Learning Management System (LMS) Research During 1991–2021: How Technology Affects Education

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Abstract-Learning Management System (LMS) has been a widely-used learning media so a study is required to know the trend of its development. The present study aimed to analyze the types of documents, languages, contributing countries, top affiliates, sponsorship funding, top productive authors, research citations, subject areas, top source titles, trend mapping visualization, and top-cited 100 publications, and review some publications on LMS research during 1991–2021 using bibliometric analysis. The metadata were obtained by Scopus database and analyzed by VOSViewer within 2.689 documents. The bibliometric analysis results showed that LMS research had conference papers as the most widely published document type and English was the most commonly used language. The country with the most publications was the United States of America. National Natural Science Foundation of China became the top funding sponsor. The top affiliate was Bina Nusantara University. The most productive authors were Sabine Graf. Top cited author achieved by Fred D. Davis, and the top subject areas were Computer Science. Then, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence and Lecture Notes In Bioinformatics became the title of the top source. Trends of LMS research in 1991-2021 were: 1) related to E-learning; 2) implementation of learning activities and student-teacher cases; 3) technology integration in learning; 4) distance learning; 5) technology education; 6) online learning environment; and 7) interactive learning environment.

Keywords-bibliometric, education, learning management system

1 Introduction

The learning implementation has undergone many transformations and developments, especially in the learning management system. In this widely altered situation, skills and propensities are essential for the 21st-century citizens to live, work, and function effectively, hence, they have been comprehensively identified [1]–[5]. Technology is an essential aspect of most school or university curriculum [6]–[9]. The learning management system (LMS) is an education platform providing an integrated objective for publishing, collaborating, and sharing educational materials among teachers, learners, and institution managers [10]. Adapting LMS in higher education or another level of education has been a significant concern for the implementation of the digital learning process [11], [12]. Practitioners and experts emphasize that portraying the role of the new LMS needs to be consistent with teaching and learning theories [13]. LMS is a software or application that assists teachers in managing reporting, tracking, documentation, and delivering educational courses or training programs [14].

As LMS has become a promising technical tool in recent education, the precursors to adopting and using these educational techniques need to be considered in terms of consumer behavior. More specifically, a study in Malaysia required consideration of acceptance and preparation when using LMS for distance learning due to a lack of learner control and communication [15], [16]. LMS enables the integration of various objects and services into the ecosystem, especially in the education field and sequent students' training experiences. The main advantage of LMS is advanced tracking features and communication [17], [18].

Opportunities offered by using LMS include the ease of organizing and conducting online courses, ability to complete online assessments, accessibility and availability of learning materials, ways to save time and money for students and faculty, and communication and interactivity [19]. In addition, the LMS challenges that students face when adopting these technologies have the following shortcomings: Lack of student self-discipline and the discrepancy between LMS and specific academic programs [20]–[23]. However, as LMS technology increases in different countries, environments, consumer styles, traditional or creative, there are no boundaries in LMS research [24].

Research publications on LMS education tend to increase every year. A simple method that can be undertaken is through the bibliometric to input on Scopus with the keyword "Learning Management System Education or LMS Education,". The findings in 2018 resulted on 16 publications and 27 publications in 2021. This shows that research on LMS in education is increasing year by year. Therefore, in order to develop and adequately support a research topic, efforts must be made to find and understand the situation and trends of the research topic [25], [26], especially in LMS Education. Bibliometric studies can provide a solid foundation and objective for subject progress and relevant information on scientific publications [27]–[30]. Previous research [31] conducted an analysis review on choosing the proper LMS education. The study provided readers with data to help them make their judgments when selecting an LMS platform depending on their school's demands. This previous research used a literature study to discuss the potential of LMS. Hence, to distinguish from previous research, the present study is conducted using the bibliometric study to digest the information about LMS technology trends and their contribution to the education field.

This study conducted a bibliometric analysis on LMS in 1991–2021 using the metadata in the Scopus database and assisted by the VOSViewer mapping application. This study was expected to find out trends, patterns, novelty, and future education in the LMS Education. Specifically, the objectives of this study are drawn as follows:

- a. To analyze the documents, languages, and countries that contributed to LMS research during 1991–2021
- b. To analyze the top affiliates and sponsorship funding of LMS research during 1991-2021

- c. To identify the top 10 most productive authors of the LMS research during 1991–2021
- d. To analyze the research citations, subject areas, and top source titles on LMS research during 1991–2021
- e. To identify the results of research trend mapping visualization on LMS research during 1991–2021
- f. To identify the results of research trend mapping visualization in the top 100 cited publications in LMS research during 1991–2021
- g. To analyze the distribution of top 100 cited publications in LMS research during 1991–2021
- h. To explore the top 5 cited publications in LMS research in the Education field
- i. during 1991–2021

2 Methods

This study was a bibliometric study using descriptive analysis. To analyze the publication data, this study needed to structure the database [32]–[36] on the Scopus (<u>www.scopus.com</u>). Scopus was the most extensive database and had more than 77.8 million core records from various fields with various metadata and document types, either non-academic or academic fields [36]–[41]. Hence, Scopus was chosen as the database source for this research. Figure 1 illustrates the research stages.



Fig. 1. Research stages

The data were collected on March 3, 2022. The obtained results were sorted by "citation count" from high citation to low citation. Afterwards, the data for the one hundred most cited articles were downloaded in .csv and .ris file format. These 100 documents were shortened with the 'highest citation' criteria. Then, it was suggested to

upload those files into VOSViewer software to detail the transcript of the data and visualize the bibliometric mapping [42]–[46]. For the final stage, the data were analyzed descriptively to answer the research objectives.

3 Results and discussion

3.1 Types of document, language, and countries that contributed to LMS research

As the final search and filteration process, there were 2,689 documents (LMS research for 1991–2021) consisting of conference papers with a total of 1371 documents, articles with 1106 documents, book chapters with 134 documents, and other types of document types including reviews, editorials, erratum, books, notes, conference reviews as many as 78 documents. Thus, the distribution of documents was broader and more widely used by many people as a reference source. Most researchers published conference papers because they had a high-quality reputation compared to other sources. Moreover, it had a more significant and more accessible influence, as it was displayed at a conference to be seen by many experts from various fields [47]. In coping with the language use, English became the most widely used language (2612 documents) and it was followed by Spanish (32 documents), German (20 documents), Chinese (11 documents), and Portuguese (7 documents). It was due to the fact that English was an international language that everyone could understand [48]–[51].



Fig. 2. Top 10 contributed countries to LMS research during 1991–2021 *Source:* Scopus – created with Datawrapper.

The metric search results showed that 116 countries had contributed to LMS research during 1991–2021. Figure 2 shows the top 10 countries that significantly contributed to LMS research. The United States of America led the productivity with 391 documents and it was followed by China with 191 documents and Malaysia with 146 documents in the top 3 countries.



Fig. 3. Cluster countries mapping

Figure 3 shows mapping countries by cluster. There were six main clusters found the present study. Cluster 1 consisted of 18 countries namely Austria, Bangladesh, Bosnia and Herzegovina, Brazil, Canada, Chile, Croatia, Ireland, Japan, Kenya, North Macedonia, Norway, Russian Federation, Serbia, Slovenia, South Korea, Taiwan, and Vietnam that were connected by the red line. Cluster 2 consisted of 16 countries covering Finland, Ghana, Hong Kong, India, Indonesia, Iraq, Malaysia, Nigeria, Oman, Pakistan, Palestine, Philippines, South Africa, Thailand, Turkey, and the United Kingdom, which were connected by the green line.

Cluster 3 consisted of 13 countries namely Belgium, Colombia, Czech Republic, France, Iran, Italy, Mexico, Morocco, Romania, Slovakia, Spain, Tunisia, and the United States, which were connected by a blue thread. Cluster 4 consisted of 12 countries namely Australia, Bulgaria, China, Denmark, Egypt, Germany, Israel, Netherlands, Poland, Sweden, Switzerland, and Ukraine, which were connected by the yellow line. Cluster 5 consisted of 7 countries covering Singapore, Jordan, Lebanon, Qatar, Kuwait, New Zealand, and Saudi Arabia, which were connected by the purple line. And, cluster 6 consisted of 4 countries namely Cyprus, Greece, Portugal, and United Arab Emirates, which were connected by aqua line. The collaboration between countries on LMS research had been relatively good, as more than 70 countries involved.

3.2 Top funding sponsors and top affiliation

Table 1 shows the top 5 funding sponsors and top affiliations in LMS research within thirty years. In accordance with the top 5 funding sponsors, the most sponsorship funding was the National Natural Science Foundation of China with 28 documents, the National Science Foundation with 26 documents, the European Commission with 24 documents, the National Research Foundation of Korea with 21 documents, and the Japan Society for the Promotion of Science with 16 documents.

Top Funding Sponsors		Top Affiliations	
Funding Sponsor	Total	Affiliation	Total
National Natural Science Foundation of China	28	Bina Nusantara University	28
National Science Foundation	26	Universiti Kebangsaan Malaysia	26
European Commission	24	Athabasca University	23
National Research Foundation of Korea	21	Universiti Putra Malaysia	20
Japan Society For the Promotion of Science	16	Universidad Nasional de Educacion a Distancia	18

Table 1. The top 5 funding sponsors and affiliations with LMS research during 1991–2021

In addition, the top 5 affiliations were Bina Nusantara University with 28 documents, Universiti Kebangsaan Malaysia with 26 documents, Athabasca University with 23 documents, Universiti Putra Malaysia with 20 documents, and Universidad Nasional de Educacion a Distancia with 18 documents. This implied that publications on LMS research were not focused on one country but were evenly spread from Asia to Europe.

3.3 The top 10 most productive authors

The metadata results on Scopus showed the author of the publication of LMS research in 1991–2021. Table 2 depicts the top 10 most productive authors of LMS research in 1991–2021.

	Top 10 Autho	rship	
Author	Total	Author	Total
Graf, S.	17	Chkouri, M.Y.	8
Kinshuk	11	Colazzo, L.	8
Molinari, A.	11	Outloud, M.	8
Lonn, S.	9	Sahari, N.	8
Castro, M.	8	Smith, S.	8

Table 2. The top 10 most productive authors on LMS research during 1991–2021

According to Table 2, Graf, S. was the most prolific author with 17 publications, followed by Kinshuk and Molinari, A. with 11 publication documents each. Then, other authors had fewer than 10 publications.

3.4 Top research citations, subject areas, and sources titles

Table 3 shows the top 10 research citations, subject areas, and source titles for LMS research during 1991–2021. Based on research citations, Wang Q., Woo H.L., Quek C.L., Yang Y., and Liu M. were the author with the most citations namely 369 citations.

Top Cited A	Authors	Top Subject A	reas	Top Source Titles	
Author	Cited By	Subject Areas	Total	Source Titles	Total
Davis, F.D.	373	Computer Science	1617	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	90
Venkatesh, V.	318	Social Sciences	1001	ACM International Conference Proceeding Series	55
Romero, C.	147	Engineering	760	Communications In Computer And Information Science	40
Ventura, S.	136	Mathematics	302	Journal of Physics Conference Series	35
Wang, Y.	133	Business, Management, and Accounting	241	Advances In Intelligent Systems And Computing	34
Ajzen, I.	118	Decision Sciences	193	ASEE Annual Conference And Exposition Conference Proceedings	26
Morris, M.G.	117	Energy	117	Coeur Workshop Proceedings	24
Mclean, E.R.	114	Physics and Astronomy	97	Turkish Online Journal of Distance Education	21
Hair, J.F.	109	Medicine	85	Education And Information Technologies	20
Delone, W.H	108	Arts and Humanities	67	International Journal of Emerging Technologies In Learning	18

 Table 3. Top research citations, subject areas, and source titles on LMS research during 1991–2021



Fig. 4. Top-cited authors mapping visualization on LMS research during 1991-2021

Figure 4 shows that some top-cited authors were interconnected with each other. There were 7 clusters found in the top-cited authors. Davis, F.D. was considered the author with the most citations on LMS research from 1991–2021, namely 373 citations. He was followed by Venkatesh, V. with 318 citations and McGill T.J., Klobas J.E. with 147 citations. The seven main clusters were indicated by several colored nodes: the first cluster with red nodes (n=173), the second cluster with green nodes (n=136), the third cluster with blue nodes (n=27), the fourth cluster with chartreuse nodes (n=2) and the seventh cluster with orange nodes (n=1). Davis, F.D. was the most cited because of the highest number of citations and the link strength, but it belonged to the third cluster.

Based on subject areas, there were "Computer Science" with a total of 1617 publications, "Social Sciences" with 1001 publications, "Engineering" with 760 publications. Other subjects included Mathematics (n=302), Business, Management and Accounting (n=241), Decision Sciences (n=193), Energy (n=117), Physics and Astronomy (n=97), Medicine (n=85), and Arts and Humanities (n=67). In coping with the title of the top source, "Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics" was the main source in LMS research with a total of 90 citations, followed by "ACM International Conference Proceeding Series" with a total of 55 publications and "Communications in Computer and Information Science" with 40 publications.

3.5 Mapping-trend visualization to fundamental contribution

LMS was the main keyword in LMS research. The most occurrence keywords were analyzed before mapping out the visualization of LMS research trends during 1991–2021 (see Table 4). The highest total link strength and the most frequently occurring keywords were "Learning Management System," 5171 and 721 respectively. The second keyword was "E-learning," with total link strength of 4903 and an occurrence of 609, then was followed by Learning Systems, Students, Teaching, Education, Management, LMS, Learning, and Distance Education.

Based on this pattern, the trends of LMS research in 1991–2021 were related to E-learning, implementation of teaching and learning activities for students and teachers, technology integration in learning, distance learning, technology education, online learning environment, and Interactive learning environment.

All LMS Research			Top 100 Cited Research			
Keyword	Total Link Strength	Occurrence	Keyword	Total Link Strength	Occurrence	
Learning Management System	5171	721	E-Learning	82	30	
E-learning	4903	609	Learning Systems	73	25	
Learning Systems	4570	554	Learning Management System	70	25	
Students	3127	359	Students	66	16	
Teaching	2342	239	Education	64	15	
Education	2238	239	Management	60	14	
Management	1719	192	Learning Management Systems	49	15	
LMS	851	131	Teaching	44	11	
Learning	783	87	Interactive Learning Environments	33	6	
Distance Education	651	83	Distance Education	27	6	
Higher Education	530	89	Surveys	27	6	
Learning Management Systems	361	64	Artificial Intelligence	24	11	
Educational Technology	358	40	Learning	13	7	
Technology Acceptance Model	253	36	Knowledge Management Learning	12	7	
Online Learning Environment	150	15	LMS	9	6	

Table 4. Top 15 keywords of all and top 100 cited LMS research during 1991–2021

To find the novelty of previous research, the mapping of metadata keywords was suggested to be undertaken [52]–[55]. Therefore, it was essential to look at the relationships between minor keywords or fewer keywords.



Fig. 5. Mapping visualization of keywords co-occurrence on all LMS research (1991–2021)

Figure 5 shows visualizations of keyword co-occurrences in all LMS research over the past thirty years to find the novelty and interrelationships between studies. The mapping visualization showed eight main clusters as the focus of LMS research. The first cluster was indicated by a red node (n=185) consisting of 5G mobile communication, artificial intelligence, deep learning, and reinforcement learning. The second cluster was indicated by green nodes (n=93) consisting of communication systems, e-learning, educational process, laboratories, and web-based learning. The third cluster was indicated by blue nodes (n=87) comprising learning management systems, blended learning environments, computer self-efficacy, conceptual frameworks, higher learning institutions, and secondary schools.





Fig. 6. Some specific keywords of mapping visualization results in the keywords of a) LMS, b) e-learning, c) education, d) gamification, e) multimedia systems, and f) websites

Figures 6a–6c were the top trends in LMS research during 1991–2021, whereas Figures 6d–6f were the opposite. If future researchers wanted to explore LMS on the top trends, there was still a chance to explore LMS research because the top trends still had a wide range and various fields of terms. This was because LMS could improve and assist education in many aspects. Some examples of specific keyword mapping visualization results on LMS encompassed e-learning, education, gamification, multi-media systems, and websites.

Whereas for fewer trends such as Figures 6d–6f, these could be used as an alternative future research field, especially to investigate LMS on gamification, multimedia systems, and website focus. For instance, future researchers wanted to explore LMS in a websites field (see Figure 6f). In that case, they might focus on web services, computer-aided instruction, e-learning, teaching, education, management, and learning systems.

Therefore, there was still a chance for future research to develop the LMS research based on the mapping visualization of the keywords. As mentioned, there were still possible opportunities to conduct research in LMS to less-used keywords or make an improvement to greater-used keywords.

3.6 Mapping-trend visualization on top 100 cited

In accordance with Table 4, the keyword that had the most total link strength and often appeared was E-learning. There were some other keywords such as learning systems (n=25), LMS (n=25), students (n=16), education (n=15), management (n=14), teaching (n=11), and distance education (n=6). Thus, it could be concluded that these keywords greatly influenced LMS research. Future researchers could conduct research in those fields because they had impactful research and a high citation rate.



Fig. 7. Mapping visualization of keywords co-occurrence on all LMS research during 1991–2021 within the top 100 cited articles

Figure 7 shows visualizations of keyword co-occurrences on all LMS research over the past thirty years for the top 100 cited articles. Mapping visualization showed the existence of four clusters. First, the cluster of the red-coded line (n=7) focused on learning management systems, e-learning, education, LMS, knowledge management, and learning management systems. The second cluster of the green-coded line (n=7) was in the field of distance education, interactive learning environment, management, post-secondary education, students, surveys, and teaching. Third, the cluster of the blue-coded line (n=5) focused on artificial intelligence, energy management, energy management systems, information management, and learning systems. The last cluster of yellow-coded line (n=1) focused on the field of internet research.

3.7 Distribution top 100 cited publications

Table 5 shows the distribution of publications on LMS research over the past thirty years, with 100 cited publications. According to Table 5, 1992–1996, 1998–2000, 2004, and 2020 had no published documents. In 2010, it was the year with the most publications. Furthermore, the fewest citations were 1992–1996, 1998–2000, 2004, and 2020 because they did not have published documents, followed by 2019 with 49 citations. Meanwhile, the highest citation was in 2018 with 1052 citations.

Year	Paper	Cited	ACPP	ACPPY	Citable Years
1992	0	0	0.00	0.00	30
1993	0	0	0.00	0.00	29
1994	0	0	0.00	0.00	28
1995	0	0	0.00	0.00	27
1996	0	0	0.00	0.00	26
1997	2	220	110.00	4.40	25
1998	0	0	0.00	0.00	24
1999	0	0	0.00	0.00	23
2000	0	0	0.00	0.00	22
2001	2	111	55.50	2.64	21
2002	2	277	138.50	6.93	20
2003	3	364	121.33	6.39	19
2004	0	0	0.00	0.00	18
2005	2	325	162.50	9.56	17
2006	4	265	66.25	4.14	16
2007	5	489	97.80	6.52	15
2008	7	586	83.71	5.98	14
2009	7	913	130.43	10.03	13
2010	11*	706	64.18	5.35	12
2011	4	310	77.50	7.05	11
2012	6	722	120.33	12.03	10
2013	3	184	61.33	6.81	9
2014	8	571	71.38	8.92	8
2015	9	617	68.56	9.79	7
2016	9	764	84.89	14.15	6
2017	7	622	88.86	17.77	5
2018	6	1052*	175.33*	43.83	4
2019	2	94	47.00	15.67	3
2020	0	0	0.00	0.00	2
2021	1	49	49.00	49.00*	1
Total	100	9241	1874.38	246.96	-

 Table 5. Top 100 cited distribution publications

Notes: * = the highest number; ACPPY = Average Citation Per Paper Per Year; ACPP = Average Citation Per Paper.

3.8 Review of top 5 cited publications in LMS research

Table 6 reviews the top 5 publications cited as impactful studies on LMS research during 1991–2021. Each article was analyzed based on the citation, Scimago Journal and Country Rank (SJR) accessed on <u>www.scimagojr.com</u> [56]–[59], CiteScore accessed on <u>www.scopus.com</u> (per March 6, 2022), and findings and recommendations in the publication.

Author(s)	Citation	SIR	CiteScore and Percentile to Education	Findings	Recommendations
Wang, Qiyun; Woo, Huay Lit; Quek, Choon Lang; Yang, Y.; Liu, M. [60]	368	1.79 (Q1)	7.6 (98th)	Basically, students were happy with Facebook's offer because the basic functionality of LMS could be easily integrated into Facebook groups. However, there were certain restrictions on using Facebook groups as an LMS. Direct uploads in other file formats were not supported, and The discussion was not threaded. In addition, students did not feel safe and comfortable due to potential privacy breaches.	Future research should consider comparing the learning benefits of students when using Facebook as an LMS and when using a commercial LMS in an online-only learning environment. This gives us a better understanding of Facebook's potential. Still, it can also be an improbable temporary obstacle that the limits currently being considered can be overcome in the spirit of ongoing research efforts.
Coates, H.; James, R.; Baldwin, G. [61]	278	0.62 (Q2)	2.3 (70th)	It was a broad and critical review of the potential impact of these online systems on university education and learning. In particular, it describes the potential implications of LMS on classroom practice and students. Commitment to the nature of scientific research and the management of scientific knowledge.	We need to conduct future LMS in higher education in lively and wide-ranging education-oriented discussions and debates.
McGill, T. J.; Klobas, J. E. [62]	271	3.03 (Q1)	14.4 (99th)	The results of the research strongly supported the importance of task and technology compatibility. This influenced the perception of the direct and indirect impact on learning through the level of use. The suitability of tasks and technology had a substantial impact on the perceptual effects of LMS on the process of learning but had a weak impact on student performance-related outcomes. Contrary to expectations, shared social norms and supportive conditions did not affect the LMS performance.	This research should explore further the impact of task technology on the success of LMS. This research also makes an essential contribution by recognizing the role that student awareness and teacher beliefs play in the importance of using LMS for the success of LMS. When teachers question the value of LMS in the classroom, it can potentially unknowingly and adversely affect student performance.

Table 6. Review of top 5 cited publications in LMS research

Paper-Learning Management System (LMS) Research During 1991-2021: How Technology Affects...

(Continued)

		TUNIT	AM TO MOTION	an puoliculum in this issue of the	(n)	
Author(s)	Citation	SIR	CiteScore and Percentile to	Findings	Recommendations	
S; Teasley, S. D.	239	3.03 (Q1)	Duncation 14.4 (99th)	The perceived advantages of using LMS to support traditional learning were reported by students also faculty at major Midwestern universities in the United States. This research surveyed two years of research data that focused on specific platforms of LMS that emphasized either efficient interactive or communication teaching and learning practices. This research matched the sum of user log data appropriate to the survey items to determine if system usage matches the pattern of survey results.	Find out how specific teachers successfully attracted students in and out of the classroom using more interactive tools. Furthermore, future research was needed to help students and teachers to identify the most effective ways to use these technologies to improve education and the learning process, especially in higher education.	
S.; Kinshuk; . C. [64]	13%	1.45 (Q1)	7.2 (97th)	This research described an automated student modeling approach to identify their learning style based on the LMS-Felder Silverman-learning style model and the tools that implemented this approach and make it applicable to teachers. The proposed approach was to use the student's behavior during the learning style. By applying a simple rule-based mechanism, students' learning styles tend to be calculated based on the clues. The evaluation of the approach was suitable for identifying the students' learning style associated with FSLSM and demonstrating the functionality of the tool.	Development of the concept of dynamic automatic student modeling was needed. In addition, future research needed to plan to work on evaluating and improving the usability of DeLeo in the future to better support teachers.	A

Table 6. Review of top 5 cited publications in LMS research (Continued)

The review and analysis results in the top 5 cited publications presented in the Table 6 tended to examine the impact of LMS in education. The use of LMS could be integrated into the classroom from various levels of education. LMS was able to provide positive results in classroom learning. Implications of the review of the top 5 cited publications required more integration of better technology use and further research related to the attitudes of students and teachers in the use of LMS. These publications became fundamental for future research, so they had outstanding citations and impacted on LMS subjects' development. On March 6, 2022, most of the top 5 cited publications were listed in the rank journal Quartile 1 (Q1) with CiteScore of 7.2–14.4, of which they got a percentile of 97th–99th in the field of education. Journals with quartile rank 2 (Q2) had CiteScore 0.62 with a percentile of 70th in the field of education. This implied that publications with top 5 cited performance were publications with undoubted credibility since the publisher had a good reputation. Analysis of the SJR indicator assigned a different score to citations based on the importance of the citation source journal. Hence, citations from influential journals will be more valuable, and the journals receiving them will gain more fame [65].

4 Conclusions

This pioneering study is to review and analyze bibliometric top-cited publications on LMS research during 1991–2021 using the Scopus database and assisted by the VOSViewer application. This focus has become one of the research fields that has undergone significant development and improvement and technological development along with its contribution to education impact. This study has eight conclusions. First, conference paper becomes the most widely published type of document with English as the most widely spoken language. Moreover, the country with the most publications is the USA. Second, National Natural Science Foundation of China becomes top funding sponsors and the top affiliate that most often uses LMS keywords is Bina Nusantara University. The most prolific authors are Graf, S, then Kinshuk and Molinari, A.. Third, top cited author was Davis, F.D. and the subject areas that has been published the most is Computer Science and Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics. Fourth, the trends of LMS research in 1991–2021 were related to E-learning, implementation of learning activities and students' and teachers' cases, technology integration in learning, distance learning, technology education, online learning environment, and interactive learning environment. In the top 100 cited research, e-learning becomes the most widely used keyword, learning systems, and LMS. Hence, future researchers can research these subjects for they have an impactful study and high citation rate. Sixth, the years 1992–1996, 1998–2000, 2004, and 2020 had no published documents, while 2010 becomes the year with the most publications. The fewest citations are in 1992-1996, 1998-2000, 2004, and 2020 because there have been no published documents, and so does in 2019.

Meanwhile, the highest citation is in 2018. Seventh, the review and analysis results in the top 5 cited publications tend to examine the impact of LMS in education. The use of LMS can be integrated into the classroom from various levels of education. LMS is able to provide positive results in classroom learning. These publications become

fundamental for future research, so they have outstanding citations and an impact on LMS subjects' development. Eight, most of the top 5 cited publications are listed in the rank journal with Quartile 1 (Q1) level and CiteScore ranging from 70th, 97th to 99th in the field of education.

The implication of this study is to digest the information about LMS technology trends and their contribution to the education field. Furthermore, future researchers can develop or improve the LMS ideas research to contribute to increasing the education field. Moreover, future researchers are welcome to define a profile of the types of documents that can be given to further focus on the research path. The researchers can find the topics most relevant to Scopus' LMS and the authors who have had the most significant impact and identify the main research lines in each defined period. Therefore, it also helps to narrow down the following trends that can be developed in this field of research.

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May 9, 2022

Dear Dominik May, Ph.D. (Dr.-Ing.)

Thanks to editors and reviewers for having spent a great deal of time and care to provide positive recommendations for our articles. Researchers welcome all positive recommendations with pleasure because reviewer feedback has greatly helped improve the quality of our articles. Title: Learning Management System (LMS) Research During 1991-2021: Impact Technology to Education. Researchers have revised all feedback from the reviewer (attached). Our great hope is our article can be published in the International Journal of Emerging Technologies in Learning in 2022. Thank you very much.

Best Regards,

Binar Kurnia Prahani

Universitas Negeri Surabaya

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Comment 1

Reviewer: The method used by the author was adequate for the objectives of the paper. The topic is timely, and the authors organized the article to be easily comprehensible. The authors clearly stated the methods used in selecting the manuscripts reviewed under each section in an unbiased way.

Author: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles

> Comment 2

Reviewer: The most obvious shortcomings of the paper are errors in grammar, spelling, and duplication of words.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been re-checking the grammar, spelling and duplication words by the researchers.

Comment 3

Reviewer: The submission contains a number of grammatical errors, which reduces the overall readability of the work. Throughout the manuscript, there are spelling, grammatical, and punctuation errors. Before publication, I would recommend that the paper be thoroughly edited or proofread.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been re-checking the grammar, spelling and duplication words by the researchers.

> Comment 4

Reviewer: It is unclear what Authors[31] discovered during their analysis review and how this study adds to previous work. In essence, what distinguishes this work from previous LMS reviews? **Authors:** Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been stated by researchers on page 2.

> Comment 5

Reviewer: Furthermore, the narrowing of the search to 100 documents appears to introduce bias and requires further justification, especially given that the goal of a bibliometric review is to capture a broad scope of study.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been stated by researchers on page 3 to 4.

Comment 6

Reviewer: The paper mentioned a high level of publications as a conference paper and implied that they are highly reputable in comparison to other sources. The sources should be mentioned in the paper or this claim backed up with a reference.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been stated by researchers on page 4.

> Comment 7

Reviewer: The label for Figure 3 appears to be too long, and it is suggested that concise labels be used for all tables and figures.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been stated by researchers on page 5.

> Comment 8

Reviewer: Section 3.5 appears to make an important contribution; however, it is suggested that it be revised for clarity.

Authors: Thanks to the reviewer who has given a positive recommendation for our manuscript. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles. The results of the revisions have been stated by researchers on page 8 to 10.

Full Paper— Learning Management System (LMS) Research During 1991-2021: Impact Technology ...

Learning Management System (LMS) Research During 1991-2021: Impact Technology to Education

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Abstract- Learning Management System (LMS) has become a learning media tool that is quite widely used, so a study is needed to know the trend of LMS development. The objectives of this study are to analyze the types of documents, languages, contributing countries, top affiliates, sponsorship funding, top productive authors, research citations, subject areas, top source titles, trend mapping visualization, and top-cited 100 publications, also review some publications on LMS research over 1991-2021 using bibliometric analysis. The metadata gathered is by Scopus database and analyzed by VOSViewer within 2.689 documents. The bibliometric analysis results show LMS research has conference paper being the most widely published document type, and English is the most commonly used language. The country with the most publications is the United States of America. National Natural Science Foundation of China became the top funding sponsor. The top affiliate is Bina Nusantara University. The most productive authors are Graf, S. Top cited author achieved by Davis, F.D., and the top subject areas are Computer Science. Then, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics became the title of the top source. Trends of LMS research in 1991-2021 are: 1) related to E-learning; 2) implementation of learning activities and students and teachers; 3) integration of technology in learning; 4) distance learning; 5) Technology education; 6) Online learning environment; 7) Interactive learning environment.

Keywords-Bibliometric, Learning Management System, Education

1 Introduction

The learning implementation process has undergone many transformations and developments, especially in the management of learning systems. In this changing situation, skills, abilities, and propensities that are essential for 21st-century citizens to live, work, and function effectively have been identified [1]–[5]. Technology is an essential component of this school or university curriculum [6]–[9]. The learning management system (LMS) is a platform for the educational field within an institution, providing an integrated platform for publishing, collaborating, and sharing educational materials

among teachers, learners, and institution managers [10]. Adapting LMS in higher education or another level of education has become a significant concern for the implementation of digital learning [11], [12]. Practitioners and experts emphasize that portraying the role of the new LMS needs to be consistent with teaching and learning theories[13]. LMS is a software or application that assists in managing reporting, tracking, documentation and delivering educational courses or training programs [14].

As LMS has become a promising technical tool in today's education, the precursors to adopting and using these educational techniques need to be considered in terms of consumer behavior. More specifically, a study in Malaysia required consideration of acceptance and preparation when using LMS for distance learning due to a lack of learner control and communication [15], [16]. LMS enables the integration of various objects and services into the ecosystem. Especially in the education field, in sequence students training any time experience. The main advantage of LMS is advanced tracking features and communication for discussion. [17], [18].

Opportunities offered by using LMS in education include ease of organizing and conducting online courses, ability to complete online assessments, accessibility and availability of learning materials, ways to save time and money for students and faculty, and communication and interactivity [19]. In addition, the LMS challenges that students face when adopting these technologies have the following shortcomings: Lack of student self-discipline and the discrepancy between LMS and specific academic programs [20]–[23]. However, as LMS technology increases in different countries, environments, consumer styles, traditional or creative, there are no boundaries in LMS research [24].

Research publications on LMS Education tend to increase every year. A simple method that can be done is through the bibliometric to input on Scopus with the keyword "Learning Management System Education or LMS Education," find results in 2018 as many as 16 publications, while in 2021 as many as 27 publications. This shows that research on LMS in education is increasing year by year. Therefore, in order to develop and adequately support a research topic, efforts must be made to find and understand the situation and trends of the research topic [25], [26], especially in LMS Education. Bibliometric studies can provide a solid foundation and objectively for subject progress and relevant information on scientific publications [27]-[30]. Previous research [31] has conducted an analysis review on choosing the proper LMS education. The study findings provide readers with data to help them make their judgments when selecting an LMS platform depending on the demands of their school. This previous research uses a literature study to discuss the potential of LMS. Hence, to distinguish from previous research, this research is conducted using the bibliometric study to digest the information about LMS technology trends and their contribution to the education field.

This research will conduct a bibliometric analysis on LMS in 1991-2021 using metadata in the Scopus database and assisted by the VOSViewer mapping application. This research is expected to find out trends, patterns, novelty, and future education in the LMS in the Education field. Specifically, the objectives of this research are as follows:

a. To analyze the documents, language, and countries that contributed to LMS research during 1991-2021.

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- b. To analyze the top affiliates and sponsorship funding of LMS research during 1991-2021.
- c. To identify the top 10 most productive authors of the LMS research during 1991-2021.
- d. To analyze the research citations, subject areas, and top source titles on LMS research during 1991-2021.
- e. To identify the results of research trend mapping visualization on LMS research during 1991-2021.
- f. To identify the results of research trend mapping visualization in the top 100 cited publications in LMS research during 1991-2021.
- g. To analyze the distribution of top 100 cited publications in LMS research during 1991-2021.
- h. To explore the top 5 cited publications in LMS research in the Education field
- i. during 1991-2021.

2 Methods

This research is a bibliometric study using descriptive analysis. To analyze the publication data, this research needs to structured database [32]–[36] on the Scopus (www.scopus.com). Scopus is the most extensive database and has more than 77.8 million core records from various fields with various metadata and document types, either non-academic or academic fields [36]–[41]. Hence, Scopus was chosen as the database source for this research. The research stages are shown in **Figure 1**.



Fig. 1. Research stages

The data mining was collected on March 3, 2022. The results obtained are sorted by "citation count" from high citation to low citation count. Following stages, the data for the one hundred most cited articles were downloaded in .csv and .ris file format. These

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100 documents are shortened with the 'highest citation' criteria. Then uploaded those files into VOSViewer software to detail the transcript of the data and visualize the bibliometric mapping [42]–[46]. For the final stage, data are analyzed descriptively to answer the research objectives.

3 Results and Discussion

3.1 Types of Document, Language, and Countries That Contributed to LMS Research

Based on the final search results after filtering, there are 2,689 documents (LMS research for 1991-2021), consisting of the most types of data types are conference papers with a total of 1371 documents, articles with 1106 documents, book chapters with 134 documents, and other types of document types including reviews, editorials, erratum, books, notes, conference reviews as many as 78 documents. Thus, the distribution of documents will be broader and more widely used or read by many people as a reference source. Most researchers publish conference papers because they have a high-quality reputation compared to other sources. Also, it has a more significant and more accessible influence, as it is displayed at a conference to be seen by many experts from various fields [47]. For language, English is the most widely spoken language (2612), Spanish (32), German (20), Chinese (11), and Portuguese (7). It is because English is an international language that everyone can understand [48]–[51].



The metric search results show that 116 countries have contributed to LMS research during 1991-2021. Figure 2 shows the top 10 most countries that contributed to LMS

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research. The United States of America leads the productivity with 391 documents, followed by China with 191 documents, Malaysia with 146 documents, etc.

Based on **Figure 3** shows mapping countries by cluster. Six main clusters are cluster 1 consists of 18 countries: Austria, Bangladesh, Bosnia and Herzegovina, Brazil, Canada, Chile, Croatia, Ireland, Japan, Kenya, North Macedonia, Norway, Russian Federation, Serbia, Slovenia, South Korea, Taiwan and Vietnam which are connected by the red line. Then, cluster 2 consists of 16 countries: Finland, Ghana, Hong Kong, India, Indonesia, Iraq, Malaysia, Nigeria, Oman, Pakistan, Palestine, Philippines, South Africa, Thailand, Turkey, and the United Kingdom, connected by the green line.

Cluster 3 consists of 13 countries: Belgium, Colombia, Czech Republic, France, Iran, Italy, Mexico, Morocco, Romania, Slovakia, Spain, Tunisia, and the United States, connected by a blue thread. Cluster 4 consists of 12 countries: Australia, Bulgaria, China, Denmark, Egypt, Germany, Israel, Netherlands, Poland, Sweden, Switzerland, and Ukraine, connected yellow threads. Cluster 5 consists of 7 countries: Singapore, Jordan, Lebanon, Qatar, Kuwait, New Zealand, and Saudi Arabia, consisting of a purple line. Cluster 6 consists of 4 countries: Cyprus, Greece, Portugal, and United Arab Emirates, connected by aqua yarn. Collaboration between countries on LMS research has been relatively good, as evidenced by more than 70 countries.

3.2 Top Sponsorship Funding and Top Affiliation

Table 1 shows **the** top 5 sponsorship funding and top affiliation in LMS research within thirty years. Based on the top 5 funding sponsors, the most sponsorship funding is the National Natural Science Foundation of China with 28 documents, the National Science Foundation with 26 documents, the European Commission with 24 documents, the National Research Foundation of Korea with 21 documents, and the Japan Society for the Promotion of Science with 16 documents.

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Top Funding Sponsor		Top Affiliation		
Funding Sponsor	Total	Affiliation	Total	
National Natural Science Founda- tion of China	28	Bina Nusantara University	28	
National Science Foundation	26	Universiti Kebangsaan Malaysia	26	
European Commission	24	Athabasca University	23	
National Research Foundation of Korea	21	Universiti Putra Malaysia	20	
Japan Society For the Promotion of Science	16	Universidad Nasional de Edu- cacion a Distancia	18	

Table 1. The top 5 funding sponsors and affiliation with LMS research during 1991-2021

Meanwhile, the top 5 affiliations are Bina Nusantara University with 28 documents, Universiti Kebangsaan Malaysia with 26 documents, Athabasca University with 23 documents, Universiti Putra Malaysia with 20 documents, and Universidad Nasional de Educacion a Distancia with 18 documents. This shows that publications on LMS research are not focused on one country but are evenly spread from Asia to Europe.

3.3 The Top 10 Most Productive Authors

The metadata results on Scopus can show the author of the publication of LMS research in 1991-2021. **Table 2** shows the top 10 most productive authors of LMS research in 1991-2021.

Top 10 Authorship						
Author	Total	Author	Total			
Graf, S.	17	Chkouri, M.Y.	8			
Kinshuk	11	Colazzo, L.	8			
Molinari, A.	11	Outloud, M.	8			
Lonn, S.	9	Sahari, N.	8			
Castro, M.	8	Smith, S.	8			

Table 2. The top 10 most productive authors on LMS research during 1991-2021

According to **Table 2** Graf, S. is the most prolific author with 17 publications. The prolific authors in second and third place are Kinshuk and Molinari, A. with 11 publication documents each. Then, other authors have fewer than 10 publications. Research citations, subject areas, and top source titles.

3.4 Top Research Citations, Subject Areas, and Sources Titles

Table 3 shows the top 10 research citations, subject areas, and sources titles to LMS research during 1991-2021. Based on research citations, Wang Q., Woo H.L., Quek C.L., Yang Y., Liu M. is the author with the most citations, 369 citations.

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Ton Cited Auth	or	Ton Subject	Areas	Ton Sources Titles	
Author	Cited	Subject Areas	To- tal	Sources Titles	To- tal
Davis, F.D.	373	Computer Science	1617	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	90
Venkatesh, V.	318	Social Sci- ences	1001	ACM International Conference Pro- ceeding Series	55
Romero, C.	147	Engineering	760	Communications In Computer And Information Science	40
Ventura, S.	136	Mathematics	302	Journal of Physics Conference Series	35
Wang, Y.	133	Business, Management, and Account- ing	241	Advances In Intelligent Systems And Computing	34
Ajzen, I.	118	Decision Sci- ences	193	ASEE Annual Conference And Ex- position Conference Proceedings	26
Morris, M.G.	117	Energy	117	Coeur Workshop Proceedings	24
Mclean, E.R.	114	Physics and Astronomy	97	Turkish Online Journal of Distance Education	21
Hair, J.F.	109	Medicine	85	Education And Information Technol- ogies	20
Delone, W.H	108	Arts and Hu- manities	67	International Journal of Emerging Technologies In Learning	18

 Table 3. Top research citations, subject areas, and sources titles on LMS research during 1991-2021



Fig. 4. Top-cited authors mapping visualization on LMS research during 1991-2021

Figure 4 shows that some top-cited authors are interconnected with each other. In mapping visualization on LMS research during *1991-2021*, there are 7 clusters. Based on the top-cited author, Davis, F.D. is considered the author with the most citations on

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LMS research over the 1991-2021, namely 373 citations. Followed by Venkatesh, V. with 318 authorities and McGill T.J., Klobas J.E. with 147 citations. The seven main clusters: the first cluster with red nodes (n=173), the second cluster with green nodes (n=136), the third cluster with blue nodes (n=127), the fourth cluster with chartreuse nodes (n=12), the fifth cluster with purple nodes (n=3), the sixth cluster with turquoise nodes (n=2) and the seventh cluster with orange nodes (n=1). Davis, F.D. Are the most cited because of the highest number of citations and the link strength, but it belongs to the third cluster.

Based on subject areas, "Computer Science" with a total of 1617 publications, "Social Sciences" with 1001 publications, "Engineering" with 760 publications, and so on. Other subjects are Mathematics (n=302), Business, Management and Accounting (n=241), Decision Sciences (n=193), Energy (n=117), Physics and Astronomy (n=97), Medicine (n=85) and Arts and Humanities (n=67). As for the title of the top source, "Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics" is the main source in LMS research with a total of 90 publications. Followed by the "ACM International Conference Proceeding Series" with a total of 55 publications, "Communications in Computer and Information Science" with 40 publications, and so on.

3.5 Mapping-Trend Visualization to Fundamental Contribution

LMS is the main keyword in LMS research. The most occurrence keywords are analyzed before mapping out the visualization of LMS research trends over 1991-2021, as shown in **Table 4**. It can be seen that the highest total link strength and the most frequently occurring keywords are "Learning Management System," respectively 5171 and 721. At the same time, the second-order is "E-learning," with total link strength of 4903 and an occurrence of 609. Followed by E-learning, Learning Systems, Students, Teaching, Education, Management, LMS, Learning, Distance Education, etc.

Based on this pattern, it can be found that the trends of LMS research in 1991-2021 are: 1) related to E-learning; 2) implementation of teaching and learning activities for students and teachers; 3) technology integration in learning; 4) distance learning; 5) technology education; 6) Online learning environment; 7) Interactive learning environment.

All LMS research			Top 100 cited research		
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence
Learning Manage- ment System	5171	721	E-Learning	82	30
E-learning	4903	609	Learning Systems	73	25
Learning Systems	4570	554	Learning Manage- ment System	70	25
Students	3127	359	Students	66	16
Teaching	2342	239	Education	64	15
Education	2238	239	Management	60	14

Table 4. Top 15 keywords of all and top 100 cited LMS research during 1991-2021

All L	MS research		Top 100 cited research			
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence	
Management	1719	192	Learning Manage- ment Systems	49	15	
LMS	851	131	Teaching	44	11	
Learning	783	87	Interactive Learning Environments	33	6	
Distance Educa- tion	651	83	Distance Education	27	6	
Higher Education	530	89	Surveys	27	6	
Learning Manage- ment Systems	361	64	Artificial Intelligence	24	11	
Educational Tech- nology	358	40	Learning	13	7	
Technology Acceptance Model	253	36	Knowledge Manage- ment Learning	12	7	
Online Learning Environment	150	15	LMS	9	6	

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To find the novelty of previous research, the mapping of metadata keywords [52]–[55]. To find a novelty of the research based on the mapping results, look at the relationships between minor keywords or fewer keywords.



Fig. 5. Mapping visualization of keywords co-occurrence on all LMS research (1991-2021)

Figure 5 shows visualizations of keyword co-occurrences in all LMS research over the past thirty years to find novelty and interrelationships between studies. The mapping visualization shows eight main clusters as the focus of LMS research. The first cluster is indicated by a red node (n=185 items) consisting of 5G mobile communication, artificial intelligence, deep learning, reinforcement learning, etc. The second cluster is indicated by green nodes (n=93 items) consisting of communication systems, e-learning, educational process, laboratories, web-based learning, etc. The third cluster is indicated Full Paper— Learning Management System (LMS) Research During 1991-2021: Impact Technology ...

by blue nodes (n=87 items) consisting of learning management systems, blended learning environments, computer self-efficacy, conceptual frameworks, higher learning institutions, secondary schools, etc.



Fig. 6. Some specific keywords of mapping visualization results in the keyword of a) LMS, b) e-learning, c) education, d) gamification, e) multimedia systems, and f) websites

Figure 6a-6c is the top trend in LMS research during 1991-2021, whereas **Figure 6d-6f** is the opposite. If future researchers want to explore LMS on top trends, there is still any chance to explore more about LMS research because the top trends still have a wide range and various fields of terms. This is because LMS can improve and assist education in many aspects. Some examples of specific keyword mapping visualization results on LMS, e-learning, education, gamification, multimedia systems, and websites.

Whereas for fewer trends such as **Figure 6d-6f**, these can be used as an alternative future research field, especially to investigate LMS on gamification, multimedia systems, and website focus. For example, suppose future researchers want to explore LMS in a websites field (see **Figure 6f**). In that case, they can focus on web services, computer-aided instruction, e-learning, teaching, education, management, and learning systems.

Therefore, there is still any chance for future research to develop the LMS research based on the mapping visualization of the keywords. As mentioned, there are still possible opportunities to conduct research in LMS to less-used keywords or make an improvement to greater-used keywords. Full Paper— Learning Management System (LMS) Research During 1991-2021: Impact Technology

3.6 Mapping-Trend Visualization on Top 100 Cited

Still based on **Table 4** on the top 100 cited articles in LMS research over 1991-2021, slightly different, the keyword that has the most total link strength and often appears is E-learning. Differences, occurrence in keyword learning systems (n=25), LMS (n=25), students (n=16), education (n=15), management (n=14), teaching (n=11), distance education (n=6) and so on. So it can be concluded that these keywords greatly influence LMS research. Future researchers can conduct research in those fields because they have impactful research and a high citation rate.



Fig. 7. Mapping visualization of keywords co-occurrence on all LMS research during 1991-2021 within the top 100 cited

Figure 7 shows visualizations of keyword co-occurrences on all LMS research over the past thirty years for the top 100 cited. Mapping visualization shows the existence of four clusters, with the first cluster red coded (n = 7) focus on learning management systems, e-learning, education, LMS, knowledge management, and learning management systems, the second cluster green coded (n = 7) in the field of distance education, interactive learning environment, management, post-secondary education, students, surveys, and teaching, the third cluster blue code (n = 5) focus research in the field of artificial intelligence, energy management, energy management systems, information management, and learning systems, the last cluster of yellow coded (n = 1) focuses on the field of internet research.

3.7 Distribution Top 100 Cited Publications

Table 5 shows the distribution of publications on LMS research over the past thirty years, with 100 cited publications. According to Table 5, 1992-1996, 1998-2000, 2004, and 2020 had no published documents. And 2010 became the year with the most publications. Furthermore, the fewest citations were 1992-1996, 1998-2000, 2004, and
2020 because they did not have published documents, followed by 2019 (49 citations). Meanwhile, the highest citation was in 2018 (1052 citations).

Year	Paper	Cited	ACPP	ACPPY	Citable Years
1992	0	0	0.00	0.00	30
1993	0	0	0.00	0.00	29
1994	0	0	0.00	0.00	28
1995	0	0	0.00	0.00	27
1996	0	0	0.00	0.00	26
1997	2	220	110.00	4.40	25
1998	0	0	0.00	0.00	24
1999	0	0	0.00	0.00	23
2000	0	0	0.00	0.00	22
2001	2	111	55.50	2.64	21
2002	2	277	138.50	6.93	20
2003	3	364	121.33	6.39	19
2004	0	0	0.00	0.00	18
2005	2	325	162.50	9.56	17
2006	4	265	66.25	4.14	16
2007	5	489	97.80	6.52	15
2008	7	586	83.71	5.98	14
2009	7	913	130.43	10.03	13
2010	11*	706	64.18	5.35	12
2011	4	310	77.50	7.05	11
2012	6	722	120.33	12.03	10
2013	3	184	61.33	6.81	9
2014	8	571	71.38	8.92	8
2015	9	617	68.56	9.79	7
2016	9	764	84.89	14.15	6
2017	7	622	88.86	17.77	5
2018	6	1052*	175.33*	43.83	4
2019	2	94	47.00	15.67	3
2020	0	0	0.00	0.00	2
2021	1	49	49.00	49.00*	1
Total	100	9241	1874.38	246.96	-
Descrip	tion: *=the hi	ighest number; A	ACPPY= Avera	age Citation Per	Paper Per Year
		ACPP= Aver	age Citation Pe	er Paper	

Table 5. Top 100 cited distribution publications

3.8 Review of Top 5 Cited Publications in LMS Research

Table 6 reviews the top 5 publications cited as impactful studies on LMS research during 1991-2021. Each article was analyzed based on the citation, Scimago Journal and Country Rank (SJR) accessed on www.scimagojr.com [56]–[59], CiteScore accessed on www.scopus.com (per March 6, 2022), also findings and recommendations in the publication.

Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to	Findings	Recommendations
Wang, Qiyun; Woo, Huay Lit; Quek, Choon Lang; Yang, Y.; Liu, M. [60]	368	1.79 (Q1)	7.6 (98 th)	Basically, students were happy with Face- book's offer because the basic functionality of LMS can be easily integrated into Face- book groups. However, there are certain re- strictions on using Fa- cebook groups as an LMS. Direct uploads in other file formats were not supported, and The discussion was not threaded. In addition, students did not feel safe and comfortable due to potential privacy breaches.	Future research should consider com- paring the learning benefits of students when using Face- book as an LMS and when using a com- mercial LMS in an online-only learning environment. This gives us a better un- derstanding of Face- book's potential. Still, it can also be an improbable tempo- rary obstacle that the limits currently being considered can be overcome in the spirit of ongoing re- search efforts.
Coates, H.; James, R.; Bald- win, G. [61]	278	0.62 (Q2)	2.3 (70 th)	A broad and critical re- view of the potential impact of these online systems on university education and learning. In particular, it de- scribes the potential implications of LMS on classroom practice and students. Commitment to the nature of scien- tific research and the management of scien- tific knowledge.	We need to conduct future LMS in higher education in lively and wide-ranging ed- ucation-oriented dis- cussions and debates.
McGill, T. J.; Klobas, J. E.[62]	271	3.03 (Q1)	14.4 (99 th)	The results of the re- search strongly support the importance of task and technology com- patibility. This influ- enced the perception of the direct and indirect impact on learning through the level of use. The suitability of tasks and technology	Explore further the impact of task tech- nology on the suc- cess of LMS. This re- search also makes an essential contribu- tion by recognizing the role that student awareness and teacher beliefs play in the importance of using LMS for the

Table 6.	. Review	of top 5	cited	publications	in LMS	research
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A11-	Cita-		CiteScore and		
thor(s)	tion	SIR	Percentile to Education	Findings	Recommendations
				had a substantial im- pact on the perceptual effects of LMS on the process of learning but has a weak impact on student performance- related outcomes. Con- trary to expectations, shared social norms and supportive condi- tions did not affect the LMS performance.	success of LMS. When teachers ques- tion the value of LMS in the class- room, it can poten- tially unknowingly adversely affect stu- dent performance.
Lonn, S; Teasley, S. D.[63]	239	3.03 (Q1)	14.4 (99 th)	The perceived ad- vantages of using LMS to support traditional learning are reported by students also faculty at major Midwestern uni- versities in the United States. This research surveyed two years of research data that fo- cused on specific plat- forms of LMS that em- phasized either effi- cient interactive or communication teach- ing and learning prac- tices. This research matched the sum of user log data appropri- ate to the survey items to determine if system usage matches the pat- tern of survey results.	Find out how spe- cific teachers suc- cessfully attract stu- dents in and out of the classroom using more interactive tools. Furthermore, future research is needed to help stu- dents and teachers to identify the most ef- fective ways to use these technologies to improve education and the learning pro- cess, especially in higher education.
Graf, S.; Kinshuk; Liu, T. C.[64]	138	1.45 (Q1)	7.2 (97 th)	This research described an automated student modeling approach to identify their learning style based on the LMS-Felder Silver- man-learning style model and the tools that implement this ap- proach and make it ap- plicable to teachers. The proposed approach is to use the student's behavior during the	Development of the concept of dynamic automatic student modeling is needed. In addition, future re- search needs to plan to work on evaluat- ing and improving the usability of DeLeo in the future to better support teachers.

Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to Education	Findings	Recommendations
				learning process to col- lect clues about the learning style. By ap- plying a simple rule- based mechanism, stu- dents' learning styles tend to be calculated based on the clues. The evaluation of the ap- proach gave good re- sults showing that the approach is suitable for identifying the stu- dents' learning style as- sociated with FSLSM and demonstrating the functionality of the tool	

The review and analysis results in the top 5 cited publications in the **Table 6** tend to examine the impact of LMS in education: The use of LMS can be integrated into the classroom from various levels of education. LMS is felt to be able to provide positive results in classroom learning. Implications of the review of the top 5 cited publications require more integration of better technology use and further research related to the attitudes of students and teachers in the use of LMS. These publications become fundamental for future research, so they have outstanding citations and impact LMS subjects' development. Based on March 6, 2022, most of the top 5 cited publications are listed in the rank journal Quartile 1 (Q1) has CiteScore 7.2 – 14.4 with a percentile 97th - 99th in the field of education. Journals with quartile rank 2 (Q2) have CiteScore 0.62 with a percentile of 70th in the field of education. This shows that publications that become top 5 cited are publications with undoubted credibility. Because the publisher of the publication has a good reputation. Analysis of the SJR indicator assigns a different score to citations based on the importance of the citation source journal. Hence, citations from influential journals will be more valuable, and the journals receiving them will gain more fame [65].

4 Conclusions

This research is the first to review and analyze bibliometric top-cited publications on LMS research during 1991-2021 using the Scopus database and assisted by the VOSViewer application. This subject has become one of the research fields that has undergone significant development and improvement and technological development and its contribution to education impact. This research has eight conclusions: 1) Conference paper became the most widely published type of document, English became the

most widely spoken language significantly and The country with the most publications is the USA; 2) National Natural Science Foundation of China became top funding sponsors, the top affiliate that most often uses LMS keywords is Bina Nusantara University and the most prolific authors were Graf, S, then Kinshuk and Molinari, A.; 3) Top cited author achieved by Davis, F.D., the subject areas that has been published the most is Computer Science and Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics became the most source titles; 4) Trends of LMS research in the 1991-2021 are: related to E-learning, implementation of learning activities and students and teachers, integration of technology in learning, distance learning; technology education; online learning environment; interactive learning environment; 5) In the top 100 cited research, e-learning became the most widely used keyword, learning systems, and LMS. Hence, future researchers can research these subjects because they have an impactful study and high citation rate; 6) Years of 1992-1996, 1998-2000, 2004, and 2020 had no published documents, while 2010 became the year with the most publications. The fewest citations were 1992-1996, 1998-2000, 2004, and 2020 because they did not have published documents, followed by 2019.

Meanwhile, the highest citation was in 2018; 7) the review and analysis results in the top 5 cited publications tend to examine the impact of LMS in education: The use of LMS can be integrated into the classroom from various levels of education. LMS is felt to be able to provide positive results in classroom learning. These publications become fundamental for future research, so they have outstanding citations and impact on LMS subjects' development; 8) Most of the top 5 cited publications are listed in the rank journal Quartile 1 (Q1) with CiteScore ranging from 70th, 97th to 99th in the field of education.

The implication of this research tends to digest the information about LMS technology trends and their contribution to the education field. Furthermore, future researchers can develop or improve the LMS ideas research to contribute to increasing the education field. The type of research presented allows future researchers to define a profile of the types of documents that can be given to further focus on the research path. The researchers can find the topics most relevant to Scopus' LMS and the authors who have had the most significant impact and identify the main research lines of scientists in each defined period. Therefore, it also helps to narrow down the following trends that can be developed in this field of research.

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Learning Management System (LMS) Research During 1991-2021: Impact Technology to Education

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Abstract- Learning Management System (LMS) has become been a widelylearningused learning media tool that is quite widely used, so a study is needed required to know the trend of LMS-its development. The objectives of this present study are-aimed to analyze the types of documents, languages, contributing countries, top affiliates, sponsorship funding, top productive authors, research citations, subject areas, top source titles, trend mapping visualization, and top-cited 100 publications, also and review some publications on LMS research over-during 1991-2021 using bibliometric analysis. The metadata gathered-were obtained is by Scopus database and analyzed by VOSViewer within 2.689 documents. The bibliometric analysis results showed that LMS research has had conference papers being as the most widely published document type, and English is-was the most commonly used language. The country with the most publications is-was the United States of America. National Natural Science Foundation of China became the top funding sponsor. The top affiliate is was Bina Nusantara University. The most productive authors are-were Sabine Graf. Top cited author achieved by Fred D. Davis, and the top subject areas are-were Computer Science. Then, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence aAnd Lecture Notes In Bioinformatics became the title of the top source. Trends of LMS research in 1991-2021 arewere: 1) related to E-learning; 2) implementation of learning activities and student-s and teacher cases; 3) technology integration of technology in learning; 4) distance learning; 5) tFechnology education; 6) oonline learning environment; and 7) interactive learning environment.

Keywords—Bibliometric, <u>Education</u>, Learning Management System, <u>Educa-</u> tion

1 Introduction

The learning implementation process has undergone many transformations and developments, especially in the learning management of learning systems. In this changingwidely altered-situation, skills_ abilities, and propensities that are essential for the 21st century 21st century citizens to live, work, and function effectively, hence, they

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have been comprehensively identified [1]-[5]. Technology is an essential aspect of most school or university curriculum [6]-[9]. The learning management system (LMS) education platform is an providing an integrated objective for publishing, collaborating, and sharing educational materials among teachers, learners, and institution managers [10]. Adapting LMS in higher education or another level of education has been a significant concern for the implementation of the digital learning process [11], [12]. Practitioners and experts emphasize that portraying the role of the new LMS needs to be consistent with teaching and learning theories [13]. LMS is a software or application that assists teachers in managing reporting, tracking, documentation, and delivering educational courses or training programs [14].

As LMS has become a promising technical tool in recent education, the precursors to adopting and using these educational techniques need to be considered in terms of consumer behavior. More specifically, a study in Malaysia required consideration of acceptance and preparation when using LMS for distance learning due to a lack of learner control and communication [15], [16]. LMS enables the integration of various objects and services into the ecosystem, especially in the education field and sequent students' training experiences. The main advantage of LMS is advanced tracking features and communication for discussion. [17], [18].

Opportunities offered by using LMS include <u>the</u> ease of organizing and conducting online courses, ability to complete online assessments, accessibility and availability of learning materials, ways to save time and money for students and faculty, and communication and interactivity [19]. In addition, the LMS challenges that students face when adopting these technologies have the following shortcomings: Lack of <u>student</u> self-discipline and the discrepancy between LMS and specific academic programs [20]–[23]. However, as LMS technology increases in different countries, environments, consumer styles, traditional or creative, there are no boundaries in LMS research [24].

Research publications on LMS education tend to increase every year. A simple method that can be <u>undertaken</u> is through the bibliometric to input on Scopus with the keyword "Learning Management System Education or LMS Education,". <u>The findings</u> in 2018 resulted on 16 publications and 27 publications in 2021. This shows that research on LMS in education is increasing year by year. Therefore, in order to develop and adequately support a research topic, efforts must be made to find and understand the situation and trends of the research topic [25], [26], especially in LMS Education. Bibliometric studies can provide a solid foundation and objective for subject progress and relevant information on scientific publications [27]–[30]. Previous research [31] conducted an analysis review on choosing the proper LMS education. The study provided readers with data to help them make their judgments when selecting an LMS platform depending on thei<u>r school's</u> demands. This previous research used a literature study to discuss the potential of LMS. Hence, to distinguish from previous research, the <u>present study</u> is conducted using the bibliometric study to digest the information about LMS technology trends and their contribution to the education field.

This <u>study</u> conducted a bibliometric analysis on LMS in 1991-2021 using <u>the</u> metadata in the Scopus database and assisted by the VOSViewer mapping application. This <u>study was</u> expected to find out trends, patterns, novelty,

and future education in the LMS Education. Specifically, the objectives of this <u>study</u> are drawn as follows:

- a. To analyze the documents, languages, and countries that contributed to LMS research during 1991-2021
- b. To analyze the top affiliates and sponsorship funding of LMS research during 1991-2021
- c. To identify the top 10 most productive authors of the LMS research during 1991-2021
- d. To analyze the research citations, subject areas, and top source titles on LMS research during 1991-2021
- e. To identify the results of research trend mapping visualization on LMS research during 1991-2021
- f. To identify the results of research trend mapping visualization in the top 100 cited publications in LMS research during 1991-2021
- g. To analyze the distribution of top 100 cited publications in LMS research during 1991-2021
- h. To explore the top 5 cited publications in LMS research in the Education field
- i. during 1991-2021

2 Methods

This <u>study was</u> a bibliometric study using descriptive analysis. To analyze the publication data, this <u>study needed</u> to <u>structure</u> the database [32]–[36] on the Scopus (www.scopus.com). Scopus was the most extensive database and <u>had</u> more than 77.8 million core records from various fields with various metadata and document types, either non-academic or academic fields [36]–[41]. Hence, Scopus was chosen as the database source for this research. Figure 1 illustrates the research stages.



Figure 1. Research stages

The data <u>were</u> collected on March 3, 2022. The <u>obtained</u> results <u>were</u> sorted by "citation count" from high citation to low citation. <u>Afterwards</u>, the data for the one hundred most cited articles were downloaded in .csv and .ris file format. These 100 documents <u>were</u> shortened with the 'highest citation' criteria. Then, <u>it was suggested to</u> upload those files into VOSViewer software to detail the transcript of the data and visualize the bibliometric mapping [42]–[46]. For the final stage, <u>the</u> data <u>were</u> analyzed descriptively to answer the research objectives.

3 Results and Discussion

3.1 Types of Document, Language, and Countries That Contributed to LMS Research

the final search_ and filteration process there As were 2,689 documents (LMS research for 1991-2021) consisting of conference papers with a total of 1371 documents, articles with 1106 documents, book chapters with 134 documents, and other types of document types including reviews, editorials, erratum, books, notes, conference reviews as many as 78 documents. Thus, the distribution of documents was broader and more widely used by many people as a reference source. Most researchers published conference papers because they had a high-quality reputation compared to other sources. Moreover, it had a more significant and more accessible influence, as it was displayed at a conference to be seen by many experts from various fields [47]. In coping with the language use, English became the most widely used language (2612 documents) and it was followed by Spanish (32 documents), German (20 documents), Chinese (11 documents), and

Portuguese (7 <u>documents</u>). It <u>was due to the fact that</u> English <u>was</u> an international language that everyone <u>could</u> understand [48]–[51].



Figure 2. Top 10 contributed countries to LMS research during 1991-2021

The metric search results showed that 116 countries <u>had</u> contributed to LMS research during 1991-2021. **Figure 2** shows the top 10 countries that <u>significantly</u> contributed to LMS research. The United States of America <u>led</u> the productivity with 391 documents and it was followed by China with 191 documents and Malaysia with 146 documents in the top 3 countries.



Figure 3. Cluster countries mapping

Figure 3 shows mapping countries by cluster. <u>There were six main clusters found</u> the present study. <u>C</u>luster 1 consist<u>ed</u> of 18 countries <u>namely</u> Austria, Bangladesh, Bosnia and Herzegovina, Brazil, Canada, Chile, Croatia, Ireland, Japan, Kenya, North Macedonia, Norway, Russian Federation, Serbia, Slovenia, South Korea, Taiwan, and Vietnam <u>that were</u> connected by the red line. <u>Cluster 2 consisted</u> of 16 countries <u>covering</u> Finland, Ghana, Hong Kong, India, Indonesia, Iraq, Malaysia, Nigeria, Oman, Pakistan, Palestine, Philippines, South Africa, Thailand, Turkey, and the United Kingdom, <u>which were</u> connected by the green line.

Cluster 3 consisted of 13 countries <u>namely</u> Belgium, Colombia, Czech Republic, France, Iran, Italy, Mexico, Morocco, Romania, Slovakia, Spain, Tunisia, and the United States, <u>which were</u> connected by a blue thread. Cluster 4 consisted of 12 countries <u>namely</u> Australia, Bulgaria, China, Denmark, Egypt, Germany, Israel, Netherlands, Poland, Sweden, Switzerland, and Ukraine, <u>which were</u> connected <u>by the yellow</u> <u>line</u>. Cluster 5 consisted of 7 countries <u>covering</u> Singapore, Jordan, Lebanon, Qatar, Kuwait, New Zealand, and Saudi Arabia, <u>which were</u> connected <u>by the</u> purple line. <u>And, cluster 6 consisted of 4 countries <u>namely</u> Cyprus, Greece, Portugal, and United Arab Emirates, <u>which were</u> connected by aqua <u>line</u>. <u>The</u> collaboration between countries on LMS research <u>had</u> been relatively good, as more than 70 countries <u>involved</u>.</u>

3.2 Top Funding Sponsors and Top Affiliation

1

Table 1showsthetop5fundingsponsorsandtopaffiliationsin LMSresearchwithin thirtyyears.Inaccordancewiththetop5fundingsponsors, themost sponsorshipfundingwastheNaturalScienceFoundationof Chinawith 28documents, theNationalScienceFoundationwith 26documents, theEuropeanCommissionwith 24documents, theNationalResearchFoundation of Koreawith 21documents, and theJapanSociety for thePromotion of Sciencewith 16documents.

Table 1.	The top	5 funding s	ponsors and	affiliations	with LMS	research during	1991-2021

Top Funding Sponsor		Top Affiliations		
Funding Sponsor	Total	Affiliation	Total	
National Natural Science Founda- tion of China	28	Bina Nusantara University	28	
National Science Foundation	26	Universiti Kebangsaan Malaysia	26	
European Commission	24	Athabasca University	23	
National Research Foundation of Korea	21	Universiti Putra Malaysia	20	
Japan Society For the Promotion of Science	16	Universidad Nasional de Edu- cacion a Distancia	18	

MeanwhileIn addition, the top 5 affiliations are were Bina Nusantara University with 28 documents, Universiti Kebangsaan Malaysia with 26 documents, Athabasca Uni-

versity with 23 documents, Universiti Putra Malaysia with 20 documents, and Universidad Nasional de Educacion a Distancia with 18 documents. This <u>implied</u> that publications on LMS research <u>were not</u> focused on one country but <u>were evenly spread</u> from Asia to Europe.

3.3 The Top 10 Most Productive Authors

The metadata results on Scopus show<u>ed</u> the author of the publication of LMS research in 1991-2021. Table 2 <u>depicts</u> the top 10 most productive authors of LMS research in 1991-2021.

 Table 2. The top 10 most productive authors on LMS research during 1991-2021

Top 10 Authorship								
Author	Total	Author	Total					
Graf, S.	17	Chkouri, M.Y.	8					
Kinshuk	11	Colazzo, L.	8					
Molinari, A.	11	Outloud, M.	8					
Lonn, S.	9	Sahari, N.	8					
Castro, M.	8	Smith, S.	8					

According to Table 2, Graf, S. is-was the most prolific author with 17 publications, followed by- The prolific authors in second and third place are Kinshuk and Molinari, A. with 11 publication documents each. Then, other authors have had fewer than 10 publications. Research citations, subject areas, and top source titles.

3.4 Top Research Citations, Subject Areas, and Sources Titles

Table 3 shows the top 10 research citations, subject areas, and <u>sourcessource</u> titles to for LMS research during 1991-2021. Based on research citations, Wang Q., Woo H.L., Quek C.L., Yang Y., and Liu M. is were the author with the most citations <u>namely</u>, 369 citations.

 Table 3. Top research citations, subject areas, and sources titles on LMS research during

 1991-2021

Top Cited Autho	Top Cited Authors		Areas	Top Sources Titles	
Author Cited by		Subject Areas	To- tal	Sources Titles	To- tal
Davis, F.D.	373	Computer Science	1617	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	90
Venkatesh, V.	318	Social Sci- ences	1001	ACM International Conference Pro- ceeding Series	55
Romero, C.	147	Engineering	760	Communications In Computer And Information Science	40
Ventura, S.	136	Mathematics	302	Journal of Physics Conference Series	35

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Top Cited Auth	Top Cited Authors		Areas	Top Sources Titles	
Author	Cited by	Subject To- Areas tal		Sources Titles	To- tal
Wang, Y.	133	Business, Management, and Account- ing	241	Advances In Intelligent Systems And Computing	34
Ajzen, I.	118	Decision Sci- ences	193	ASEE Annual Conference And Ex- position Conference Proceedings	26
Morris, M.G.	117	Energy	117	Coeur Workshop Proceedings	24
Mclean, E.R.	114	Physics and Astronomy	97	Turkish Online Journal of Distance Education	21
Hair, J.F.	109	Medicine	85	Education And Information Technol- ogies	20
Delone, W.H	108	Arts and Hu- manities	67	International Journal of Emerging Technologies In Learning	18



Figure 4. Top-cited authors mapping visualization on LMS research during 1991-2021

Figure 4 shows that some top-cited authors are were interconnected with each other. In mapping visualization on LMS research during 1991-2021, tThere are were 7 clusters found in the top-cited authors. Based on the top-cited author, Davis, F.D. is-was considered the author with the most citations on LMS research over-from the-1991-2021, namely 373 citations. Followed He was followed by by Venkatesh, V. with 318 authorities-citations and McGill T.J., Klobas J.E. with 147 citations. The seven main clusters were indicated by several colored nodes: the first cluster with red nodes (n=173), the second cluster with green nodes (n=136), the third cluster with blue nodes (n=127), the fourth cluster with chartreuse nodes (n=2) and the seventh cluster with orange nodes (n=1). Davis, F.D. Are-was the most cited because of the highest number of citations and the link strength, but it belongeds to the third cluster.

Based on subject areas, <u>there were</u> "Computer Science" with a total of 1617 publications, "Social Sciences" with 1001 publications, "Engineering" with 760 publications. Other subjects <u>included</u> Mathematics (n=302), Business, Management and Accounting (n=241), Decision Sciences (n=193), Energy (n=117), Physics and Astronomy (n=97), Medicine (n=85), and Arts and Humanities (n=67). In coping with the title of the top source, "Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics" was the main source in LMS research with a total of 90 <u>citations</u>, followed by "ACM International Conference Proceeding Series" with a total of 55 publications.

3.5 Mapping-Trend Visualization to Fundamental Contribution

LMS was the main keyword in LMS research. The most occurrence keywords were analyzed before mapping out the visualization of LMS research trends during 1991-2021 (see Table 4). The highest total link strength and the most frequently occurring keywords were "Learning Management System," 5171 and 721 respectively. The second keyword was "E-learning," with total link strength of 4903 and an occurrence of 609_a then was followed by Learning Systems, Students, Teaching, Education, Management, LMS, Learning, and Distance Education.

Based on this pattern, the trends of LMS research in 1991-2021 were related to E-learning_implementation of teaching and learning activities for students and teachers_technology integration in learning_distance learning_technology education, online learning environment, and Interactive learning environment.

All L	MS research		Top 100 cited research			
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence	
Learning Manage- ment System	5171	721	E-Learning	82	30	
E-learning	4903	609	Learning Systems	73	25	
Learning Systems	4570	554	Learning Manage- ment System	70	25	
Students	3127	359	Students	66	16	
Teaching	2342	239	Education	64	15	
Education	2238	239	Management	60	14	
Management	1719	192	Learning Manage- ment Systems	49	15	
LMS	851	131	Teaching	44	11	
Learning	783	87	Interactive Learning Environments	33	6	
Distance Educa- tion	651	83	Distance Education	27	6	
Higher Education	530	89	Surveys	27	6	
Learning Manage- ment Systems	361	64	Artificial Intelligence	24	11	

Table 4. Top 15 keywords of all and top 100 cited LMS research during 1991-2021

All L	MS research		Top 100 cited research			
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence	
Educational Tech- nology	358	40	Learning	13	7	
Technology Acceptance Model	253	36	Knowledge Manage- ment Learning	12	7	
Online Learning Environment	150	15	LMS	9	6	

To find the novelty of previous research, the mapping of metadata keywords <u>was</u> suggested to be undertaken [52]–[55]. To find a novelty of the research based on the <u>mapping results</u>, <u>Therefore</u>, it was essential to look at the relationships between minor keywords or fewer keywords.



Figure 5. Mapping visualization of keywords co-occurrence on all LMS research (1991-2021)

Figure 5 shows visualizations of keyword co-occurrences in all LMS research over the past thirty years to find the novelty and interrelationships between studies. The mapping visualization showed eight main clusters as the focus of LMS research. The first cluster is was indicated by a red node (n=185-items) consisting of 5G mobile communication, artificial intelligence, deep learning, and reinforcement learning, etc. The second cluster is was indicated by green nodes (n=93-items) consisting of communication systems, e-learning, educational process, laboratories, and web-based learning, etc. The third cluster is was indicated by blue nodes (n=87-items) consisting of comprising learning management systems, blended learning environments, computer self-efficacy, conceptual frameworks, higher learning institutions, and secondary schools, etc. Formatted: Indent: First line: 0 cm



Figure 6. Some specific keywords of mapping visualization results in the keywords of a) LMS, b) e-learning, c) education, d) gamification, e) multimedia systems, and f) websites

Figures 6a-6c were the top trends in LMS research during 1991-2021, whereas **Figures 6d-6f** were the opposite. If future researchers wanted to explore LMS on the top trends, there was still a chance to explore LMS research because the top trends still had a wide range and various fields of terms. This was because LMS could improve and assist education in many aspects. Some examples of specific keyword mapping visualization results on LMS encompassed e-learning, education, gamification, multimedia systems, and websites.

Whereas for fewer trends such as **Figure 6d-6f**, these <u>could</u> be used as an alternative future research field, especially to investigate LMS on gamification, multimedia systems, and website focus. For <u>instance</u>, future researchers wanted to explore LMS in a websites field (see **Figure 6f**). In that case, they <u>might</u> focus on web services, computer-aided instruction, e-learning, teaching, education, management, and learning systems.

Therefore, there <u>was</u>_still <u>a</u>_chance for future research to develop the LMS research based on the mapping visualization of the keywords. As mentioned, there <u>were</u> still possible opportunities to conduct research in LMS to less-used keywords or make an improvement to greater-used keywords.

3.6 Mapping-Trend Visualization on Top 100 Cited

In accordance with **Table 4**, the keyword that <u>had</u> the most total link strength and often appeared was E-learning. There were some other keywords such as learning systems (n=25), LMS (n=25), students (n=16), education (n=15), management (n=14), teaching (n=11), and distance education (n=6). Thus, it <u>could</u> be concluded that these keywords greatly influenced LMS research. Future researchers <u>could</u> conduct research in those fields because they <u>had</u> impactful research and a high citation rate.



Figure 7. Mapping visualization of keywords co-occurrence on all LMS research during 1991-2021 within the top 100 cited<u>articles</u>

Figure 7 shows visualizations of keyword co-occurrences on all LMS research over the past thirty years for the top 100 cited <u>articles</u>. Mapping visualization showed the existence of four clusters. <u>First</u>, the cluster of the red_coded <u>line</u> (n = 7) focused on learning management systems, e-learning, education, LMS, knowledge management, and learning management systems. The second cluster of the green_coded <u>line</u> (n = 7) was in the field of distance education, interactive learning environment, management, post-secondary education, students, surveys, and teaching. <u>Third</u>, the cluster of the blue_coded line (n = 5) focused on artificial intelligence, energy management, energy management systems, information management, and learning systems. The last cluster of yellow_coded <u>line</u> (n = 1) focused on the field of internet research.

3.7 Distribution Top 100 Cited Publications

 Table 5 shows the distribution of publications on LMS research over the past thirty years, with 100 cited publications. According to Table 5, 1992-1996, 1998-2000, 2004, and 2020 had no published documents. In 2010, it was the year with the most publications. Furthermore, the fewest citations were 1992-1996, 1998-2000,

2004, and 2020 because they did not have published documents, followed by 2019 <u>with</u> 49 citations. Meanwhile, the highest citation was in 2018 <u>with</u> 1052 citations.

Year	Paper	Cited	ACPP	ACPPY	Citable Years
1992	0	0	0.00	0.00	30
1993	0	0	0.00	0.00	29
1994	0	0	0.00	0.00	28
1995	0	0	0.00	0.00	27
1996	0	0	0.00	0.00	26
1997	2	220	110.00	4.40	25
1998	0	0	0.00	0.00	24
1999	0	0	0.00	0.00	23
2000	0	0	0.00	0.00	22
2001	2	111	55.50	2.64	21
2002	2	277	138.50	6.93	20
2003	3	364	121.33	6.39	19
2004	0	0	0.00	0.00	18
2005	2	325	162.50	9.56	17
2006	4	265	66.25	4.14	16
2007	5	489	97.80	6.52	15
2008	7	586	83.71	5.98	14
2009	7	913	130.43	10.03	13
2010	11*	706	64.18	5.35	12
2011	4	310	77.50	7.05	11
2012	6	722	120.33	12.03	10
2013	3	184	61.33	6.81	9
2014	8	571	71.38	8.92	8
2015	9	617	68.56	9.79	7
2016	9	764	84.89	14.15	6
2017	7	622	88.86	17.77	5
2018	6	1052*	175.33*	43.83	4
2019	2	94	47.00	15.67	3
2020	0	0	0.00	0.00	2
2021	1	49	49.00	49.00*	1
Total	100	9241	1874.38	246.96	-
Descrip	otion: *=the hi	ghest number; A ACPP= Aver	ACPPY = Average Citation Pe	age Citation Per er Paper	Paper Per Year

Table 5. Top 100 cited distribution publications

3.8 Review of Top 5 Cited Publications in LMS Research

Table 6 reviews the top 5 publications cited as impactful studies on LMS research during 1991-2021. Each article was analyzed based on the citation, Scimago Journal and Country Rank (SJR) accessed on www.scimagojr.com [56]–[59], CiteScore accessed on www.scopus.com (per March 6, 2022), also-and findings and recommendations in the publication.

Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to Education	Findings	Recommendations
Wang, Qiyun; Woo, Huay Lit; Quek, Choon Lang; Yang, Y.; Liu, M. [60]	368	1.79 (Q1)	7.6 (98 th)	Basically, students were happy with Face- book's offer because the basic functionality of LMS <u>enn-could</u> be easily integrated into Facebook groups. However, there are were certain re- strictions on using Fa- cebook groups as an LMS. Direct uploads in other file formats were not supported, and The discussion was not threaded. In addition, students did not feel safe and comfortable due to potential privacy breaches.	Future research should consider com- paring the learning benefits of students when using Face- book as an LMS and when using a com- mercial LMS in an online-only learning environment. This gives us a better un- derstanding of Face- book's potential. Still, it can also be an improbable tempo- rary obstacle that the limits currently being considered can be overcome in the spirit of ongoing re- search efforts.
Coates, H.; James, R.; Bald- win, G. [61]	278	0.62 (Q2)	2.3 (70 th)	It was aA broad and critical review of the potential impact of these online systems on university education and learning. In partic- ular, it describes the po- tential implications of LMS on classroom practice and students. Commitment to the na- ture of scientific re- search and the manage- ment of scientific knowledge.	We need to conduct future LMS in higher education in lively and wide-ranging ed- ucation-oriented dis- cussions and debates.
McGill, T. J.; Klobas, J. E.[62]	271	3.03 (Q1)	14.4 (99 th)	The results of the re- search strongly sup- ported the importance of task and technology compatibility. This in- fluenced the perception of the direct and indi- rect impact on learning through the level of use. The suitability of tasks and technology	This research should <u>e</u> Explore further the impact of task tech- nology on the suc- cess of LMS. This re- search also makes an essential contribu- tion by recognizing the role that student awareness and teacher beliefs play

Table 6. Review of top 5 cited publications in LMS research

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Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to Education	Findings	Recommendations
				had a substantial im- pact on the perceptual effects of LMS on the process of learning but has-had a weak impact on student perfor- mance-related out- comes. Contrary to ex- pectations, shared so- cial norms and support- ive conditions did not affect the LMS perfor- mance.	in the importance of using LMS for the success of LMS. When teachers ques- tion the value of LMS in the class- room, it can poten- tially unknowingly and adversely affect student performance.
Lonn, S; Teasley, S. D.[63]	239	3.03 (Q1)	14.4 (99 th)	The perceived ad- vantages of using LMS to support traditional learning <u>are_were</u> re- ported by students also faculty at major Mid- western universities in the United States. This research surveyed two years of research data that focused on specific platforms of LMS that emphasized either effi- cient interactive or communication teach- ing and learning prac- tices. This research matched the sum of user log data appropri- ate to the survey items to determine if system usage matches the pat- tern of survey results.	Find out how specific teachers successfully attracted students in and out of the class- room using more in- teractive tools. Fur- thermore, future re- search is-was needed to help students and teachers to identify the most effective ways to use these technologies to im- prove education and the learning process, especially in higher education.
Graf, S.; Kinshuk; Liu, T. C.[64]	138	1.45 (Q1)	7.2 (97 th)	This research described an automated student modeling approach to identify their learning style based on the LMS-Felder Silver- man-learning style model and the tools that implemented this ap- proach and make it ap- plicable to teachers. The proposed approach	Development of the concept of dynamic automatic student modeling is was needed. In addition, future research need- eds to plan to work on evaluating and improving the usabil- ity of DeLeo in the future to better sup- port teachers.

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A 11-	Cito	SIR	CiteScore and		
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uior(s)	uon		Education		
				is-was to use the stu- dent's behavior during the learning process to collect clues about the learning style. By ap- plying a simple rule- based mechanism, stu- dents' learning styles tend to be calculated based on the clues. The evaluation of the ap- proach gave good re- sults showing that the approach is-was suita- ble for identifying the students' learning style associated with FSLSM and demon- strating the functional- ity of the tool.	

The review and analysis results in the top 5 cited publications presented in the Table 6 tended to examine the impact of LMS in education. The use of LMS can-could be integrated into the classroom from various levels of education. LMS is was felt to be able to provide positive results in classroom learning. Implications of the review of the top 5 cited publications required more integration of better technology use and further research related to the attitudes of students and teachers in the use of LMS. These publications becaome fundamental for future research, so they have had outstanding citations and impacted on LMS subjects' development. Based on On March 6, 2022, most of the top 5 cited publications are-were listed in the rank journal Quartile 1 (Q1) has with CiteScore of 7.2 – 14.4, of which they got with a percentile of $97_{A}^{th} - 99_{A}^{th}$ in the field of education. Journals with quartile rank 2 (Q2) have-had CiteScore 0.62 with a percentile of 70th in the field of education. This shows-implied that publications that become with top 5 cited performance are-were publications with undoubted credibility since. Because the publisher of the publication has had a good reputation. Analysis of the SJR indicator assigneds a different score to citations based on the importance of the citation source journal. Hence, citations from influential journals will be more valuable, and the journals receiving them will gain more fame [65].

4 Conclusions

This <u>pioneering research-study</u> is the first-to review and analyze bibliometric topcited publications on LMS research during 1991-2021 using the Scopus database and Formatted: Superscript
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assisted by the VOSViewer application. This focus has become one of the research fields that has undergone significant development and improvement and technological development along with its contribution to education impact. This study has eight conclusions. First, conference paper becomes the most widely published type of document with English as the most widely spoken language. Moreover, the country with the most publications is the USA. Second, National Natural Science Foundation of China becomes top funding sponsors and the top affiliate that most often uses LMS keywords is Bina Nusantara University. The most prolific authors are Graf, S, then Kinshuk and Molinari, A., Third, top cited author was Davis, F.D. and the subject areas that has been published the most is Computer Science and Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics. Fourth, the trends of LMS research in 1991-2021 were related to E-learning, implementation of learning activities and students' and teachers' cases, technology integration in learning, distance learning, technology education, online learning environment, and interactive learning environment. In the top 100 cited research, e-learning becomes the most widely used keyword, learning systems, and LMS. Hence, future researchers can research these subjects for they have an impactful study and high citation rate. Sixth, the years 1992-1996, 1998-2000, 2004, and 2020 had no published documents, while 2010 becomes the year with the most publications. The fewest citations are in 1992-1996, 1998-2000, 2004, and 2020 because there have been no published documents, and so does in 2019.

Meanwhile, the highest citation <u>is</u> in 2018. <u>Seventh</u> the review and analysis results in the top 5 cited publications tend to examine the impact of LMS in education. The use of LMS can be integrated into the classroom from various levels of education. LMS is able to provide positive results in classroom learning. These publications become fundamental for future research, so they have outstanding citations and <u>an</u> impact on LMS subjects' development. <u>Eight</u>, most of the top 5 cited publications are listed in the rank journal with Quartile 1 (Q1) <u>level and</u> CiteScore ranging from 70th, 97th to 99th in the field of education.

The implication of this <u>study is</u> to digest the information about LMS technology trends and their contribution to the education field. Furthermore, future researchers can develop or improve the LMS ideas research to contribute to increasing the education field. <u>Moreover</u>, future researchers <u>are welcome</u> to define a profile of the types of documents that can be given to further focus on the research path. The researchers can find the topics most relevant to Scopus' LMS and the authors who have had the most significant impact and identify the main research lines in each defined period. Therefore, it also helps to narrow down the following trends that can be developed in this field of research.

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Learning Management System (LMS) Research During 1991-2021: The Impact of Technology toon Education

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Abstract- Learning Management System (LMS) has become been a widelylearningused learning media tool that is quite widely used, so a study is needed required to know the trend of LMS its development. The objectives of this present study are aimed to analyze the types of documents, languages, contributing countries, top affiliates, sponsorship funding, top productive authors, research citations, subject areas, top source titles, trend mapping visualization, and top-cited 100 publications, also and review some publications on LMS research over-during 1991-2021 using bibliometric analysis. The metadata gathered-were obtained is by Scopus database and analyzed by VOSViewer within 2.689 documents. The bibliometric analysis results showed that LMS research has had conference papers being as the most widely published document type, and English is was the most commonly used language. The country with the most publications is-was the United States of America. National Natural Science Foundation of China became the top funding sponsor. The top affiliate is was Bina Nusantara University. The most productive authors are-were Graf, S. Top cited author achieved by Davis, F.D., and the top subject areas are-were Computer Science. Then, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence <u>a</u>And Lecture Notes In Bioinformatics became the title of the top source. Trends of LMS research in 1991-2021 arewere: 1) related to E-learning; 2) implementation of learning activities and student-s and teacher cases; 3) technology_integration of technology-in learning; 4) distance learning; 5) trechnology education; 6) OOnline learning environment; and 7) Interactive learning environment.

Keywords—Bibliometric, <u>Education</u>, Learning Management System, <u>Educa-</u> tion

1 Introduction

The learning implementation process has undergone many transformations and developments, especially in the learning management of learning systems. In this changingwidely altered-situation, skills_.abilities, and propensities that are essential for the 21st-century21st-century citizens to live, work, and function effectively, hence, they **Commented [MOU1]:** Suggestion: How Technology Affects Education

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have been comprehensively identified [1]-[5]. Technology is an essential aspect of most school or university curriculum [6]-[9]. The learning management system (LMS) is education platform an providing an integrated objective for publishing, collaborating, and sharing educational materials among teachers, learners, and institution managers [10]. Adapting LMS in higher education or another level of education has been a significant concern for the implementation of the digital learning process [11], [12]. Practitioners and experts emphasize that portraying the role of the new LMS needs to be consistent with teaching and learning theories [13]. LMS is a software or application that assists teachers in managing reporting, tracking, documentation, and delivering educational courses or training programs [14].

As LMS has become a promising technical tool in recent education, the precursors to adopting and using these educational techniques need to be considered in terms of consumer behavior. More specifically, a study in Malaysia required consideration of acceptance and preparation when using LMS for distance learning due to a lack of learner control and communication [15], [16]. LMS enables the integration of various objects and services into the ecosystem, especially in the education field and sequent students' training experiences. The main advantage of LMS is advanced tracking features and communication for discussion. [17], [18].

Opportunities offered by using LMS include <u>the</u> asse of organizing and conducting online courses, ability to complete online assessments, accessibility and availability of learning materials, ways to save time and money for students and faculty, and communication and interactivity [19]. In addition, the LMS challenges that students face when adopting these technologies have the following shortcomings: Lack of <u>student</u> self-discipline and the discrepancy between LMS and specific academic programs [20]–[23]. However, as LMS technology increases in different countries, environments, consumer styles, traditional or creative, there are no boundaries in LMS research [24].

Research publications on LMS education tend to increase every year. A simple method that can be <u>undertaken</u> is through the bibliometric to input on Scopus with the keyword "Learning Management System Education or LMS Education,". <u>The findings</u> in 2018 resulted on 16 publications and 27 publications in 2021. This shows that research on LMS in education is increasing year by year. Therefore, in order to develop and adequately support a research topic, efforts must be made to find and understand the situation and trends of the research topic [25], [26], especially in LMS Education. Bibliometric studies can provide a solid foundation and objective for subject progress and relevant information on scientific publications [27]–[30]. Previous research [31] conducted an analysis review on choosing the proper LMS education. The study provided readers with data to help them make their judgments when selecting an LMS platform depending on thei<u>r school's</u> demands. This previous research used a literature study to discuss the potential of LMS. Hence, to distinguish from previous research, the <u>present study</u> is conducted using the bibliometric study to digest the information about LMS technology trends and their contribution to the education field.

This <u>study</u> conducted a bibliometric analysis on LMS in 1991-2021 using <u>the</u> metadata in the Scopus database and assisted by the VOSViewer mapping application. This <u>study was</u> expected to find out trends, patterns, novelty,

and future education in the LMS Education. Specifically, the objectives of this <u>study</u> are drawn as follows:

- a. To analyze the documents, languages, and countries that contributed to LMS research during 1991-2021
- b. To analyze the top affiliates and sponsorship funding of LMS research during 1991-2021
- c. To identify the top 10 most productive authors of the LMS research during 1991-2021
- d. To analyze the research citations, subject areas, and top source titles on LMS research during 1991-2021
- To identify the results of research trend mapping visualization on LMS research during 1991-2021
- f. To identify the results of research trend mapping visualization in the top 100 cited publications in LMS research during 1991-2021
- g. To analyze the distribution of top 100 cited publications in LMS research during 1991-2021
- h. To explore the top 5 cited publications in LMS research in the Education field
- i. during 1991-2021

2 Methods

This <u>study was</u> a bibliometric study using descriptive analysis. To analyze the publication data, this <u>study</u> needed to <u>structure</u> the database [32]–[36] on the Scopus (www.scopus.com). Scopus was the most extensive database and <u>had</u> more than 77.8 million core records from various fields with various metadata and document types, either non-academic or academic fields [36]–[41]. Hence, Scopus was chosen as the database source for this research. Figure 1 illustrates the research stages.


Figure 1. Research stages

The data <u>were</u> collected on March 3, 2022. The <u>obtained</u> results <u>were</u> sorted by "citation count" from high citation to low citation. <u>Afterwards</u>, the data for the one hundred most cited articles were downloaded in .csv and .ris file format. These 100 documents <u>were</u> shortened with the 'highest citation' criteria. Then, <u>it was suggested to</u> upload those files into VOSViewer software to detail the transcript of the data and visualize the bibliometric mapping [42]–[46]. For the final stage, <u>the</u> data <u>were</u> analyzed descriptively to answer the research objectives.

3 Results and Discussion

3.1 Types of Document, Language, and Countries That Contributed to LMS Research

the final search_ and filteration process there As were 2,689 documents (LMS research for 1991-2021) consisting of conference papers with a total of 1371 documents, articles with 1106 documents, book chapters with 134 documents, and other types of document types including reviews, editorials, erratum, books, notes, conference reviews as many as 78 documents. Thus, the distribution of documents was broader and more widely used by many people as a reference source. Most researchers published conference papers because they had a high-quality reputation compared to other sources. Moreover, it had a more significant and more accessible influence, as it was displayed at a conference to be seen by many experts from various fields [47]. In coping with the language use, English became the most widely used language (2612 documents) and it was followed by Spanish (32 documents), German (20 documents), Chinese (11 documents), and

Portuguese (7 <u>documents</u>). It <u>was due to the fact that</u> English <u>was</u> an international language that everyone <u>could</u> understand [48]–[51].



Figure 2. Top 10 contributed countries to LMS research during 1991-2021

The metric search results show<u>ed</u> that 116 countries <u>had</u> contributed to LMS research during 1991-2021. **Figure 2** shows the top 10 countries that <u>significantly</u> contributed to LMS research. The United States of America <u>led</u> the productivity with 391 documents<u>and it was</u> followed by China with 191 documents<u>and</u> Malaysia with 146 documents<u>in the top 3 countries</u>.



Figure 3. Cluster countries mapping

Figure 3 shows mapping countries by cluster. <u>There were six main clusters found</u> the present study. <u>C</u>luster 1 consist<u>ed</u> of 18 countries <u>namely</u> Austria, Bangladesh, Bosnia and Herzegovina, Brazil, Canada, Chile, Croatia, Ireland, Japan, Kenya, North Macedonia, Norway, Russian Federation, Serbia, Slovenia, South Korea, Taiwan, and Vietnam <u>that were</u> connected by the red line. <u>Cluster 2 consisted</u> of 16 countries <u>covering</u> Finland, Ghana, Hong Kong, India, Indonesia, Iraq, Malaysia, Nigeria, Oman, Pakistan, Palestine, Philippines, South Africa, Thailand, Turkey, and the United Kingdom, <u>which</u> <u>were</u> connected by the green line.

Cluster 3 consisted of 13 countries <u>namely</u> Belgium, Colombia, Czech Republic, France, Iran, Italy, Mexico, Morocco, Romania, Slovakia, Spain, Tunisia, and the United States, <u>which were</u> connected by a blue thread. Cluster 4 consisted of 12 countries <u>namely</u> Australia, Bulgaria, China, Denmark, Egypt, Germany, Israel, Netherlands, Poland, Sweden, Switzerland, and Ukraine, <u>which were</u> connected <u>by the yellow</u> <u>line</u>. Cluster 5 consisted of 7 countries <u>covering</u> Singapore, Jordan, Lebanon, Qatar, Kuwait, New Zealand, and Saudi Arabia, <u>which were connected</u> <u>by the</u> purple line. <u>And, cluster 6 consisted of 4 countries <u>namely</u> Cyprus, Greece, Portugal, and United Arab Emirates, <u>which were connected by aqua line</u>. <u>The</u> <u>collaboration</u> between countries on LMS research <u>had</u> been relatively good, as more than 70 countries <u>involved</u>.</u>

3.2 Top <u>Funding</u> Sponsors and Top Affiliation

1

Table 1showsthetop5fundingsponsorsandtopaffiliationsin LMSresearchwithinthirtyyears.Inaccordancewiththetop5fundingsponsors, themost sponsorshipfundingwastheNationalNaturalScienceFoundationofChinawith 28documents, theNationalScienceFoundationwith 26documents, theEuropeanCommissionwith 24documents, theNationalResearchFoundationofKoreawith 21documents, and theJapanSocietyfor thePromotion ofSciencewith 16documents.

Table 1.	The top	5 funding spon	sors and affiliations	with LMS	research during	1991-2021

Top Funding Sponsors		Top Affiliations		
Funding Sponsor	Total	Affiliation	Total	
National Natural Science Founda- tion of China 28		Bina Nusantara University		
National Science Foundation	26	Universiti Kebangsaan Malaysia	26	
European Commission	24	Athabasca University	23	
National Research Foundation of Korea	21	Universiti Putra Malaysia	20	
Japan Society For the Promotion of Science	16	Universidad Nasional de Edu- cacion a Distancia	18	

MeanwhileIn addition, the top 5 affiliations are were Bina Nusantara University with 28 documents, Universiti Kebangsaan Malaysia with 26 documents, Athabasca Uni-

versity with 23 documents, Universiti Putra Malaysia with 20 documents, and Universidad Nasional de Educacion a Distancia with 18 documents. This <u>implied</u> that publications on LMS research <u>were</u> not focused on one country but <u>were</u> evenly spread from Asia to Europe.

3.3 The Top 10 Most Productive Authors

The metadata results on Scopus show<u>ed</u> the author of the publication of LMS research in 1991-2021. Table 2 <u>depicts</u> the top 10 most productive authors of LMS research in 1991-2021.

Table 2. The top 10 most productive authors on LMS research during 1991-2021

Top 10 Authorship						
Author	Total					
Graf, S.	17	Chkouri, M.Y.	8			
Kinshuk	11	Colazzo, L.	8			
Molinari, A.	11	Outloud, M.	8			
Lonn, S.	9	Sahari, N.	8			
Castro, M.	8	Smith, S.	8			

According to Table 2, Graf, S. is-was the most prolific author with 17 publications, followed by- The prolific authors in second and third place are Kinshuk and Molinari, A. with 11 publication documents each. Then, other authors have had fewer than 10 publications. Research citations, subject areas, and top source titles.

3.4 Top Research Citations, Subject Areas, and Sources Titles

Table 3 shows the top 10 research citations, subject areas, and <u>sourcessource</u> titles to <u>for</u> LMS research during 1991-2021. Based on research citations, Wang Q., Woo H.L., Quek C.L., Yang Y., <u>and Liu M. is were</u> the author with the most citations <u>namely</u>, 369 citations.

 Table 3. Top research citations, subject areas, and sources titles on LMS research during 1991-2021

Top Cited Autho	Top Subject Areas		Top Sources Titles		
Author Cited by		Subject Areas	To- tal Sources Titles		To- tal
Davis, F.D.	373	Computer Science	1617	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	90
Venkatesh, V.	318	Social Sci- ences	1001	ACM International Conference Pro- ceeding Series	55
Romero, C.	147	Engineering	760	Communications In Computer And Information Science	40
Ventura, S.	136	Mathematics	302	Journal of Physics Conference Series	35

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Top Cited Auth	Top Cited Authors		Areas	Top Sources Titles	
Author	Author Cited by		To- tal	Sources Titles	To- tal
Wang, Y.	133	Business, Management, and Account- ing	241	Advances In Intelligent Systems And Computing	34
Ajzen, I.	118	Decision Sci- ences	193	ASEE Annual Conference And Ex- position Conference Proceedings	26
Morris, M.G.	117	Energy	117	Coeur Workshop Proceedings	24
Mclean, E.R.	114	Physics and Astronomy	97	Turkish Online Journal of Distance Education	21
Hair, J.F.	109	Medicine	85	Education And Information Technol- ogies	20
Delone, W.H	108	Arts and Hu- manities	67	International Journal of Emerging Technologies In Learning	18



Figure 4. Top-cited authors mapping visualization on LMS research during 1991-2021

Figure 4 shows that some top-cited authors are were interconnected with each other. In mapping visualization on LMS research during 1991-2021, tThere are were 7 clusters found in the top-cited authors. Based on the top-cited author, Davis, F.D. is-was considered the author with the most citations on LMS research over from the 1991-2021, namely 373 citations. Followed He was followed by by Venkatesh, V. with 318 authorities-citations and McGill T.J., Klobas J.E. with 147 citations. The seven main clusters were indicated by several colored nodes: the first cluster with red nodes (n=173), the second cluster with green nodes (n=136), the third cluster with blue nodes (n=127), the fourth cluster with chartreuse nodes (n=2) and the seventh cluster with orange nodes (n=1). Davis, F.D. Are-was the most cited because of the highest number of citations and the link strength, but it belongeds to the third cluster.

Based on subject areas, <u>there were</u>."Computer Science" with a total of 1617 publications, "Social Sciences" with 1001 publications, "Engineering" with 760 publications. Other subjects <u>included</u> Mathematics (n=302), Business, Management and Accounting (n=241), Decision Sciences (n=193), Energy (n=117), Physics and Astronomy (n=97), Medicine (n=85), and Arts and Humanities (n=67). In coping with the title of the top source, "Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics" was the main source in LMS research with a total of 90 <u>citations</u>, followed by "ACM International Conference Proceeding Series" with a total of 55 publications.

3.5 Mapping-Trend Visualization to Fundamental Contribution

LMS was the main keyword in LMS research. The most occurrence keywords were analyzed before mapping out the visualization of LMS research trends during 1991-2021 (see Table 4). The highest total link strength and the most frequently occurring keywords were "Learning Management System," 5171 and 721 respectively. The second keyword was "E-learning," with total link strength of 4903 and an occurrence of 609, then was followed by Learning Systems, Students, Teaching, Education, Management, LMS, Learning, and Distance Education.

Based on this pattern, the trends of LMS research in 1991-2021 were related to E-learning_implementation of teaching and learning activities for students and teachers_technology integration in learning_distance learning_technology education, online learning environment.

All L	MS research		Top 100 cited research			
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence	
Learning Manage- ment System	5171	721	E-Learning	82	30	
E-learning	4903	609	Learning Systems	73	25	
Learning Systems	4570	554	Learning Manage- ment System	70	25	
Students	Students 3127 359 Students		Students	66	16	
Teaching	2342	239	Education	64	15	
Education	2238	239	Management	60	14	
Management	1719	192	Learning Manage- ment Systems	49	15	
LMS	851	131	Teaching	44	11	
Learning	783	87	Interactive Learning Environments	33	6	
Distance Educa- tion	Distance Educa- tion 651 83 Distance Education		Distance Education	27	6	
Higher Education	530	89	Surveys	27	6	
Learning Manage-	361	64	Artificial Intelligence	24	11	

Table 4. Top 15 keywords of all and top 100 cited LMS research during 1991-2021

All L	MS research		Top 100 cited research			
Keyword	Total Link Strength	Occur- rence	Keyword	Total Link Strength	Occur- rence	
Educational Tech- nology	358	40	Learning	13	7	
Technology Acceptance Model	253	36	Knowledge Manage- ment Learning	12	7	
Online Learning Environment	150	15	LMS	9	6	

To find the novelty of previous research, the mapping of metadata keywords <u>was</u> suggested to be undertaken [52]–[55]. To find a novelty of the research based on the <u>mapping results,Therefore, it was essential to</u> look at the relationships between minor keywords or fewer keywords.



Figure 5. Mapping visualization of keywords co-occurrence on all LMS research (1991-2021)

Figure 5 shows visualizations of keyword co-occurrences in all LMS research over the past thirty years to find the_novelty and interrelationships between studies. The mapping visualization showeds eight main clusters as the focus of LMS research. The first cluster is was indicated by a red node (n=185-items) consisting of 5G mobile communication, artificial intelligence, deep learning, and reinforcement learning, etc. The second cluster is was indicated by green nodes (n=93-items) consisting of communication systems, e-learning, educational process, laboratories, and web-based learning, etc. The third cluster is was indicated by blue nodes (n=87-items) consisting of comprising learning management systems, blended learning environments, computer self-efficacy, conceptual frameworks, higher learning institutions, and secondary schools, etc. Formatted: Indent: First line: 0 cm



Figure 6. Some specific keywords of mapping visualization results in the keywords of a) LMS, b) e-learning, c) education, d) gamification, e) multimedia systems, and f) websites

Figures 6a-6c were the top trends in LMS research during 1991-2021, whereas **Figures 6d-6f** were the opposite. If future researchers wanted to explore LMS on the top trends, there was still a chance to explore LMS research because the top trends still had a wide range and various fields of terms. This was because LMS could improve and assist education in many aspects. Some examples of specific keyword mapping visualization results on LMS encompassed e-learning, education, gamification, multimedia systems, and websites.

Whereas for fewer trends such as **Figure 6d-6f**, these <u>could</u> be used as an alternative future research field, especially to investigate LMS on gamification, multimedia systems, and website focus. For <u>instance</u>, future researchers wanted to explore LMS in a websites field (see **Figure 6f**). In that case, they <u>might</u> focus on web services, computer-aided instruction, e-learning, teaching, education, management, and learning systems.

Therefore, there <u>was</u> still <u>a</u> chance for future research to develop the LMS research based on the mapping visualization of the keywords. As mentioned, there <u>were</u> still possible opportunities to conduct research in LMS to less-used keywords or make an improvement to greater-used keywords.

3.6 Mapping-Trend Visualization on Top 100 Cited

In accordance with **Table 4**, the keyword that <u>had</u> the most total link strength and often appeared was E-learning. There were some other keywords such as learning systems (n=25), LMS (n=25), students (n=16), education (n=15), management (n=14), teaching (n=11), and distance education (n=6). Thus, it <u>could</u> be concluded that these keywords greatly influenced LMS research. Future researchers <u>could</u> conduct research in those fields because they <u>had</u> impactful research and a high citation rate.



Figure 7. Mapping visualization of keywords co-occurrence on all LMS research during 1991-2021 within the top 100 cited<u>articles</u>

Figure 7 shows visualizations of keyword co-occurrences on all LMS research over the past thirty years for the top 100 cited <u>articles</u>. Mapping visualization showed the existence of four clusters. <u>First</u>, the cluster of the red_coded <u>line</u> (n = 7) focused on learning management systems, e-learning, education, LMS, knowledge management, and learning management systems. The second cluster of the green_coded <u>line</u> (n = 7) was in the field of distance education, interactive learning environment, management, post-secondary education, students, surveys, and teaching. <u>Third</u>, the cluster of the blue_coded line (n = 5) focused on artificial intelligence, energy management, energy management systems, information management, and learning systems. The last cluster of yellow_coded <u>line</u> (n = 1) focused on the field of internet research.

3.7 Distribution Top 100 Cited Publications

 Table 5 shows the distribution of publications on LMS research over the past thirty years, with 100 cited publications. According to Table 5, 1992-1996, 1998-2000, 2004, and 2020 had no published documents. In 2010, it was the year with the most publications. Furthermore, the fewest citations were 1992-1996, 1998-2000,

2004, and 2020 because they did not have published documents, followed by 2019 <u>with</u> 49 citations. Meanwhile, the highest citation was in 2018 <u>with</u> 1052 citations.

Year	Paper	Cited	ACPP	ACPPY	Citable Years			
1992	0	0	0.00	0.00	30			
1993	0	0	0.00	0.00	29			
1994	0	0	0.00	0.00	28			
1995	0	0	0.00	0.00	27			
1996	0	0	0.00	0.00	26			
1997	2	220	110.00	4.40	25			
1998	0	0	0.00	0.00	24			
1999	0	0	0.00	0.00	23			
2000	0	0	0.00	0.00	22			
2001	2	111	55.50	2.64	21			
2002	2	277	138.50	6.93	20			
2003	3	364	121.33	6.39	19			
2004	0	0	0.00	0.00	18			
2005	2	325	162.50	9.56	17			
2006	4	265	66.25	4.14	16			
2007	5	489	97.80	6.52	15			
2008	7	586	83.71	5.98	14			
2009	7	913	130.43	10.03	13			
2010	11*	706	64.18	5.35	12			
2011	4	310	77.50	7.05	11			
2012	6	722	120.33	12.03	10			
2013	3	184	61.33	6.81	9			
2014	8	571	71.38	8.92	8			
2015	9	617	68.56	9.79	7			
2016	9	764	84.89	14.15	6			
2017	7	622	88.86	17.77	5			
2018	6	1052*	175.33*	43.83	4			
2019	2	94	47.00	15.67	3			
2020	0	0	0.00	0.00	2			
2021	1	49	49.00	49.00*	1			
Total	100	9241	1874.38	246.96	-			
Descrip	Description: *=the highest number; ACPPY= Average Citation Per Paper Per Year ACPP= Average Citation Per Paper							

Table 5. Top 100 cited distribution publications

3.8 Review of Top 5 Cited Publications in LMS Research

Table 6 reviews the top 5 publications cited as impactful studies on LMS research during 1991-2021. Each article was analyzed based on the citation, Scimago Journal and Country Rank (SJR) accessed on www.scimagojr.com [56]–[59], CiteScore accessed on www.scopus.com (per March 6, 2022), <u>also-and</u> findings and recommendations in the publication.

Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to Education	Findings	Recommendations
Wang, Qiyun; Woo, Huay Lit; Quek, Choon Lang; Yang, Y.; Liu, M. [60]	368	1.79 (Q1)	7.6 (98 th)	Basically, students were happy with Face- book's offer because the basic functionality of LMS enn-could be easily integrated into Facebook groups. However, there are were certain re- strictions on using Fa- cebook groups as an LMS. Direct uploads in other file formats were not supported, and The discussion was not threaded. In addition, students did not feel safe and comfortable due to potential privacy breaches.	Future research should consider com- paring the learning benefits of students when using Face- book as an LMS and when using a com- mercial LMS in an online-only learning environment. This gives us a better un- derstanding of Face- book's potential. Still, it can also be an improbable tempo- rary obstacle that the limits currently being considered can be overcome in the spirit of ongoing re- search efforts.
Coates, H.; James, R.; Bald- win, G. [61]	278	0.62 (Q2)	2.3 (70 th)	It was aA broad and critical review of the potential impact of these online systems on university education and learning. In partic- ular, it describes the po- tential implications of LMS on classroom practice and students. Commitment to the na- ture of scientific re- search and the manage- ment of scientific knowledge.	We need to conduct future LMS in higher education in lively and wide-ranging ed- ucation-oriented dis- cussions and debates.
McGill, T. J.; Klobas, J. E.[62]	271	3.03 (Q1)	14.4 (99 th)	The results of the re- search strongly sup- ported the importance of task and technology compatibility. This in- fluenced the perception of the direct and indi- rect impact on learning through the level of use. The suitability of tasks and technology	This research should <u>e</u> Explore further the impact of task tech- nology on the suc- cess of LMS. This re- search also makes an essential contribu- tion by recognizing the role that student awareness and teacher beliefs play

Table 6. Review of top 5 cited publications in LMS research

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Au- thor(s)	Cita- tion	SIR	CiteScore and Percentile to Education	Findings	Recommendations
				had a substantial im- pact on the perceptual effects of LMS on the process of learning but has-had a weak impact on student perfor- mance-related out- comes. Contrary to ex- pectations, shared so- cial norms and support- ive conditions did not affect the LMS perfor- mance.	in the importance of using LMS for the success of LMS. When teachers ques- tion the value of LMS in the class- room, it can poten- tially unknowingly and adversely affect student performance.
Lonn, S; Teasley, S. D.[63]	239	3.03 (Q1)	14.4 (99 th)	The perceived ad- vantages of using LMS to support traditional learning are were re- ported by students also faculty at major Mid- western universities in the United States. This research surveyed two years of research data that focused on specific platforms of LMS that emphasized either effi- cient interactive or communication teach- ing and learning prac- tices. This research matched the sum of user log data appropri- ate to the survey items to determine if system usage matches the pat- tern of survey results.	Find out how specific teachers successfully attracted students in and out of the class- room using more in- teractive tools. Fur- thermore, future re- search is-was needed to help students and teachers to identify the most effective ways to use these technologies to im- prove education and the learning process, especially in higher education.
Graf, S.; Kinshuk; Liu, T. C.[64]	138	1.45 (Q1)	7.2 (97 th)	This research described an automated student modeling approach to identify their learning style based on the LMS-Felder Silver- man-learning style model and the tools that implemented this ap- proach and make it ap- plicable to teachers. The proposed approach	Development of the concept of dynamic automatic student modeling is was needed. In addition, future research need- eds to plan to work on evaluating and improving the usabil- ity of DeLeo in the future to better sup- port teachers.

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Au-	Cita-		CiteScore and		
thor(s)	tion	SIR	Percentile to	Findings	Recommendations
Au- thor(s)	Citation	SIR	Percentile to Education	Findings is-was_to use the stu- dent's behavior during the learning process to collect clues about the learning style. By ap- plying a simple rule- based mechanism, stu- dents' learning styles tend to be calculated based on the clues. The evaluation of the ap- proach gave good re- sults showing that the approach is-was_suita- ble for identifying the students' learning style associated with FSLSM and demon- strating the functional-	Recommendations

The review and analysis results in the top 5 cited publications presented in the Table 6 tended to examine the impact of LMS in education... The use of LMS can could be integrated into the classroom from various levels of education. LMS is was felt to be able to provide positive results in classroom learning. Implications of the review of the top 5 cited publications required more integration of better technology use and further research related to the attitudes of students and teachers in the use of LMS. These publications becaome fundamental for future research, so they have had outstanding citations and impacted on LMS subjects' development. Based on On March 6, 2022, most of the top 5 cited publications are-were listed in the rank journal Quartile 1 (Q1) has with CiteScore of 7.2 – 14.4, of which they got with a percentile of $97_{A}^{th} - 99_{A}^{th}$ in the field of education. Journals with quartile rank 2 (Q2) have had CiteScore 0.62 with a percentile of 70th in the field of education. This shows-implied that publications that become with top 5 cited performance are were publications with undoubted credibility since. Because the publisher of the publication has had a good reputation. Analysis of the SJR indicator assigneds a different score to citations based on the importance of the citation source journal. Hence, citations from influential journals will be more valuable, and the journals receiving them will gain more fame [65].

4 Conclusions

This <u>pioneering research-study</u> is the first to review and analyze bibliometric topcited publications on LMS research during 1991-2021 using the Scopus database and Formatted: Superscript
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assisted by the VOSViewer application. This focus has become one of the research fields that has undergone significant development and improvement and technological development along with its contribution to education impact. This study has eight conclusions. First, conference paper becomes the most widely published type of document with English as the most widely spoken language. Moreover, the country with the most publications is the USA. Second, National Natural Science Foundation of China becomes top funding sponsors and the top affiliate that most often uses LMS keywords is Bina Nusantara University. The most prolific authors are Graf, S, then Kinshuk and Molinari, A., Third, top cited author was Davis, F.D. and the subject areas that has been published the most is Computer Science and Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics. Fourth, the trends of LMS research in 1991-2021 were related to E-learning, implementation of learning activities and students' and teachers' cases, technology integration in learning, distance learning, technology education, online learning environment, and interactive learning environment. In the top 100 cited research, e-learning becomes the most widely used keyword, learning systems, and LMS. Hence, future researchers can research these subjects for they have an impactful study and high citation rate. Sixth, the years 1992-1996, 1998-2000, 2004, and 2020 had no published documents, while 2010 becomes the year with the most publications. The fewest citations are in 1992-1996, 1998-2000, 2004, and 2020 because there have been no published documents, and so does in 2019.

Meanwhile, the highest citation is in 2018. Seventh, the review and analysis results in the top 5 cited publications tend to examine the impact of LMS in education. The use of LMS can be integrated into the classroom from various levels of education. LMS is able to provide positive results in classroom learning. These publications become fundamental for future research, so they have outstanding citations and an impact on LMS subjects' development. Eight, most of the top 5 cited publications are listed in the rank journal with Quartile 1 (Q1) level and CiteScore ranging from 70th, 97th to 99th in the field of education.

The implication of this <u>study is</u> to digest the information about LMS technology trends and their contribution to the education field. Furthermore, future researchers can develop or improve the LMS ideas research to contribute to increasing the education field. <u>Moreover</u>, future researchers <u>are welcome</u> to define a profile of the types of documents that can be given to further focus on the research path. The researchers can find the topics most relevant to Scopus' LMS and the authors who have had the most significant impact and identify the main research lines in each defined period. Therefore, it also helps to narrow down the following trends that can be developed in this field of research.

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