Digital Learning Research in the Last 30 Years: Important Role of Interactive Learning in Physics

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Abstract **– The aim is to analyze top 100 highest citations of digital learning research topics and the important role of interactive learning in physics in 1992-2021. This study uses bibliometric analysis and literature review. The trend of digital learning topics is increasing steadily, from 2014 to 2021. Digital learning shows an excellent contribution to physics learning. The important role of interactive learning in physics is to improve student learning outcomes, deepen understanding and make learning more interesting. More intensively, further research can be carried out by comparing other learning systems applied in physics learning.**

Keywords **– bibliometric, digital learning, education, physics learning.**

1. Introduction

Various kinds of learning systems have been applied according to surrounding conditions, the example is digital learning.

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The development of learning systems must pay attention to the ease of adaptation and transformation [1], [2]. Learning development can be done by combining organizational learning theory and general systems theory.

There are many impacts of the covid-19 pandemic, one of which is in the world of education. One of the updates from the covid-19 case on October 10, 2021, all countries have reported 219 million positive cases of covid-19 with 4.55 million deaths [3]. With the danger that threatens, many countries are trying to make learning sustainable [4]. Efforts are made to organize healthy learning during the covid-19 pandemic crisis [5]. The covid-19 outbreak has led to the closure of schools and colleges, so educational institutions are designed to be more flexible, namely the learning process can be carried out even though it is not face-to-face, reducing learning hours and utilizing digital platforms. Research conducted by Schirmel [6], Neil [7], and David [8] concluded that during the covid-19 pandemic, student responses showed good acceptance of digital learning. Students accepted and adapted easily to digital technology during the covid-19 pandemic.

Physics learning is closely related to natural phenomena and experimental activities. The flexibility of physics learning can be done using digital technology or without it [9]. By learning physics through digital learning students are challenged to be more independent, must easily adapt and be willing to learn. However, there are shortcomings in the implementation of digital learning, namely some places have limited access to digital media and potential dependence on digital technology [10]. Mentoring and supervision by physics teachers will determine the success of digital learning [11].

From the existing studies, there is still no discussion that shows the contribution of digital learning in physics learning and the important role of

interactive learning in physics. Some studies tend to discuss digital learning, but to show the right data regarding the analysis, bibliometric studies and literature reviews are needed. Bibliometric analysis is a method to provide knowledge regarding the growth and flow of literature in a particular publication field [12]. This bibliometric study uses empirical data to track existing publications [13]. This study can analyze the distribution of manuscripts sorted by country, source, year and more [14].

This research was carried out with an explanation of the importance of digital learning as well as the existing shortcomings. The aim is to analyze top 100 highest citations of digital learning research topics, and the important role of interactive learning in physics from 1992 to 2021. For analysis are used bibliometrics and also literature review. The objective research included:

1. Analysis of the trend of digital learning publications from the last thirty years.
2. Identifying the most widely used keywords, the country and author that contribute the most to the publication of digital learning in the last thirty years.
3. Identifying document types and source titles for digital learning from the last thirty years.
4. Identifying the year wise distribution of the top 100 cited digital learning publications from the last thirty years.
5. Identifying the contribution of digital learning in physics learning over the last thirty years.
6. Identifying the advantages and disadvantages of digital learning.
7. Analysis of the important role of interactive learning in physics.

2. Methods

This study uses bibliometric analysis and literature review. The data used in this study were taken from Scopus. Scopus is well-known for its largest database of publications in various fields including academic fields such as natural sciences, computing and others [15], [16]. Data from Scopus can be adjusted according to the needs of the year, title, country, keywords, and so on [17]. In addition, this study uses a literature review from previous studies as a reinforcement of research data.

Research data was taken on April 1, 2022. The data in Scopus is selected based on the keywords you want to search for. In this study, the keyword selection stage was carried out twice, the first regarding digital learning. Furthermore, the second keywords are connected with physics learning to find the contribution of digital learning, more details can be seen in Figure 1. The data was obtained in the form of .csv which was then analyzed using Microsoft excel and .ris which was analyzed using VOSViewer [18].

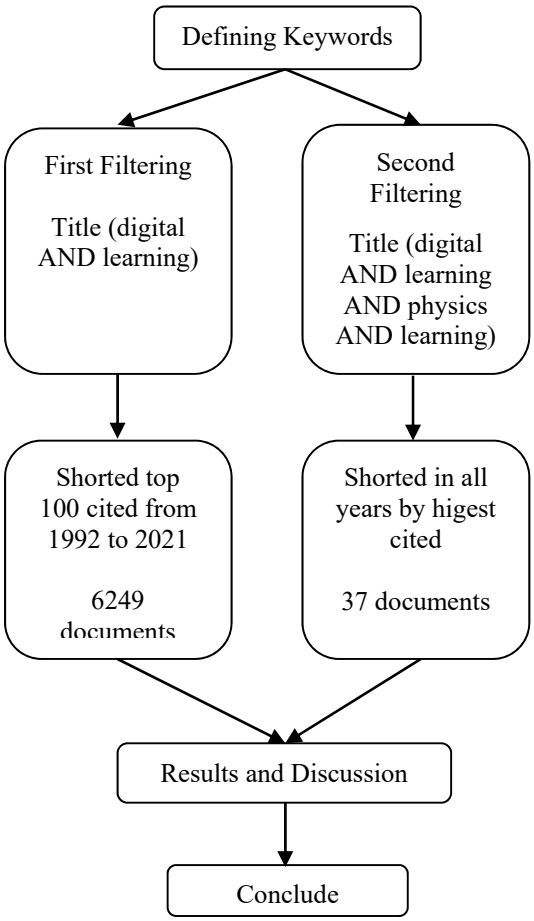

Figure 1. Flowchart for the keyword filtering

3. Results and Discussion

3.1. Publication Trend in the Last 30 Years

From Figure 2., we can see the trend of publications related to digital learning. The trend of publication is an important aspect to pay attention to and follow up [19]. Considering that publications must be in accordance with current conditions, which mean the development of a topic is determined from the trend of publications each year [20].

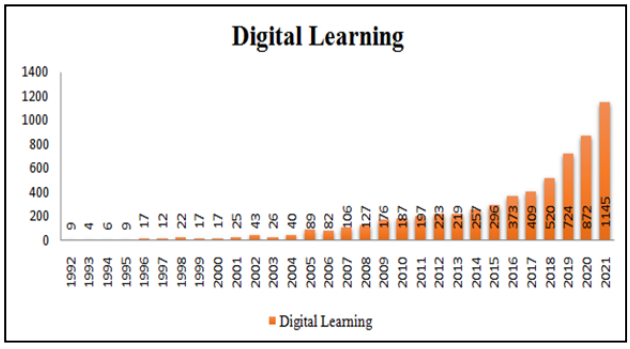

Figure 2. Digital learning publication trends

The highest digital learning publication was in 2021 with 1145 documents and the lowest in 1993 with 4 documents. Digital learning publications began to increase steadily, from 2014 to 2021. The highest increase occurred in 2021 with as many as 273 documents from 2020. The researchers tend to be interested in raising the topic of digital learning [21]. This is in line with the fact that the majority of education in the world has used digital learning due to the emergence of the Covid-19 pandemic [22]. So that research related to digital learning has high potential for future research.

3.2. Visualization of the Most Used Keywords, Top Countries and Top Authors Who Contributed the Most

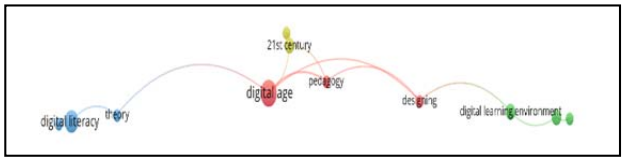

Figure 3. The keywords visualization of digital learning

Figure 3. shows the keyword visualization using VOSViewer. Keywords can describe the subject matter in a publication [23]. For digital learning topics, the most commonly used keyword is "digital age" which has 8 occurrences and "digital literacy" has 6 occurrences.

Table 1. Comparison of the top 10 countries with the most publications in the last thirty years

Top 10 countries	Publications
United States	1,359
United Kingdom	460
China	422
Germany	347
Australia	319
Taiwan	306
Spain	281
Indonesia	221
Canada	208
India	187

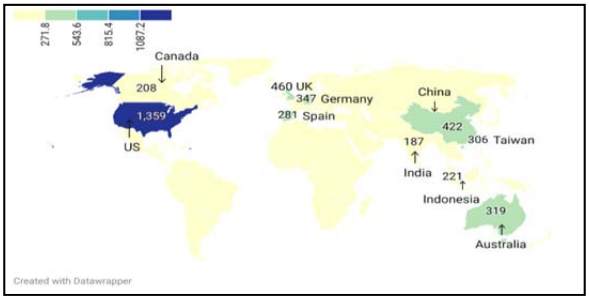

Figure 4. Top 10 Countries with publications about digital learning

From Table 1. and Figure 4., it can be concluded that the United States produced the highest number of papers over the last thirty years on the topic of digital learning. There are five countries that consistently occupy the top 10 on all publication topics related to digital learning including the United States, China, United Kingdom, Australia and Spain. To identify the author who has the most publications on each topic of digital learning, we were using VOS viewer and Microsoft Excel analysis. The results of the Microsoft Excel analysis are shown in Table 2.

Table 2. The top 10 author with the highest citations in the last thirty years

Author	Total Citations	Country
M. Papastergiou	1,880	Greece
K. Kiili	1,978	Finland
C.M. Greenhow	2,509	United States
A.R. Janowczyk	1,269	United States
D.B. Clark	3,069	Canada
A. Madabhushi	14,845*	United States
B. Gros	660	Spain
S. Erhel	429	France
A. Sadik	367	Egypt
B.Q. Huynh	590	United States

Table 2. shows the top 10 authors from the highest citations for the topic of digital learning, M. Papastergiou from Greece. Meanwhile, the highest total citation was owned by A. Madabhushi from the United States. To find out which writers on digital learning topics produce the most digital learning papers and who are most connected to other authors, we can use a software called VOSViewer. With VOSViewer we can identify the classification of top authors [24]. The grouping and connection of each author is indicated by the presence of clusters [25]. The first results of the digital learning topic are divided into 3 clusters, namely red (n=5), green (4), blue (n=2). H. Beetham is the main author because he has 3 documents with 2 total links strength which is more than any other author.

3.3. The Document Types and Source Titles of Top 100 Highest Cited Publications in the Last 30 Years

Table 3. The document types of top 100 highest cited digital learning publication in the last 30 years

Document Type	Freq-uency	Cited	Mean	Med-ian	SD
Article	81*	14206*	175.3	125	160.8*
Conference paper	7	808	115.4	95	47.2
Review	4	810	202.5*	209.5*	96.6
Note	0	0	0	0	-
Book	7	1011	144.4	129	63.1
Editorial	1	376	376	376	-

Table 3. shows digital learning topics, most of the publications are in the form of articles (n=81). Digital learning has been totally cited 14,206. The standard deviation is quite high, namely digital learning (n=160.8).

Table 4. The source titles of top 100 highest cited publication in the last 30 years

Source Title	TD	TC
Computers and Education	13	2983
Educational Technology and Society	4	415
Journal of Computer Assisted Learning	3	565
Journal of Research on Technology in Education	3	530
Language and Learning in the Digital Age	3	468
Geoderma	3	386
ReCALL	3	325
Internet and Higher Education	2	1008
Rethinking Pedagogy for a Digital Age: Designing and Delivering E-Learning	2	343
Learning, Media and Technology	2	264
TD = Total Documents TC = Total Citations		

Table 4. shows that the source titles of digital learning are varied and we can see that the source title which produces the most digital learning topics, namely Computers and Education (n=13 documents). The highest total citation is 2,983 namely source title is Computers and Education.

3.4. The Year Wise Distribution of Top 100 Highest Cited Publications in the Last 30 Years

Table 5. contains information on the distribution of the top 100 cited publications on the topics of digital learning. The range of data used is from 1992 to 2021.

Table 5. The year wise distribution of top 100 highest cited publications in the last 30 years

Year	Citable Year	Digital Learning			
		TC	TD	ACPP	ACPPY
1992	30	0	0	0	0
1993	29	0	0	0	0
1994	28	0	0	0	0
1995	27	215	2	107.5	3.9
1996	26	0	0	0	0
1997	25	0	0	0	0
1998	24	0	0	0	0
1999	23	0	0	0	0
2000	22	0	0	0	0
2001	21	420	2	210	10
2002	20	0	0	0	0
2003	19	0	0	0	0
2004	18	454	2	227	12.6
2005	17	1237	4	309.2*	18.2
2006	16	270	2	135	8.4
2007	15	891	5	178.2	11.8
2008	14	869	5	173.8	12.4
2009	13	2282	7	326	25.1
2010	12	421	3	140.3	11.6
2011	11	932	7	133.1	12.1
2012	10	1327	10	132.7	13.3
2013	9	1199	7	171.3	19
2014	8	894	8	111.7	13.9
2015	7	443	4	110.7	15.8
2016	6	2699*	11*	245.4	40.9
2017	5	567	4	141.7	28.4
2018	4	881	6	146.8	36.7
2019	3	884	9	98.2	32.7
2020	2	326	2	163	81.5*
2021	1	0	0	0	0
*The Highest Number					

This information can be used to see in what year the top 100 cited publications were produced on the topic. From this study it was found that the highest year is 2016 (n=11 documents). In addition, from this study it was found that the highest year is 2016 (n=2,699 citations). The highest average citation per paper per year in 2020 is 81,5.

3.5. Literature Review of Digital Learning to Physics Learning

Table 6. contains the results of the literature review by taking into account the quartiles, citations, and findings to provide recommendations regarding the selected paper.

Table 6. Top 5 highest cited paper showing contribution of digital learning to physics learning

Author	SJR	Citation	Findings
Anderson, J. L., & Barnett, M. [26]	1,03 (Q1)	46	Digital learning with game simulations has a positive impact on the learning outcomes of junior high school students in physics learning.
Sengupta, P., Krinks, K. D., & Clark, D. B. [27]	4,06 (Q1)	22	The results of the study show that the combination of using digital learning fosters student physics learning motivation.
Melo, M. [28]	0,54 (Q2)	4	The use of digital learning 4C/ID model in physics content to students has a positive impact on learning outcomes.
Euler, E., Prytz, C., & Gregorcic, B. [29]	0,34 (Q3)	1	Digital learning using the Algodoo application gives students the opportunity to explore physics learning materials for free and able to attract students' attention in learning.
Sukarno & Widdah, M.E. [30]	0,49 (Q2)	1	Students' metacognitive and digital literacy skills increase in physics learning.

The ranking system of reputable journals based on the subject or category of the related journal field is also called quartiles [31]. From these results, it can be seen that the topic of digital learning has the highest citation 46, thus, research related to digital learning in physics will have a lot of potentials, and its novelty will be quite high. Digital learning tends to take advantage of interactive learning applications to increase student motivation and learning outcomes [32].

3.6. Advantage and Disadvantage of Digital Learning to Physics Learning

Table 7. Discussion about digital learning

Discussion	Digital Learning
Meaning	Learning media that can be done digitally without having to wait for internet access to start.
Characteristics	▪ Some digital learning can be accessed without internet ▪ Not tied to face-to-face or non-face-to-face learning ▪ More towards the learning media
Advantage	Can be used in various places, can trigger students to think creatively and innovatively
Disadvantage	Can lead to dependence on digital tools so that it can cause laziness in students

From Table 7., broadly speaking, it can be concluded that digital learning has advantages in flexibility and types of media that utilize sophisticated digital tools. While the disadvantages have an impact on students' lifestyles which can become dependent on digital learning media.

3.7. Analysis of the Important Role of Interactive Learning in Physics Based on Digital Learning Research

Learning physics still tends to be difficult for most students to understand. Physics learning needs to be set more interactively for students. The use of interactive learning media can be integrated using a combination of video, graphics, text, and sound. Digital learning by applying interactive virtual reality can deepen students' understanding of physics material. In addition, through good quality worksheets in digital learning can be improved the students' critical thinking skills in learning physics. Practical activities can play an important role in engaging students with the world of science, especially when using digital tools. So, it can be concluded that interactive learning can improve student learning outcomes [33].

The majority of students in the 21st century is proficient in advanced technology and are adaptable. For example, the use of interactive modules is also very important to apply because, according to research [34], digital learning of physics with interactive modules shows compatibility and a positive impact. Since the last three years, the world has been affected by the pandemic, so academic units must also think about effective learning methods that can still improve student achievement. Therefore, interactive learning in physics is starting to be more widely applied. One of them is by using interactive multimedia, which is able to improve students' understanding of concepts [35]. Interactive learning plays an important role in deepening the concept of physics and making the learning atmosphere more interesting even through digital learning.

4. Conclusion

Research results analysis using bibliometric studies and literature reviews related to digital learning research get several conclusions. The conclusion is that the trend of digital learning topics is increased steadily, from 2014 to 2021. The most commonly used keywords are digital age, and digital literacy. The United States (US) has made the highest contribution over the last thirty years on digital learning. The author with the highest citation on

digital learning is M. Papastergiou from Greece. The type of document that is often published by the author is in the form of articles. The highest source titles digital learning is the paper *Computers and Education*. The highest average citation per paper per year is in 2020 where digital learning (n=81,5). The digital learning topics contribute to learning physics. From the explanation above, the future research related to digital learning in physics will have a lot of potentials, and its novelty will be quite high. The important role of interactive learning in physics is to improve student learning outcomes, train critical thinking skills, deepen understanding of concepts and make learning more interesting. The advantages of digital learning is in flexibility such as the learning process can be carried out even though it is not face-to-face, reducing learning hours and types of media that utilize sophisticated digital tools. While the disadvantages have an impact on students' lifestyles which can become dependent on digital learning media and because it's using the internet network, which requires costs and a strong signal because not all areas have a strong network connection.

The implication of this research is to show the trend of publication of digital learning topics so that future researchers can show more benefits related to these topics. With this article, researchers can find out the strengths and weaknesses of digital learning topic and can find updates for future research. The limitation of the study is that some research results at Scopus are limited to full access. More intensively, further research can be carried out by comparing other learning systems applied in physics learning.

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