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Interactive Websites in Physics Education: A Bibliometric Analysis and Trends Review

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Abstract

This study examines the trend and contribution of interactive websites in physics education through bibliometric analysis. Using R Bibliometrix, 38 articles from 1999 to 2024 were analyzed in annual scientific production, country scientific production, most cited countries, most cited documents globally, and word clouds. The types of documents obtained from the Scopus database in the form of articles, book chapters, conference papers, and conference reviews. The findings of the analysis show that the key trends include students, websites, e-learning, education, and teaching. While gaps remain in interactive learning tools, learning experiences, learning management systems, learning processes, and differentiation. This study could serve as a global guide for researchers and educators creating interactive physics learning websites.

Keywords: bibliometric analysis; interactive websites; literature review; physics learning

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INTRODUCTION

Increasingly sophisticated information and communication technology (ICT) has brought significant changes in life. These changes make developments and have an impact in various domains, including the realm of education (Indriyanti et al., 2023). The use of technology in education has significantly changed the way people interact and learn in the classroom (Iskandar et al., 2023). Thus, demands in the world of education are needed to adjust the development of technology by improving the quality of education (Rahmawati et al., 2022). This is in line with the goals of Sustainable Development 4 (SDG-4), which is based on the agenda of sustainable development in 2030 by the United Nations to achieve high-quality education, justice, and inclusiveness and meet the needs of student education, digital technology must be included in the educational system (Haleem et al., 2022). Therefore, integrating digital technology into the education system is a necessity and an inseparable part of an effort to achieve sustainable development goals. Digital technology can make education more efficient, effective, and inclusive for all students (Azizah & Hendriyani, 2024). Thus, improving the quality of education can be achieved through the use of appropriate and integrated technology in the learning process.

Physics learning is one of the lessons mostly avoided by students. Students have difficulty understanding the concept

of physics, and considering that physics is a difficult subject because there are too many formulas, it is difficult to work on questions and not attractive (Ady & Warliani, 2022). In addition to the perception of students who consider physics to be difficult lessons, other factors that influence the disinterest of students' learning is the teacher's lack of varied learning media (Dasmo et al., 2020). The characteristics and principles of the relevant curriculum must be considered while selecting learning material. One of the learning innovations using information and communication technology that can be utilized is an interactive website, which can attract students and increase their understanding and involvement in learning physics concepts (Susanto et al., 2024). The interactive website offers features that allow students to be involved more actively in learning, such as simulations, animation, and virtual experiments.

Several studies, as conducted by Zatarain-Cabada (2023), have shown that the results of the use of web-based learning tools that use AR and VR to study the concepts of kinematics and dynamics significantly increase student learning motivation (Zatarain-Cabada et al., 2023). Furthermore, other research has also shown that web-based learning can increase productivity and effectiveness of learning because it is flexible and equipped with features that support learning so that students can learn independently anytime and anywhere, following their abilities without limited time, and increase motivation to learn interest (Puspitasari et al., 2018). The development of interactive learning media to support education in the 21st century by Raudah et al. (2021) states that the interactive learning media of Carrd.co that has been developed is feasible to use and can increase the quality and motivation of students' learning.

Through interactive websites in physics education, students can learn independently, increase motivation, and actively participate in the learning process. Thus, interactive website learning has also improved the quality of education from year to year (Wahyuningrum et al., 2021). However, the extent to which interactive websites have been developed and utilized in physics education has not been comprehensively identified.

It seems important to make an overview of the current research results on an interactive website in physics education. While the review article by Prahani et al. (2022) provides a comprehensive overview of the trends and contributions of web learning in physics education during the COVID-19 pandemic, Tsalist & Habibulloh (2023) conducted a bibliometric analysis of the use of Moodle e-learning in physics learning media. However, we identified a research gap regarding the current survey of scientific results in the field, which lacks an exploration of the application of innovative learning methods, such as interactive websites in physics. With the study presented in this article, we contribute to closing this gap by identifying the research and trends about interactive websites in physics education; it can be analyzed using bibliometric analysis.

Bibliometric analysis is a general and comprehensive technique used to exploit or investigate large amounts of scientific data to determine the trend and investigate the academic structure of the published literature (Wibowo et al., 2024). This approach lists the author's articles, the best journals, the methodology employed, and the results obtained (Susanty et al., 2022). Therefore, this approach was chosen because bibliometric analysis research can be discussed in terms of publication characteristics, citation impact, subjects' analysis, and country analysis. Bibliometric analysis differs from meta-

analyses and systematic reviews (Donthu et al., 2021).

As previously explained, this study aims to examine how interactive websites are used in physics education through bibliometric mapping. It also aims to see the trend of the development of scientific publications about the use of interactive websites in physics education. This research is expected to provide information related to the two keywords so that it can be used as further research analysis to find out information about the development of interactive websites in physics education.

METHOD

This study employed a bibliometric analysis and a literature review. Bibliometric analysis offers a quantitative evaluation of a publication or research product (Novia et al., 2021). Bibliometric analysis in this study utilizes the R software package Bibliometric. R software can be used by users in an open-source environment (Agbo et al., 2021). R software is equipped with integrated capabilities intended for reproduction, statistical modelling, data studies, and visualization. The articles analyzed use data from the Scopus Database. Scopus contains a variety of published literature with a wide scope (Echchakoui, 2020). Scopus offers a substantial peer-reviewed collection in various disciplines (Lefosse et al., 2023). Therefore, utilizing the Scopus Database is the best option because it provides a diverse range of literature that has passed peer review in various scientific subjects. This increases the validity and accuracy of the analysis. Researchers can ensure that the information utilized in their analyses is up to date and has undergone a rigorous peer review procedure by using data from the Scopus Database. As a result, errors and biases in the analysis can be reduced.

The bibliometric analysis uses five stages: determining keywords, initial research, research refinement, data analysis, and conclusions. The analysis stages can be seen in Figure 1.

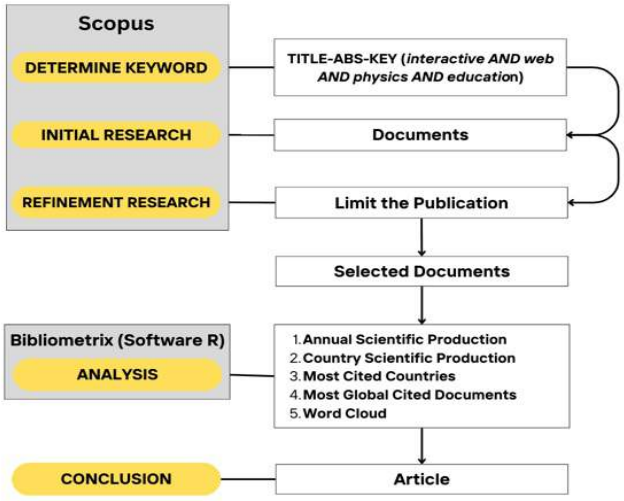

Figure 1 Stages of bibliometric analysis with R software and content analysis

A literature search was conducted online in September 2024 with 2 search terms, namely 'Interactive Website' and 'Physics Education,' using binary operators such as "AND". For the next stage, refinement of the research was carried out by utilizing built-in filters such as year of publication, document type, language, and access type, which were adjusted to the article criteria: (1) the article discusses the use of interactive websites or digital technology in physics

learning, (2) published within the last 25 years to ensure current relevance, (3) in the form of a scientific article in a peer-reviewed journal, academic conference proceedings, conference review, and book chapter, (4) written in English, and (5) available in full-text format. This is applied to ensure consistency and accuracy in data searches. After that, data from Scopus is exported in CSV (comma-separated values) format.The exported data in CSV (comma-separated values) format is entered into the bibliometrix software R for analysis. The analysis in this study focuses on annual scientific production, country scientific production, the most cited countries, the most globally cited documents, and *Word Cloud*. After the analysis was carried out using the bibliometrix software R, statistical analysis and visualization was obtained in the form of Microsoft Excel. The final step is to determine the trends and contributions of interactive websites in physics learning.

RESULTS AND DISCUSSION

In order to learn more about scholarly contributions and gaps, this study employs bibliometric analysis to find trends and patterns in research on interactive websites in physics education. Table 1 provides the distribution of key details of the data collection information with keyword searches for “Interactive Websites” and “Physics Education” identified from 1999 to 2024. The keyword search was conducted using the Scopus database, identifying various documents with the most conference paper details, 24, followed by articles with 1, conference reviews with 2, and book chapters as the least frequent, only 1. The document content includes 413 keywords, complemented by 81 author keywords. The results of this analysis indicate that the topic of "Interactive Websites" in the context of "Physics Education" has been a major focus in various scientific publications during the mentioned time period. Looking at the detailed distribution of the types of documents identified, it can be concluded that the topic is highly relevant and attracts the interest of researchers from various disciplines. In addition, the presence of 81 author keywords also indicates significant contributions from various experts in developing an understanding of the topic.

Table 1 Bibliometric statistical data description of interactive website and physics education

Dynamics		Structure	
Timespan	1999 - 2024	Authors	135
Source (Journal, Books, etc.)	31	Author of single-authored docs	5
Documents	38	Single-authored documents	7
Average citations per document	10.13	Co-Authors per Document	3.92
Keyword Plus (ID)	413	International co-authorships %	18.42
Author’s Keywords (DE)	81	Annual growth rate %	-2.73

In addition, Table 1 also describes the structure of research products (author specifications and references, etc.). Among the authors of the documents, a total of 135 documents were identified, with 5 documents written by a single author and 130 documents with multiple authors. In addition, there were seven documents with a single author, each with an average of 3.92 co-authors. The percentage of international collaboration in authorship was 18.42%, and the annual growth rate was -2.73%. Lack of innovation, regional focus, restricted networks or funding, and obstacles to research accessibility could all contribute to the low degree of international collaboration and negative annual growth. The relatively low collaboration rate may hinder the dissemination of

diverse perspectives in this field. In order to improve cross-country collaboration, measures like expanding financial support, fortifying global networks, and granting access to research findings are required. This aligns with Okoye et al.'s research (2022).

The collected data shows that collaboration between authors is common in research on interactive websites in physics education. This shows the importance of collaboration between researchers in producing higher-quality knowledge. In addition, the lack of references per document shows that further research is still needed to support the existing findings and further develop this field of study. Thus, future researchers need to consider appropriate resources and collaborate to explore this topic further.

The publication trend is one of the most significant indicators in a field or sector (Tekdal, 2021); trends and development directions in a particular scientific domain support strategic decision-making in research and publication development (Dubyna et al., 2022). A total of 38 documents published between 1999 and 2024 were discovered. Figure 2 illustrates the annual scientific production using the keywords "interactive website" and "physics education" over the years.

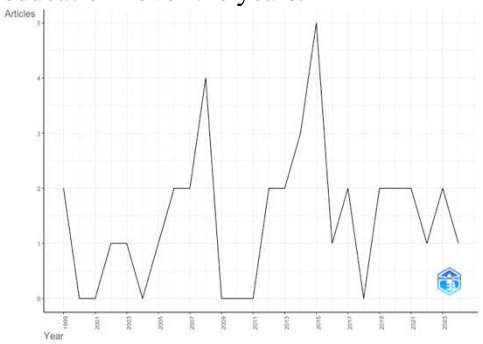

Figure 2 Annual scientific production of interactive website in physics education

The trend of scientific publications shows a slight oscillation in 2 documents from 1999 to 2006. However, there was a significant increase in 2008 of 4 documents. Then it experienced a drastic decline in 2009. The highest peak of the writing trend occurred in 2015, reaching five published articles. Technological advancements and academic trends that embraced digital solutions to support more flexible and effective education were the main drivers of the sharp rise in website research in 2015 (Santika, 2021). However, from 2016 to 2024, it showed oscillation again in 2 documents.

The top 20 countries in scientific production publishing papers on interactive websites in physics education have been ranked based on the data obtained. The publications of these countries are shown in Table 2.

Table 2 Countries' scientific production

Rank	Country	Freq
1	USA	71
2	China	8
3	Germany	7
4	Mexico	7
5	Austria	6
6	Colombia	5
7	Lithuania	5
8	Canada	4
9	Romania	4
10	Belgium	3
11	Hungary	2
12	Indonesia	2
13	Norway	2
14	Poland	2
15	South Africa	2
16	Brazil	1
17	Czech Republic	1
18	France	1
19	Israel	1
20	Japan	1

Active countries in this context refer to countries that have significantly contributed to the literature on interactive websites in physics education by publishing five or more papers during the specified period. These countries are regarded as having made significant contributions to research on the topic, demonstrating a high level of interest and productivity in research on interactive

websites in physics education. Due to its highly advanced technological infrastructure, substantial investments in research and development (R&D), and strong innovation and technology adoption culture within educational institutions (Okoye et al., 2022), the United States leads with a frequency of 71. China is in second place, with eight publications. The development of learning technology is also fueled by strong market demand and government support through educational policies. The third-ranked country, Germany, has a total of 7 publications. Furthermore, it is evident from the data wrapper that researchers worldwide, including those in Indonesia, are interested in studying interactive websites in physics education.

The most cited countries significantly contribute to the education community's understanding of interactive websites and physics education. Table 3 shows the ranking of seven countries by citation volume. The Americas and Europe, particularly the United States and Austria, have had the largest influence on interactive websites and physics education research. The publication trend in the Americas is also widespread. For example, the United States (America) and Austria (Europe) have the most citations (294 and 9, respectively). Mexico (America) and Canada (America) are third and fourth, with 7 and 5 citations, respectively. Other countries, including Poland (Europe), Brazil (America), and China (Asia), are also important. The quantity of citations from various countries demonstrates the severe worldwide competition for interactive websites and physics education research. Countries like Poland, Brazil, and China are also involved in the competition and contribute significantly to the citations. This shows that interest and focus on interactive website development and physics education research are spread across the world. Thus, it can be concluded that the global scientific community is increasingly involved in efforts to improve the accessibility and quality of physics education through online platforms.

Table 3 Most cited countries

Rank	Country	Total Citations
1	USA	294
2	Austria	9
3	Mexico	7
4	Canada	5
5	Poland	3
6	Brazil	1
7	China	1

The most referenced papers about interactive physics education websites provide high-quality content on leading research subjects, drawing academics from related fields. A document's total number of citations demonstrates its significance to the scientific community. Using R software and the bibliometric tool Biblioshiny, seven published publications were ranked according to the number of citations based on the provided data. Table 4 lists the documents that have been cited the most globally. The top three are the most often cited journal papers over the given time frame.

Table 4 The top 15 most globally cited articles in scopus explore results

Author, Year, Journal	Total Cited	Finding
Perkins et al., 2006, Phys Teach	226	PhET: Interactive Simulations for Teaching and Learning Physics
Dikshit et al., 2005, Comput Med Imaging Graph	34	A web-based system for simulating medical imaging that can be used to instruct trainees and students aspiring to careers in medical imaging.
González et al., 2017, J Phys Conf Ser	18	Virtual labs for PCs, consoles, mobile devices, and websites are an innovative way to study physics.

Author, Year, Journal	Total Cited	Finding
Eslahpazir et al., 2014, J Vasc Surg	17	High-quality endovascular simulators available on the market today generally use an interactive virtual environment with pre-programmed physics and physiology models to accurately replicate surgical conditions.
Miller et al., 2014, Plos Comput Biol	11	The CHARMMing simulation platform can be used for both user and development purposes.
Nagy & Tasnádi, 2014, Eur J Phys	10	Through interactive simulations, the Zeeman machine can be a useful and entertaining tool for teaching students about chaotic motion.
Pascual et al., 2013, Semin Nucl Med	9	The IAEA has integrated online educational tools for nuclear medicine specialists, such as the Human Health Campus website, e-learning modules, and interactive webinars.
Roselli et al., 2008, Asee Annu Conf Expos Conf Proc	9	Web-based authoring tools developed with VaNTH CAPE technology have been effective in assisting instructors, teaching assistants, and students in solving engineering quantitative problems, interactively by providing real-time formative feedback.
Khlopov, 2012, Bled Workshops Phys	8	The Virtual Institute of Astroparticle Physics (VIA), integrated into the Laboratory of Astroparticle Physics and Cosmology (APC), has successfully created a multifunctional e-science and e-learning platform that supports interactive online participation in conferences, scientific meetings and educational programs in the field of astroparticle physics.
Zatarain-Cabada et al., 2023, Comput Appl Eng Educ	7	FisicARtivo, a web-based learning tool that uses AR and VR to learn the concepts of kinematics and dynamics. The survey results showed that both technologies, AR and VR, significantly increased students' learning motivation.
Vo & Sharp, 2019, J Med Imaging Radiat Sci	5	The OpenPhys platform can address existing gaps in the delivery of physics education and has the potential to be part of blended learning initiatives.
Fisher & Michielssen, 1999, Ieee Antennas Propag Soc Int Symp: Wirel Technol Inf Netw, Aps - Held Conjunction Usnc/Ursi National Radio Sci Meet	4	The Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign has considerably improved teaching efficacy with Antenna Web Server (AWS), a web-based learning and simulation environment for antenna education.
Foley et al., 2003, Proc Spie Int Soc Opt Eng	4	Mississippi State University developed WebTOP, a three-dimensional interactive computer graphics system, to teach students about waves and optics. WebTOP has been useful in teaching basic physics and advanced optical concepts.
Faridani & Gramoll, 2008, Asee Annu Conf Expos Conf Proc	3	Developing interactive 2D and 3D content for microelectromechanical systems (MEMS) that enables students to learn, design, and analyze MEMS devices online without the need for expensive software, as well as expanding access to MEMS experiments in educational institutions.

Author, Year, Journal	Total Cited	Finding
Basitere & Ivala, 2015, Proc Int Conf E-Lear, Icel	3	Wiley PLUS (WBH) web with automated grading in an entry-level Engineering Physics course significantly improves student learning and student collaboration.

Table 4 shows that the paper was written by Perkins K. The article published in the journal "PHYS. Teach" in 2006 obtained the greatest number of quotes (226). Next, a paper by Dikshit A., published in 2005 in "Computerized Medical Imaging and Graphics," includes 34 quotes. The third rank is a paper by González JD., which was published in 2017 in the "Journal of Physics Conference Series.". Those articles have many citations because they offer significant contributions, are relevant to current issues, are published in a reputable journal, and/or have a multidisciplinary scope. In addition, the authors' reputation, the article's availability, and the methodology's relevance also play an important role.

This visualization investigation aims to connect the findings of the main ideas and which articles are the most influential and have the biggest significant impact in influencing subjects and fields of physics education research.

Suggestions for interactive websites in physics education should be made and developed more extensively since, according to Table 4, interactive websites play many significant functions that benefit physics education. Various media-generated and related websites have shown their success in positively influencing physics education. Because of the considerable advantages of interactive websites in physics education, chances for interactive online research in physics education will arise in the future.

Furthermore, the visualization of Word Cloud in software R provides an overview of the frequency of certain keywords being used. It can also help identify the main themes in research related to interactive websites in physics learning. Researchers can use this information to understand the latest research trends, explore developing areas, and find the right collaboration potential of the relationship between research topics. This mapping is an effective tool for analyzing the direction and focus of research on using interactive websites in physics education. The word cloud of interactive websites and physics education in Scopus is shown in Figure 3.

Figure 3 Word cloud of interactive website and physics education in scopus

The results of processing using R Bibliometrix software from *Word Cloud* analysis show research theme trends ranging from the most frequently discussed to the least noticed. The research theme trends of interactive websites in physics learning that are often discussed are those related to students, websites, e-learning, education, and teaching. Meanwhile, topics that receive less attention are interactive learning devices, learning experiences, learning management systems, and learning processes. This is consistent with the findings of Prahani et al. (2022). The topics that receive less attention have the potential to develop innovations in research related to learning the use of interactive websites in physics education.

CONCLUSION

The results of this study have analyzed the trends and contributions of research related to interactive websites in physics learning. All data were obtained from the Scopus database of 38 articles. The extraction and visualization processes were carried out using Bibliometrix R software. The data processing results focused on five studies: annual scientific production, country scientific production, most cited countries, most globally cited documents, and Word Cloud. The analysis findings show that interactive website research in physics education is still lacking in number. The country that contributes the most to interactive website research in physics education is the USA. The most widely published document type is a conference paper. The top source title in this topic that is often cited is "PhET: Interactive Simulations for Teaching and Learning Physics," and the top publisher is "Phys. Teach." The dominant topics on interactive websites in physics learning and research topic trends are students, websites, e-learning, education, and teaching. Less researched topics are interactive learning tools, learning experiences, learning management systems, and learning processes. This study's limitation is that it only uses one database to collect research data. Future studies on interactive website learning in physics education can be conducted and improved more thoroughly using databases other than Scopus. Another idea in a study on interactive website learning in physics education is to focus on less investigated subjects, such as interactive learning tools, learning experiences, learning management systems, and learning processes.

The implication of this research is to show the trend of the publication of interactive websites in physics education so that future researchers can show more benefits related to these topics. With this article, researchers can find out the strengths and weaknesses of interactive websites in physics education and can find updates for future research. The limitation of this study is that it only uses one database to collect research data. More intensively, educators should include interactive websites that focus on under-explored areas such as learning processes. Policymakers can fund interdisciplinary collaborations to improve digital learning tools, and further research can be carried out by focusing on under-researched subjects such as interactive learning tools, learning experiences, learning management systems, and learning processes.

REFERENCES

Ady, W. N., & Warliani, R. (2022). Analisis kesulitan belajar siswa sma terhadap mata pelajaran fisika pada materi gerak lurus beraturan. *Jurnal Pendidikan Dan Ilmu Fisika*, *2*(1), 104–108. https://doi.org/10.52434/jpif.v2i1.1599

Agbo, F. J., Sanusi, I. T., Oyelere, S. S., & Suhonen, J. (2021). Application of virtual reality in computer science education: A systemic review based on bibliometric and content analysis methods. *Education Sciences*, *11*(3), 142. https://doi.org/10.3390/educsci11030142

Azizah, N., & Hendriyani, W. (2024). Implementasi penggunaan teknologi digital sebagai media pembelajaran pada pendidikan inklusi di indonesia. *Jurnal Educatio*, *10*(2), 644–651. https://doi.org/10.31949/educatio.v10i2.8586 ISSN

Basitere, M., & Ivala, E. N. (2015). The effects of Wiley PLUS web-based homework system on student performance in the chemical engineering extended curriculum program: Introductory physics course. *Proceedings of the*

International Conference on E-Learning, ICEL, 31–40.

Dasmo, Puji Lestari, A., & Alamsyah, M. (2020). Peningkatan hasil belajar fisika melalui penerapan media pembelajaran interaktif berbasis ispring suite 9. *Prosiding Seminar Nasional Sains*, *1*(1), 99–102.

Dikshit, A., Wu, D., Wu, C., & Zhao, W. (2005). An online interactive simulation system for medical imaging education. *Computerized Medical Imaging and Graphics*, *29*(6), 395–404. https://doi.org/10.1016/j.compmedimag.2005.02.001

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*(April), 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dubyna, M., Popelo, O., Kholiavko, N., Zhavoronok, A., Fedyshyn, M., & Yakushko, I. (2022). Mapping the literature on financial behavior: A BIBLIOMETRIC ANALYSIS USING THE VOSVIEWER PROGRAM. *WSEAS Transactions on Business and Economics*, *19*(December 2021), 231–246. https://doi.org/10.37394/23207.2022.19.22

Echchakoui, S. (2020). Why and how to merge Scopus and Web of Science during bibliometric analysis: the case of sales force literature from 1912 to 2019. *Journal of Marketing Analytics*, *8*(3), 165–184. https://doi.org/10.1057/s41270-020-00081-9

Eslahpazir, B. A., Goldstone, J., Allemang, M. T., Wang, J. C., & Kashyap, V. S. (2014). Principal considerations for the contemporary high-fidelity endovascular simulator design used in training and evaluation. *Journal of Vascular Surgery*, *59*(4), 1154–1162. https://doi.org/10.1016/j.jvs.2013.11.074

Faridani, S., & Gramoll, K. (2008). Online interactive MEMS experiments and web-based curriculum. *ASEE Annual Conference and Exposition, Conference Proceedings*, 13.948.1-13.948.15. https://doi.org/10.18260/1-2--4190

Fisher, S. E., & Michielssen, E. (1999). An integrated online environment for antenna education. *IEEE Antennas and Propagation Society International Symposium: Wireless Technologies and Information Networks, APS 1999 - Held in Conjunction with USNC/URSI National Radio Science Meeting*, *1*, 78–81. https://doi.org/10.1109/APS.1999.789087

Foley, J. T., Mzoughi, T., Herring, S. D., Morris, M., Gillbert, P. J., & Moore, D. T. (2003). The optics project on the web (WebTOP). *Optics InfoBase Conference Papers*, *9663*. https://doi.org/10.1117/12.2207350

González, J. D., Escobar, J. H., Sánchez, H., De La Hoz, J., & Beltrán, J. R. (2017). 2D and 3D virtual interactive laboratories of physics on Unity platform. *Journal of Physics: Conference Series*, *935*(1), 012069. https://doi.org/10.1088/1742-6596/935/1/012069

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

Indriyanti, F., Fauziah, T. N., & Nuryadin, A. (2023). Analisis bibliometrik penggunaan video pembelajaran di sekolah dasar tahun 2013-2022 menggunakan aplikasi

vosviewer. *Jurnal Educatio*, *9*(1), 23–31. https://doi.org/10.31949/educatio.v9i1.3906

Iskandar, A., Winata, W., Kurdi, M. S., Sitompul, P. H. S., Kurdi, M. S., Nurhayati, S., Hasanah, M., Arisa, M. F., & Haluti, F. (2023). *Peran Teknologi dalam dunia pendidikan* (1st ed.). Yayasan Cendekiawan Inovasi Digital Indonesia.

Khlopov, M. Y. (2012). Virtual institute of astroparticle physics - science and education online. *Bled Workshops in Physics*, *13*(2), 1–9.

Lefosse, D., van Timmeren, A., & Ratti, C. (2023). Biophilia upscaling: A systematic literature review based on a Three-Metric Approach. *Sustainability (Switzerland)*, *15*(22), 1–34. https://doi.org/10.3390/su152215702

Miller, B. T., Singh, R. P., Schalk, V., Pevzner, Y., Sun, J., Miller, C. S., Boresch, S., Ichiye, T., Brooks, B. R., & Woodcock, H. L. (2014). Web-based computational chemistry education with CHARMMing I: Lessons and tutorial. *PLoS Computational Biology*, *10*(7), e1003719. https://doi.org/10.1371/journal.pcbi.1003719

Nagy, P., & Tasnádi, P. (2014). Zeeman catastrophe machines as a toolkit for teaching chaos. *European Journal of Physics*, *35*(1), 1–22. https://doi.org/10.1088/0143-0807/35/1/015018

Novia, N., Permanasari, A., & Riandi, R. (2021). Research on educational games in STEM area 2010-2020: A bibliometric analysis of literature. *Journal of Physics: Conference Series*, *1806*(1), 012209. https://doi.org/10.1088/1742-6596/1806/1/012209

Okoye, K., Nganji, J. T., Escamilla, J., Fung, J. M., & Hosseini, S. (2022). Impact of global government investment on education and research development: A comparative analysis and demystifying the science, technology, innovation, and education conundrum. *Global Transitions*, *4*, 11–27. https://doi.org/10.1016/j.glt.2022.10.001

Pascual, T. N., Dondi, M., Paez, D., Kashyap, R., & Nunez-Miller, R. (2013). IAEA programs in empowering the nuclear medicine profession through online educational resources. *Seminars in Nuclear Medicine*, *43*(3), 161–166. https://doi.org/10.1053/j.semnuclmed.2012.11.005

Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., & Lemaster, R. (2004). PhET: Interactive simulations for teaching and learning physics. *The Physics Teacher*, *44*(1), 18–23.

Prahani, B. K., Jatmiko, B., Amelia, T., Pristianti, M. C., Mahtari, S., & Uulaa, R. F. R. (2022). Web learning research in physics education during the covid-19 pandemic. *Journal of Physics: Conference Series*, *2392*(1). https://doi.org/10.1088/1742-6596/2392/1/012002

Puspitasari, E. D. T., Surjono, H. D., & Minghat, A. D. (2018). Utilizing web based learning as 21st century learning media for vocational education. *International Journal of Engineering and Technology(UAE)*, *7*(4), 157–160. https://doi.org/10.14419/ijet.v7i4.33.23522

Rahmawati, Y., Febriyana, M. M., Bhakti, Y. B., Astuti, I. A. D., & Suendarti, M. (2022). Pengembangan media pembelajaran fisika berbasis game edukasi: Analisis bibliometrik menggunakan software vosviewer (2017-2022). *Jurnal Penelitian Pembelajaran Fisika*, *13*(2), 257–266.

https://doi.org/10.26877/jp2f.v13i2.13170

Raudah, Mansur, H., & Satrio, A. (2021). Pengembangan media pembelajaran interaktif carrd.co untuk menyonsong pendidikan di abad 21. *Journal of Instructional Technology*, *2*(2), 151–159.

Roselli, R., Gilbert, S. B., Howard, L., Blessing, S. B., Raut, A., & Pandian, P. (2008). Integration of an intelligent tutoring system with a web-based authoring system to develop online homework assignments with formative feedback. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://doi.org/10.18260/1-2--4020

Santika, I. G. N. (2021). Grand desain kebijakan strategis pemerintah dalam bidang pendidikan untuk menghadapi revolusi industri 4.0. *Jurnal Education and Development*, *9*(2), 369–377.

Susanto, A., Saleh, M., Putri, K., & Annisa, N. (2024). Pelatihan pengembangan media pembelajaran fisika berbasis website menggunakan platform wix pada materi gelombang mekanik di sma negeri 5 takalar. *Nanggroe: Jurnal Pengabdian Cendikia*, *3*(7), 1–8. https://doi.org/10.5281/zenodo.13882650

Susanty, A. I., Artadita, S., Pradana, M., Neo, T.-K., Neo, M., & Amphawan, A. (2022). Twenty years of cooperative learning: A data analytic with bibliometric approach. *2022 International Conference Advancement in Data Science, E-Learning and Information Systems (ICADEIS)*. https://doi.org/10.1109/ICADEIS56544.2022.10037477

Tekdal, M. (2021). Trends and development in research on computational thinking. *Education and Information Technologies*, *26*(5), 6499–6529.

Tsalist, S. L., & Habibulloh, M. (2023). Analisis bibliometrik penggunaan e-learning moodle dalam pembelajaran fisika. *Seminar Nasional Fisika (SNF)*, 18–25. https://fisika.fmipa.unesa.ac.id/proceedings/index.php/snf/article/view/206

Vo, M. K., & Sharp, J. C. (2019). Design, development, and content creation for an open education physics website for mrt education. *Journal of Medical Imaging and Radiation Sciences*, *50*(2), 212–219. https://doi.org/10.1016/j.jmir.2019.03.180

Wahyuningrum, T., Kartiko, C., Wardhana, A. C., & Soares, T. G. (2021). Revised web impact factor analysis of timor leste university website during covid-19 pandemic. *Bulletin of Electrical Engineering and Informatics*, *10*(3), 1678–1686. https://doi.org/10.11591/eei.v10i3.3034

Wibowo, F. C., Darman, D. R., Guntara, Y., Nulhakim, L., Prahani, B. K., Kurniawan, B. R., Fatkhomi, F., Siwanto, Prajoko, S., Ahmad, N. J., & Karlin, K. A. A. (2024). Unveil creative thinking in the physics education: Bibliometric analysis and literature review. *AIP Conference Proceedings*, *3116*(1). https://doi.org/10.1063/5.0210197

Zatarain-Cabada, R., Barrón-Estrada, M. L., Cárdenas-Sainz, B. A., & Chavez-Echeagaray, M. E. (2023). Experiences of web-based extended reality technologies for physics education. *Computer Applications in Engineering Education*, *31*(1), 63–82. https://doi.org/10.1002/cae.22571