25 (3), 2024, 1165-1182

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Trends and Visualization of Website-Based Physics Learning: A Bibliometric Analysis from 2002 to 2023

Silvia Laeli*, Jumadi Jumadi, Heru Kuswanto, & Novita Wulandari

Department of Physics Education, Universitas Negeri Yogyakarta, Indonesia

Abstract: Websites are now widely accessible across all disciplines. The aim of this study is to analyze the comparative trends in research on the 100 most cited website-based learning publications across all fields, to identify comparative visualizations of trend mapping in website-based learning publications in physics education research, and to determine the countries that have published the most website-based learning research from 2002 to 2023. This study conducts a bibliometric analysis using the keywords 'website-based learning' as a general field and 'website-based physics' to specifically investigate the implementation of websites in physics education. The metadata collected is sourced from the Scopus database and analyzed and visualized using VOSviewer and datawrapper. This research shows that the research trend in website-based learning across all fields is increasing annually. The main keywords used in website-based physics learning research are 'Websites', 'Learning systems', and 'Artificial intelligence' with a total link strength of 23, 16, and 14, respectively.

Keywords: website, bilbliometric, physics learning.

▪ INTRODUCTION

The digital revolution, initiated in the early 21st century, has brought about a profound transformation of human society (Hilbert, 2020; Omol, 2024). This digital transformation has not only permeated the industrial, economic, and social sectors but has also extended into the educational domain. In the context of physics instruction, the digital revolution has opened up new vistas, facilitating more innovative and effective pedagogical approaches (Castro Benavides, Tamayo Arias, Arango Serna, Branch Bedoya, & Burgos, 2020; Haleem, Javaid, Qadri, & Suman, 2022). The rapid evolution of information technology has given rise to a multitude of online platforms and tools designed specifically to support the learning process. Learning Management Systems (LMS), for example, have become the mainstay of many educational institutions in the structured management of learning materials (Jasiyah, Rumahlewang, Mundung, Sairdama, & Saputra, 2024), assignments, and assessments (Furqon, Sinaga, Liliasari, & Riza, 2023).

Website-based interactive simulations have also become increasingly common for visualizing abstract physics concepts, allowing students to conduct virtual experiments and observe physical phenomena firsthand (Onu, Pradhan, & Mbohwa, 2024). Moreover, sophisticated data visualization tools enable students to visually analyze experimental data, thereby deepening their understanding of physics concepts. The emergence of these technological innovations has significantly transformed the landscape of physics education (Gligorea et al., 2023; Prayogi & Verawati, 2024; Winarko et al., 2024). Learning, which was previously passive and teacher-centered, has now shifted towards a more active and student-centered approach (Kassem, 2018; Keiler, 2018). Students are no longer merely passive recipients of information but can interact with learning materials, explore, and construct their own knowledge (Aparicio-Gómez, Ostos-Ortiz, &

Silvia Laeli
*Email: silvialaeli.2023@student.uny.ac.id

DOI: http://dx.doi.org/10.23960/jpmipa/v25i3.pp1165-1182
Received: 25 November 2024
Accepted: 06 December 2024
Published: 10 December 2024

Abadía-García, 2024). Thus, information technology has opened up opportunities for creating more engaging, relevant, and meaningful physics learni experiences for students.

The advancement of digital technology has given birth to numerous innovations in the field of education, one of which is the utilization of websites as a learning medium. Websites offer a high degree of flexibility in delivering content, enabling educators to integrate text, images, videos, animations, and simulations into a single platform (Khamparia & Pandey, 2017; Kurdi, 2023; Wienand, Wulfert, & Hoang, 2024). Websites also provide extensive accessibility, allowing students to learn anytime and anywhere. Consequently, websites have become a highly potential tool for enhancing the quality of physics education.

One of the primary advantages of websites is their ability to deliver interactive learning experiences. Through websites, students can engage in a variety of learning activities, such as completing practice problems, conducting virtual experiments, or discussing concepts with classmates (Al-Duhani, Saat, & Abdullah, 2024; Mahardika & Gunawan, 2022). These interactive features not only make learning more engaging but also help students develop a deeper understanding of physics concepts (Agyei & Agyei, 2021; Mustakim, Ajwar, Kertih, & Lasmawan, 2024). Additionally, websites enable personalized learning, allowing each student to learn at their own pace and in a style that suits them best.

PhET is one of the leading web-based simulation platforms. Previous research has demonstrated that the use of PhET simulations can enhance students' motivation, conceptual understanding, and problem-solving skills (Abdi, Mustafa, & Pada, 2021; Agusmin, Nirwana, & Rohadi, 2018; Agustina, Sahidu, & Gunada, 2020). Unlike traditional passive learning methods, PhET simulations actively engage students in the learning process. By conducting virtual experiments, students can develop a deeper comprehension of physical phenomena and connect abstract concepts to real-world applications. Moreover, PhET simulations facilitate collaborative learning, allowing students to work together to complete tasks and share ideas.

Research on website trends in physics education fills a significant gap in the science education literature. The discipline of physics, which demands a strong conceptual understanding and deep visualization, stands to benefit greatly from the flexibility and interactivity offered by web-based simulations. Therefore, an in-depth study of website trends is imperative to optimize the physics learning process. The rapid development of web technologies and open-source software has enriched the simulation ecosystem, making ongoing research essential to identify best practices and maximize the potential of simulations in enhancing students' conceptual understanding, problem-solving skills, and motivation.

Over the past two decades, the utilization of websites in physics education has experienced significant growth. Previous studies have demonstrated that websites can enhance students' motivation to learn, facilitate independent learning (Bohne, Heine, Mueller, Zuercher, & Eger, 2023; C. W. Tsai et al., 2024), creative thinking (Indah & Cahya, 2024), and provide more timely feedback (Kusairi, 2020). Websites have become increasingly popular tools in physics instruction (Karuku, 2023). By employing visualizations, abstract physics concepts can be presented in a more concrete and comprehensible manner for students.

This research is expected to make a significant contribution to the advancement of technology-based physics education. By identifying trends and patterns in website usage and visualization, this study can provide recommendations for educators, instructional materials developers, and policymakers in designing more effective and innovative physics learning experiences (Dahlan, Abdul Halim, Kamarudin, & Zuraine Ahmad, 2023). Furthermore, the findings of this research can serve as a reference for future studies in the same field.

The utilization of websites in education, particularly in physics education, has opened up vast opportunities for research and innovation. While previous studies have extensively explored the role of websites in the general learning process, there remains a gap in delving deeper into the specific contributions of websites to physics education. A comprehensive bibliometric analysis spanning 22 years using the Scopus database will enable us to identify clearer trends, uncover the contributions of websites to physics education, and pinpoint research gaps that warrant further investigation.

The bibliometric analysis in this study will provide a comprehensive overview of how the trends in website usage and visualization in physics education have evolved over time (Passas, 2024). Additionally, this study will identify the factors influencing this development. Are there specific trends in the use of particular types of websites, the most frequently used features, or the most effective types of visualizations? Questions like these will be answered through an in-depth analysis of the existing literature.

The focus on physics education in this study is grounded in the unique characteristics of this subject. Physics, with its often abstract, microscopic, and macroscopic concepts, requires effective tools to assist students in comprehending the subject matter (Lin, Yen, Liang, Chiu, & Guo, 2016; Wiyono et al., 2024). Websites, with their ability to present information visually, interactively, and flexibly (Al Said & Al-Said, 2022; Ismail & Kuppusamy, 2022), hold immense potential for addressing the challenges in physics learning (Indah & Cahya, 2024). Consequently, this research is expected to make a significant contribution to the development of technology-based physics learning, and inspire further research in the same field.

This study conducts a bibliometric analysis using the keyword 'website-based learning' as a general domain and aims to determine the objectives of implementing websites in physics education and compare them. Publications indexed in Scopus were used to collect metadata. Furthermore, this research aims to contribute to our understanding of the role of websites in transforming physics learning. By comprehensively analyzing relevant scientific literature, we will identify trends, patterns, and best practices in the use of websites in physics education. The bibliometric analysis conducted using VOSviewer will enable us to identify collaboration networks among researchers, emerging topics, and the influence of various factors on the development of this research (McAllister, James, Lennertz, Lora, & Zayuris, 2021; Van Eck & Waltman, 2022). The results of this study are expected to serve as a reference for educators, researchers, and policymakers in developing more effective and innovative physics learning strategies, comparing trends, patterns, novelties, and future research in websites across various fields and in physics education over the past twenty-one years (2002-2023). Specifically, the objectives of this study are as follows:

1. A comprehensive analysis of the top 100 publications on websites across all scientific disciplines from 2002 to 2023 will be undertaken to systematically identify and compare prevailing research trends.
2. Mapping the Research Landscape: This study will map the countries that have made the most significant contributions to website-related research by analyzing the 100 most influential publications in the field.
3. Visualization of Trends in Physics: A comprehensive visualization analysis will be undertaken to map the progression of research trends concerning the utilization of websites for physics pedagogy spanning the years 2002 to 2023.

▪ METHOD

Research Design

This study adopts a bibliometric approach to conduct an in-depth analysis of the evolution of website usage, particularly in the context of physics education. Scopus is employed as the primary database due to its extensive and comprehensive coverage, encompassing millions of publications across various disciplines (Gusenbauer & Haddaway, 2020; Pranckutė, 2021). Scopus has been widely recognized as a reliable data source for bibliometric research (Arfiansyah, Satiadharma, Nur Siswanto, & Mohamad Rizaldi, 2023; Hakim & Munir, 2023; Lim, Kumar, & Donthu, 2024; You, Awang, & Wu, 2024). By leveraging the rich metadata available in Scopus, we are able to conduct a more in-depth analysis of research trends, collaboration patterns, and institutional contributions in this field.

Search Strategy

The bibliometric analysis employed in this study involved several stages. Firstly, a clear research design was defined, including the determination of keywords and the research period. Secondly, relevant publication data was collected from Scopus based on the established criteria. Subsequently, the collected data was analyzed descriptively to identify research trends and patterns. The final stage involved data interpretation and visualization to present the research findings more clearly and attractively. This analysis process follows the general framework of bibliometric analysis consisting of four phases (Hakim & Munir, 2023; Muhamad Juliardi & Ibnu Malik, 2023; Zahra et al., 2021). In this study, we conducted two stages of keyword filtering to focus the analysis on the use of website-based learning in a general context, as shown in Figure 1, and the use of websites specifically in physics learning, as shown in Figure 2, during the period 2002-2023.

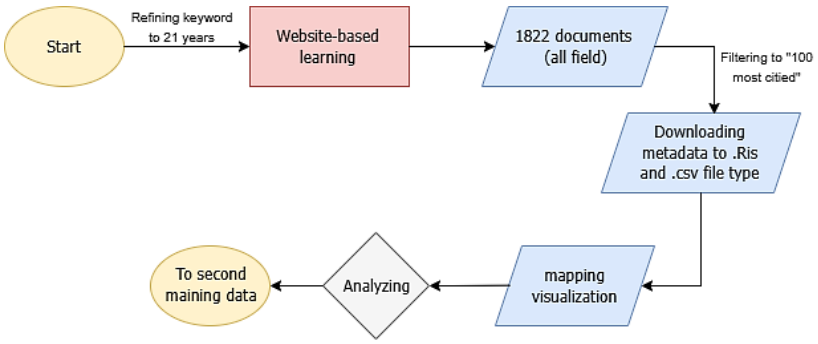

Figure 1. Research flowchart to the general keywords

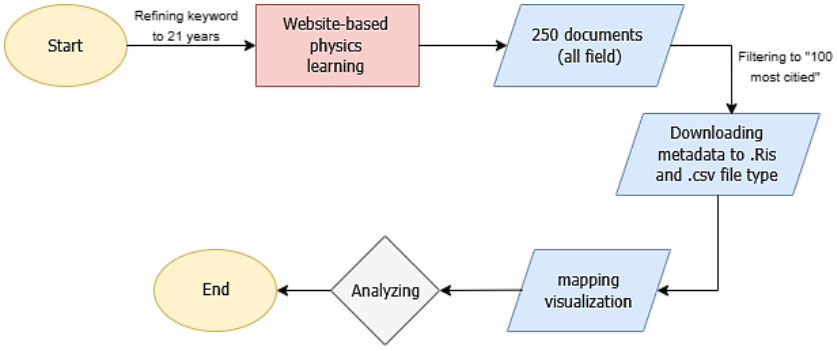

Figure 2. Research flowchart to the specified keywords

Inclusion and Exclusion Criteria

This bibliometric study selected articles based on specific inclusion criteria. First, the time frame of the research is from 2002 to 2023. Second, the article database is Scopus. Third, the articles must meet the predetermined keywords, which are 'website-based learning' and 'website based physics learning'. Studies that do not meet these criteria will not be analyzed in this study. Specifically, the exclusion criteria are non-open access scientific articles. The next process is identification based on the inclusion and exclusion criteria in all fields. From the review, 1822 articles were found for the keyword 'website-based learning' and 250 articles for the keyword 'website based physics learning' that met the bibliometric inclusion and exclusion criteria. Of these articles, the top 100 with the highest citation count were selected for review, and visualization was performed using VOSviewer and Datawrapper.

Data Analysis

On November 10, 2024, research data was collected and arranged based on the highest number of citations. The data was then converted into CSV and RIS formats, compatible with the VOSviewer software. VOSviewer was utilized to conduct bibliometric visualization and analysis, as previously employed in earlier studies (Al Husaeni & Nandiyanto, 2022; Padmalia, 2023; Van Eck & Waltman, 2018). The final stage of this analysis involved a descriptive interpretation of the data to answer the research questions.

VOSviewer is a widely used software in the field of bibliometrics for visualizing and analyzing scholarly publication data. It enables researchers to identify patterns, trends, and relationships among various elements within a corpus of literature. By employing VOSviewer, researchers can create network maps that depict the connections between authors, institutions, keywords, or journals. These network maps are invaluable for identifying collaborations, trending research topics, and the influence of various institutions (Van Eck & Waltman, 2018, 2022).

One of the key strengths of VOSviewer lies in its ability to process large datasets and generate interactive visualizations. Researchers can easily modify and explore the resulting network maps to gain deeper insights. Furthermore, VOSviewer can be used to conduct cluster analysis, enabling researchers to identify groups of publications that share similar topics or methodologies (Bukar et al., 2023; Hasugian & Nadeak, 2020). Consequently, VOSviewer has become an invaluable tool for researchers seeking to understand the research landscape in a specific field.

Datawrapper (https://www.datawrapper.de/) has emerged as an indispensable tool for researchers conducting bibliometric analysis. Following the data collection and analysis phase using software such as VOSviewer, the subsequent step involves presenting research findings in a clear and engaging manner (Färber, Menne, & Harth, 2018). Datawrapper plays a pivotal role in this regard, facilitating the creation of visually appealing and informative data visualizations.

With its user-friendly interface and a wide range of template options, Datawrapper.de enables researchers to swiftly transform raw data from bibliometric analysis into various informative visualizations. From simple bar and line charts to complex interactive maps and network diagrams, all can be created with ease. These visualizations not only enhance the presentation of data but also aid in uncovering patterns, trends, and relationships that may be hidden within the raw data (Färber et al., 2018; Galahartlambang, Khotiah, & Jumain, 2021). Datawrapper collaborates to provide the best graphics platform for anyone seeking to present their data in visually appealing maps, charts, and tables.

One of the primary advantages of Datawrapper lies in its capacity to adapt visualizations to a wide range of bibliometric data types. For instance, researchers can generate bar charts to depict the number of publications per year, maps to illustrate the geographical distribution of authors, or network diagrams to visualize collaborations among researchers (Färber et al., 2018). Moreover, Datawrapper empowers users to incorporate annotations, labels, and interactive filters, thereby rendering the generated visualizations more dynamic and informative.

▪ RESULT AND DISSCUSSION

Trends in Website-Based Learning Research Across All Disciplines from 2002 to 2023

Based on the filtering and analysis of metadata, an annual trend in the publication of website-based learning across all research fields from 2002 to 2023 has been identified. This trend demonstrates researchers' interest in investigating the research subject. The trend of website-based learning across all fields from 2002 to 2023 is depicted in Figure 3.

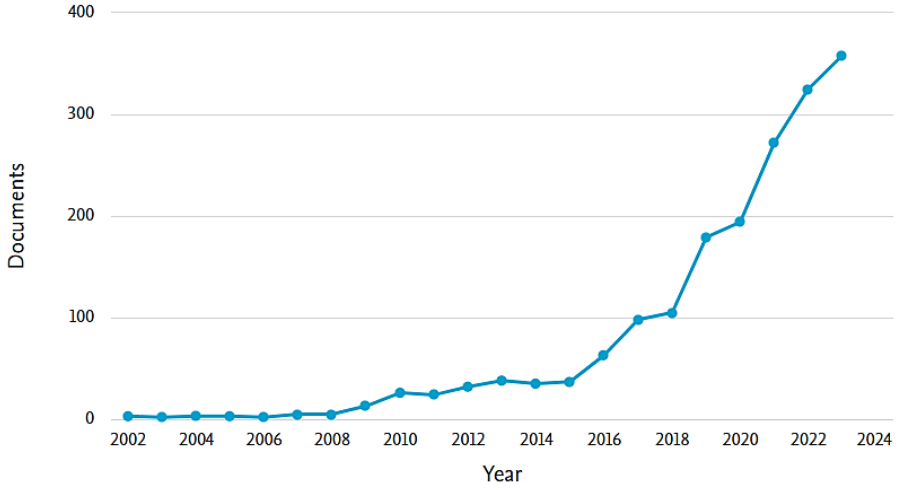

Figure 3. Trends in website-based learning research across all disciplines from 2002 to 2023

As depicted in Figure 3, there has been a consistent upward trend in research on website-based learning across all disciplines over the past twenty-one years. This indicates a growing interest and sustained momentum in the field of website-based learning, solidifying its position as a compelling topic for scholarly inquiry. Furthermore, it is evident that website-based learning has emerged as an enduring trend, with research interest steadily increasing from 2002 to 2023.

The COVID-19 pandemic has acted as a significant catalyst, accelerating the adoption of web-based learning, particularly within the domain of physics. The imposition of mobility restrictions and the closure of physical educational institutions necessitated an urgent demand for flexible and effective alternative learning solutions. As a result, there has been a substantial surge in research dedicated to the design, implementation, and evaluation of web-based learning strategies.

Concurrently, the rapid advancements in information and communication technologies (ICT), especially artificial intelligence (AI) and big data analytics, have facilitated the creation of more personalized, adaptive, and interactive learning platforms. AI-powered tools can analyze vast amounts of student data to identify individual learning needs and tailor instructional content accordingly. Additionally, AI-driven chatbots and virtual tutors can provide real-time support and guidance to learners. The integration of big data analytics enables the identification of complex patterns and trends in student behavior, allowing educators to make data-driven decisions to improve learning outcomes.

Therefore, following the analysis using VOSviewer, it is possible to identify the keywords frequently used in publications on website-based learning from 2002 to 2023 across all fields. The keywords frequently used in publications on website-based learning across all fields from 2002 to 2023 are as presented in Figure 4.

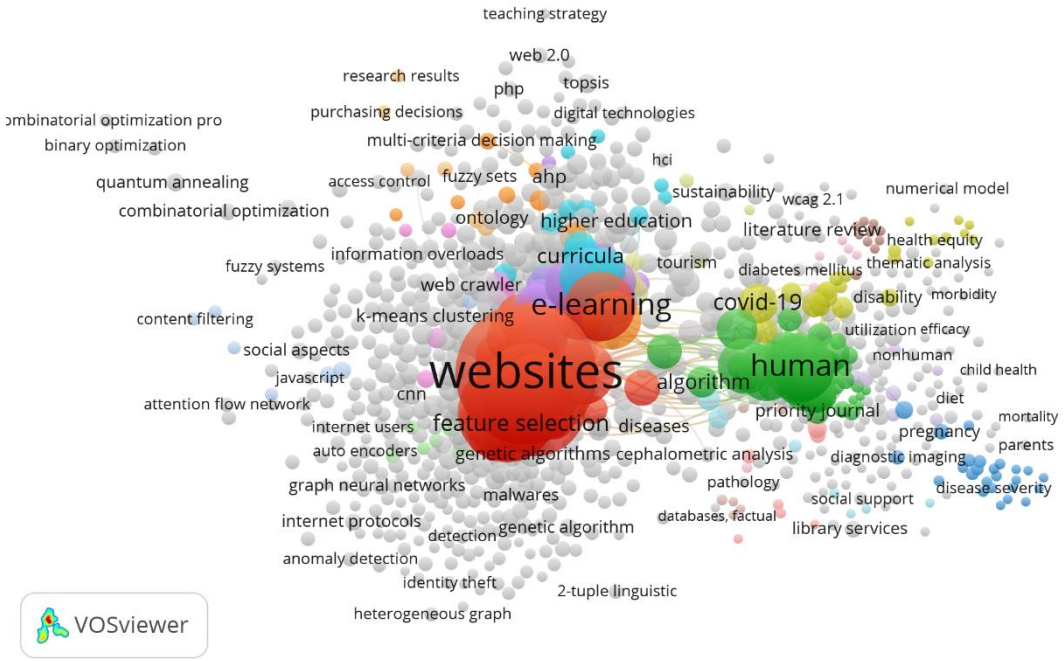

Figure 4. Provides an illustration of the most frequently used keywords in publications on website-based learning

A keyword analysis of the top 100 cited publications on website-based learning from 2002 to 2023 (Figure 4) revealed that 'Websites' (n=477), 'Machine Learning' (n=243), 'Computer Crime' (n=228), 'Phishing' (n=185), and 'Learning Systems' (n=165) were the most prominent terms (Beldad, De Jong, & Steehouder, 2010; Harkin et al., 2016; Sahingoz, Buber, Demir, & Diri, 2019). This suggests a strong focus on the technological underpinnings and potential security threats associated with web-based learning. The growing interest in research on web-based learning, particularly in the domain of physics, has significant implications for the development of digital-based curricula. Future physics curricula will increasingly emphasize personalized learning, allowing students to learn at their own pace and in a manner that suits their individual learning styles. The integration of technologies such as interactive simulations and big data analytics will facilitate the understanding of abstract physics concepts. Furthermore, digital-based curricula will foster the development of 21st-century skills such as critical thinking, problem-solving, and collaboration, which are highly relevant to today's workforce demands.

Top-Ranking Countries of the 100 Most Cited Website-Based Learning Publications Across All Disciplines from 2002 to 2023

Based on the filtered and analyzed metadata, Figure 5 visually maps the top countries in website-based learning publications from 2002 to 2023 (Beldad et al., 2010; Harkin et al., 2016; Karimi, Jannach, & Jugovac, 2018; Long et al., 2017; Sahingoz et al., 2019; Sheng, Amankwah-Amoah, & Wang, 2017; Somesha, Pais, Rao, & Rathour, 2020; W. H. Tsai, Chou, & Lai, 2010). This visualization was created using Datawrapper.

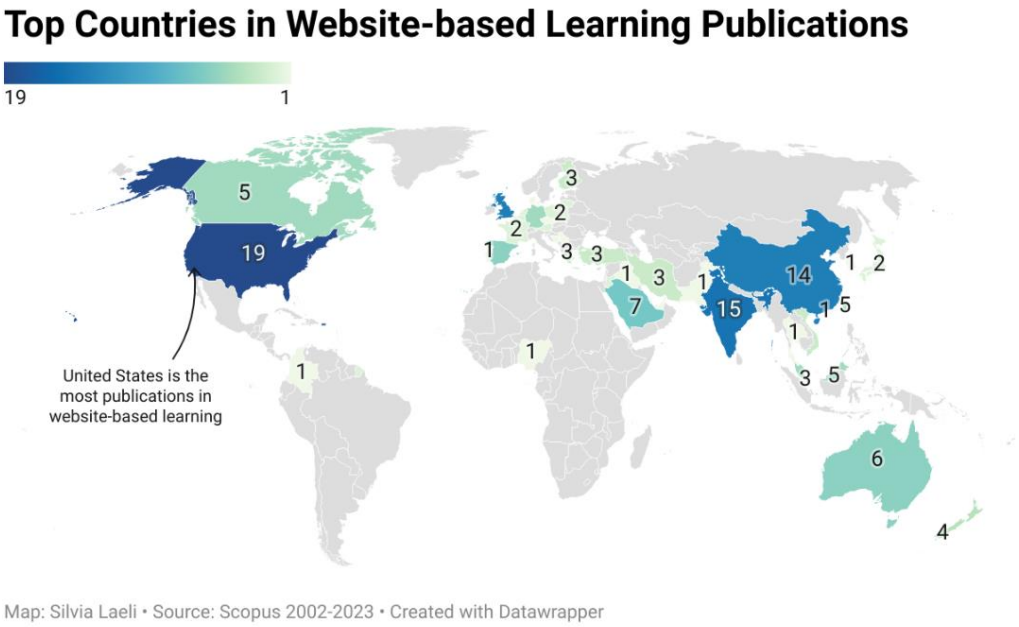

Figure 5. Top contries in website-based learning from 2002 until 2023

Based on Figure 5, it can be analyzed that the top 10 countries in terms of website-based learning publications are the United States with 19 publications, India with 15

publications, the United Kingdom and China with 14 publications each, Saudi Arabia with 7 publications, Spain and Australia with 6 publications each, and Canada, Taiwan, Germany, and Malaysia with 5 publications each. Other countries had an average of less than 5 publications from 2002 to 2023. The United States and India have exhibited significant productivity in web-based learning research from 2002 to 2023. This dominance can be attributed to several interconnected factors. First, pro-technology educational policies in both countries have fostered an environment conducive to the development and implementation of educational technologies. Substantial investments in initiatives such as e-learning and digital literacy in the United States, coupled with programs to increase technology access in India, have acted as growth catalysts. Second, dynamic innovation ecosystems characterized by conducive investment climates have spurred the growth of numerous education technology startups and companies. Third, the presence of robust research communities in educational technology in both countries has contributed to a substantial production of knowledge. While further analysis is needed to quantify the relative contributions of each factor, the combination of supportive policies, dynamic innovation ecosystems, and active research communities has positioned the United States and India as hubs for web-based learning development.

The dominance of the United States and India in web-based learning research has significant implications for developing countries. On the one hand, developing countries may face widening digital divides, dependence on foreign technologies, and a lack of curriculum relevance. On the other hand, this dominance also presents opportunities for developing countries to access global resources, forge international collaborations, and develop learning solutions more relevant to local contexts. To maximize opportunities and address challenges, developing countries need to proactively build technological infrastructure, develop human capital, forge international partnerships, formulate supportive policies, and focus on student-centered learning. By doing so, developing countries can leverage technological advancements to improve the quality of education and prepare future generations for global challenges.

Visualisasi Trend Mapping Website-based Physics Learning Tahun 2002-2023

The most frequently occurring keywords were analyzed prior to mapping the visualization of website-based physics learning in physics education research over a twenty-one-year period (2002-2023), as shown in Table 1.

Table 1. Top 14 keywords used in website-based physics learning, 2002-2023

No	Keyword	Occurrens	Total Link Strength
1	Websites	11	23
2	Learning systems	7	16
3	Artificial intelligence	9	14
4	Deep learning	9	14
5	Information systems	5	13
6	Information use	6	13
7	E-commerce websites	5	10
8	Machine learning	7	10
9	Internet of things	6	6
10	Phishing	5	6

11	User experience	5	5
12	E-learning	5	4
13	Face recognition	5	2
14	Quantum annealing	6	0

As shown in Table 1, the keyword with the highest total link strength and the most frequent occurrence was "Websites" (n=23). This clearly indicates that every keyword is inherently linked to website-based physics learning. The second most frequent keyword was "Learning systems" (n=16), followed by "Artificial intelligence" (n=14). Although Table 1 suggests that website-based physics learning remains strongly associated with the keyword "websites," it is possible that this relationship might weaken over time as distinctions become more pronounced with each publication. Based on this pattern, we can identify the following trends in website-based physics learning from 2002 to 2023: 1) association with learning; 2) implementation of technology-based learning activities for students and teachers; 3) rules governing website usage; and 4) physics education. In particular, trends in website-based physics learning may involve interactive experiences that combine computer-generated content into a system (Chen, Zheng, Zhou, Liao, & Liu, 2020; Do, Selamat, Krejcar, Yokoi, & Fujita, 2021; Hendriyana & Sutisna, 2021; Liliana, Raharjo, & Jauhari, 2020; Nembrini, Ferrari Dacrema, & Cremonesi, 2021; Souza et al., 2022).

The integration of AI into web-based learning, coupled with the advancement of Learning Management Systems (LMS), has opened new avenues for personalized learning, real-time adaptation based on student performance, and in-depth learning data analytics. AI-powered LMS can provide tailored learning experiences, intelligent tutoring systems, and automated feedback mechanisms. Moreover, the utilization of big data enables the identification of complex learning patterns and trends, informing the development of more effective pedagogical strategies. The convergence of these technological advancements and the growing emphasis on online learning has created a conducive ecosystem for the exponential growth of research in the field of web-based learning, particularly in the context of physics. Therefore, to identify novel research based on the mapping results, we can examine relationships between smaller or less frequent keywords, as illustrated in Figure 6.

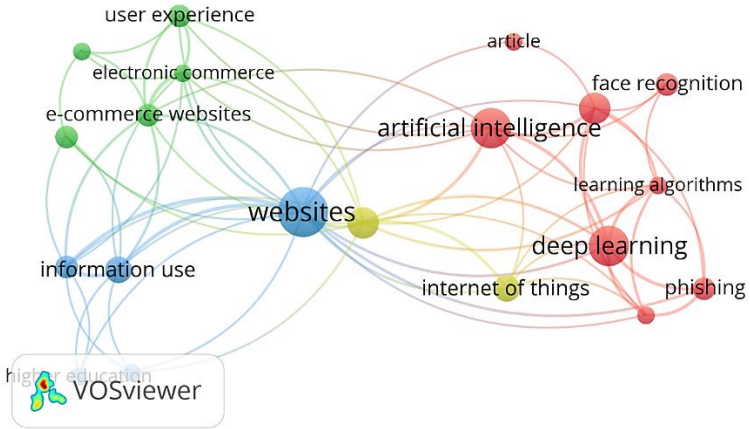

Figure 6. Keyword mapping of trends in website-based physics learning, 2002-2023

To identify novelties in previous research, keyword co-occurrence mapping of metadata was conducted. A comparison of keyword co-occurrence visualization in website-based physics learning research from 2002 to 2021 is presented in Figure 6. This was analyzed to discover novelties among studies. Figure 6 shows that there are four main clusters for website-based physics learning: 1) Cluster 1 with red nodes (n=8 items); 2) Cluster 2 with green nodes (n=5 items); 3) Cluster 3 with blue nodes (n=5 items); and 4) Cluster 4 with yellow nodes (n=2 items). Some examples of specific keyword mapping results in website-based physics learning are websites, higher education, information use, internet of things, phishing, deep learning, learning algorithms, artificial intelligence, face recognition, article, user experience, and e-commerce websites.

This study represents the first attempt to conduct a comprehensive bibliometric review and analysis comparing website-based learning in general and physics education over the past two decades (2002-2023). The integration of website-based learning across various professional fields has been a topic of considerable interest, particularly in education. This is due to the perception that website-based learning can serve as a versatile learning medium, especially in the 21st century where technology has become ubiquitous in education. Our findings reveal a growing interest in research on the use of website-based learning in Humanities and article-based research.

The United States has emerged as the leading nation in publications on website-based learning. Findings indicate that the US has been the most influential country, based on the number of publications over the past two decades. This aligns with previous research that identified the US, India, the United Kingdom, and China as the most influential nations in website-based learning publications across all fields. Notably, the top keywords in website-based learning publications include websites, machine learning, computer crime, phishing, and learning systems. These findings suggest that a significant portion of website-based learning research is rooted in computer science, consistent with the US's leading position in this domain.

Based on these findings, website-based physics learning has significantly contributed to both students and e-learning in physics education. The emergence of website-based physics learning concepts in physics is on the rise, particularly given the abstract and challenging nature of the subject. The development of Learning Management Systems (LMS) based on website-based physics learning is highly suitable for use as a learning medium in high schools (Effendy, Purwanti, & Akbar, 2021; Fadhel, Idrus, Abdullah, Ibrahim, & Omar, 2020; Handayani et al., 2020; Istikomah, Puji Astutik, & Jannah, 2021). By integrating website-based physics learning into physics classrooms, student independence in learning physics can be enhanced, guiding students towards higher levels of digital literacy in physics, and stimulating students' motivation to learn more deeply. Additionally, problem-based website-based physics learning research makes learning more meaningful. Technological innovations, such as website-based physics learning, have the potential to fundamentally transform education by making complex concepts accessible and available to beginners. Meanwhile, the use of website-based physics learning provides promising media for educational researchers due to its high degree of systematicity and flexibility in the learning process(Chen et al., 2020; Nembrini et al., 2021; Wienand et al., 2024). The website-based physics learning environment has improved both students' perceptions and their critical thinking skills in physics learning.

The utilization of website-based physics learning within e-learning environments has demonstrated positive effects on learners. Previous studies analyzed in this research were published in journals indexed in Scopus. This indicates that the publications are undoubtedly credible, as the publishing houses have established reputations. The Source Normalized Impact per Paper (SNIP) metric, which assigns different citation weights based on the importance of the citing journal, supports this claim. Consequently, citations from influential journals are more valuable, and the journals that receive them gain greater prominence.

▪ CONCLUSION

Website-based learning has emerged as a rapidly growing research field, fueled by advancements in technology and its increasing contributions to education, particularly in the realm of physics instruction. In conclusion, this research has yielded seven key findings: 1) Research trends in website-based learning across all disciplines have shown a consistent upward trajectory over the years (2002-2023); 2) The United States is the leading country in website-based learning publications; 3) The top keywords used in website-based physics learning are 'Websites', 'Learning systems', and 'Artificial intelligence', with respective total link strengths of 23, 16, and 14.

This research is limited to the Scopus database. Consequently, the implications of this study tend to uncover novel research on website-based learning, its trends, and contributions to physics education over a twenty-two-year period (2002-2023) through mapping, visualization patterns, and literature review. Future researchers are encouraged to determine profiles with other metadata, such as ERIC, DOAJ, and Web of Science, and combine them. Researchers can identify topics most relevant to physics education and authors with the most significant impact, as well as identify the main research lines of scientists in each specified period.

Therefore, this also helps to narrow down the following trends that can be developed in this research field, particularly in the field of physics education. Future researchers can explore website-based physics learning in the top trends. There is still room for further exploration of website-based physics learning research as the top trends still have a broad scope and various sub-fields such as artificial intelligence. Website-based physics learning can still be improved and assist educators in many aspects.

▪ REFERENCES

Abdi, M. U., Mustafa, M., & Pada, A. U. T. (2021). *Penerapan pendekatan stem berbasis simulasi phet untuk meningkatkan pemahaman konsep fisika peserta didik.* Jurnal IPA & Pembelajaran IPA, 5(3), 209–218. https://doi.org/10.24815/jipi.v5i3.21774

Agusmin, R., Nirwana, N., & Rohadi, N. (2018). *Peningkatan motivasi dan hasil belajar siswa dengan model problem based learning berbantuan simulasi PhET di Kelas XI IPA-C SMAN 6 Kota Bengkulu.* Jurnal Kumparan Fisika, 1(2), 53–59. https://doi.org/10.33369/jkf.1.2.53-59

Agustina, K., Sahidu, H., & Gunada, I. W. (2020). *Pengaruh model pembelajaran inkuiri terbimbing berbantuan media phet terhadap kemampuan pemecahan masalah dan berpikir kritis fisika peserta didik SMA.* Jurnal Pendidikan Fisika Dan Teknologi, 6(1), 17–24. https://doi.org/10.29303/jpft.v6i1.1514

Agyei, E. D., & Agyei, D. D. (2021). Enhancing students' learning of physics concepts with simulation as an instructional ICT Tool. European Journal of Interactive Multimedia and Education, 2(2), e02111. https://doi.org/10.30935/ejimed/11259

Al-Duhani, F., Saat, R. M., & Abdullah, M. N. S. (2024). Effectiveness of web-based virtual laboratory on grade eight students' self-regulated learning. Eurasia Journal of Mathematics, Science and Technology Education, 20(3), 1–20. https://doi.org/10.29333/ejmste/14282

Al Husaeni, D. F., & Nandiyanto, A. B. D. (2022). Bibliometric using vosviewer with publish or perish (using google scholar data): from step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. ASEAN Journal of Science and Engineering, 2(1), 19–46. https://doi.org/10.17509/ajse.v2i1.37368

Al Said, N., & Al-Said, K. M. (2022). The effect of visual and informational complexity of news website designs on comprehension and memorization among undergraduate students. AI and Society, 37(1), 401–409. https://doi.org/10.1007/s00146-021-01164-6

Aparicio-Gómez, O. Y., Ostos-Ortiz, O. L., & Abadía-García, C. (2024). Convergence between emerging technologies and active methodologies in the university. Journal of Technology and Science Education, 14(1), 31–44. https://doi.org/10.3926/jotse.2508

Arfiansyah, F., Satiadharma, M., Nur Siswanto, B., & Mohamad Rizaldi, F. (2023). Bibliometric analysis of customers' purchase intention in e-commerce. Income Journal., 2(1), 1–10. https://doi.org/10.61911/income.v2i1.26

Beldad, A., De Jong, M., & Steehouder, M. (2010). How shall i trust the faceless and the intangible? A literature review on the antecedents of online trust. Computers in Human Behavior, 26(5), 857–869. https://doi.org/10.1016/j.chb.2010.03.013

Bohne, T., Heine, I., Mueller, F., Zuercher, P. D. J., & Eger, V. M. (2023). Gamification intensity in web-based virtual training environments and its effect on learning. IEEE Transactions on Learning Technologies, 16(5), 603–618. https://doi.org/10.1109/TLT.2022.3208936

Bukar, U. A., Sayeed, M. S., Razak, S. F. A., Yogarayan, S., Amodu, O. A., & Mahmood, R. A. R. (2023). A method for analyzing text using VOSviewer. MethodsX, 11(August), 102339. https://doi.org/10.1016/j.mex.2023.102339

Castro Benavides, L. M., Tamayo Arias, J. A., Arango Serna, M. D., Branch Bedoya, J. W., & Burgos, D. (2020). Digital transformation in higher education institutions: a systematic literature review. Sensors (Basel, Switzerland), 20(11), 1–22. https://doi.org/10.3390/s20113291

Chen, Y., Zheng, R., Zhou, A., Liao, S., & Liu, L. (2020). Automatic detection of pornographic and gambling websites based on visual and textual content using a decision mechanism. Sensors (Switzerland), 20(14), 1–21. https://doi.org/10.3390/s20143989

Dahlan, M. M., Abdul Halim, N. S., Kamarudin, N. S., & Zuraine Ahmad, F. S. (2023). Exploring interactive video learning: Techniques, applications, and pedagogical insights. International Journal of Advanced and Applied Sciences, 10(12), 220–230. https://doi.org/10.21833/ijaas.2023.12.024

Do, N. Q., Selamat, A., Krejcar, O., Yokoi, T., & Fujita, H. (2021). Phishing webpage classification via deep learning-based algorithms: An empirical study. Applied Sciences (Switzerland), 11(19). https://doi.org/10.3390/app11199210

Effendy, F., Purwanti, E., & Akbar, R. F. (2021). Evaluation of e-learning: a case study of PsyCHE. AIP Conference Proceedings, 2329(February). https://doi.org/10.1063/5.0042126

Fadhel, I. E. I., Idrus, S. Z. B. S., Abdullah, M. S. Y., Ibrahim, A. A. E. A., & Omar, M. (2020). An Integration between Information Systems Engineering and Software Engineering Theories towards Engineering a Novel Instrument and Framework of Web-Based Systems Success: Hypothesis Testing. Journal of Physics: Conference Series, 1529(2). https://doi.org/10.1088/1742-6596/1529/2/022006

Färber, M., Menne, C., & Harth, A. (2018). A Linked data wrapper for crunchbase. Semantic Web, 9(4), 505–515. https://doi.org/10.3233/SW-170278

Furqon, M., Sinaga, P., Liliasari, L., & Riza, L. S. (2023). The impact of learning management system (LMS) usage on students. TEM Journal, 12(2), 1082–1089. https://doi.org/10.18421/TEM122-54

Galahartlambang, Y., Khotiah, T., & Jumain, J. (2021). *Visualisasi data dari dataset covid-19 menggunakan pemrograman python.* Jurnal Ilmiah Intech : Information Technology Journal of UMUS, 3(01), 58–64. Retrieved from http://jurnal.umus.ac.id/index.php/intech/article/view/417

Gligorea, I., Cioca, M., Oancea, R., Gorski, A. T., Gorski, H., & Tudorache, P. (2023). Adaptive learning using artificial intelligence in e-learning: a literature review. Education Sciences, 13(12). https://doi.org/10.3390/educsci13121216

Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. Research Synthesis Methods, 11(2), 181–217. https://doi.org/10.1002/jrsm.1378

Hakim, L., & Munir, M. S. (2023). Takaful industrial research developments: a bibliometric analysis on the scopus database. IQTISHADUNA: Jurnal Ilmiah Ekonomi Kita, 12(1), 66–79. https://doi.org/10.46367/iqtishaduna.v12i1.1020

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3(February), 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Handayani, K., Juningsih, E. H., Riana, D., Hadianti, S., Rifai, A., & Serli, R. K. (2020). Measuring the quality of website services covid19.kalbarprov.go.id using the webqual 4.0 method. Journal of Physics: Conference Series, 1641(1), 0–6. https://doi.org/10.1088/1742-6596/1641/1/012049

Harkin, B., Webb, T. L., Change, B. P. I., Prestwich, A., Conner, M., Kellar, I., … Sheeran, P. (2016). Does monitoring goal progress promote goal attainment? A meta-analysis of t...: EBSCOhost. Psychological Bulletin, 142(2), 142(2), 198–229. Retrieved from https://web.p.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=0&sid=adb12cbb-1c1d-4b8e-9221-5d27b47db577%40redis

Hasugian, P. M., & Nadeak, B. (2020). Bibliometric analysis on techniques for data visualization-paska marto hasugian bibliometric analysis on techniques for data visualization. 7889(01), 425–433. https://doi.org/10.58471/JIS.v13i01

Hendriyana, H., & Sutisna, M. R. (2021). Data infrastructure and information design of e-learning in primary school. Journal of Physics: Conference Series, 1987(1). https://doi.org/10.1088/1742-6596/1987/1/012007

Hilbert, M. (2020). Digital technology and social change: The digital transformation of society from a historical perspective. Dialogues in Clinical Neuroscience, 22(2), 189–194. https://doi.org/10.31887/dcns.2020.22.2/mhilbert

Indah, D., & Cahya, P. (2024). Development of physics websites based on stem assisted of google sites on momentum and impulse materials to improve creative thinking skills. 10(9), 6766–6776. https://doi.org/10.29303/jppipa.v10i9.5168

Ismail, A., & Kuppusamy, K. S. (2022). Web accessibility investigation and identification of major issues of higher education websites with statistical measures: A case study of college websites. Journal of King Saud University - Computer and Information Sciences, 34(3), 901–911. https://doi.org/10.1016/j.jksuci.2019.03.011

Istikomah, Puji Astutik, A., & Jannah, M. (2021). The website-based information literacy system and application in education facing the age of industrial revolution 4.0. Journal of Physics: Conference Series, 1779(1), 0–9. https://doi.org/10.1088/1742-6596/1779/1/012055

Jasiyah, R., Rumahlewang, E., Mundung, B. I., Sairdama, S. S., & Saputra, N. (2024). Learning management system difficulties during the learning process in higher education. Journal for Lesson and Learning Studies, 7(1), 1–12. https://doi.org/10.23887/jlls.v7i1.68665

Karimi, M., Jannach, D., & Jugovac, M. (2018). News recommender systems – Survey and roads ahead. Information Processing and Management, 54(6), 1203–1227. https://doi.org/10.1016/j.ipm.2018.04.008

Karuku, S. (2023). Systematic literature review: analysis of the use of website-based physics learning devices to support students' abilities in learning physics in high schools. Journal Evaluation in Education (JEE), 4(3), 80–87. https://doi.org/10.37251/jee.v4i3.336

Kassem, H. M. (2018). The impact of student-centered instruction on efl learners' affect and achievement. English Language Teaching, 12(1), 134. https://doi.org/10.5539/elt.v12n1p134

Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. International Journal of STEM Education, 5(1). https://doi.org/10.1186/s40594-018-0131-6

Khamparia, A., & Pandey, B. (2017). Impact of interactive multimedia in E-learning technologies: Role of multimedia in E-learning. Enhancing Academic Research With Knowledge Management Principles, (March), 199–227. https://doi.org/10.4018/978-1-5225-2489-2.ch007

Kurdi, M. S. (2023). E-Learning strategies for enhancing second language acquisition in madrasah ibtidaiyah. Jurnal Bintang Pendidikan Indonesia, 1(3), 167–183. Retrieved from https://ejurnal.stie-trianandra.ac.id/index.php/JUBPI/article/view/1671%0A https://ejurnal.stie-trianandra.ac.id/index.php/JUBPI/article/download/1671/1342

Kusairi, S. (2020). A web-based formative feedback system development by utilizing isomorphic multiple choice items to support physics teaching and learning. Journal

of Technology and Science Education, 10(1), 117–126. https://doi.org/10.3926/jotse.781

Liliana, R. A., Raharjo, W., & Jauhari, I. (2020). The development of interactive learning media with lectora inspire in gas kinetic theory subject to improve the result and students' interest of the eleventh grade students of senior high school. Journal of Physics: Conference Series, 1567(3). https://doi.org/10.1088/1742-6596/1567/3/032092

Lim, W. M., Kumar, S., & Donthu, N. (2024). How to combine and clean bibliometric data and use bibliometric tools synergistically: Guidelines using metaverse research. Journal of Business Research, 182(May), 114760. https://doi.org/10.1016/j.jbusres.2024.114760

Lin, J. W., Yen, M. H., Liang, J. C., Chiu, M. H., & Guo, C. J. (2016). Examining the factors that influence students' science learning processes and their learning outcomes: 30 years of conceptual change research. Eurasia Journal of Mathematics, Science and Technology Education, 12(9), 2617–2646. https://doi.org/10.12973/eurasia.2016.000600a

Long, E., Lin, H., Liu, Z., Wu, X., Wang, L., Jiang, J., … Liu, Y. (2017). An artificial intelligence platform for the multihospital collaborative management of congenital cataracts. Nature Biomedical Engineering, 1(2), 1–8. https://doi.org/10.1038/s41551-016-0024

Mahardika, P. S., & Gunawan, A. A. N. (2022). Modeling of water temperature in evaporation pot with 7 Ds18b20 sensors based on Atmega328 microcontroller. Linguistics and Culture Review, 6, 184–193. https://doi.org/10.21744/lingcure.v6ns3.2123

McAllister, James, Lennertz, Lora, & Zayuris, M. (2021). Mapping a discipline: a guide to using vosviewer for bibliometric and visual analysis. Science & Technology Libraries. https://doi.org/10.1080/0194262X.2021.1991547

Muhamad Juliardi, & Ibnu Malik. (2023). Bibliometric analysis of data science: trends, contributions, and research developments. West Science Interdisciplinary Studies, 1(07), 365–375. https://doi.org/10.58812/wsis.v1i07.81

Mustakim, M., Ajwar, M., Kertih, I. W., & Lasmawan, I. W. (2024). The Use of Technology in curriculum development and social studies learning design in elementary schools : a critical analysis and literature review. Jurnal Humanitas Katalisator Perubahan Dan Inovator Pendidikan.

Nembrini, R., Ferrari Dacrema, M., & Cremonesi, P. (2021). Feature selection for recommender systems with quantum computing. Entropy, 23(8). https://doi.org/10.3390/e23080970

Omol, E. J. (2024). Organizational digital transformation: from evolution to future trends. Digital Transformation and Society, 3(3), 240–256. https://doi.org/10.1108/DTS-08-2023-0061

Onu, P., Pradhan, A., & Mbohwa, C. (2024). Potential to use metaverse for future teaching and learning. In Education and Information Technologies (Vol. 29). https://doi.org/10.1007/s10639-023-12167-9

Padmalia, M. (2023). Firm resilience research development : A Bibliometric Analysis with Vosviewer. Business and Accounting Research (IJEBAR) , 7(1), 274–286. Retrieved from https://jurnal.stie-aas.ac.id/index.php/IJEBAR

Passas, I. (2024). Bibliometric analysis: the main steps. Encyclopedia, 4(2), 1014–1025. https://doi.org/10.3390/encyclopedia4020065

Pranckutė, R. (2021). Scopus and Web of Science stands out for systematic reviews, offering comprehensive coverage across disciplines, including journals, conferences, and patents. Publications, 9(1), 1–59.

Prayogi, S., & Verawati, N. N. S. P. (2024). Physics learning technology for sustainable development goals (sdgs): a literature study. International Journal of Ethnoscience and Technology in Education, 1(2), 155. https://doi.org/10.33394/ijete.v1i2.12316

Sahingoz, O. K., Buber, E., Demir, O., & Diri, B. (2019). Machine learning based phishing detection from URLs. Expert Systems with Applications, 117, 345–357. https://doi.org/10.1016/j.eswa.2018.09.029

Sheng, J., Amankwah-Amoah, J., & Wang, X. (2017). A multidisciplinary perspective of big data in management research. International Journal of Production Economics, 191(June), 97–112. https://doi.org/10.1016/j.ijpe.2017.06.006

Somesha, M., Pais, A. R., Rao, R. S., & Rathour, V. S. (2020). Efficient deep learning techniques for the detection of phishing websites. Sadhana - Academy Proceedings in Engineering Sciences, 45(1). https://doi.org/10.1007/s12046-020-01392-4

Souza, A. M., Martins, E. O., Roditi, I., Sá, N., Sarthour, R. S., & Oliveira, I. S. (2022). An application of quantum annealing computing to seismic inversion. Frontiers in Physics, 9(January), 1–8. https://doi.org/10.3389/fphy.2021.748285

Tsai, C. W., Lee, L. Y., Cheng, Y. P., Lin, C. H., Hung, M. L., & Lin, J. W. (2024). Integrating online meta-cognitive learning strategy and team regulation to develop students' programming skills, academic motivation, and refusal self-efficacy of Internet use in a cloud classroom. Universal Access in the Information Society, 23(1), 395–410. https://doi.org/10.1007/s10209-022-00958-9

Tsai, W. H., Chou, W. C., & Lai, C. W. (2010). An effective evaluation model and improvement analysis for national park websites: A case study of Taiwan. Tourism Management, 31(6), 936–952. https://doi.org/10.1016/j.tourman.2010.01.016

Van Eck, N. J., & Waltman, L. (2018). VOSviwer Manual version 1.6.10. Universiteit Leiden, (January), pp.1-53. Retrieved from https://www.vosviewer.com/ documentation/Manual_VOSviewer_1.6.10.pdf

Van Eck, N. J., & Waltman, L. (2022). Manual VOSviewer. Univeristeit Leiden, (January), 54.

Wienand, M., Wulfert, T., & Hoang, H. (2024). Design principles for e-learning platforms featuring higher-education students' enterprise systems end-user training. In Discover Education (Vol. 3). Springer International Publishing. https://doi.org/10.1007/s44217-024-00165-z

Winarko, B., Fatadona, H., Nganjuk, M. U., Maarif, U., Latif, H., & Surabaya, U. N. (2024). The digitalization policy in the education sector : 5(3), 236–251.

Wiyono, K., Ismet, I., Andriani, N., Fitonia, A., Nadia, H., Meitasari, D., & Nazhifah, N. (2024). Exploration of physics concepts in local wisdom of south sumatera as an effort to develop students' 21st-century skills. Jurnal Penelitian & Pengembangan Pendidikan Fisika, 10(1), 61–78. https://doi.org/10.21009/1.10106

You, C., Awang, S. R., & Wu, Y. (2024). Bibliometric analysis of global research trends on higher education leadership development using Scopus database from 2013–2023. Discover Sustainability, 5(1). https://doi.org/10.1007/s43621-024-00432-x

Zahra, A. A., Nurmandi, A., Tenorio, C. B., Rahayu, R., Benectitos, S. H., Mina, F. L. P., & Haictin, K. M. (2021). Bibliometric analysis of trends in theory-related policy publications. Emerging Science Journal, 5(1), 96–110. https://doi.org/10.28991/ESJ-2021-01261