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Trend of mobile, web, E-learning research in 2002-2021: Contribution to physics learning

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Abstract

The existence of a research topic can be seen from the research trend. Analysis that can map data to determine the trend of a study is using bibliometrics. The purpose of this study is to compare trends of mobile, web, and e-learning research and their contribution to physics learning in the last twenty years. The data was obtained from Scopus which was processed using Ms. Excel and VOSviewer. The three topics show a steady increasing trend in the last three years. The highest average citation per paper per year is in 2020. The most widely used keywords are mobile learning, web-based learning and e-learning. The contribution of the three topics to physics learning includes increasing motivation, learning outcomes, etc. Future research can be carried out to compare the contribution of the three topics to other learning systems such as STEM, STEAM, etc. using databases other than Scopus.

Keywords: Bibliometrics; E-Learning; Mobile Learning; Physics Learning; Web Learning.

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1. Introduction

Gen Z is the internet generation or iGeneration. Students belonging to gen Z will not be separated from the internet because they were born and grew up in the midst of technological developments (Schlee et al., 2020; Dass et al., 2021; Miliou & Angeli, 2021; Kody, 2021). They are proficient in operating the internet for study, entertainment or work. And supported by the development of the industrial revolution era 4.0 which caused the development of digital technology to be very rapid (Smolyaninova & Bezyzestnykh, 2019; Brata et al., 2022; Kammerlohr et al., 2021). So that learning in schools can integrate technology into it.

With the fact that there was a pandemic from 2019 the world's education system switched to distance learning. According to research by Daineko et al., (2022) distance learning utilizes e-learning such as mobile technology, interactive web, augmented reality, and so on. However, there are still many negative sides to the use of mobile, web, e-learning such as research by Latifah et al., (2021) students have the freedom to explore so that negative impacts such as seeing content that should not be seen, mobile dependence, lack of teacher supervision during exams. The positive impact of using web learning according to research by Azlan, et al., (2020); Delgado, (2021) is that it can improve skills in using internet technology, and student learning outcomes have been shown to increase. So that research related to mobile, web, e-learning continues to be carried out by researchers from year to year as new discoveries, improvements to previous research and looking for solutions.

Physics is a discipline that is difficult for students to learn independently. This is because students see that physics has too many formulas so that it is boring (Khouna et al., 2020; Ramankulov et al., 2020; Park & Lee., 2021; Zhang et al., 2021). Student learning outcomes in physics lessons on average are still unsatisfactory (Mbonyieyivuze et al., 2021). Motivation to learn physics must be increased through interactive learning (Harjono et al., 2020; Puspita et al., 2020). One of them is by utilizing modern technology such as mobile learning which can create a more pleasant learning atmosphere (Zakaria et al., 2019).

The existence of a research topic can be seen from the research trend. One of the analyzes that can map data to determine the trend of a study is using bibliometrics (Hernandez et al., 2017; Reis et al., 2017). The results of bibliometric analysis can be a starting point for future research (Herrera et al., 2018). Previous research by Mutiawani et al., (2022); Guerrero et al., (2020) proved that web-based e-learning made it easier for teachers to deliver material and succeeded in improving students' critical thinking skills. Research by Churiyaha et al., (2022) states that mobile learning does not reduce students' academic achievement related to physics. Mobile e-learning is an alternative for learning during an emergency (Neffati et al., 2021).

1.1. Research Objectives

None of the previous studies have compared the three flexible learning, namely mobile, web, and e-learning. This learning allows students to get learning materials from many sources and can be accessed anytime (Safonov et al., 2021; Khodabandelou et al., 2022). Interactive learning in physics will increase student involvement in the classroom so that students can better understand the material presented (Binek et al., 2018; Soliman & Guetl, 2020; Pompongtechavanich & Wannapiroon, 2021). So from the explanation above about the importance of mobile, web, and e-learning as well as the shortcomings that exist, this research was carried out. The research objectives include analysis using bibliometrics as well as literature study. The aim is to compare trends of mobile, web, and e-learning research and their contribution to physics learning in the last twenty years from 2002 to 2021. The research objectives are:

1. To analyze the trend of mobile, web, and e-learning research from the last twenty years.
2. To identify and compare the year-wise distribution of the top 100 cited of mobile, web, and e-learning research from the last twenty years.

3. To identify countries, and the authors that contributed the most to the mobile, web, and e-learning research from the last twenty years.
4. To identify the most used keyword of the top 100 cited of mobile, web, and e-learning research from the last twenty years.
5. To identify document types and source titles of the top 100 cited of mobile, web, and e-learning research from the last twenty years.
6. To identify and compare mobile, web, and e-learning
7. To analyze the contributuion of mobile, web, and e-learning for interactive learning in physics

2. Methods

The data from this study were obtained through Scopus. Because Scopus is the largest database for various topics and is multidisciplinary (Purnell, 2022). Data collection was carried out on May 22, 2022 through two stages. The first stage is based on the keywords mobile learning, web learning, e-learning in the range of 2002 to 2021. While the second stage is filtering articles related to physics learning on each topic. For more details related to keywords filtering can be seen in Figure 1.

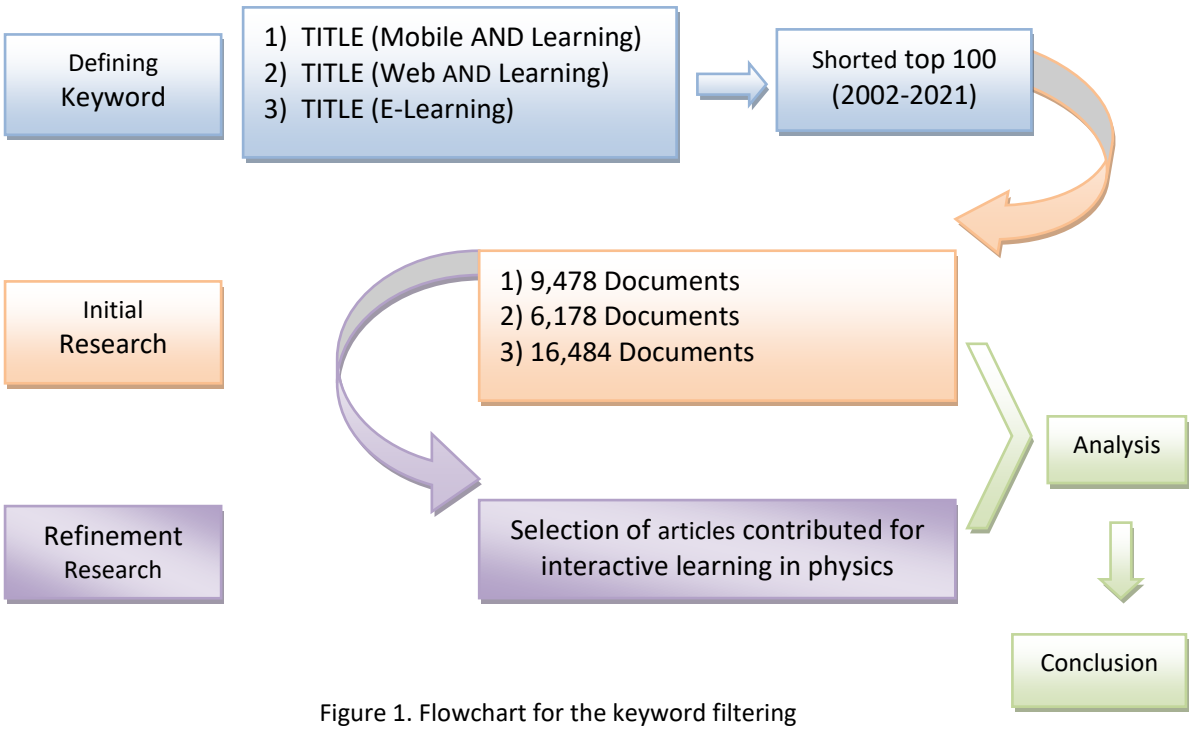


Figure 1. Flowchart for the keyword filtering

2.1. Data Analysis

This is a kind of descriptive research. This research uses bibliometric analysis and literature review. The use of bibliometrics is intended to obtain a classification from the research data obtained (Lucena et al., 2019; Sikandar et al., 2021; Gao et al., 2022). Bibliometric analysis has 5 stages: determining keywords; initial search results, refinement research; initial statistical data; data analysis (Ali et al., 2021). Meanwhile, the literature review is aimed at finding research with relevant topics that have been done previously as a reference material looking for novelty and shortcomings in research trends (Sie-Yi and ChePa, 2020).

The data obtained from this study are in .csv and .ris formats. The .csv format data will be processed through Microsoft Excel, while the .ris format data will be processed through the VOSviewer. In VOSviewer able to map various types of bibliometric analysis; supports several major bibliographic databases; the time dimension is ignored; limited to analyzing small to medium

amounts of data; intended for the function of processing text; using layout techniques, etc (Munir et al., 2022).

3. Result and Discussion

3.1. Research trend of mobile, web, and e-learning in last 20 years

Overall, trends from research on mobile, web, e-learning show fewer stable results. However, in the last three years, research has shown increasing results. Where this is in line with research by Azizan et al. (2022); Dolzhich et al. (2021) which states that during a learning pandemic all countries switch to utilizing mobile and internet technology to organize safe learning during the covid-19 pandemic. Therefore, predictions for research on these three topics in the next few years will be needed as a refinement of existing research and the latest findings. However, if the three topics, research related to mobile learning has the greatest opportunity to be studied in the following year because seen from research in 20 years, mobile learning research has graph results that stable and increase every year. For a more detailed analysis of each topic, see Figure 2a-2c.

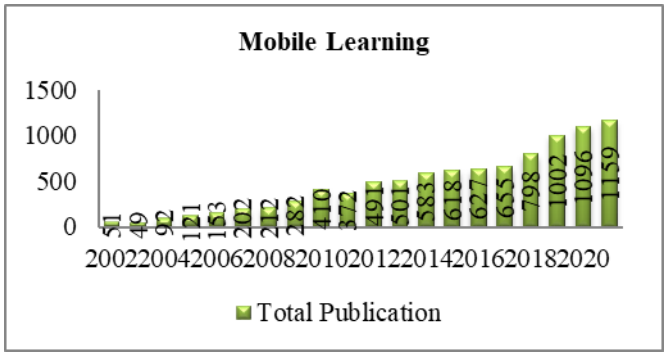


Figure 2a. Mobile learning research trend

Judging from the graph for the topic of mobile learning research, it is quite stable increasing. The decrease in the intensity of research related to mobile learning only occurred twice, namely in 2003 as many as 2 documents from the previous year, and in 2011 as many as 38 documents from the previous year. During the covid-19 pandemic, research related to mobile learning increased quite significantly, namely in 2019 it increased by 204 documents from 2018. The increasing trend of research continues until 2021. This means that the topic of mobile learning has a great opportunity to increase in the following years.

Figure 2b. Web learning research trend

On the topic of web learning, it can be seen that the research trend shows similarities to the sinusoidal waveform. However, when viewed from the latest research pattern in 2021, the number of research on the topic of web learning has the opportunity to increase in the next few years until it reaches the peak of the highest number of researches. The highest increase in

the number of research was in 2008 as many as 76 documents from the previous year. And the biggest decrease was in 2012 as many as 69 documents from the previous year.

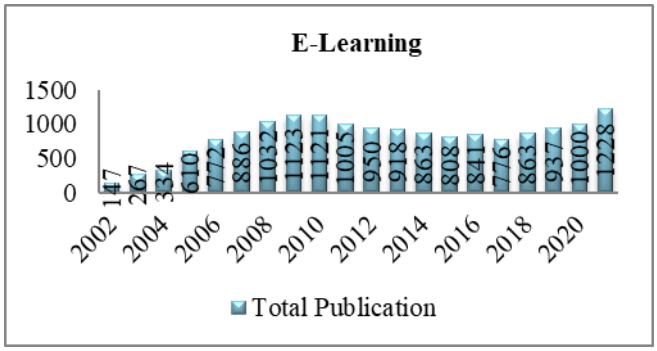


Figure 2c. E-learning publication trend

Research trends related to e-learning have almost the same pattern as web-learning, which is sinusoidal. The highest increase occurred in 2005 as many as 276 documents from the previous year. And the biggest decrease was in 2011 as many as 116 documents from the previous year.

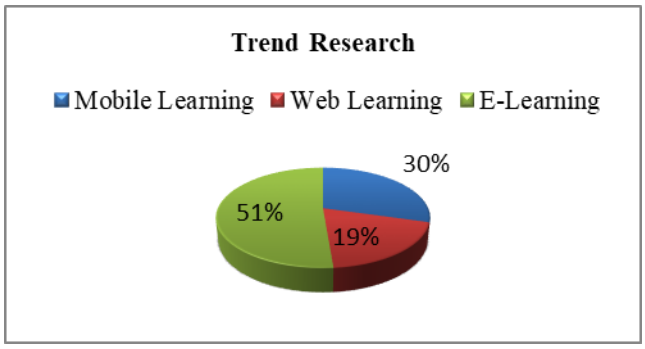


Figure 3. Total top 100 cited research of mobile, web, e-learning in the last 20 years

Figure 3 illustrates the results when viewed as a whole based on the number of research documents on the topic of mobile, web, e-learning. The highest number was obtained by e-learning topics by 51%. This means that the topic of e-learning gets a lot of attention from researchers around the world for further investigation. Researchers have a greater opportunity to generate new findings or ideas from web and mobile learning topics.

The data from this study were obtained through Scopus. Because Scopus is the largest database for various topics and is multidisciplinary (Iskandar et al., 2021; Purnell, 2022). Data collection was carried out on May 22, 2022 through two stages. The first stage is based on the keywords mobile learning, web learning, e-learning in the range of 2002 to 2021. While the second stage is filtering articles related to physics learning on each topic.

3.2. The year wise distribution in last 20 years

Table 1. The year-wise distribution of the top 100 highest cited publications in the last 20 years

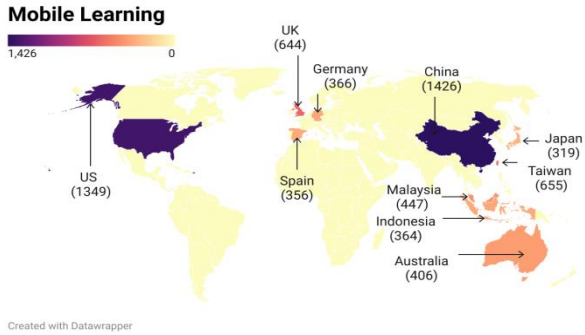
Year	Citable Year	Mobile Learning				Web Learning				E-Learning			
		TC	TD	ACPP	ACPPY	TC	TD	ACPP	ACPPY	TC	TD	ACPP	ACPPY
2002	20	885	4	221.3	11.1	2493	10	249.3	12.5	278	1	278	13.9
2003	19	1233	5	246.6	12.9	1734	5	346.8*	18.3	416	2	208	10.9
2004	18	472	2	236	13.1	2104	10	210.4	11.7	1303	4	325.8	18.1
2005	17	621	2	310.5	18.3	1219	8	152.4	8.9	3260	13	250.8	14.8

Year	Citable Year	Mobile Learning				Web Learning				E-Learning			
		TC	TD	ACPP	ACPPY	TC	TD	ACPP	ACPPY	TC	TD	ACPP	ACPPY
2006	16	163	1	163	10.2	652	2	326	20.4	4239*	8	529.9*	33.1
2007	15	2054	7	293.4	19.6	1856	9	206.2	13.7	3694	11	335.8	22.4
2008	14	1490	6	248.3	17.7	3088	12	257.3	18.4	4050	10	405	28.9
2009	13	2936	10	293.6	22.6	3402*	14	243	18.7	3570	11	324.5	24.9
2010	12	1963	8	245.4	20.4	1693	8	211.6	17.6	2234	6	372.3	31
2011	11	2409	7	344.1	31.3	629	3	209.7	19.1	2168	6	361.3	32.8
2012	10	1973	5	394.6*	39.5	1129	7	161.3	16.1	1350	6	225	22.5
2013	9	1500	5	300	33.3	1525	5	305	33.9	1099	4	274.8	30.5
2014	8	1045	5	209	26.1	410	1	410	51.3	847	3	282.3	35.3
2015	7	577	3	192.3	27.5	147	1	147	21	355	1	355	50.7
2016	6	2573*	9	285.9	47.6	0	0	-	-	799	3	266.3	44.4
2017	5	1831	8	228.9	45.8	213	1	213	42.6	862	5	172.4	34.5
2018	4	1227	6	204.5	51.1	379	2	189.5	47.4	395	2	197.5	49.4
2019	3	1600	5	320	106.7	160	1	160	53.3	0	0	-	-
2020	2	528	2	264	132*	119	1	119	59.5*	772	4	193	96.5*
2021	1	0	0	-	-	0	0	-	-	0	0	-	-

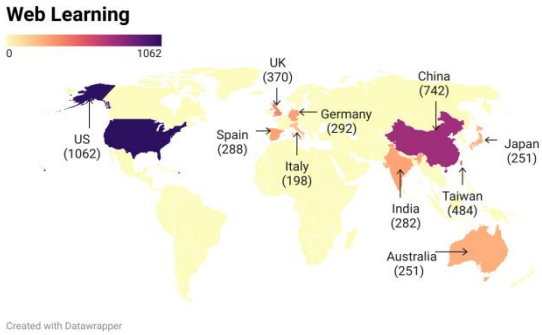
TC=Total Cited TD=Total Document
*ACPP= Average Citation Per Paper ACPPY= Average Citation Per Paper Per Year *The highest number*

Table 1. contains information on the distribution of the top 100 cited publications on mobile, web, and e-learning. The range of data used is from 2002 to 2021. The purpose of looking for a year wise distribution is to obtain information related to what year the top 100 cited publications were produced (Sharma & Khurana, 2021). From this research, it was found that the highest years included: 2009 (n=10 documents) for mobile learning publications; 2009 (n=14 documents) for web learning publications; 2005 (n=13 documents) for e-learning publications. In addition, from this study it was found that the highest years included: 2016 (n=2,573 citations) for mobile learning publications; 2009 (n=3,402) for web learning publications; 2006 (n=4,239) for e-learning publications. The highest average citation per paper per year is in 2020 where mobile learning (n = 132); web learning (n=59.5) and e-learning (n=96.5).

3.3. The top countries and author who contributed the most



a)



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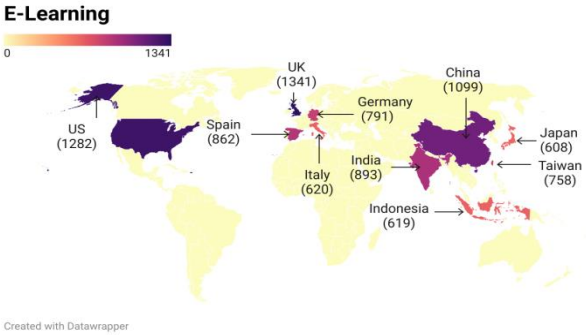


c)

Figure 4. Top countries who contributed the most to a) Mobile Learning, b) Web Learning, c) E-Learning

Table 2. Comparison of the top 10 countries who contributed the most in the last twenty years

	Mobile Learning	Web Learning	E-Learning
1	China (n = 1,426)	United States (n = 1,062)	United Kingdom (n = 1,341)
2	United States (n = 1,349)	China (n = 742)	United States (n = 1,282)
3	Taiwan (n = 655)	Taiwan (n = 484)	China (n = 1099)
4	United Kingdom (n = 644)	United Kingdom (n = 370)	India (n = 893)
5	Malaysia (n = 447)	Germany (n = 292)	Spain (n = 862)
6	Australia (n = 406)	Spain (n = 288)	Germany (n = 791)
7	Germany (n = 366)	India (n = 282)	Taiwan (758)
8	Indonesia (n = 364)	Australia (n = 251)	Italy (620)
9	Spain (n = 356)	Japan (n = 251)	Indonesia (n = 619)
10	Japan (n = 319)	Italy (n = 198)	Japan (608)

n = Total Documents

From Table 2 and Figure 4 above, it can be seen that the countries that have contributed the most to research related to mobile, web and e-learning in the last 20 years are different. For mobile learning, namely China with a total of 1,426 documents. For web learning, it is US with a total of 1,062 documents. For e-learning, namely UK with a total of 1,341 documents. The country with the most publications on a topic means that a topic is needed and considered appropriate to solve existing problems so that researchers continue to conduct research to improve previous research in that country (Kulakli & Osmanaj, 2020).

Table 3. Comparison of the top 10 author who contributed the most in the last twenty years

Mobile Learning			Web Learning			E-Learning		
Author	TC	Country	Author	TC	Country	Author	TC	Country
Sung, Y.T.	4,331	Taiwan	Huang, P.	2,587	United Kingdom	Sun, P.	2,265	Taiwan
Wang, Y.S.	7,637	Taiwan	Yi, M.	4,206	South Korea	Ruiz, J.G.	2,661	United States
Gikas, J.	642	United States	Greenhow, C.M.	2,564	United States	Roca, J.C.	1,501	Spain

Mobile Learning			Web Learning			E-Learning		
Author	TC	Country	Author	TC	Country	Author	TC	Country
Motiwalla, L.F.	1,008	United States	Doan, A.	7,215	United States	Tzeng, G.H.	428	Taiwan
Zhang, C.	983	China	Phan, X.H.	941	Vietnam	Park, S.Y.	1,235	South Korea
Wu, W.	1,575	Taiwan	Ma, J.	5,443	United States	Lee, M.	2,138	Taiwan
Hwang, G.	14,999 *	Taiwan	Chiu, C.	8,266	Taiwan	Zhang, D.	4,745 *	United States
Cheon, J.	784	United States	McLoughlin, C.E.	1,813	Australia	Liaw, S.	3,244	Taiwan
Traxler, J.M.	1,905	United Kingdom	Zeng, H.	2,636	China	Moore, J.L.	1,554	United States
Park, Y.	879	South Korea	Zheng, Y.	23,013 *	China	Selim, H.M.	1,521	UAE

*TC = Total Citations *The Highest Number*

From Table 3 it can be concluded that the author who has the highest citations for the three topics is dominated by researchers from Taiwan, China and United States. The authors who had the highest total citations by the authors overall were: Hwang, G from Taiwan as many as 14,999; Zheng, Y from China as many as 23,013; and Zhang, D from the United States as many as 4,745. While the top author for each topic, namely for the topic of mobile learning is Hwang, the citation for the topic of mobile learning is Sung Yao Ting from Taiwan with 666 citations out of a total of 4,331 citations. For the topic of web learning, namely Huang Posen from England, there were 1,018 citations out of a total of 2,587 citations. For e-learning topics, namely Sun Peichen from Taiwan, there were 1,346 citations out of a total of 2,265 citations. The author's contribution in a research can also be seen from his connection with other authors for each topic of mobile, web, and e-learning. VOSviewer can detect connections between authors through research that has been done (Jatmiko et al., 2021). The connection will be divided into several clusters (Effendi et al., 2010). This cluster represents the research streams of green manufacturing.

The result from VOSviewer includes: 1) The topic of mobile learning is divided into 7 clusters, namely red (n=5), green (n=4), dark blue (n=4), yellow (n=3), purple (n=2), light blue (n=2), orange (n=2); 2) The topic of web learning is divided into 3 clusters, namely red (n=4), green (n=4), dark blue (n=3); 3) The topic of e-learning is divided into 3 clusters, namely red (n=5), green (n=4), dark blue (n=3). For the topic of mobile learning, the most connected author is Hwang, G-J from the green cluster with 8 documents and 14 total link strength. For the topic of web learning, namely Ma, J from the green cluster with 2 documents and 7 total link strength. For e-learning topics, namely Sun, P is from the red cluster with 2 documents and 8 total link strengths.*3.4. Research trend of mobile, web, and e-learning in last 20 years*

Table 4. Top 10 the most used keywords in the last 20 years

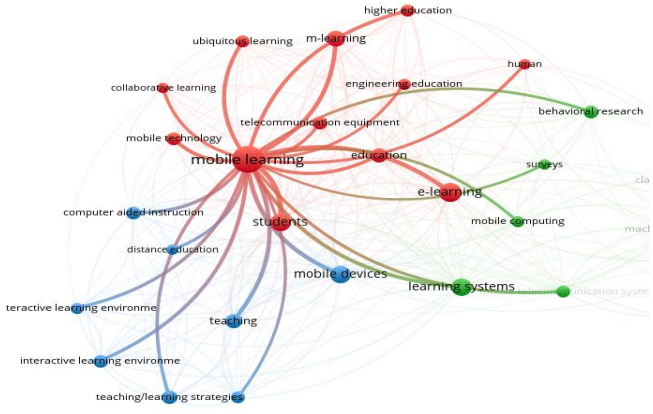
Mobile Learning			Web Learning			E-Learning		
Keyword	Occurences	TLS	Keyword	Occurences	TLS	Keyword	Occurences	TLS
Mobile learning	41	116	Web-based learning	10	48	E-Learning	74	258
Students	17	89	Education	4	46	Lerning System	37	148
Mobile devices	17	71	Learning algorithms	6	40	Teaching	22	114
Learning systems	17	64	Semantics	9	40	Students	20	96
Education	11	56	Natural language processing systems	8	39	Internet	17	92

Mobile Learning			Web Learning			E-Learning		
Keyword	Occurences	TLS	Keyword	Occurences	TLS	Keyword	Occurences	TLS
Teaching	11	54	Virtual Reality	5	38	Education	14	84
Computer aided instruction	8	43	Female	3	35	Multimedia System	13	78
Teaching	9	43	Male	3	35	Perceived usefulness	13	73
Deep learning	17	41	Machine learning	5	34	Computer aided instruction	12	53
Interactive learning environments	8	41	Questionnaire	3	33	Distance education	10	48

TLS = Total Link Strength

From the data in Table 4 we can see the keyword that has the highest occurrence rate and total link strength in the first topic is mobile learning. In the second topic, the keywords that have the highest occurrence rate and total link strength is web-based learning. While the third topic is e-learning. The high occurrence rate and total link strength indicated the researchers' interest in the topic (Suliyanah et al., 2021).

From Figure 5 there are several findings. From the pattern of visualization of the topic of mobile learning was found that its implementation to students and teaching using mobile devices and also telecommunication equipment. For the topic of web learning, it was found that it can create interactive learning using computer instructions. Meanwhile, on the topic of e-learning, it was found that it was applied to students by using the internet for teaching. The three topics can be implemented in distance learning.



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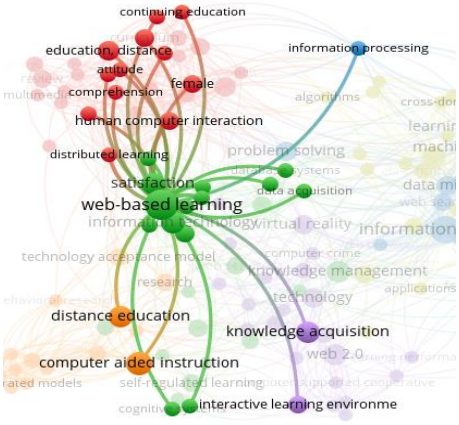

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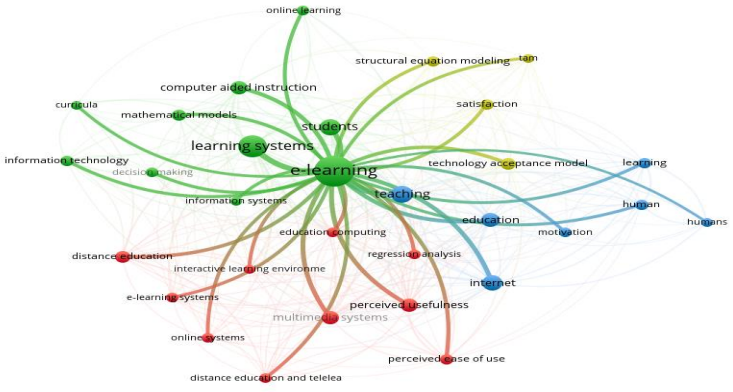

c)

Figure 5. The most frequently used keywords in top 100 cited research of a) Mobile Learning, b) Web Learning, c) E-Learning

3.5. The document types and source titles in last 20 year

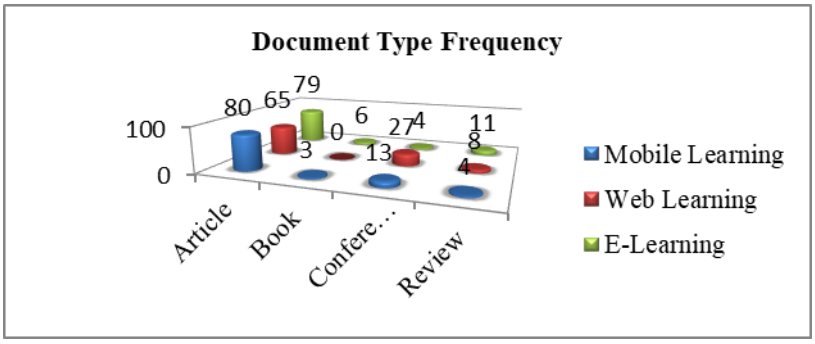

Figure 6. The document type frequency of the top 100 highest cited publications in the last 20 years

From Figure 6 we can see that on mobile, web, and e-learning topics, the most publications are in the form of articles. Where from the whole of each topic with a total of 100 documents, it was found that mobile learning (n=80), web learning (n=65), and e-learning (n=79).

Table 5. The document types of the top 100 highest cited publications in the last 20 years

Document Type	Cited			Mean			Median			S.D.		
	ML	WL	EL	ML	WL	EL	ML	WL	EL	ML	WL	EL
Article	21528*	13791*	25626*	269.1	212.2	324.4*	218.5	160	252*	126.4	128.6	195.6
Book	978	0	1651	326	0	275.2	302	-	218.5	59.7	-	102.3
Conference paper	3204	7769	876	246.5	287.7*	219	237	213*	211.5	78.7	212.4*	46.4
Review	1370	1392	3538	342.5*	174	321.6	372*	168.5	207	132.1*	43.9	299.8*

ML=Mobile Learning WL=Web Learning EL=E-Learning
*SD=Standar Deviation *The Highest Number*

From Table 5, we know from the three topics, the highest citation was owned by e-learning (n=25.626) in the form of articles. The highest mean was owned by mobile learning (n=342.5) in the form of review. The standard deviation of the three topics is quite high, namely mobile learning (n=132.1) in the form of review, web learning (n=212.4) in the form of conference paper, and e-learning (n=299.8) in the form of articles.

Table 6. The source titles of the top 100 highest cited researches in the last 20 years

Mobile Learning			Web Learning			E-Learning		
Source Title	TD	TC	Source Title	TD	TC	Source Title	TD	TC
Comput Educ	21	6403	Comput Educ	12	2299	Comput Educ	31	11782
J. Comput. Assisted Learn.	12	2982	Int. World Wide Web Conf., WWW	6	6449	Comput. Hum. Behav.	11	3418
Br J Educ Technol	5	1998	Internet Higher Educ	6	1086	Educational Technology and Society	5	1766
Educational Technology	5	1139	Int J Hum Comput Stud	4	1304	Expert Sys Appl	3	1174

Mobile Learning			Web Learning			E-Learning		
Source Title	TD	TC	Source Title	TD	TC	Source Title	TD	TC
and Society								
Comput. Hum. Behav.	4	834	Educational Technology and Society	4	582	Br J Educ Technol	3	771
Recall	3	896	Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min.	3	978	Educ. Technol. Res. Dev.	3	547
IEEE Network	3	671	Innov. Educ. Teach. Int.	3	684	Internet Higher Educ	2	801
IEEE Commun. Surv. Tutor.	2	917	Br J Educ Technol	3	620	J. Comput. Assisted Learn.	2	350
Int. Rev. Res. Open Distance Learn.	2	891	Comput. Hum. Behav.	3	427	Int J Hum Comput Stud	2	1057
Lang. Learn. Technol.	2	489	Australas. J. Educ. Technol.	2	677	Inf Manage	2	1051

TD = Total Documents TC = Total Citations

From Table 6, we know the top source titles that talk a lot about mobile, web, and e-learning are Comput Educ from the United Kingdom with SJR 3.68 which means occupying Q1. This means that topics related to mobile, web, and e-learning are highly relevant and have a high chance of being included in these source titles. For the highest total citation of mobile learning, namely Comput Educ (n=6,403); web learning namely Int.World Wide Web Conf., WWW (n=6,449); e-learning, namely Comput Education (n=11,782).

3.6. Comparison of mobile, web, and e-learning

Table 7. Comparison of mobile, web, and E-Learning

Comparison	Mobile Learning	Web Learning	E-Learning
Meaning	Learning using mobile device technology such as smartphones, tablets, and notebooks.	Web technology applications in the world of learning for an educational process.	The learning model is carried out through the use of information and communication technology services such as the internet, video/audio conferencing, or CD-ROM.
Characteristics	• Has a high degree of flexibility and portability • Video tutorials and virtual practicums related to learning • Has great learning effectiveness	• Easy to access virtual classroom or virtual university • Using the internet with all the facilities • Learning can be done interactively	• Take advantage of electronic technology services • Take advantage of the computer • Independent teaching materials are stored on a computer so that they can be accessed by teachers and students anytime and anywhere
Advantage	• Improve and expand the reach of teaching and learning • Increase students' interest and	• The learning process is not limited by time as usual face-to-face • The length of study time also depends on the ability of each student	• Students and fellow students or teachers and fellow teachers can communicate relatively easily without being limited by protocol matters • Educational administration can be viewed at any time on the computer

Comparison	Mobile Learning	Web Learning	E-Learning
	attention to learning materials • Increase students' independence to explore learning materials	• There is accuracy and up-to-date learning material	• The learning atmosphere will be more fun
Disadvantage	The tendency to use and play games on cellphones all the time, as a result, other things related to lessons are left out	Disadvantages from the side of the device such as processor capability, less memory capacity, signal, etc.	Some E-Learning methods are one-way. This causes the interaction of teachers and students to be reduced. Lack of supervision in learning with the E-Learning system causes students to cheat during exams, etc.

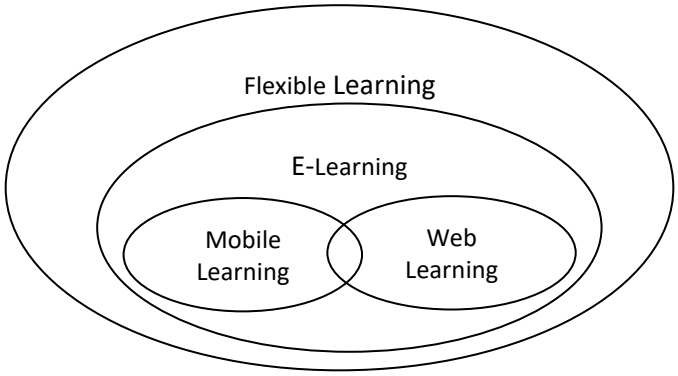

Figure 7. Flexible learning subset

From Figure 7 and Table 7, in general, mobile, web, e-learning have a relationship where the three topics are flexible learning. Flexible learning provides space for both teachers and students to carry out activities without being limited by space and time, which means adjusting to certain conditions (Hashimova et al., 2020; Grabar et al., 2022). Mobile and web learning are part of e-learning because E-learning technology covers all parts of applications and processes, including Computer Based Learning, Web based Learning, Virtual Classroom and Digital Collaboration (Ramananda & Srinivasan, 2019). Some of the mobile learning uses web-based so that the two topics intersect. Web learning itself can use access from mobile phones, PC, CD-ROM, STEM, STEAM (Bravou & Drigas, 2019).

3.7. Literature review of mobile, web, and e-learning for physics learning

With innovations in mobile learning can contribute to interactive learning in physics. With the flexible nature of mobile learning, it can improve student learning outcomes (Darmaji et al., 2019). Mobile learning can adapt local wisdom so that learning is more interactive and able to improve students' physics argumentation skills (Liliarti & Kuswanto, 2018). Some physics learning topics that are difficult for students to imagine can be made an interactive application or platform, from research by Mardiana & Kuswanto, (2017); Criollo-C et al., (2021); Tan & Heh., (2019); Ruiz-Rube et al., (2019) with the development of interactive applications for mobile learning, can improve critical thinking and problem solving skills, and students show positive responses, more active, high level of satisfaction. Interactive media can trigger positive mental health and increase students' self-confidence (Gharaibeh & Gharaibeh, 2020; Gasah et al., 2020).

In mobile learning, you can also take advantage of website-based media. From mobile learning itself, students are proven to be able to improve science process skills and solve physics problems that are HOTs (Nugroho & Surjono, 2019; Dasilva & Suparno, 2019). In addition, through a web-based learning system can also improve student learning outcomes and deepen students' understanding of

physics (Jonsson, 2005; Chandra & Watters, 2012; Hundt et al., 2017). Interactive web learning in physics is considered important because it will create a more interesting learning atmosphere so that students will be motivated and more satisfied to learn (Prasetya et al., 2018; Tsai et al., 2019; Ahmadaliev et al., 2018). The benefits of web-based learning using LMS are also felt by teachers and education practitioners to make reports in teaching (Thomton, 2010).

E-learning is the same as mobile learning, web learning is closely related to efficiency and flexibility. For e-learning itself, it can be done through virtual 3D, moodle, videos that can improve student understanding, increase motivation, and be more active (Violante & Vezzetti, 2015; Laskais et al., 2017; Lamph et al., 2018; Afify, 2020., Widyaningsih & Yusuf, 2020). E-learning can help so that education can take place even during the COVID-19 pandemic (Olivares et al., 2021). Research by Rodriguez et al., (2013) states that with e-learning, geometric optical material can be conveyed well and train students' independence. The emergence of the development of several media for e-learning physics such as Kahoot by Diana et al., (2021); AluMATTER by Hisch et al., (2006) and CoSci by Wachirawut et al., (2022) can help students deepen their understanding of physics on difficult materials.

4. Conclusion

This is the first study to compare three learning that utilizes technology and is flexible, namely mobile, web, and e-learning. From the results of bibliometric analysis and literature review, several findings were obtained: (1) Research related to these three topics has an unstable research trend over the last twenty years, although it has experienced a steady increase over the past three years. Mobile learning shows the most stable trend every year. So that this topic has the opportunity to be carried out in the next year; (2) The highest average citation per paper per year is in 2020 where mobile learning (n = 132); web learning (n=59.5) and e-learning (n=96.5); (3) he countries that contributed the most to mobile, web, and e-learning research, respectively, were China, the United States and the United Kingdom. Meanwhile, the authors who contributed the most in a row were Sung Yao Ting from Taiwan, Huang Posen from UK, and Sun Peichen from Taiwan; (4) The most widely used keywords in mobile, web, and e-learning research, respectively, are mobile learning, web-based learning, and e-learning; (5) Articles are the most widely used document type in the three topics and Comput Educ are the source titles with the most number of documents covering the three topics; (7) For mobile, web, and e-learning both have advantages in terms of flexibility and effectiveness and disadvantages in terms of available networks and devices, causing students to depend on technology and weak supervision of students; (8) The three topics have a contribution to interactive learning in physics including increasing motivation, learning outcomes, critical thinking skills, solving problems to being able to create a more pleasant classroom atmosphere.

The implications of this research can be felt by future researchers and in the international literature, namely information that compares the three learning topics and gets better references for the topics to be raised. This research succeeded in proving that the topics related to mobile, web, and e-learning that were raised contributed a lot to the interactive learning of physics. So that further research can be carried out to compare the contribution of these three topics to other learning systems such as STEM, STEAM, etc. using databases other than Scopus.

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