RESEARCH ON ONLINE LEARNING IN SCIENCE EDUCATION: A BIBLIOMETRIC REVIEW OF SELECTED JOURNALS

Anam, R. S.[1*], Budiastra, A. A. K.[1], Handayani, M.[1]

[1]*Universitas Terbuka (INDONESIA)*

rifat.official@ecampus.ut.ac.id

Abstract

This research aims to investigate the development of research regarding Online Learning (OL) in science education by considering aspects as represented in selected science journals regarding 1) the distribution of OL research in scientific journals, 2) the proportion of articles related to OL in the journals studied, 3) research methods regarding OL; 4) authors and citations of CT research articles, 5) level of education regarding OL research, and 6) scientific disciplines discussed regarding OL. This research was conducted by analyzing 22 articles from 3 reputable international journals in the field of science education, namely the Journal of Science Education (IJSE), Journal of the Learning Science (JOLS), and Studies in Science Education (SEE). The findings of this research show that research on OL will always increase from 2022. This study also shows that the mixed method is the most widely used research method related to OL. In addition, this study also found that research on OL, in general, does not focus on just one scientific discipline because of the general learning nature of online science learning. Other findings are discussed in detail in this study. Thus, this research provides researchers with essential knowledge regarding the latest developments in OL.

Keywords: Online learning, science education, bibliometric review

1 INTRODUCTION

Online learning, also known as e-learning or digital learning, has become an integral part of the modern education landscape. With the advancement of technology and the proliferation of the internet, online learning offers flexible, accessible, and cost-effective educational opportunities for a global audience. This mode of learning allows students to access educational resources, participate in virtual classrooms, and engage with instructors and peers from anywhere in the world. Moreover, with the existence of Corona Virus Disease 2019 or known as Covid-19, learning is forced to be carried out online to avoid contracting the virus. At the time of the outbreak of this pandemic, all elements were forced to accelerate the facilities and infrastructure as well as the ability to do everything online.

However, as time goes by, the importance of online learning has been highlighted by several researchers. According to research conducted by El-Sabagh (2021) online learning provides many benefits, such as increased access to education for underserved communities, personalized learning experiences, and the ability to accommodate diverse learning styles. Additionally, online learning platforms often include interactive elements, such as quizzes, forums, and multimedia content, which improve student engagement and information retention (Liu and Correia 2021)

However, the transition to online learning is not without its challenges. Problems such as the digital divide, lack of technological infrastructure, and diverse levels of digital literacy among students and educators can hinder the effectiveness of implementing online learning (Mathrani, Sarvesh, and Umer 2022). In addition, maintaining academic integrity and ensuring the quality of online education remains an important concern that institutions must address (Garg and Goel 2022). One of the lessons that students from childhood to high school always learn is science. Science lessons also need to be optimized in online learning because at this time in general people/students will be very familiar with this mode of learning (Wong 2023).

Despite these challenges, a growing body of literature is showing that online learning in science lessons, when designed and implemented effectively, can achieve learning outcomes comparable to traditional face-to-face teaching. This is supported by meta-analysis and systematic reviews, which show that online learning can be just as effective, if not more effective, than conventional classrooms (Ge et al. 2020). Based on this explanation, this study aims to discuss how the development of online learning in science education is based on the results of research published in internationally reputable journals. The formulation of the problem of this study is as follows:

1. How are online learning articles distributed in science education based on publication each year?
2. What is the proportion of online learning articles on science education from selected journals?
3. What is the most commonly used method in online learning articles on science education?
4. Who is the author and how to cite online learning topics in science education?

5. How is the publication of online learning topics in science education reviewed from the educational level?
6. What are the disciplines and topics in the study of online learning in science education?

2 METHODOLOGY

This study is a bibliometric review study using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Cheung and Erduran 2023; Moher et al. 2009). The main objective of this study is to investigate research trends that focus on online learning in science education. The sample articles used in this study include research in the form of theoretical and empirical or other types. The way we get articles in the journal is by using the keyword "Online Learing" in the search menu in three internationally reputable journals in the field of science education from Publisher Routledge. The journals targeted in this study include the International Journal of Science Education (IJSE), Journal of the Learning Science (JOLS), and Studies in Science Education (SEE). Meanwhile, for book chapters, book reviews, and editorials, we do not include them in the inclusion criteria. In addition, we limit the analyzed articles to the last three years, starting from 2022 – 2024 and the search was carried out in June 2024. We believe that within the past three years there have been several articles published in reputable journals in the field of science education. Then why are we in 2022 because we know that Covid-19 has changed the learning process that has been going on for a long time and of course there will be a lot of perspective regarding online learning research in science education. In addition, the data we took in 2024 is in July 2024, so if there are other articles outside of that time, they will not be included in our study.

4.1 Review Procedure

We carried out the research steps according to Figure 1. This flow is used to make it easier for researchers to conduct studies regarding the chosen theme both in terms of its implementation and reporting. This review process is carried out with the following flow: 1) **Identification**, by searching for appropriate/relevant research themes, 2) **Screening**, by adjusting to relevant titles, 3) **Eligibility**, through further analysis regarding the content of the article that is netted, and 4) **Included**, by speaking in accordance with the formulation of the problem in the research. The results of what was done can be seen in Figure 1.

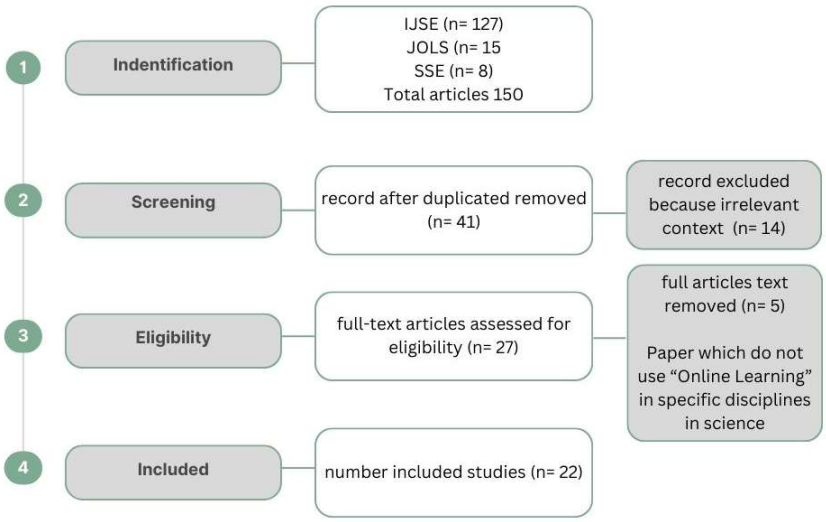

Figure 1. Four-stage flowchart of bilbliometric review

10. Coding Analysis

In order to answer the questions from our study, you created Table 1 to analyze the articles we selected.

Table 1. The use of codes in analyzing corresponding categories

No	Question	Categories	Codes
1.	How are online learning articles distributed in science education based on publication each year?	Presented in article title	Online learning
2.	What is the proportion of online learning articles on science education from selected journals?	Writer	First author
3.	What is the most commonly used method in online learning articles on science education?	Research Methods	Quantitative; Qualitative; Mix-Method; Review the article.
4.	Who is the author and how to cite online learning topics in science education?	Sum	Google scholar; Citation.
5.	How is the publication of online learning topics in science education reviewed from the educational level?	Type of Research	Primary school; Secondary schools; High school; Serjana School; Teacher

No	Question	Categories	Codes
6.	What are the disciplines and topics in the study of online learning in science education?	Subject/topic	Physics, Biology, environmental science, geology, unspecific.

11. Analysis Scheme Development

The analysis of this article was carried out by a research team that has more than 10 years of research experience in the field of science education. Each research team has the following tasks: 1) ensure that the title found is related to the selected theme, 2) check the content of the abstract of each selected article, 3) look in detail with the research method contained in the article. Furthermore, the evaluation was carried out in accordance with the use of an open coding system agreed upon by all researchers. These articles are then coded to get a category that matches the research question. The use of this code is used to facilitate the conversion of the observed criteria into cientative data shown in Table 1.

After developing such a coding scheme, we consider whether the generated code effectively covers the various categories contained in our research question. To ensure the reliability of the coding scheme, the author of the article acts as an assessor. Initially, all researchers individually analyzed the article documents to establish the basis for categorization. After the analysis is complete, the agreement is determined in accordance with the rules set by (Caramaschi et al. 2022) Agreements between researchers were scored one (1), while disagreements or lack of agreement were scored zero (0). The total accumulated deals are then calculated and divided by the total number of instances recorded. The methodology used refers to the Miles and Huberman approach (as cited in (Anam and Gumilar 2024; Caramaschi et al. 2022)), which suggests that agreement rates above 80% indicate acceptable reliability. Using the entire code, we reached a 100% agreement among all authors, signifying a complete consensus in calculating the percentage of relevant categories according to the research question.

3 FINDINGS AND DISCUSSION

3.1 Findings

Based on the research we conducted regarding the development of online learning in three internationally reputable journals. This study discusses six main questions, namely research trends from year to year, the distribution of journals that are publication sites, methods that are often used, the distribution of authors and the number of citations, education level, and disciplines and study topics in the selected articles. These questions are answered and explained in detail through comprehensive bibliometric analysis as follows.

3.2.3 Distribution of Online Learning in Science Education

The first question discussed in this study is to know the research trend of online learning in science education from year to year. This study will review selected journals within the last three years (2022 – 2024). The results of this study are distributed in full by the author and the distribution of years can be seen in Table 2.

Table 2. The proportion of the article in each year.

No	Author	Published years	Number (%)
1.	Lin, Y. R.	2022	7 (32%)
2.	Wu, J. Y.		
3.	Feldman-Maggor, Y.		
4.	Korukluoğlu, P.		
5.	Park, J.		
6.	Kapici, H. O.,		
7.	Bozzo, G.		
8.	Saribas, D.	2023	7 (32%)
9.	Özdeniz, Y.		
10.	Feldman, A.		
11.	Borge, M.		
12.	Lizárraga, J. R.		
13.	Matovu, H.		
14.	Arztmann, M.		
15.	Shlomo, A.,	2024	8 (36%)

No	Author	Published years	Number (%)
16.	Carter, I.		
17.	Chakawodza, J. M.		
18.	Assi, A.		
19.	Yeoh, C, P.		
20.	Passentin, S.		
21.	Hubbard, K.		
22.	Arthars, N.		

Based on Table 2, we can see that research on OL in science education is the most in 2024 and it shows a positive trend. We can see that even though 2022 and 2023 the number of articles published in the selected journals is the same, the trend regarding online learning will be more and more and various types and applications are used to facilitate students in learning.

3.2.4 The Proportion of the Articles in the Selected Journal

This study aims to find out how articles about OL are distributed in science education. in the selected scientifically reputable journal. Table 3 will show the distribution of articles published over three years from the selected journal.

Table 3. The proportion of the articles in each journal

Journal	Online learning	Total number (%)
IJSE	17	77
JOLS	3	14
SSE	2	9

Table 3 shows that currently IJSE is the journal that publishes the most OL in science education while the other two still have a very large difference, namely 3 for JOLS and 2 for SSE.

3.2.5 Research Method in the Research of Computational Thinking

The research method that is generally used in research with the theme of OL in science education in the analysis carried out can be seen in Figure 3.

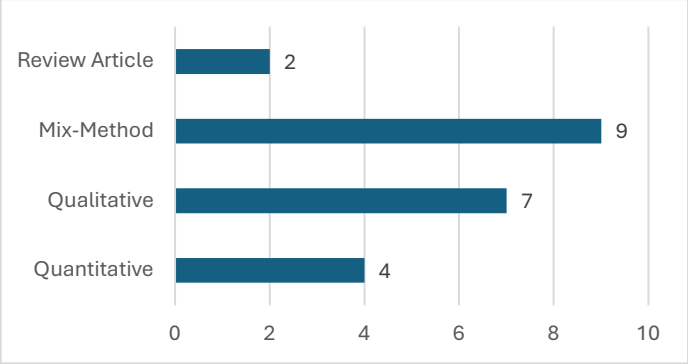

Figure 2. The research method of selected articles

Mix-method is the most common or often used research method in research on the theme being researched. Research methods in the form of quantitative and article reviews are still very limited.

3.2.6 The authors on the online learning in science education topic

The discussion of the author's contribution and the number of citations related to the theme studied found that none of the authors had more than one article published in the selected time and journal. Of the total 22 main authors (22 articles), only one published article in the field of OL in science education. The following table 4 illustrates the contribution of the author and the author team to each published article.

Table 4. The authors on the online learning in science education topic

It	Author	Number	Title	Citation
1.	(Lin 2022)	1	The influence of students' position on argumentation learning through online and face-to-face environments	2
2.	(Wu and Tsai 2022)	1	Harnessing the power of promising technologies to transform science education: prospects and challenges to promote adaptive epistemic beliefs in science learning.	4
3.	(Feldman-Maggor, Tuvi-Arad,	1	Development and evaluation of an online course on nanotechnology for the professional development of chemistry teachers.	11

It	Author	Number	Title	Citation
	and Blonder 2022)			
4.	(Korukluoğlu and Yucel-Toy 2022)	1	Digital storytelling in online elementary science education: a case study on science and technology club activities.	4
5.	(Park et al. 2022)	1	Features of and representational strategies in instructional videos for primary science classes,"	2
6.	(Kapici, Akcay, and Cakir 2022)	1	Investigating the effects of different levels of guidance in inquiry-based hands-on and virtual science laboratories	12
7.	(Bozzo et al. 2022)	1	Combining real and virtual activities about electrostatic interactions in primary school,	2
8.	(Saribas 2023)	1	An online laboratory applications course for the development of scientific practices and scientific method,	0
9.	(Özdeniz, Aktamış, and Bildiren 2023)	1	The effect of differentiated science module application on the scientific reasoning and scientific process skills of gifted students in a blended learning environment,	5
10.	(Feldman and Alsultan 2023)	1	Engaging science teachers virtually in dialogical collaborative action research to improve science teaching during the COVID-19 pandemic,	1
11.	(Borge and Xia 2023)	1	Beyond the individual: The regulation and negotiation of socioemotional practices across a learning ecosystem	6
12.	(Lizárraga 2023)	1	Cyborg sociopolitical reconfigurations: Designing for speculative fabulation in learning,	16
13.	(Matovu et al. 2023)	1	Immersive virtual reality for science learning: Design, implementation, and evaluation	68
14.	(Arztmann et al. 2023)	1	Effects of games in STEM education: a meta-analysis on the moderating role of student background characteristics	37
15.	(Shlomo and Rosenberg-Kima 2024)	1	F2F, zoom, or asynchronous learning? Higher education students' preferences and perceived benefits and pitfalls	0

It	Author	Number	Title	Citation
16.	(Arztmann et al. 2023)	1	An examination of an inquiry-based hybrid online/in-person science methods course	1
17.	(Chakawodza, Nakedi, and Kizito 2024)	1	Effectiveness of flipped classroom pedagogy in promoting learning engagement in grade-12 students in the context of South Africa and COVID-19,	0
18.	(Assi and Cohen 2024)	1	Context-based learning in flipped middle school chemistry class	3
19.	(Yeoh, Li, and Hou 2024)	1	Game-based collaborative scientific inquiry learning using realistic context and inquiry process-based multidimensional scaffolding,	0
20.	(Passentin and Fortus 2024)	1	Motivational shifts when moving from face-to-face to distance learning	0
21.	(Hubbard et al. 2024)	1	Developing undergraduate practical skills and independence with 'at home practical kits'	1
22.	(Arthars, Markauskaite, and Goodyear 2024)	1	Constructing shared understanding of complex interdisciplinary problems: Epistemic games in interdisciplinary teamwork	3

Table 4 shows the number of citations for each article. The two most cited articles were "Immersive virtual reality for science learning: Design, implementation, and evaluation" in 2023 with 68 citations and "Effects of games in STEM education: a meta-analysis on the moderating role of student background characteristics" in 2023 with 37 citations. Twenty other articles have different citations, and some articles are still uncited at the time of this study.

3.2.7 Publications Online Learning in Science Education in the Levels of Education

Another discussion expressed in this study is the distribution of publications based on the level of education related to OL in science education. The following table 5 will illustrate the distribution of articles based on journals and by education level.

Table 5. The percentage of publications in several levels of education journal

Journal	Percentage in level of education (number (%))					
	Primary	Secondary	High	Undergraduate	Teacher	Unspecific
IJSE	3 (14)	3 (14)	2 (9)	4 (18)	3 (14)	2 (9)
JOLS	1 (5)	0	0	1 (5)	0	1 (5)
SSE	0	0	0	0	0	2 (5)

Undergraduate and non-specific education levels are the most frequently used subjects in the research in this research theme. Unspecific in this study is research that is carried out not only at one level of Education, as an example of one of the existing researches, there are teachers and high school students. In addition, it has been discussed before that IJSE is the journal that publishes the most research results in this field. Meanwhile, at other levels, it is said to be quite even. However, at the high school level, it is necessary to pay attention.

3.2.8 The Most Significant Science Discipline in Online Learning

Another part that needs to be discussed in this study is related to the field of science and the topics discussed in the selected articles. Table 6 will discuss in detail the disciplines of science discussed in the selected articles.

Table 6. The most significant science discipline in online learning

Journal	Percentage in science discipline (number (%))					
	Physics	Chemistry	Biology	Environmental science	Geology	Unspecific
IJSE	2 (9)	3 (14)	0	0	0	12 (55)
JOLS	0	0	1 (5)	0	0	2 (9)
SSE	0	0	0	0	0	2 (9)

Unspecific science disciplines are a mixture of various scientific disciplines studied. We found that as many as 73% belong to this unspecific category. In more detail, IJSE is the main forum

for researchers to publish their research results in this topic. Many are unspecific because the learning process is carried out in the form of a collection of several lessons because in general, the OL carried out in this study is an activity that is carried out continuously in the learning process. Based on the analysis we conducted, it shows that in other fields of science it is necessary to pay attention to it so that it is more specific and can also be the next research opportunity, especially in geology and environmental lessons.

3.2 DISCUSSION

The discussion of this study will focus on the results of the analysis that we have obtained related to the six main points that need to be considered for research related to OL in science education.

3.1.1 Positive Trends of OL Research in Science Education from Year to Year

The results of the study suggest that research related to OL is a positive trend that has been seen to increase over the past three years, although not too significant. This shows that OL learning is growing, especially in the field of science education. OL learning provides accessibility and flexibility because through OL students can access subject matter anytime and anywhere as well as learning time that can be adjusted to their own rhythm to allow for a reduction in stress and fatigue in learning (Archambault, Leary, and Rice 2022). Therefore, a curriculum is needed that can support so that the achievement of learning becomes better and based on competence. In addition, OL can also create collaborative activities and a wide social network because of the use of a platform that allows to connect with the wider outside world (Archambault et al. 2022; Ge et al. 2020).

OL learning can also provide interactivity and engaging visual experiences. Of course, the use of interactive media such as photos, videos, and simulations will make it easier for students to understand science concepts better (Abdulrahaman et al. 2020). Through online learning, it is also possible to present more personalized and adaptive learning. Personalization means that teachers can identify individual learning needs and provide appropriate materials, while adaptive is a learning application that can be adjusted according to the level of difficulty or learning content based on students' abilities and learning speed (Ge et al. 2020; Morze et al. 2021).

3.1.2 Significant difference in the number of articles published in selected journals

Based on Table 3, we can see that the research related to OL is not evenly distributed in the selected journals. Of the three journals, IJSE has the most publications. Although these three journals are the best journals in the field of science education. However, with regard to the publication of articles, of course, it cannot be separated from the subjectivity of the journal editor (Soderberg et al. 2021), but with the potential offered by this OL, we believe that research with this theme is certainly a hope and also the potential for its development will always be something that will always be interesting to be researched and applied in the learning process, especially with extraordinary technological developments.

3.1.3 Mix method of the most frequently used research method

The Mix-Method is an approach that is widely used in the articles we review. This may be because through this method, researchers can gain a deeper understanding of the phenomenon being studied (McKim 2017; Romero Errabo et al. 2021). In addition, the mixed method fills the gap that exists between quantitative and qualitative research. Quantitatively, this method can reveal the impact or change due to a certain treatment, while in terms of qualitative, this method allows analysis to understand students' perception of the treatment. Research on OL has broad potential for development with a variety of other methodological approaches. This view is reinforced by the findings of the study, which suggest that research with a focus on OL can still be expanded to produce better research and more optimal descriptions.

usual.

3.1.4 There are no authors who focus on OL learning and citations are still not significant.

The results of this study show that until now there has been no research that has produced more than one publication related to online learning (OL). This phenomenon can be explained by the fact that the articles published in the three selected journals did not have authors who specifically focused on research on OL. Although OL is an exciting field in science education, its potential can still be expanded to produce more publications in reputable journals. In addition, the citation rate for articles about OL has not reached a significant optimal level. This may be because OL is still considered a relatively new field in science education and continues to develop.

3.1.5 There is a need for more focused research on all levels of education.

In general, research at each level of Education needs to be considered because if you pay attention to the results of our analysis, there are still many that are two or more levels of

Education, so we include them in non-specific. Therefore, it is necessary to conduct more focused research on certain levels of education to produce better knowledge and application of this OL. Especially if we look at the advantages offered by this OL which has been discussed in section 3.2.1.

3.1.6 Focus on science discipline.

Overall, in every science discipline, there is still room for improvement. The articles we used in this study show that most of the research on online learning (OL) involves a combination of different science disciplines. Because OL is a continuous process, focusing on a specific discipline or even a more specific topic will be a valuable reference for other researchers. Such references can be helpful in developing similar research or even improving the ways, methods, analyses, and approaches that support OL in science education.

4 CONCLUSION

Research on online learning (OL) continues to develop to create an optimal learning experience and in accordance with the needs of students in the future. In the context of science learning, OL needs to be further expanded in order to find the best approach and support that ensures the goals of science education are optimally achieved. In addition, the development of a curriculum that supports differentiation and is accessible to various student conditions is also key.

The study we studied showed a positive trend related to OL. In the last three years, our analysis of three international journals in the field of science shows an increase in the number of studies on OL. Although we have data only up to July 2024, this trend shows that research on OL is growing.

The mixed method is the most widely used research approach in this context. The combination of quantitative and qualitative approaches complements each other. However, there are opportunities to use other research methods, such as experiments or longitudinal studies, to provide more comprehensive insights. The exploration of these alternative methods is important to explore aspects of OL that may not have been identified through a mixed approach. Thus, an understanding of how OL can be taught and applied at different levels of education and subjects can be deepened.

In this study, we found that OLs need to be focused on a specific level of education. Although there are studies that involve multi-level education, such as teachers and students, most of the research still does not specifically address specific disciplines or more in-depth concepts.

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