure 3. shows the visualization of countries researching Blended Learning in Science Education. The results showed that the United States had 12 articles, with the findings of these 12 studies being that blended learning is effective in improving student learning outcomes in science, along with significant cost reductions compared to traditional methods. This study confirmed that the teaching methods adopted, especially in the

context of blended learning, statistically positively impacted students' science, technology, mathematics, and engineering (STEM) scores. In addition, better results in the experimental group indicate that applying the flipped classroom design method in blended learning can further improve academic achievement. Despite challenges related to teacher use of technology and post-pandemic adaptations, students still showed high interest in learning using videos and digital content. Innovative hands-on programs designed to engage students, especially those who are underrepresented, show great potential in attracting students' interest in science careers. The main focus of this study is on how the blended learning model can be applied more broadly to improve science education success and increase student participation, including among minority and underrepresented groups (Bal, 2023; Breslyn & Green, 2022; Brush, 2024; Chirikov et al., 2020; Halasa et al., 2020; Hepworth et al., 2020; Jaber et al., 2022; Lahr, 2023; Lee & Hong, 2024; Marshall et al., 2023; Seage & Türegün, 2020; Stegman, 2021).

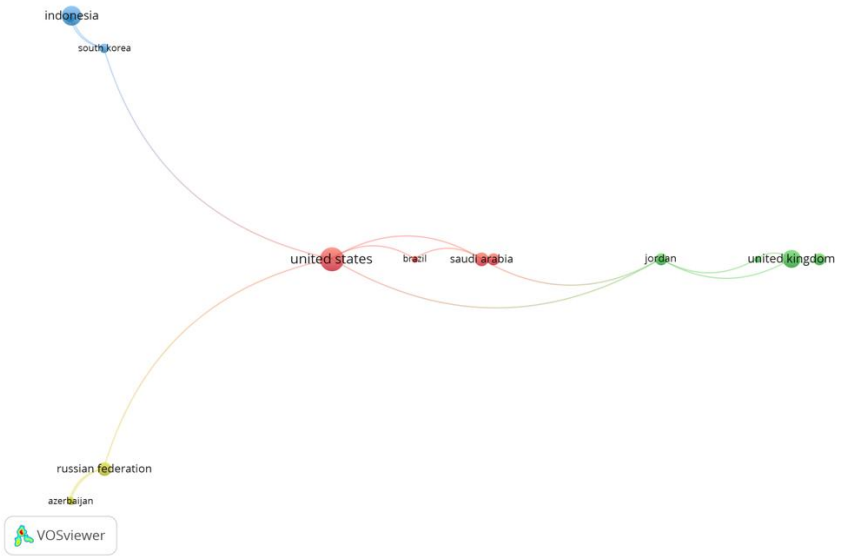
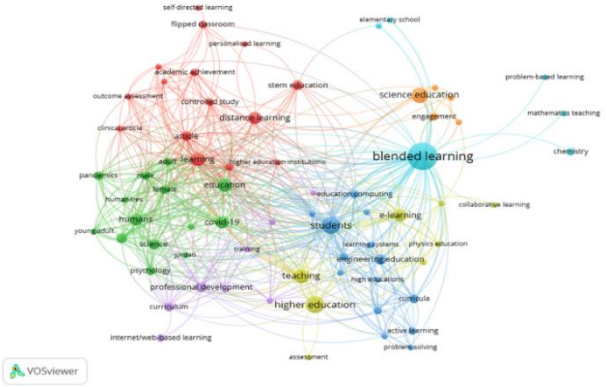


Figure 3. Visualization of the State network in the blended learning database in science learning

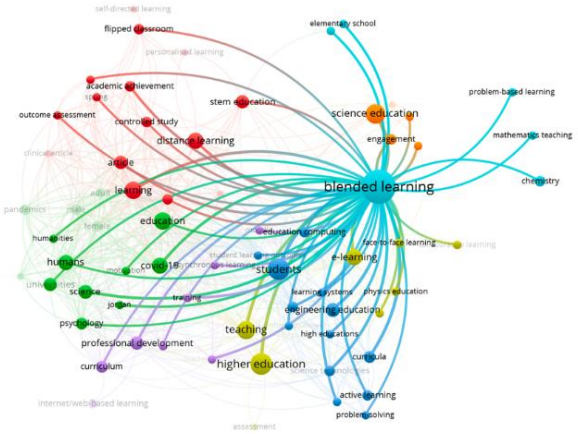
Indonesia each has 8 articles with findings from these 8 studies, namely the application of blended learning, especially through the STEM approach, significantly improves student learning outcomes in higher education. This study highlights the success of blended learning and mixed laboratory models that have been proven effective in developing collaborative skills, as well as students' ability to understand science concepts through modern technology, such as webinar applications and holographic media. The main focus of this study is on the ability of blended learning to support active learning and correct misunderstandings among students, with the hope that this blended learning will continue to be developed and optimized in the context of higher education so as to make a greater contribution to improving the quality of science education. In addition, these findings also reveal the need for further exploration of the needs of students, teachers, and technological developments to ensure the success of innovative learning methods in the future. (Agustina et al., 2024; Andrini et al., 2020; Dewi & Rahayu, 2023; Huda et al., 2022; Irwanto & Rini, 2024; Purnama et al., 2023; Taufiq et al., 2024).

Figure 4 shows the visualization display of the data network on Scopus data related to the keyword "Blended Learning in Science Learning," which has been refined in the search. Figure 4a shows the complex relationship between concepts related to blended learning and science learning. With the focus on "blended learning" connected to many terms such as "science education", "distance learning", "internet/web-based learning", students", "covid-19", and "teaching", it is clear that blended learning does not only focus on the blended learning aspect but also includes elements of curriculum and students in the context of education. This is in line with research by (Rosyid & Mubin, 2024), which emphasizes that 21st-century education aims to develop students' potential and empower them to form better characters. Several 21st-century learning innovations, such as the application of the Blended Learning Model, have been identified as relevant solutions to address challenges in Indonesia in the 21st century and prepare a learning environment that supports the achievement of 21st-century competencies. In addition, the digitalization of global society drives changes in the learning process in schools, requiring digital technology skills from teachers and students. (Santosa et al., 2024) argues that digital technology-based approaches, such as interactive e-modules, virtual laboratories, and simulation applications, significantly improve students' critical thinking skills. In addition, the integration of local culture in science learning provides great benefits in increasing student relevance and engagement. Thus,

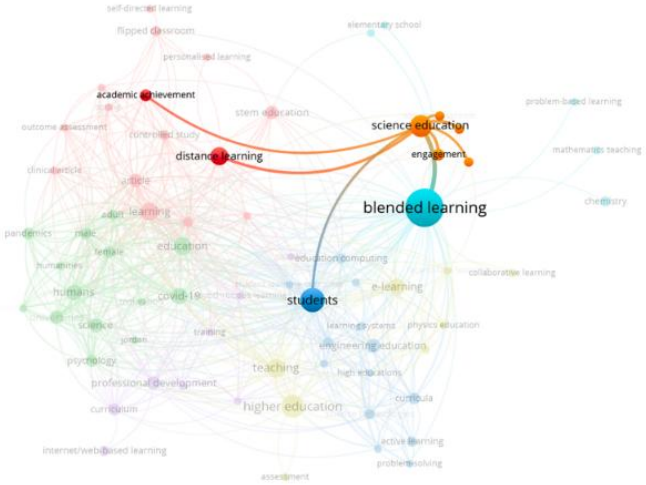
this analysis shows that the application of blended learning in learning can facilitate teaching and learning activities that can be carried out either directly in class or not in class, especially science learning.



(a)



(b)



(c)

Figure 4. (a) Network visualization in blended learning in science learning, (b) blended learning, and (c) science learning

Figure 4b depicts lines connecting "blended learning" with other terms, showing how the various aspects are related. For example, there is a relationship with "students", "teaching", and "higher education". The Education category includes "science education", "humanities", and "elementary school". The Learning Method category, such as "active learning", "problem-based learning", and "self-directed learning". The related topic category, such as "distance learning" and "STEM education", while the related category to other contextual concepts, such as "curriculum" and "assessment", shows how blended learning is applied in practice. (Agustini, 2022), stated that students of class X are active in online and offline activities in Blended Learning to improve learning outcomes in Chemistry on Chemical Bonding material. This is in line with(Lestari et al., 2016) explains that the learning tools developed can facilitate students' learning to think critically because the blended learning chosen makes students think holistically and can generate critical questions and answers from students.

Figure 4b shows a strong correlation between blended learning and various branches of science education, including chemistry, physics, and biology. In the context of chemistry, blended learning has been shown to improve understanding of abstract concepts through interactive media and online experiments. Videnovic et al. (2021) shows that the implementation of blended learning in chemistry learning in Serbia is able to increase students' motivation and active participation. In Indonesia, Sari et al. (2021) reported that blended learning based on chemical experiment videos helped improve high school students' science process skills. In physics, research, Şen et al. (2022) stated that blended learning improves physics problem-solving skills by integrating digital simulations and collaborative discussions. Similar findings were found by Fauzi et al. (2020) in Indonesia, which found that the use of blended learning with a flipped classroom approach significantly improved physics learning outcomes and student engagement. Meanwhile, in biology learning, Limniou & Smith (2020) proves that the use of blended learning with virtual laboratories increases motivation and mastery of complex biological concepts. In Indonesia, research by Altim et al. (2025) and Prasetyo et al. (2022) support this finding, by showing that blended learning is able to improve students' learning independence and learning outcomes in biology material through a combination of online and face-to-face learning that is designed contextually. Overall, these findings confirm that blended learning is an effective pedagogical approach in science education because it is able to bridge the limitations of space and time while maintaining the quality of learning.

In addition, in Figure 4c, it can be seen that blended learning has a very strong relationship with various fields of science education, including chemistry, physics, and biology. The light blue color representing the field of chemistry shows a higher number of connections and intensity of associations compared to physics (yellow) and biology. Research in the field of chemistry shows that the application of blended learning is effective in improving the understanding of abstract concepts through the integration of digital simulations and virtual experiments. For example, Seage & Turgen (2020) found that blended learning methods have a significant influence on student learning outcomes in the STEM domain, including chemistry. In the context of physics, the study Halasa et al. (2020) proves that the use of flipped classroom in blended learning can significantly improve students' academic scores. Meanwhile, biology, although not appearing as a separate node, is integrated into the general science domain (in green) and has been studied in the context of integrated science learning. Research by Yilmaz & Malone (2020) in science education found that blended learning enhances students' learning experiences, despite technical barriers that must be overcome. In Indonesia, research by Ratnasari et al. (2021) showed that project-based blended learning in science subjects, including biology, improves students' critical thinking skills. Similarly, a study by Sari & Marlina (2020) in the context of physics learning shows that blended learning is able to improve understanding of the concept of force and motion through the integration of LMS and online experiments. While in the field of chemistry, Susilawati & Wibowo (2022) found that the problem-based learning blended learning approach significantly improved the motivation and learning outcomes of high school students. These findings indicate that blended learning has a real and flexible contribution to science learning across disciplines.

This figure (4) highlights the relationship between "blended learning" and other words such as "students," "science education," "distance learning," and "academic achievement" that are connected to blended learning. This shows how these concepts interact with each other. As stated by (Koebanu & Saingo, 2024) that Blended learning is designed to increase student engagement in the learning process. (Subagiyo, 2019)explains that applying the blended learning model can improve students' understanding of concepts in chemistry learning. This shows that implementing digital-based blended learning has a stronger and very positive impact.

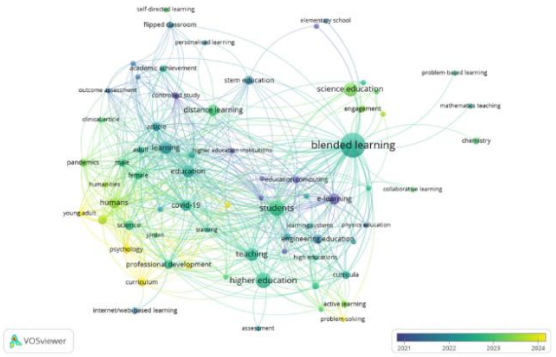
The analysis was conducted using Vosviewer software. Each cluster is connected to other keywords, showing that the research development on this subject is interrelated. Seven clusters were identified here. Table 2 shows that the keywords in each cluster represent the blended learning study stream in science learning.

Table 2. Keywords representing each cluster

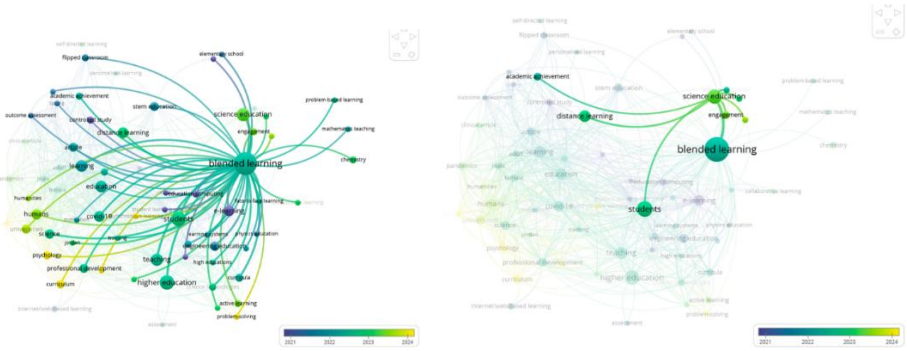
No	Cluster	Element
1	First cluster (red)	Academic achievement; articles; clinical articles; controlled studies; distance learning; flipped classroom; higher education institutions; public relations experiment; learning; outcome assessment; personalized learning; quasi experimental study; self-directed learning; spring; steam education.

2	Cluster two (green)	Adult; covid-19; education; female; humanities; humans; jordan; male; motivation; pandemics; psychology; science; universities; young adults.
3	Cluster three (Dark Blue)	Active learning; curriculum; educational computing; engineering and mathematics; engineering education; higher education; information and communication technologies; learning outcomes; learning system; problem-solving; science technologies; student learning outcomes; students.
4	Cluster four (yellow)	Assessment; collaborative learning; e-learning; educational innovation; face-to-face learning; higher education; physics education; teaching.
5	Cluster five (purple)	Asynchronous learning; curriculum; experiential learning; internet/web-based learning; moodle; professional development; teacher training; training.
6	Cluster six (light blue)	Blended learning; chemistry; elementary school; mathematics teaching; pedagogy; problem-based learning.
7	Cluster seven (orange)	Engagement; hybrid learning; science classroom; science education; secondary education.

Figure 5 shows the focus on the theme of "blended learning" connected to emerging keywords representing themes, topics, or terms related to education, such as "e-learning," "students," and "higher education." The lines connecting these words indicate the relationship or frequency of occurrence in the literature. This figure reflects current trends in education, especially those related to technology, teaching methods, and responses to changes caused by the COVID-19 pandemic. Husna (2024) the use of technology, such as e-learning, interactive learning applications, and social media integration, in learning activities can increase student participation, enrich learning resources, and provide flexibility in the learning process. This strategy also helps overcome some obstacles to conventional learning, such as space and time constraints. Firdaus (2024) also argues that using technology in e-learning and blended learning in Islamic education can improve teacher performance.



(a)



(b) **(c)**

Figure 5. (a) Overlay visualization in blended learning database in science learning (b) blended learning (c) science learning

Analysis of Figure 5b shows the relationship between blended learning and other connected words showing various aspects related to blended learning, such as "e-learning," "teaching," "students," and "higher education". Blended learning is a learning process that utilizes various approaches, media, and technologies, such as e-learning, which can be used from various places, both those with and without internet access (Tuerah, 2022). The characteristics of Blended learning, namely: 1) Learning that combines various delivery methods, educational models, learning styles, and various technology-based media; 2) As a combination of direct education (face-to-face), independent learning, and independent learning via online; 3) Learning supported by an effective combination of delivery methods, teaching methods, and learning styles; and 4) Educators and

parents of students have equally important roles, educators as facilitators, and parents as supporters (Sinaga, 2023).

The Figure 5c illustrates the concept mapping related to "blended learning" and "science education", showing how the various elements are interconnected in the educational context. With keywords such as "students," and "engagement" shows that in the context of blended learning, there is a push to increase student engagement in science education. In line with Darmawan (2013) explains that the results of the Integrated Science learning of the group of students who use the blended learning approach are higher than the group of students who use the contextual approach. In addition, the blended learning approach provides higher integrated science learning results for groups of students who have high self-confidence. In addition, distance learning is also close to "blended learning," indicating that distance learning methods are an important component of the blended learning model, especially in difficult situations such as a pandemic. This was revealed by Rahmani (2021)the fact that distance or online learning was carried out during the COVID-19 pandemic. This distance learning is carried out based on each school's capabilities. The media used in online learning are Google Classroom, Schoology, Edmodo, Telegram, Whats App, Youtube, Quiziz, and so on.

4. Conclusion

In general, all of this data article can answer questions about trend research in the field of blended learning in learning science period 5 years time last. Some words that are not used can linked and checked in study more continue. Therefore that, more Lots Topic can be developed based on keywords like amount publication each year, country, citation most, and keywords. The elements mentioned can give a more comprehensive analysis. Current research This review article journal's theme is related to the keywords " blended learning in learning science". Article collected from the Scopus database. Then, 100 articles were chosen from the original set, which is bigger than the 449 articles published in the period 2020 to 2024. To fulfill the objective study, all of these articles were classified based on the journal, article, final publication stage, in English, and the years 2019-2024. In the context of the study, it is concluded that the distribution of the author's research related to blended learning in learning science is Still dominated by the United States and Indonesia. The gap in study This shows the direction of the agenda to the front that blended learning in learning science is very important for studies. Overall, from year to year, activities Study teaching using deep blended learning science tend to increase. This is also necessary for more Lots collaboration study inter-regional involving researchers from Asia and developing countries and others in certain areas.

This study has two limitations. First, the study. This, in a way, is generally based on a limited set of keywords and also has the potential to be limited by the database (Scopus) used for the collection of articles. Second, although studies use device formal software as a tool help (device) soft VOSviewer, Mendeley, and Microsoft Excel), assessment of subjective writers happened and still possibly caused errors. Future studies recommended Using larger samples by expanding the keywords and making the database easily accessible. This study can also compare results analysis of different and recommended bibliometrics (such as BibExcel and HistCite). It is recommended that studies related more carry on give more explanation Details Because of studies discussing blended learning in learning science.

Author Contributions

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