www.ijses.net

Advancements in Online Learning: A Comprehensive Systematic Literature Review in The Last Decade

Nadya Amalia Putri Hapsari
Universitas Negeri Yogyakarta, Indonesia

Mundilarto
Universitas Negeri Yogyakarta, Indonesia

To cite this article:

Hapsari, N.A.P. & Mundilarto. (2025). Advancements in online learning: A comprehensive systematic literature review in the last decade. *International Journal of Studies in Education and Science (IJSES), 6*(1), 29-47. https://doi.org/10.46328/ijses.121

IJSES International Journal of Studies in Education and Science
2025, Vol. 6, No. 1, 29-47 https://doi.org/10.46328/ijses.121

Advancements in Online Learning: A Comprehensive Systematic Literature Review in The Last Decade

Nadya Amalia Putri Hapsari, Mundilarto

Article Info

Article History

Received:
10 August 2024
Accepted:
5 December 2024

Keywords

Education
Online learning
Physics
Physics education
Systematic literature review

Abstract

The use and popularity of online learning platforms have brought about significant changes to the delivery of physics education. This paper presents a comprehensive systematic literature review on the latest advancements in online learning for physics in the last decade from 2013-2022. The review examined 53 articles following the PRISMA protocol and categorized them based on their research focus, methods, and findings using VoSviewer as a bibliographic analyzer. Additionally, the paper discusses the growth of online learning in physics based on metadata such as papers per year, citations number, sources of articles (journals), publisher, country where the research be done, and the platforms utilized. The findings suggest that online physics learning has become more interactive, engaging, and learner-centered, resulting in improved understanding of the subject matter. However, there are still many challenges that need to be addressed and solved, including student motivation and instructor support, to optimize the effectiveness of online physics learning. This review contributes to the field by identifying the strengths and limitations of online learning in physics education and providing insights for educators and researchers to enhance the design and implementation of online physics courses in school or university.

Introduction

The field of physics education has long been interested in exploring new pedagogical approaches and technologies to enhance students' learning experiences and promote scientific literacy. With the advent of the digital age, online learning has emerged as a promising tool for achieving these goals, offering new opportunities for students to engage with physics concepts in interactive and collaborative ways (Girwidz & Tremp, 2017). The use of online learning platforms in physics education has grown rapidly over the past decade, driven by the increasing availability and accessibility of digital technologies (Koenig et al., 2020). Online learning has the potential to overcome many of the limitations of traditional classroom-based learning, such as time and location constraints, and can provide a more personalized and interactive learning experience for students (Hrastinski, 2019). In addition, online learning platforms can offer a range of tools and resources that can enhance students' understanding of complex physics concepts, such as simulations, visualizations, and interactive multimedia.

Over the past decade, there has been a growing body of research on the effectiveness of online learning in physics

education. Several studies have demonstrated the potential of online simulations and virtual labs for promoting students' understanding of complex physical phenomena (Koenig & Bake, 2021; Prasetya et al., 2022; Pratidhina et al., 2021; Sari et al., 2019). Interactive video lectures have also been shown to be effective in promoting student engagement and motivation in physics courses (Ketsman et al., 2018; Kulgemeyer & Peters, 2016; Perez-Navarro et al., 2021). In addition, online discussion forums and other social learning tools have been used to create collaborative and interactive learning environments for physics students (Kustijono et al., 2020; Kustijono & Hakim, 2020). Physics online class was very useful especially in Covid-19 era (Zhang et al., 2021).

Despite the growing interest in online learning in physics education, there is still much debate about its effectiveness and potential. Some researchers have raised concerns about the quality and rigor of online learning experiences, as well as the potential for online learning to exacerbate inequalities in access to education (Marisda & Ma'ruf, 2021; Nurliani et al., 2021; Ruggieri, 2020). Others have highlighted the importance of considering factors such as students' prior knowledge, learning styles, and cultural backgrounds when designing online learning initiatives (Fauza et al., 2020).

Moreover, there are several factors that can influence the success or failure of online learning initiatives in physics education. These factors include students' prior knowledge and skills, their learning styles and preferences, the design and delivery of online learning activities, and the quality and quantity of instructor support (Hrastinski, 2019; Wang et al., 2018). In addition, cultural and social factors can also play a significant role in shaping students' experiences and outcomes in online learning environments (Akpan et al., 2017).

In this article, we present a systematic review of literature on online learning in physics education, aimed at providing a comprehensive overview of the current state of research in the field. The review examines the effectiveness of online learning in enhancing students' achievement and attitudes towards physics, the effectiveness of different types of online learning tools as well as the factors that contribute to the success or failure of online learning initiatives. The review focuses specifically on online learning platforms and tools that have been used in physics education, including online simulations, virtual labs, interactive video lectures, and online discussion forums.

We examine the impact of online learning on different subgroups of students, such as those with different levels of prior knowledge, learning styles, and cultural backgrounds. In addition, we explore the implications of online learning for the design of physics curricula and the training of physics teachers, as well as the potential of online learning for promoting scientific literacy and engagement among students. By synthesizing the findings of previous research, we hope to provide insights into the potential of online learning for improving physics education, as well as to identify areas where further research is needed.

Overall, this systematic review provides a timely and comprehensive overview of the current state of research on online learning in physics education. The findings have important implications for the development and implementation of online learning initiatives in physics education, and can help to guide future research in the field. Research questions of this paper are:

1. How is the growth of online learning in physics in the last decade?
2. What are the most effective online learning strategies implemented for teaching physics to students?
3. What are the current trends and future directions in the use of online learning in physics education?

Method

This research is a Systematic Literature Review (SLR) study that was conducted by searching for relevant articles using the Publish or Perish software. Article data searches were performed on Google Scholar and CrossRef database within the period of 2013-2022. The keywords used during the article search were "physics e-learning," "physics and digital physics learning," "online physics course," "online physics class," and "online physics learning." A total of 3.920 articles were obtained from the search. Then, the articles were selected so that only 53 articles related to the title and purpose of this SLR article remained. The selection of articles can be easily seen in the PRISMA diagram below.

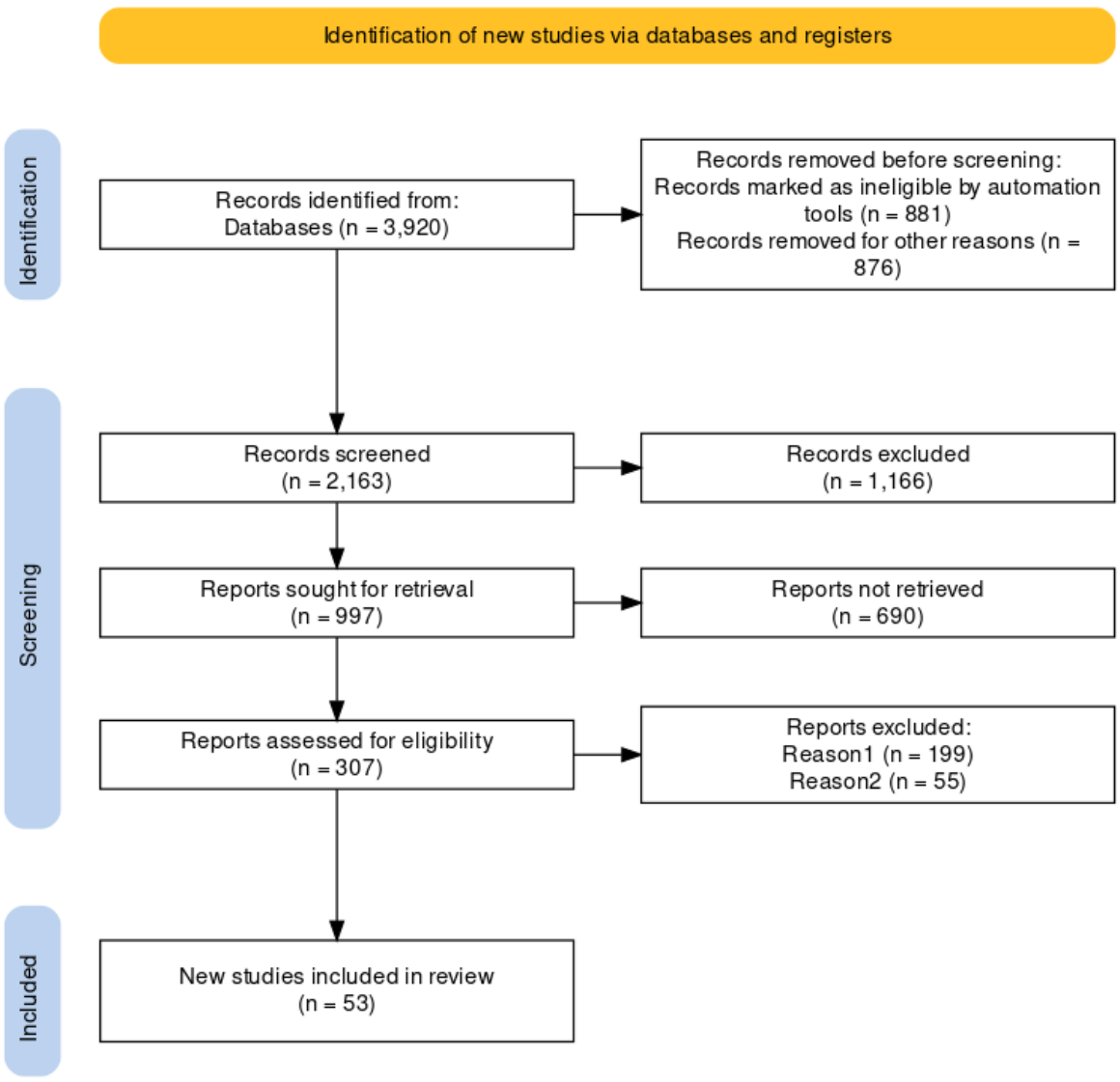

Figure 1. PRISMA Diagram Flow

The selected articles are those that meet all the criteria set by the researcher, namely articles that have been published in journals, articles that have been cited at least once, articles in English, and article titles that indicate that the research is related to physics and online learning. After screening through article metadata, the selected articles were then read for their abstracts and appropriate ones were chosen. After obtaining 53 articles, these articles were read and analyzed as a whole to be presented in this SLR article.

Results

The Growth of Online Learning in Physics

Networking the articles through VOSviewer

VOSviewer was used to analyze the relationship between the articles reviewed in this study. VOSviewer is a software tool that can be used for bibliometric analysis, which involves the quantitative analysis of research publications. The results of the analysis through VOSviewer, which could be seen in the figure provided, would provide insights into the relationships and patterns among the reviewed articles.

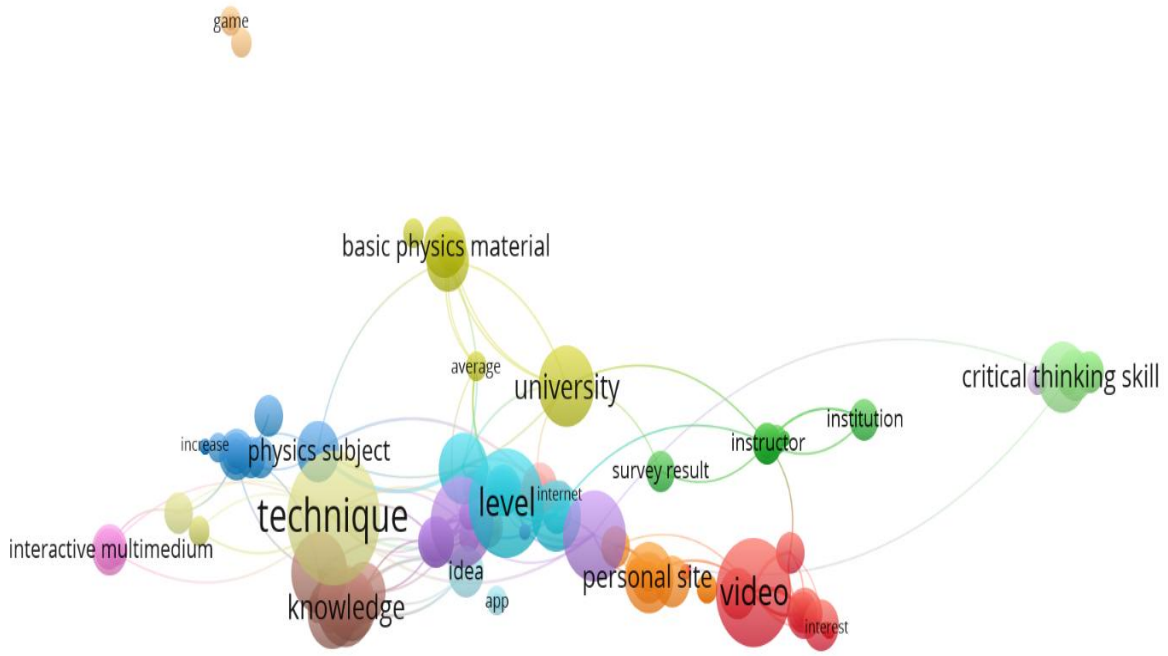

Figure 2. Network Visualization by VOSviewer

Number of Articles Per Year

The development of online learning can be seen through the increasing number of articles that investigate physics education in an online format year by year. The following diagram presents the number of articles that discuss online physics education in the last 10 years. The diagram referred to in the sentence likely shows a visual representation of the number of articles published on the topic over the past decade. This information is important as it contextualizes the scope of the research and demonstrates the relevance and timeliness of the topic.

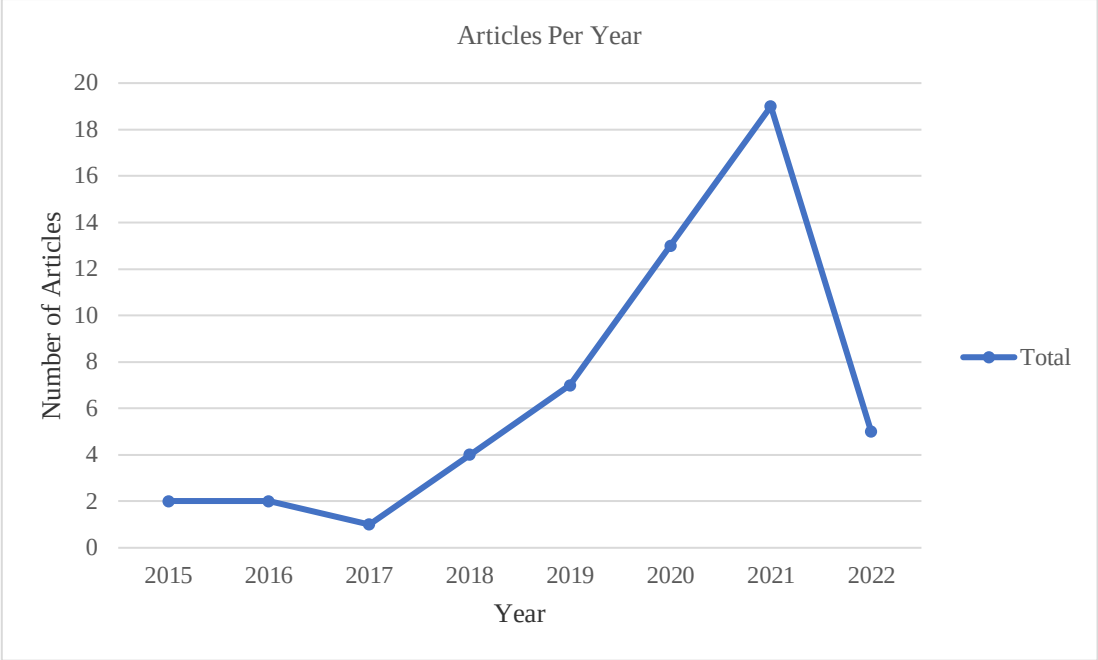

Figure 3. Number of Articles Per Year

Citations Number

The number of citations for an article is also an important factor in analyzing the growth of online physics learning. The more citations an article has, the more it indicates that articles on online physics learning are being developed.

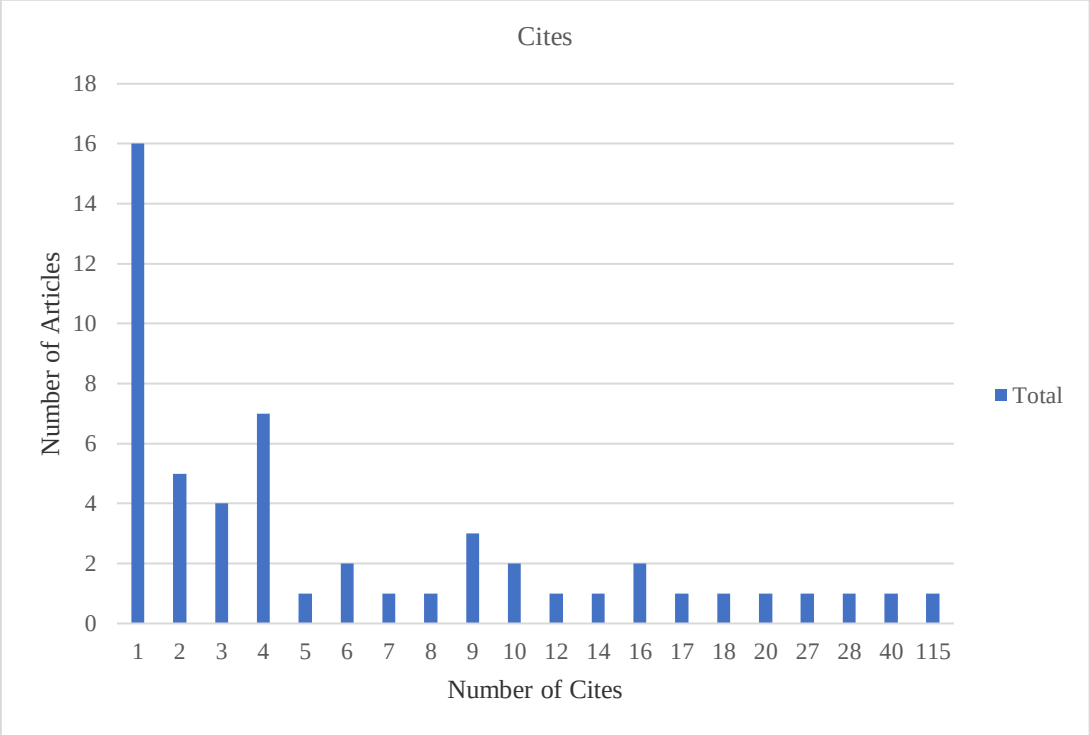

Figure 4. Citations Number

The Journals and Publishers that Provide Many Articles on Online Physics Learning

The data on articles obtained from Google Scholar and Crossref sources consist of various journals and publishers. However, among these journals, there are several journals that provide more articles on online physics learning. The diagram below shows the journals in question.

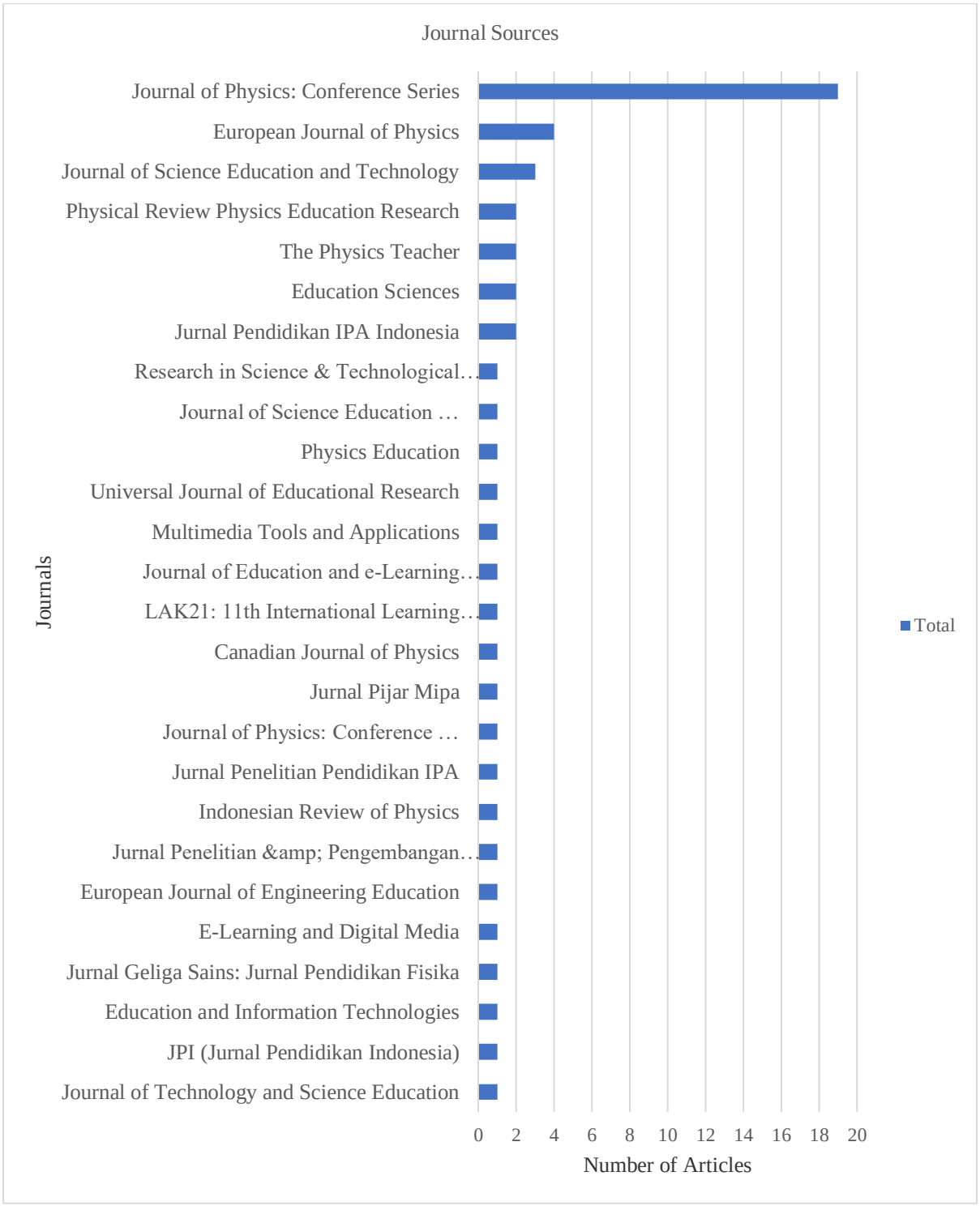

Figure 5. Article's Journal

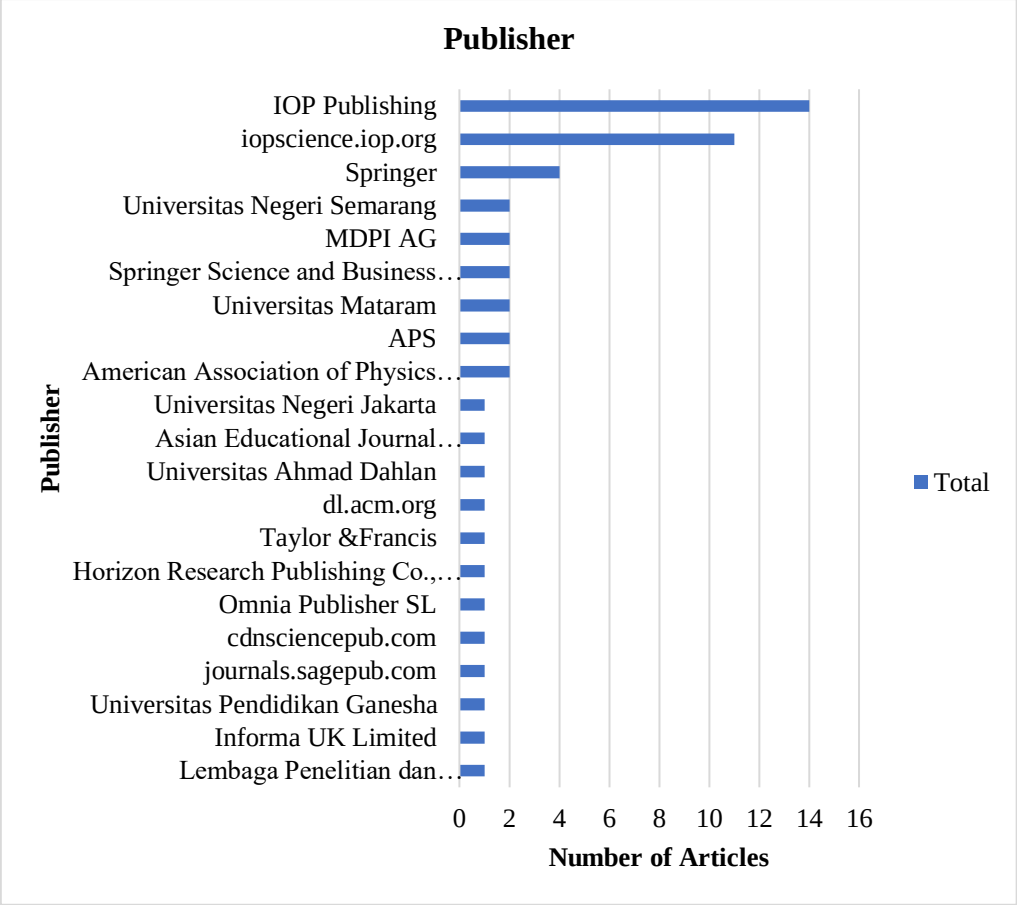

Figure 6. The Publisher of the Articles

Based on Country of Research

The country where the research was conducted is equally important to analyze the development of online physics learning. The following is a graph of the countries in question.

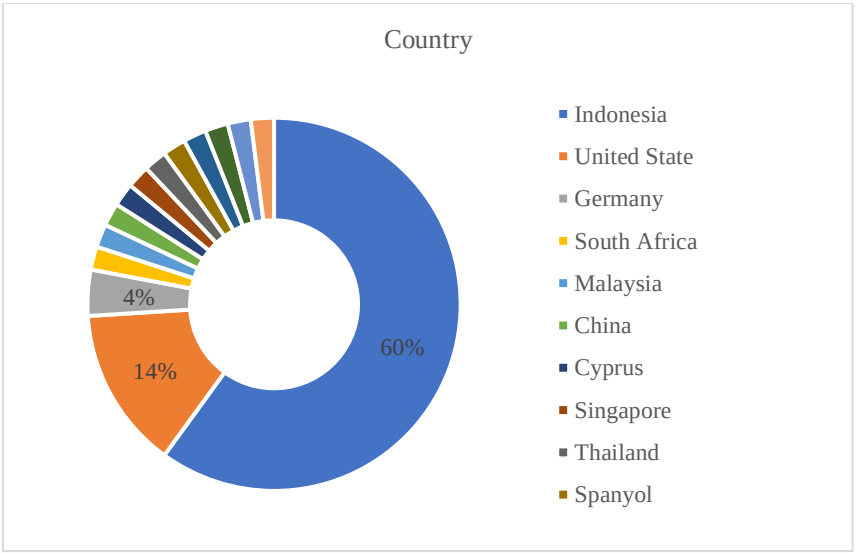

Figure 7. Country of Research

The Most Effective Online Learning Strategies for Teaching Physics

Research Methods

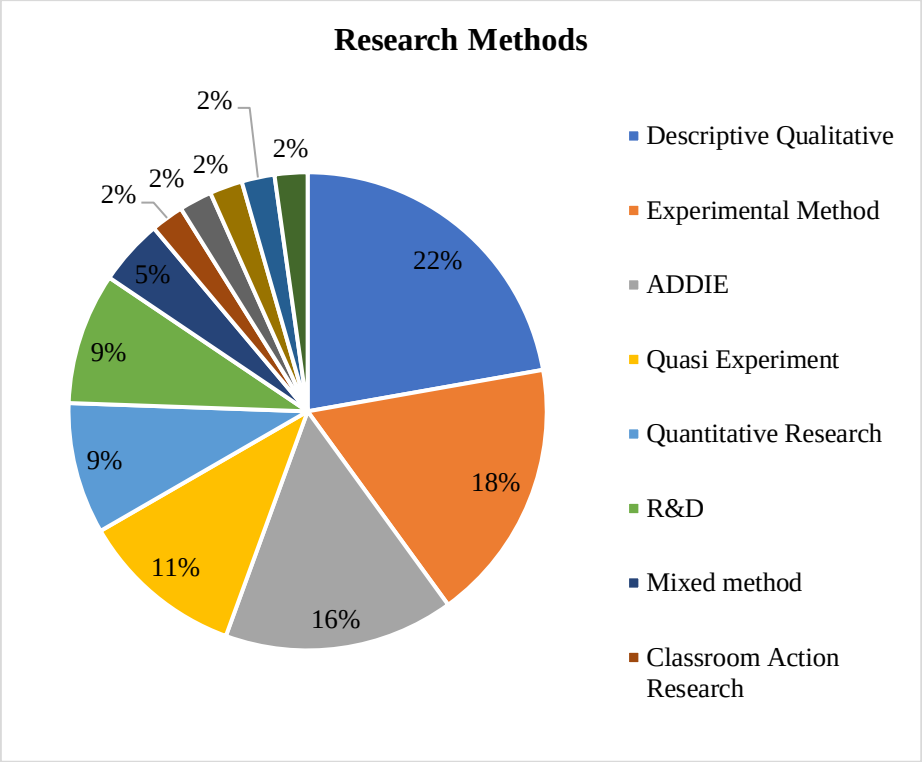

Figure 8. Research Methods

Research Subjects

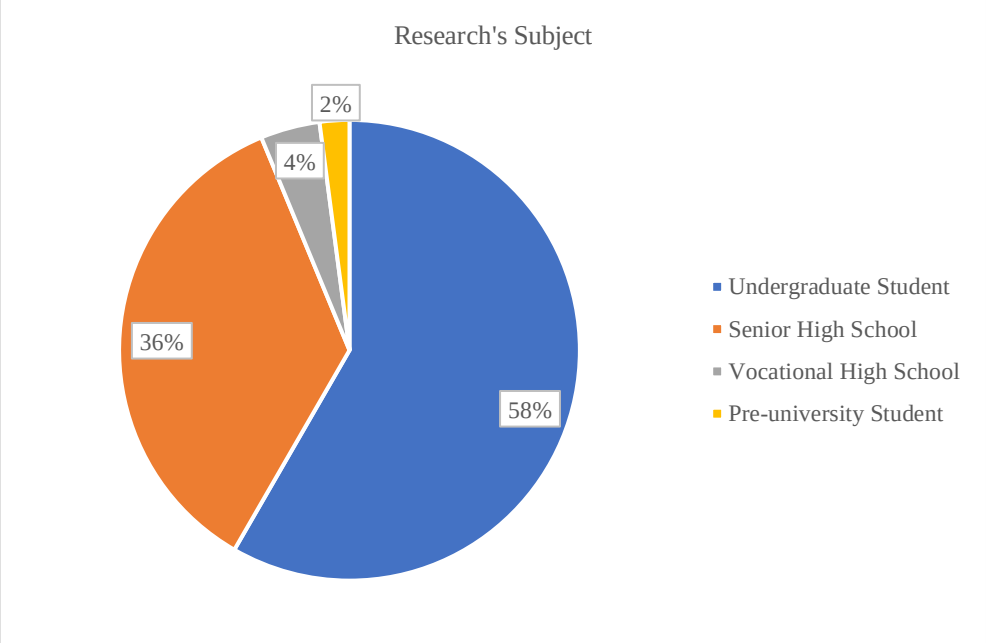

Figure 9. Research's Subject

Platform Used

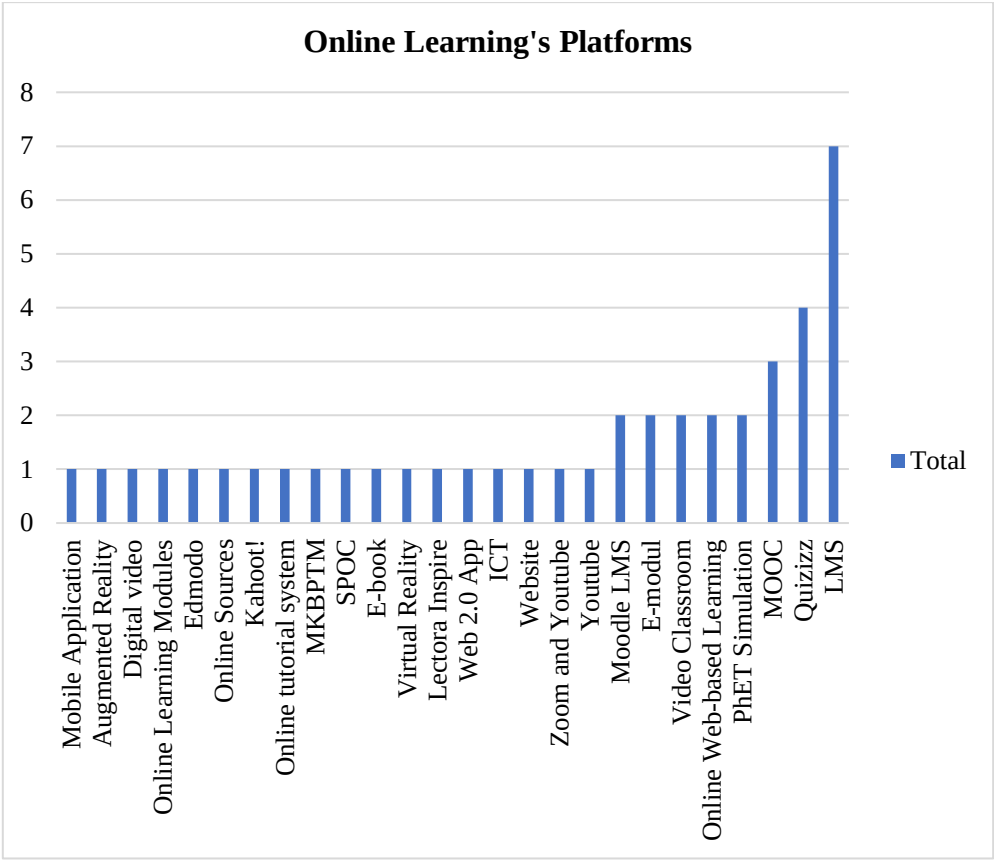

Figure 10. Platforms that Used for Online Learning in Physics

Learning Chapter

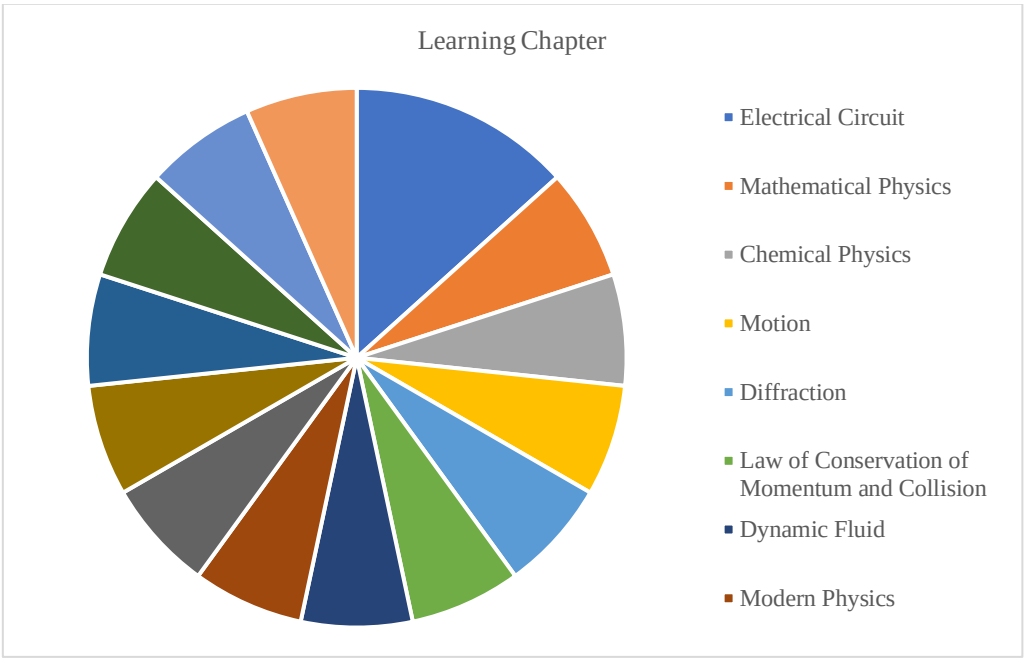

Figure 11. Learning Chapter

Trends and Future Directions Based on Findings

Table 1. Classification of findings

Article's Identity	Findings
(Balci et al., 2022; Safarati & Rahma, 2020)	Gamification tools like Quizziz and Kahoot!
(Abdullah et al., 2021; Bergeler & Read, 2021; Faulconer et al., 2018; Fauza et al., 2020; Klein et al., 2021; Kortemeyer, 2016; Kustijono & Hakim, 2020; Marisda & Ma'ruf, 2021; Nurdiana et al., 2021; Nurliani et al., 2021; Ruggieri, 2020; Surahman & Sujarwanto, 2021; Terrana et al., 2017; Uden et al., 2022; Van De Heyde & Siebrits, 2019)	The advantages and disadvantages between online learning and face to face learning
(Tsivitanidou et al., 2021)	Inquiry
(Phanphech et al., 2022)	Conceptual understanding
(Bartels & Kulgemeyer, 2019; Ketsman et al., 2018; Perez-Navarro et al., 2021)	Video or YouTube for learning physics
(Koenig & Bake, 2021; Prasetya et al., 2022; Pratidhina et al., 2021; Sari et al., 2019)	Virtual laboratory such as PhET
(Diana et al., 2021; Hikmah et al., 2021; Purba, 2020; Wang et al., 2020)	Online assessment
(Aisyah et al., 2020; Bartels & Kulgemeyer, 2019; Darma et al., 2019; Henukh et al., 2020; Liliana et al., 2020; Permatasari et al., 2019; Ramli et al., 2021; Rizal et al., 2020; Saehana et al., 2018; Sani et al., 2021; Sarah, 2021; Serevina et al., 2019; Takátsné Lucz, 2021; Tania et al., 2020; Widodo et al., 2019; Widyaningsih et al., 2020)	Learning media development
(Zhang et al., 2021)	Physics learning during Covid-19

Discussion

The Growth of Online Learning in Physics

Networking the articles trough VOSviewer

The interpretation results of the selected articles using VOSviewer software show that there are various main and supporting points that are interconnected with each other. However, the results also show that there is one point that is not connected to other points at all, which is "game". There are six points with large circles, namely "basic physics material", "technique", "level", "video", "personal site", and "university". This means that these six points are often discussed in the 53 selected articles and have connections between articles. The articles that discuss online physics learning often focus on techniques for conducting online physics learning at both school and university levels. The physics materials discussed or used in the research are basic materials appropriate for

educational levels. In addition, the dominant platforms used in these studies are personal sites and learning aided by videos such as those found on YouTube.

Number of Articles Per Year

The development of online physics learning can be observed from the number of related articles published each year. This SLR study provides an overview of the development of online physics learning based on articles found on Google Scholar and Crossref in the last decade. In 2013 and 2014, there were no articles that met the article selection criteria discussing online physics learning. Online physics learning began in 2015 and has experienced an increase every year.

The most rapid increase occurred in 2020-2021, which was the year when the whole world was affected by the Covid-19 pandemic. The pandemic had a significant impact on the learning process in various levels of education, including physics subjects in both schools and universities. Learning could not be conducted face-to-face in classrooms, but learning had to continue. This led educators and policymakers to strive for online learning. Teachers, lecturers, and researchers collaborated in developing teaching materials, software to support learning, assessment development, and virtual laboratory development, which were very beneficial for physics learning.

In 2022, there was a decrease in the number of articles discussing online physics learning. One reason is the emergence of the new normal era, where people can start to engage in activities again, and schools have started to operate offline. However, the development of online physics learning through various platforms should continue to be carried out so that the education world is better prepared to conduct learning in various conditions.

Citations

The existence of articles on online physics learning can also be seen from the number of citations received by those articles. Out of the 53 selected articles, the highest number of citations was 115. In this SLR study, the researchers did not include articles with zero citations to ensure that the articles reviewed were those that have been used as references by other researchers.

The number of citations an article receives is a measure of its impact and importance in the field. It indicates that the article has been influential in shaping the direction of research and practice in online physics learning. Therefore, it is important to consider the number of citations when assessing the significance and relevance of an article. By only including articles with at least one citation, the researchers were able to focus on those articles that have made a meaningful contribution to the field.

The Journals and Publishers that Provide Many Articles on Online Physics Learning

The 53 selected articles were published in different journals and by different publishers. The Journal of Physics: Conference Series provided the most articles on online physics learning, although the articles were presented at

conferences, they have been published as scientific journal articles. Other journals focused on physics education, science education, and even general education. The publishers of these articles were organizations that established journals, educational institutions such as universities, and Scopus-indexed article publishers such as Taylor and Francis and Springer.

Based on The Research Country

From the aspect of the country of origin of the research, it can be seen that out of the 53 reviewed articles, 60% of the research was conducted in Indonesia, 14% was conducted in the United States, 4% was carried out in Germany, and 22% in other countries. The researchers assume that before the Covid-19 pandemic, online learning had not been widely studied in Indonesia, so when the pandemic hit, research on online physics learning became more prevalent. This is different from other countries such as the United States and Germany, which may have already been developing online learning long before the pandemic occurred.

It is interesting to note that the majority of the reviewed articles (60%) were conducted in Indonesia, which suggests a growing interest in exploring online physics education in the country. This could be attributed to the sudden need to shift to online learning during the pandemic. It is also worth noting that the United States and Germany accounted for 14% and 4% of the articles, respectively. These countries may have been better equipped to adapt to online learning due to their prior experience and infrastructure. However, the fact that research on online physics education is being conducted in various countries worldwide suggests a global recognition of the importance of this area of study.

The Most Effective Online Learning Strategies for Teaching Physics

Research Methods

The articles on online physics learning discussed here use different research methods because they target different journal areas. Development research that develops various learning tools and media will use methods such as R&D, ADDIE, and DDD-E. Research that discusses the results of the application of prepared products will use research methods such as experiments, quasi-experiments, and classroom action research. These methods are used to assess the effectiveness of the developed learning tools or products. For example, experiments are conducted to test the impact of a new technology-based learning tool on student learning outcomes, while classroom action research is used to improve the learning process by implementing interventions and monitoring the results.

Research Subjects

The research from the 53 selected articles was conducted across various educational levels, including high school, vocational school, and undergraduate students. However, there were no studies conducted on students from lower educational levels such as elementary and middle school since physics is not yet included in the curriculum. In addition, research on physics learning at the junior high school level was not conducted since it is still integrated with other science subjects such as biology and chemistry under the umbrella of science education.

This finding implies that there is a need for more research in the future to explore the effectiveness of online physics learning at lower educational levels, particularly in the primary and junior high school levels. Moreover, it is important to investigate the best practices for integrating physics, biology, and chemistry into a coherent and effective science education program at the junior high school level. This would provide a more comprehensive understanding of the potential benefits of online physics learning across different educational levels.

Platform Used

The need for innovation in online physics learning to improve its quality through a supporting platform. Various existing platforms are being further developed to meet the needs of education, especially in physics. There are two types of platforms used in research: existing platforms and self-developed platforms by researchers. Examples of existing platforms are Zoom, YouTube, Kahoot!, and Quizizz. Meanwhile, examples of self-developed platforms are e-books, e-modules, and LMS which are usually tailored to the conditions and needs of learners. These online learning support platforms have various roles, some have only one role while others have multiple roles. Examples of platforms that only have one role are Quizizz and Kahoot! which are only used to provide online assessments such as quizzes and exams. Platforms that have multiple roles include e-books and mobile applications that can be used to deliver materials, provide questions, and conduct online training.

Learning Chapter

The physics subjects used in the research are diverse, ranging from basic physics topics to those that are combined with other subjects. Basic physics topics include electric circuits, forces, motion, fluids, and so on. Meanwhile, physics combined with other subjects refers to topics such as mathematical physics and chemical physics that are usually studied by college students.

It is important to note that the choice of physics topics may depend on the level of education and the specific research focus. For example, research on online physics learning for high school students may focus more on basic physics topics, while research on physics education for college students may delve into more advanced topics.

Moreover, the choice of physics topics may also be influenced by the learning platform and technology used in the research. For instance, a research project that utilizes simulations or virtual experiments may require physics topics that are more suitable for such methods. Overall, the choice of physics topics in online learning research is crucial to ensure the relevance and effectiveness of the research outcomes in improving physics education.

Trends and Future Directions Based on Findings

Based on the findings of each article, the results were grouped into 9 main themes, two of which are the most frequently cited sources. These themes are about the strengths and weaknesses of online physics learning based on survey, observation, and other research results. The weaknesses identified in these studies can be used as a

background for improvement. The next theme that is widely discussed is the development of online physics learning media. Various development studies can also be used as a background for further research by varying the research variables and subjects.

For example, a study could explore the effectiveness of different types of online physics learning media or compare the impact of online learning versus traditional classroom learning. The findings of these studies can inform the development of more effective and engaging online physics learning materials. Additionally, studies could also focus on the use of virtual labs or simulations to supplement online learning and enhance students' understanding of complex physics concepts. These types of studies can contribute to the overall improvement of online physics education.

Conclusion

The development of research on online physics learning in the last 10 years has been increasing every year. Its improvement is influenced by various factors that support the sustainability of online physics learning. The most effective strategy should be adapted to the needs, in accordance with the learning objectives to be achieved, and the material to be taught. The trend of articles on online physics learning is about evaluating its strengths and weaknesses as well as developing learning media/teaching materials used. In addition, the use of technology in online physics learning has also become an important topic in recent years, with various studies exploring its impact on student learning outcomes and engagement. Furthermore, the integration of virtual and augmented reality technology in online physics learning is also an emerging trend that has the potential to revolutionize the way physics is taught and learned online.

Recommendations

Given the potential for online learning to provide flexible and accessible learning opportunities, it is recommended that policymakers invest in the development of high-quality, accessible online resources for physics education. In order to maximize the benefits of online learning for physics education, it is recommended that educators receive training and support to effectively integrate online technologies into their teaching practices. Based on the evidence presented in the literature review, it is recommended that physics educators explore the use of interactive online simulations and virtual laboratories to supplement traditional instruction and engage students in hands-on learning activities. Further research is needed to evaluate the effectiveness of online learning strategies and technologies for teaching physics to students with different learning needs and backgrounds, and to determine how online learning can be used to promote equity and access in physics education. Future research should explore the impact of online learning on the development of students' scientific skills and competencies, such as critical thinking, problem-solving, and inquiry-based learning.

Acknowledgements

The authors would like to express a very sincere gratitude to The Indonesia Endowment Funds for

Education/*Lembaga Pengelola Dana Pendidikan* (LPDP) for providing financial support for this research. The support provided by LPDP was instrumental in the completion of this research project.

References

Abdullah, H., Malago, J. D., & Arafah, K. (2021). The Implementation of Physics Learning through Online Mode during Pandemic Covid-19 Using Metacognitive Knowledge-based Materials. *Jurnal Pendidikan IPA Indonesia*, 10(2), 220–227. https://doi.org/10.15294/jpii.v10i2.28583

Aisyah, Bukit, N., & Derlina. (2020). Blended Learning on Physics Using Augmented Reality. *Journal of Physics: Conference Series*, 1485(1), 012004. https://doi.org/10.1088/1742-6596/1485/1/012004

Akpan, J. P., Andreassen, R., & Sims, R. (2017). Cultural and social factors that affect online learning environments: A review of the literature. In Handbook of research on education and technology in a changing society (pp. 413-430). *IGI Global*.

Balci, S., Secaur, J. M., & Morris, B. J. (2022). Comparing the effectiveness of badges and leaderboards on academic performance and motivation of students in fully versus partially gamified online physics classes. *Education and Information Technologies*, 27(6), 8669–8704. https://doi.org/10.1007/s10639-022-10983-z

Bartels, H., & Kulgemeyer, C. (2019). Explaining physics: an online test for self-assessment and instructor training. *European Journal of Physics*, 40(1), 015701. https://doi.org/10.1088/1361-6404/aaeb5e

Bergeler, E., & Read, M. F. (2021). Comparing Learning Outcomes and Satisfaction of an Online Algebra-Based Physics Course with a Face-to-Face Course. *Journal of Science Education and Technology*, 30(1), 97–111. https://doi.org/10.1007/s10956-020-09878-w

Darma, R. S., Setyadi, A., Wilujeng, I., Jumadi, & Kuswanto, H. (2019). Multimedia Learning Module Development based on SIGIL Software in Physics Learning. *Journal of Physics: Conference Series*, 1233(1), 012042. https://doi.org/10.1088/1742-6596/1233/1/012042

Diana, N., Latifah, S., Yuberti, Komikesari, H., Rohman, M. H., & Tiyan, Lady. (2021). Developing an e-learning-based critical-thinking assessment as a physics learning evaluation media with Kahoot! interactive quiz. *Journal of Physics: Conference Series*, 1796(1), 012055. https://doi.org/10.1088/1742-6596/1796/1/012055

Faulconer, E. K., Griffith, J., Wood, B., Acharyya, S., & Roberts, D. (2018). A Comparison of Online, Video Synchronous, and Traditional Learning Modes for an Introductory Undergraduate Physics Course. *Journal of Science Education and Technology*, 27(5), 404–411. https://doi.org/10.1007/s10956-018-9732-6

Fauza, N., Ernidawati, E., & Syaflita, D. (2020). DIFFICULTY ANALYSIS OF PHYSICS STUDENTS IN LEARNING ONLINE DURING PANDEMIC COVID-19. *Jurnal Geliga Sains: Jurnal Pendidikan Fisika*, 8(1), 49. https://doi.org/10.31258/jgs.8.1.49-54

Girwidz, R., & Tremp, P. (2017). Introduction: Challenges and opportunities of online learning in physics education. *European Journal of Physics*, 38(1), 1-3. https://doi.org/10.1088/1361-6404/38/1/1

Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital

transparency and Open Synthesis. *Campbell Systematic Reviews*, 18(2), e1230. https://doi.org/https://doi.org/10.1002/cl2.1230

Henukh, A., Reski, A., Nikat, R. F., Waremra, R. S., & Bahri, S. (2020). Multimedia development with web-based connected massive open online course (cmoocs) in basic physics material. *Journal of Physics: Conference Series*, 1569(2), 022027. https://doi.org/10.1088/1742-6596/1569/2/022027

Hikmah, N., Putri, N. A., Nisa', K., & Jauhariyah, M. N. R. (2021). Using Quizizz to Develop an Assessment of Physics Learning: An Alternative Way for Physics Learning Assessment in the Covid-19 Pandemic Era. *Journal of Physics: Conference Series*, 1805(1), 012021. https://doi.org/10.1088/1742-6596/1805/1/012021

Hrastinski, S. (2019). A theory of online learning as online participation. *Computers & Education*, 138, 83-93. https://doi.org/10.1016/j.compedu.2019.04.012

Hrastinski, S. (2019). What we know and don't know about online learning in higher education. *In Learning and Innovation in Hybrid and Online Teaching* (pp. 3-14). Springer, Cham. https://doi.org/10.1007/978-3-319-96935-1_1

Ketsman, O., Daher, T., & Colon Santana, J. A. (2018). An investigation of effects of instructional videos in an undergraduate physics course. *E-Learning and Digital Media*, 15(6), 267–289. https://doi.org/10.1177/2042753018805594

Klein, P., Ivanjek, L., Dahlkemper, M. N., Jeličić, K., Geyer, M.-A., Küchemann, S., & Susac, A. (2021). Studying physics during the COVID-19 pandemic: Student assessments of learning achievement, perceived effectiveness of online recitations, and online laboratories. *Physical Review Physics Education Research*, 17(1), 010117. https://doi.org/10.1103/PhysRevPhysEducRes.17.010117

Koenig, K., & Bake, S. (2021). Maintaining Essential Course Features When Moving Introductory Physics Labs Online. *The Physics Teacher*, 59(6), 394–396. https://doi.org/10.1119/5.0039606

Koenig, K., Schönebeck, S., Fischer, M. R., & Fischer, F. (2020). Current trends in digital physics learning: A systematic review. *Computers & Education*, 144, 103688. https://doi.org/10.1016/j.compedu.2019.103688

Kortemeyer, G. (2016). Work Habits of Students in Traditional and Online Sections of an Introductory Physics Course: A Case Study. *Journal of Science Education and Technology*, 25(5), 697–703. https://doi.org/10.1007/s10956-016-9624-6

Kulgemeyer, C., & Peters, C. H. (2016). Exploring the explaining quality of physics online explanatory videos. *European Journal of Physics*, 37(6), 065705. https://doi.org/10.1088/0143-0807/37/6/065705

Kustijono, R., & Hakim, S. (2020). Online-based Learning to Train Students Critical Thinking in Physics Teacher Training Programs. *Journal of Physics: Conference Series*, 1569(4), 042065. https://doi.org/10.1088/1742-6596/1569/4/042065

Kustijono, R., Hakim, S., & Wiwin, E. (2020). Online-based Physics Learning to Provide Four Dimensions of Knowledge to Teacher Training Program Students. *Journal of Physics: Conference Series*, 1491(1), 012063. https://doi.org/10.1088/1742-6596/1491/1/012063

Liliana, R. A., Raharjo, W., Jauhari, I., & Sulisworo, D. (2020). Effects of the Online Interactive Learning Media on Student's Achievement and Interest in Physics. *Universal Journal of Educational Research*, 8(3B), 59–68. https://doi.org/10.13189/ujer.2020.081507

Marisda, D. H., & Ma'ruf, M. (2021). Situation analysis of mathematical physics learning with online learning during the COVID-19 pandemic. *Journal of Physics: Conference Series*, 1806(1), 012034. https://doi.org/10.1088/1742-6596/1806/1/012034

Nurdiana, I. M., Sunarno, W., & Wahyuningsih, D. (2021). Physics Online Learning during the Covid-19 Pandemic uses a Guided Inquiry Model with Experimental Methods on teamwork Ability and Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 7(3), 350–356. https://doi.org/10.29303/jppipa.v7i3.728

Nurliani, R., Sinaga, P., & Rusdiana, D. (2021). Problems of online learning and the use of information and communication technology (ICT) in physics learning at Sumedang, West Java. *Journal of Physics: Conference Series*, 1806(1), 012043. https://doi.org/10.1088/1742-6596/1806/1/012043

Perez-Navarro, A., Garcia, V., & Conesa, J. (2021). Students perception of videos in introductory physics courses of engineering in face-to-face and online environments. *Multimedia Tools and Applications*, 80(1), 1009–1028. https://doi.org/10.1007/s11042-020-09665-0

Permatasari, G. A., Ellianawati, E., & Hardyanto, W. (2019). Online Web-Based Learning and Assessment Tool in Vocational High School for Physics. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 5(1), 1–8. https://doi.org/10.21009/1.05101

Phanphech, P., Tanitteerapan, T., Mungkung, N., Arunrungrusmi, S., Chunkul, C., Songruk, A., Yuji, T., & Kinoshita, H. (2022). An Analysis of Student Anxiety Affecting on Online Learning on Conceptual Applications in Physics: Synchronous vs. Asynchronous Learning. *Education Sciences*, 12(4), 278. https://doi.org/10.3390/educsci12040278

Prasetya, I. E., Yusuf, M., & Buhungo, T. J. (2022). Description of students learning motivation towards the use of phet simulation in physics online learning in terms of self-efficacy and anxiety levels. *Jurnal Pijar Mipa*, 17(1), 23–27. https://doi.org/10.29303/jpm.v17i1.3218

Pratidhina, E., Rosana, D., & Kuswanto, H. (2021). Implementation of a Tracker-Assisted Modeling Activity in an Online Advanced Physics Experiment Course. *Journal of Education and E-Learning Research*, 8(2), 222–229. https://doi.org/10.20448/journal.509.2021.82.222.229

Purba, L. S. L. (2020). The effectiveness of the quizizz interactive quiz media as an online learning evaluation of physics chemistry 1 to improve student learning outcomes. *Journal of Physics: Conference Series*, 1567(2), 022039. https://doi.org/10.1088/1742-6596/1567/2/022039

Ramli, Z., Sunaryo, & Serevina, V. (2021). E-Book Static Fluid and Dynamic Fluid Web-Based with a Problem-Based Learning Model to Improve Students Physics Problem-Solving Skills. *Journal of Physics: Conference Series*, 2019(1), 012001. https://doi.org/10.1088/1742-6596/2019/1/012001

Rizal, R., Rusdiana, D., Setiawan, W., & Siahaan, P. (2020). Studentsâ€TM Perception of Learning Management System Supported Smartphone: Satisfaction Analysis in Online Physics Learning. *Jurnal Pendidikan IPA Indonesia*, 9(4), 600–610. https://doi.org/10.15294/jpii.v9i4.25363

Ruggieri, C. (2020). Students' use and perception of textbooks and online resources in introductory physics. *Physical Review Physics Education Research*, 16(2), 020123. https://doi.org/10.1103/PhysRevPhysEducRes.16.020123

Saehana, S., Wahyono, U., Darmadi, I. W., Kendek, Y., & Widyawati, W. (2018). Development of website for studying modern physics. *Journal of Physics: Conference Series*, 983, 012052.

https://doi.org/10.1088/1742-6596/983/1/012052

Safarati, N., & Rahma, R. (2020). The Effectiveness of Online Learning Using Quizizz Education Game Media During the Covid-19 Pandemic in Applied Physics Courses. *Indonesian Review of Physics*, 3(2), 52. https://doi.org/10.12928/irip.v3i2.3049

Sani, D. M., Sukarmin, & Suharno. (2021). The needs analysis for the development of electronic learning module (e-module) based on local wisdom information search in senior high schools' physics online learning during COVID-19 pandemic. *Journal of Physics: Conference Series*, 1796(1), 012020. https://doi.org/10.1088/1742-6596/1796/1/012020

Sarah, L. L. (2021). The implementation of discovery learning using personal site in physics online classroom. *Journal of Physics: Conference Series*, 1957(1), 012042. https://doi.org/10.1088/1742-6596/1957/1/012042

Sari, R., Perdana, R., Riwayani, Jumadi, Wilujeng, I., & Kuswanto, H. (2019). The Implementation of Problem-based Learning Model with Online Simulation to Enhance the Student's Analytical Thinking Skill in Learning Physics. *Journal of Physics: Conference Series*, 1233(1), 012030. https://doi.org/10.1088/1742-6596/1233/1/012030

Serevina, V., Raihanati, Sunaryo, & Andriana, W. (2019). Development of web based massive open online course on fundamental physics subject to increase students' higher order thinking skill. *Journal of Physics: Conference Series*, 1280(5), 052069. https://doi.org/10.1088/1742-6596/1280/5/052069

Surahman, E., & Sujarwanto, E. (2021). Physics undergraduate students' perceptions of online learning during the transition period to the new normal era. *Journal of Physics: Conference Series*, 1869(1), 012159. https://doi.org/10.1088/1742-6596/1869/1/012159

Takátsné Lucz, I. (2021). Web 2.0 applications as the tools of motivation in secondary physics education. *Journal of Physics: Conference Series*, 1929(1), 012041. https://doi.org/10.1088/1742-6596/1929/1/012041

Tania, R., Jumadi, & Astuti, D. P. (2020). The application of physics e-handout assisted by PBL model use Edmodo to improve critical thinking skills and ICT literacy of high school students. *Journal of Physics: Conference Series*, 1440(1), 012037. https://doi.org/10.1088/1742-6596/1440/1/012037

Terrana, A., Leung, A. C. K., & Jerzak, S. (2017). Use of online resources by physics students in Canada: A cross sectional study. *Canadian Journal of Physics*, 95(2), 201–208. https://doi.org/10.1139/cjp-2016-0779

Tsivitanidou, O. E., Georgiou, Y., & Ioannou, A. (2021). A Learning Experience in Inquiry-Based Physics with Immersive Virtual Reality: Student Perceptions and an Interaction Effect Between Conceptual Gains and Attitudinal Profiles. *Journal of Science Education and Technology*, 30(6), 841–861. https://doi.org/10.1007/s10956-021-09924-1

Uden, L., Sulaiman, F., & Lamun, R. F. (2022). Factors Influencing Students' Attitudes and Readiness towards Active Online Learning in Physics. *Education Sciences*, 12(11), 746. https://doi.org/10.3390/educsci12110746

Van De Heyde, V., & Siebrits, A. (2019). Students' attitudes towards online pre-laboratory exercises for a physics extended curriculum programme. *Research in Science & Technological Education*, 37(2), 168–192. https://doi.org/10.1080/02635143.2018.1493448

Wang, Q., Chen, L., & Liang, Y. (2018). The effects of instructor support and student cohesiveness on learning outcomes in online learning. *Educational Technology & Society*, 21(4), 248-258.

https://www.jstor.org/stable/26549175

Wang, Y., Wang, L., Liang, H., Zollman, D., Zhao, L., & Huang, Y. (2020). Research on the small private online course (SPOC) teaching model incorporating the just-in-time teaching (JiTT) method based on mobile Internet for learning college physics. *European Journal of Physics*, 41(3), 035701. https://doi.org/10.1088/1361-6404/ab6c6c

Widodo, A., Yennita, Azhar, & Islami, N. (2019). Development of Physics Learning Media on Rotational Materials Based on Interactive Multimedia. *Journal of Physics: Conference Series*, 1351(1), 012057. https://doi.org/10.1088/1742-6596/1351/1/012057

Widyaningsih, S. W., Yusuf, I., Prasetyo, Z. K., & Istiyono, E. (2020). Online Interactive Multimedia Oriented to HOTS through E-Learning on Physics Material about Electrical Circuit. *JPI (Jurnal Pendidikan Indonesia)*, 9(1), 1. https://doi.org/10.23887/jpi-undiksha.v9i1.17667

Zhang, T., Taub, M., & Chen, Z. (2021). Measuring the Impact of COVID-19 Induced Campus Closure on Student Self-Regulated Learning in Physics Online Learning Modules. *LAK21: 11th International Learning Analytics and Knowledge Conference*, 110–120. https://doi.org/10.1145/3448139.3448150

Author Information

Nadya Amalia Putri Hapsari
https://orcid.org/0009-0003-2566-9296
Universitas Negeri Yogyakarta
Yogyakarta
Indonesia
Contact e-mail:
nadyaamalia.2022@student.uny.ac.id

Mundilarto
https://orcid.org/0000-0003-2891-4317
Universitas Negeri Yogyakarta
Yogyakarta
Indonesia