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Mapping Scientific Research on Hypermedia Learning Technology Using Scopus Database: A Bibliometric Approach

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Several of the impactful strategies for improving learning are through use of hypermedia. The use of hypermedia in research publications is projected to grow to continue increasing. This growth is also observed in the various fields of research. This research offers a bibliometric analysis of 1,224 articles on the use of hypermedia in learning, published in 443 scholarly outlets, written by 2,584 authors (240 single-authored documents and 2,344 multi-authored documents). The objective of this research is to identify the trending topic in hypermedia learning. We collected bibliographic data from the Scopus database and analyzed it using the Bibliometrix tool in R software and VOSviewer. Based on citation analysis metrics, we have defined the most influential articles, journals, authors, countries, and affiliations. Although keywords and terms are possibly the most relevant topics and results of the research, it is feasible that several of the significant trends and issues that have been discussed in the full text are insufficient from our study. Further, future research should analyze relevant research clusters for emerging trends on hypermedia learning.

Keywords: Hypermedia systems, hypermedia learning, bibliometric analysis, literature review, instructional media

INTRODUCTION

Hypermedia explains the hypertext version by highlighting multimedia elements. Hypermedia can also be interpreted as a combination of hypertext and multimedia terms (Conradty & Bogner, 2016). Hypermedia learning systems have been used for education. The use of hypermedia in learning has increased rapidly, and projections show that its use will increase in the coming years. This condition occurs because the hypermedia framework allows learners to quickly and constructively access a lot of knowledge

(Müller & Seufert, 2018; Rosa-Jimenez et al., 2018). The use of hypermedia to facilitate learning offers numerous advantages, both at the young learners (Wang & Yang, 2016) and higher education level (Hamdan et al., 2017; Sáiz-Manzanares et al., 2019). On the other hand, hypermedia learning systems allow students to organize their learning processes without any support from a teacher or another person (Çebi & Güyer, 2019).

A wide range of research have taken place, in an effort to examine hypermedia in learning. However, as of now there is very few research on hypermedia learning, particularly analyzing literature reviews. For the first time, a literature review or multimedia bibliometric analysis was performed by J. Li et al. (2019). The research has limitations; namely, the scope of the review was limited to the English-language multimedia learning articles provided by the Web of Science (WoS) database and indexed by the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI). The database used in these studies was research conducted in the last two decades (1996-2016).

In comparison to previous research, we used general keywords, i.e., hypermedia learning, in this research. We perform citation analysis metrics to determine the most influential articles, journals, authors, countries, and affiliations. This research is structured as follows: Section 2 outlines the data collection process and the methods used in this article. The findings of a systematic bibliometric analysis are summarized in section 3. The final section of the article continues by highlighting the conclusions. This research's main objective is better to explain the quantitative and visual aspects of current literature and obtain useful results for the improvement of hypermedia learning research and trend topics in research. This research analyzed a comprehensive analysis of bibliometric analysis and knowledge mapping provided by Scopus database, Biblioshiny, and VOSviewer applications.

METHODS

We have obtained bibliometric information from Scopus, one of the most commonly used databases for this analysis. Scopus is an article and citation repository for peer research findings, which is also part of SciVerse established by Elsevier (Tober, 2011). The bibliometric method used in this analysis uses current technology in information engineering, database management, and statistics. The bibliometric approach would classify potential technical trends or research orientations utilizing the author's keywords, title keywords, and keywords plus (Chen et al., 2016). In collaboration with VOSviewer, the bibliometric method is used for the empiric and visual study of hypermedia learning research from 1988 to 2020. Bibliometric or Scientometric analysis is a research topic that focuses on understanding recent trends. It offers guidance and inspiration for future research activities (Muhuri et al., 2019). The scientific domain is the study of science,

technology, and innovation from a quantitative perspective. Scientometric outlook applies a quantitative emphasis on text and communication to interdisciplinary science and technology (Leydesdorff & Milojević, 2015). Bibliometric includes several descriptive statistics of citation data and network analysis of authors, journals, universities, countries, and keywords based on citations and frequency analysis techniques. It supports identifying research clusters, provides insights into current research interests, and reveals trends for emerging topics in a field (Munim et al., 2020).

Data Sources and Search Strategy

We used a four-step process, beginning with (1) data collection by systematic literature search, detailed field evaluation by (2) bibliometric citation analysis, and (3) network analysis focused on identifying publication patterns, the most impactful journals, studies, affiliations, countries, and authors, as well as partnerships and relationships. The final phase (4) summarizes the results and explores the enormous research potential. Our analysis's foundation is the selection of bibliography data from the most highly regarded research database—Scopus. Research papers containing hypermedia and learning in the title, abstract, and keywords. The earliest publication dates from 1988, and the most recent publication dates from 2020. The query string used for the search was: (TITLE-ABS-KEY ("hypermedia") AND TITLE-ABS-KEY ("learning")) AND (LIMIT-TO (SRCTYPE, "j")). The output of this query string was 1,224 documents. The extracted bibliography data contains author, title, abstract, source, cited references, times cited, documents type, keywords, and conference information for each of the 1,224 articles. Table 1 provides the information on 1,224 articles published between 1988 and 2020 collected from the Scopus database.

Table 1
Main information.

Main Information	Description	Result
Documents	Total number of documents	1,224
Sources	The frequency distribution of sources as journals	443
Author's keywords (DE)	Total number of keywords	1,981
Keywords plus (ID)	Total number of phrases that frequently appear in the title of an article's references	2,814
Period	Years of publication	1988-2020
Authors	Total number of authors	2,584
Authors appearances	The authors' frequency distribution	3,275
Authors of single-authored documents	The number of single authors per articles	240
Authors of multi-authored documents	The number of authors of multi-authored articles	2,344

Main Information	Description	Result
Authors per document	The average number of authors in each document	2.11
Co-authors per Documents	The average number of co-authors in each document	2.68
Average citations per documents	The average number of citations in each article	26.11
Collaboration index		2.46

Bibliometric Maps

Information on citations, bibliography, and author keywords of 1,224 documents was exported to Biblioshiny for Bibliometrix and VOSviewer software. Biblioshiny is bibliometrix for no coders. It is powered by Bibliometrix and is its web-based graphical interface. Although Bibliometrix will be described below, it was programmed in the R language to facilitate the interconnection with other R packages. It was developed by Massimo Aria and Corrado Cuccurullo from the University of Naples and the University of Campania's Luigi Vanvitelli (Italy) (Moral-Muñoz et al., 2020).

The VOSviewer software has developed a co-occurring keyword network for hypermedia learning. This tool is used to extract data, maps, and group articles. The circle's size is positively associated with the presence of the keywords in the title and abstract. Consequently, the size of the product label and the circle are determined by the object's weight. The larger the object's weight, the larger the mark and the circle of the item (Xie et al., 2020). The distance between the two nodes represents the power of the two nodes. In general, shorter distances imply a better relationship. The line between the two keywords shows that they appear together (Liao et al., 2018). The binding force between the two nodes refers to the frequency of co-occurrence. The relationship between the two nodes can be seen as a quantitative index (Pinto et al., 2014).

In the case of a co-authorship study, the strength of the relationship between countries indicates the number of publications co-authored by two affiliated countries. In contrast, the relationship's combined strength indicates the total strength of the country's co-authorship links with other countries. Similarly, in the case of a co-occurrence analysis, the strength of the connection between the author keywords describes the number of articles in which two keywords occur together. Information about the features of the VOSviewer can be found in the user manual (van Eck & Waltman, 2010).

Research Questions

Research questions were defined to keep the analysis focused. The research questions answered in this bibliometric analysis are (1) which journal is the most productive on hypermedia learning research?, (2) what are the leading countries and the top institutions most productive?, (3) who are the most active researcher in the hypermedia learning research?, and (4) what kind of research topics are selected by researchers in the hypermedia learning research?.

RESULT AND DISCUSSION

Publication Growth

The annual trend for publication is shown in Figure 1. The number of hypermedia learning publications has risen by an average of 37 papers a year. The first 20 years of growth (1988–2007) were 654 publications, marginally higher than 570 in the last 12 years (2008-2020). This number of publications indicates a rising interest in hypermedia learning research. Figure 1 also shows the impact (i.e., citations) of studies performed over a given year. Studies conducted in recent years have not come up with many citations as it takes time for studies to have an impact. The Mean Total Citation per Articles (MTCA) is a bibliometric measure that shows the average citations of studies in all other studies indexed in the Scopus database. Since 1988–2009, both the number of publications (N) and MCTA have shown a growing trend.

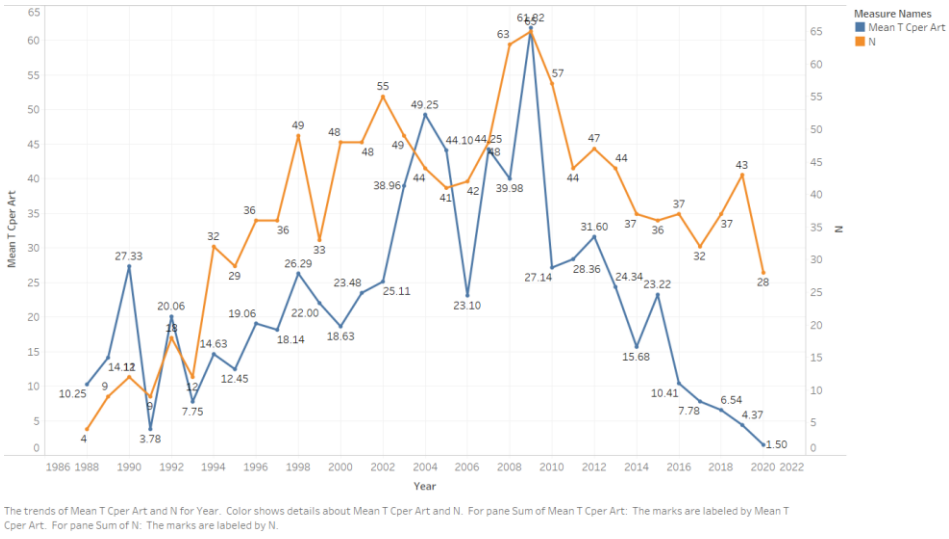

Figure 1

The Trends of N and MTCA.

The number of publications has grown exponentially year by year. A total of 101 countries contributed to serious gaming publications, in which the top ten publishing

countries were colored in Figure 2. The country was determined by the affiliation of the authors. The following figure shows ten of the most productive countries. Figure 2 displays ten of the most productive countries. In Figure 2, the United States is the largest contributor, accounting for 565 publications (46.16%). China and the United Kingdom have contributed 170 publications (13.89%) and 168 publications (13.73%) respectively to second and third positions. Germany and Spain each contributed 147 publications (12.01%) and 137 publications (11.19%) respectively. Greece, Canada, Brazil, Italy, and Netherlands each contributed 88 publications (7.19%), 58 publications (4.74%), 57 publications (4.66%), 56 publications (4.58%), and 56 publications (4.58%) respectively.

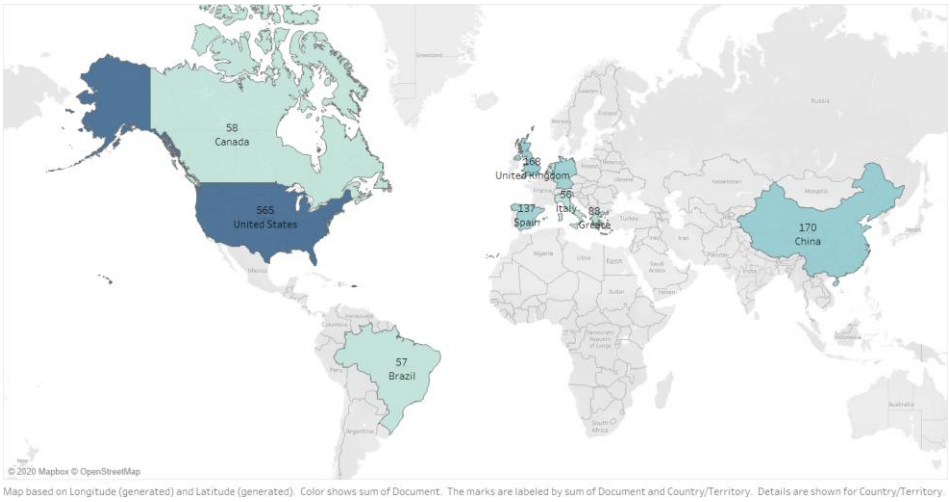

Figure 2

The Top Ten Productive Countries.

Top Journals

The sample of 1,224 studies in hypermedia learning was published in 443 academic outlets. Almost one-tenth of these studies (see Table 2) were published in 20 outlets. Two hundred two documents (16.50%) were published in Computers and Education, and 48 documents (3.93%) in the Computer in Human Behavior. Notably, the latter is the International Journal of Emerging Technologies in Learning 18 documents (1.47%). The other outlets that published twenty or more studies on hypermedia learning are Journal of Educational Computing Research (40), Educational Technology and Society (28), Educational Technology Research and Development (22), International Journal of Continuing Engineering Education and Life-Long Learning (22), and Journal of Computer Assisted Learning (22); these constitute the essential publication outlets for research on hypermedia learning.

Most Impactful Articles

In progress, our findings have shown that the top 10 most productive journals (Table 2) and most citation papers (Table 3). Bibliometric indicators such as Total Global Citation Source (TGCS) and Total Local Citation Source (TLCS) highlight contemporary or current breakthrough research. This analysis was performed using Biblioshiny for Bibliometrix software. The table below summarizes the most cited papers ranked by TLCs and TGCS. By comparing TLCS and TGCS, we can identify the relevant studies that earned most of the citations in 1,224 studies and beyond. It is claimed that Alemdag & Cagiltay (2018), with TGCS of 47 and TLCS of zero, is the most influential publication in the field of hypermedia learning. Other significant research focused on TGCS are Davis et al. (2018), Castro-Alonso et al. (2018), and Azevedo & Gašević (2018) with nineteen TGCS.

Table 2
The most relevant publication outlets.

Rank	Publication Source	Article*	Publication Source	Article**
1	Computers And Education	202	Computers And Education	867
2	Computers In Human Behavior	48	Computers In Human Behavior	637
3	Journal Of Educational Computing Research	40	Journal Of Educational Psychology	604
4	Educational Technology And Society	28	Educational Psychologist	514
5	Educational Technology Research And Development	22	Journal Of Educational Computing Research	493
6	International Journal Of Continuing Engineering Education And Life-Long Learning	22	Journal Of Educational Multimedia And Hypermedia	384
7	Journal Of Computer Assisted Learning	22	Learning And Instruction	350
8	British Journal Of Educational Technology	19	Review Of Educational Research	317
9	Journal Of Universal Computer Science	19	Educational Technology Research And Development	316
10	International Journal Of Emerging Technologies In Learning	18	Instructional Science	292

*Ranking by the most relevant sources. **Ranking by the most local cited sources.

Table 3
The most influential articles.

Rank	Article*	TLCS	TGCS	TLCS (%)
1	A systematic review of eye tracking research on multimedia learning (Alemdag & Cagiltay, 2018)	0	47	0
2	Activating learning at scale: A review of innovations in online learning strategies (Davis et al., 2018)	0	22	0
3	Learning symbols from permanent and transient visual presentations: Don't overplay the hand (Castro-Alonso et al., 2018)	0	19	0
4	Analyzing Multimodal Multichannel Data about Self-Regulated Learning with Advanced Learning Technologies: Issues and Challenges (Azevedo & Gašević, 2019)	0	19	0
5	Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education (Fidan & Tuncel, 2019)	0	18	0
6	Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis (Arici et al., 2019)	1	16	6.25
7	How are students' emotions related to the accuracy of cognitive and metacognitive processes during learning with an intelligent tutoring system? (Taub et al., 2019)	1	15	6.67
8	Adaptive multimedia: Using gaze-contingent instructional guidance to provide personalized processing support (Scheiter et al., 2019)	2	10	20
9	Instructors' pointing gestures improve learning regardless of their use of directed gaze in video lectures (Pi et al., 2019)	1	9	11.11
10	Temporal variation in children's self-regulated hypermedia learning (Paans et al., 2019)	2	8	25

*Ranking by the local and global citations.

Most Relevant Affiliations

Figure 3 shows the most relevant institutions that publish research on hypermedia learning. These ten affiliations produce almost one-tenth of the total publications. The top three institutions are in London and the United States. They are the Brunel University with 22 articles (1.80%), the University of Memphis with 19 articles (1.55%), and the University of Maryland with 18 articles (1.47%). Two of these affiliations are specialized in educational technology. The other top relevant institutions comprise universities and research centers from the United State (University of Pittsburgh), Greece (University of Athens), Taiwan (National Taiwan Normal University), Netherlands (University of Twente), Turkey (Karadeniz Technical University), United State (Indiana University), and United State (Gustavus Adolphus College).

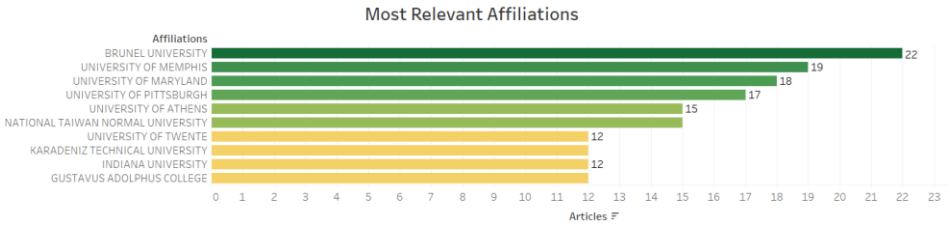

Figure 3
The Most Relevant Affiliations

The university collaboration network is shown in Figure 4. A bibliometric network consists of nodes and edges. Here, the nodes are 50 universities, and the edges indicate relations between pairs of nodes by research collaborations. The presence of several dispersed university clusters indicates that hypermedia learning is an emerging research domain. The red cluster (eight universities) is the largest and most influential. This cluster is also the most diverse, including universities from London (Brunel University), Greece (the University of Athens, Aristotle University of Thessaloniki, University of Piraeus, and the National University of Athens), United State (University of Pittsburgh), and Taiwan (National Central University and National Taiwan Normal University). The three other most famous clusters are the blue cluster (five universities), followed by the purple cluster (four universities), and the green cluster (three universities). Five clusters (pink, orange, brown, pink, light green, and grey clusters) reflect no research cooperation.

Most Impactful Authors

Through their publications, authors form the research area. Table 4 presents the most influential authors in the area of hypermedia learning. Azevedo R., Moos D. C., and Liu M. are the top three authors; together, they have contributed to 56 publications. Greene J. A. contributed 11 publications. Brusilovsky P. and Grigoriadou M. contributed ten

publications each. Gerjet S. P. and Scheiter K. contributed nine publications each. Chen S. Y. and Reed W. M. contributed eight publications each. As far as TC is concerned, Azevedo R. and Moos D. C. are the forerunners. Azevedo R. is the most famous author, with a TC of 2,688. It also has the largest number of h_index (21) and g_index (28).

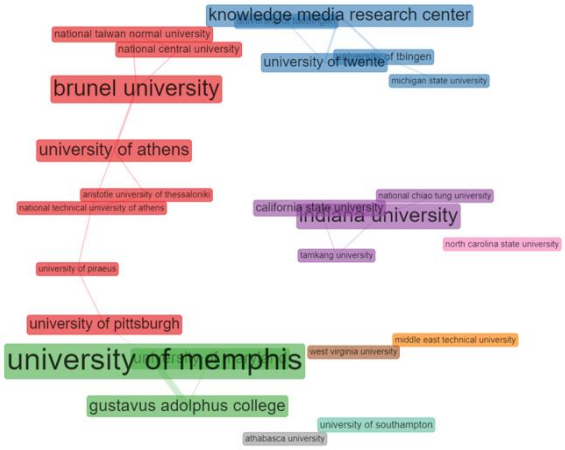

Figure 4

The University Collaboration Network (25 Nodes, 1 Minimum Edge, Walktrap Clustering Algorithm, Association Normalization)

Table 4

The most impactful authors.

Rank	Author	h_index	g_index	m_index	TC	NP	PY_start
1	Azevedo R	21	28	1.235	2688	28	2004
2	Moos DC	14	16	0.824	1114	16	2004
3	Liu M	10	12	0.37	427	12	1994
4	Greene JA	11	11	0.688	910	11	2005
5	Brusilovsky P	9	10	0.391	721	10	1998
6	Grigoriadou M	5	10	0.25	547	10	2001
7	Gerjets P	7	9	0.5	438	9	2007
8	Scheiter K	8	9	0.5	446	9	2005
9	Chen SY	8	8	0.348	628	8	1998
10	Reed WM	8	8	0.296	309	8	1994

*Ranking by the number of publications (NP). We present authors with a minimum of eight relevant publications. (Total Citation (TC), Start Year of Publication (PY_start)).

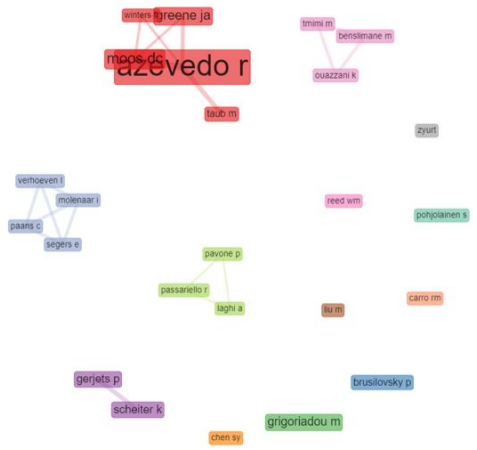

Figure 5

The Authors' Collaborative Network (25 Nodes, 2 Minimum Edges, Leading Eigenvalues Clustering Algorithm, Association Normalization)

The collaborative network of authors with 25 nodes is presented in Figure 5. Each node represents the author, and the edges represent the relationship of co-authorship between them. With five authors, the red cluster has the most prominent and essential network of author collaborations. The grey clusters consist of four different authors' network. The pink and green clusters comprised of three different authors' networks. The purple clusters consist of two different authors' network. Other clusters (orange, blue, and brown clusters) no collaboration network, suggesting poor cooperation relative to other clusters.

Three-Fields Plot

Connectivity between journals, research topics, and countries can provide valuable insights. Thus, an exciting three-field plot in Figure 6 shows the interactions between the essential publication outlets (left), author keywords (middle), and countries (right) in hypermedia learning research. We find that teaching/learning strategies and multimedia/hypermedia systems studies are mainly published in Computer and Education, mostly written by Chinese and USA scholars. Similarly, Computer and Education reported most of the hypermedia studies, again primarily written by USA scholars. Generally speaking, China excels in multimedia/hypermedia systems and adaptive hypermedia, the USA in interactive learning environments and hypermedia, and United Kingdom in hypermedia.

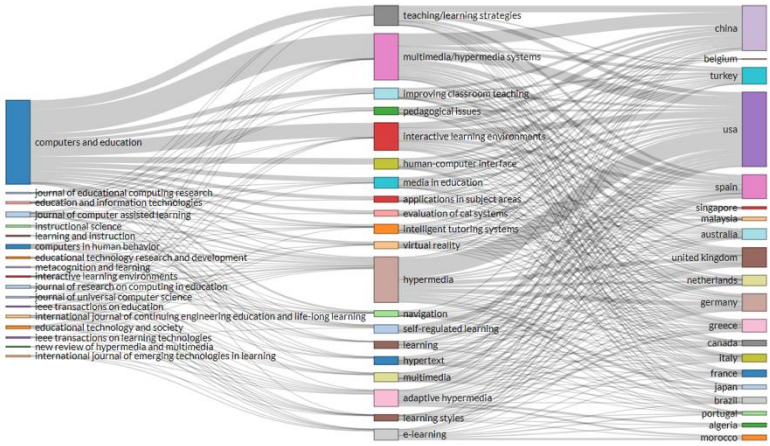

Figure 6
The Three-Fields Plot

Keyword Co-occurrences Analysis

We then evaluate the author's keywords for the VOSviewer co-occurrence. Keywords co-occurrence can effectively represent research clusters in the field of discipline and provide additional support for scientific research (H. Li et al., 2016). The VOSviewer software has developed a keyword hypermedia learning network for co-occurrence. The VOSviewer software is used to extract data, map, and group objects. The size of the circle is positively correlated with the appearance of the author keywords. Consequently, the size of the product label and the circle are determined by the item's weight. The larger the item's weight, the larger the mark and the circle of the item (Xie et al., 2020). The distance between the two nodes represents the power of the two nodes. In specific, shorter distances imply a good relationship. The line between the two keywords shows that they appear together (Liao et al., 2018). The connecting strength between the two nodes refers to the frequency of co-occurrence. The relationship between the two nodes can be seen as a quantitative index (Pinto et al., 2014). The following figure illustrates the visualization of the most influential keywords used by the authors of Scopus. There are 123 keywords at a time in all publications related to hypermedia learning. Relevant keywords, when displayed in the same color, are widely used together. The diagram shows that multimedia/hypermedia systems, hypermedia, adaptive hypermedia, multimedia, and intelligent tutoring systems are the main keywords. Besides, multimedia/hypermedia systems, interactive learning environment, teaching/learning strategies, improving classroom teaching, and pedagogical issues are closely related and frequently co-occur.

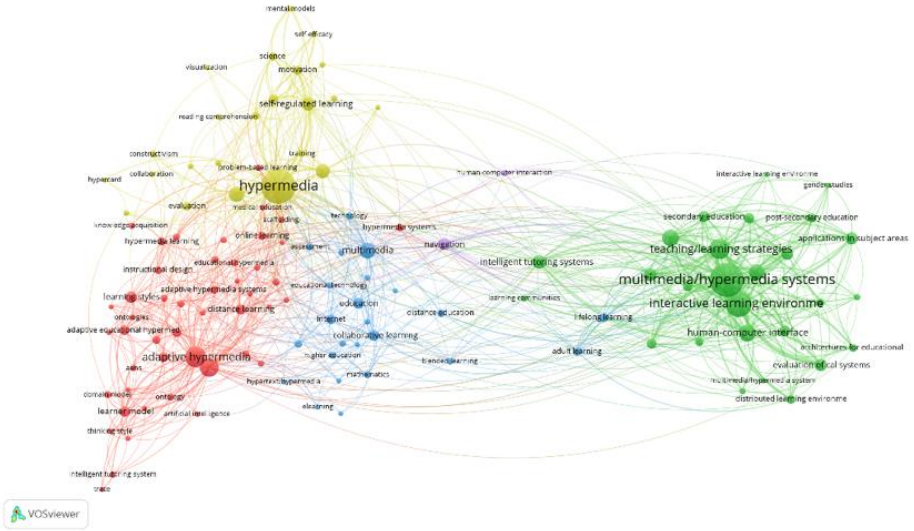

Figure 7
Author Keywords Co-Occurrences Network Visualization.

VOSviewer is capable of showing author keyword density visualizations (see Figure 8). Each node in the keyword density visualization plate has a color that depends on the node item's density. In other words, the node color depends on the number of objects in the node environment. Keywords occur more frequently in red areas; on the other hand, keywords appear less frequently in green areas (Liao et al., 2018). Figure 8 provides a visual representation of the research papers. Hypermedia is a keyword connected with elearning, mathematics, or blended learning that occurs less frequently in usage. The topic is still rather new, but it is starting to get interesting what other researchers have achieved.

The frequency of distribution of publications (Figure 9) shows the journals concerned with the subject and related issues (Secinaro et al., 2020). The graph reveals, however, the result of the Loess regression. As variables, it involves the quantity and time of publication of the journal under study. This approach allows the function to assume an unlimited distribution; that is to say, it will enable the function to assume values below zero if the data is close to zero. It leads to a better visual outcome and highlights the publication duration's discontinuity (Jacoby, 2000).

We found that the author keywords tended to occur more often during a certain period of time. It can be observed in Figure 9 that the number of main-term occurrences per year enhanced from 1998 to 2020, but several of them grew more dynamically than the others.

The terms leading to the greatest increase in use over time were ‘hypermedia’, ‘multimedia/hypermedia systems’, ‘interactive learning environments’, ‘adaptive hypermedia’, ‘teaching/learning strategies’, ‘elearning’, ‘human computer interface’, ‘media in education’, ‘multimedia’, and ‘improving classroom teaching’.

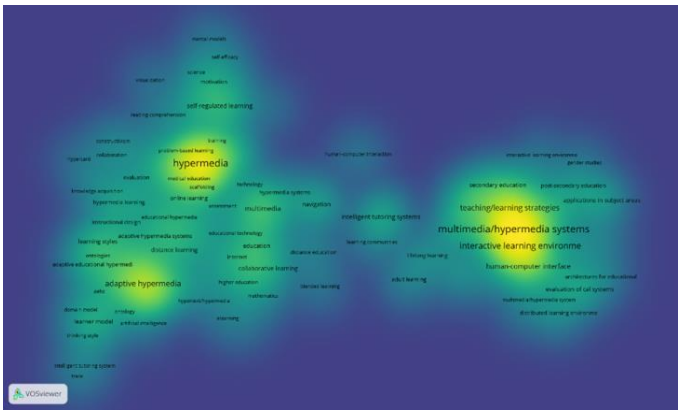

Figure 8
Author Keywords Co-Occurrences Density Visualization.

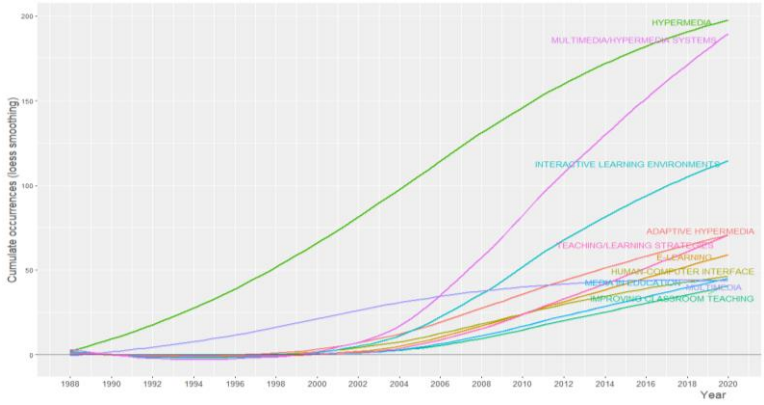

Figure 9
Word Growth. Source: Authors' Elaboration Using Bibliometrix R-Package.

Trend Topics

Figure 10 represents the most important trends based on the analysis of the keywords during 2011 to 2020. Based on our analysis, there are 16 trending topics to consider that have been occurring over the last three years (2018-2020). In 2018, the research found the number of articles concentrated on domain models, artificial intelligence, elearning,

social networks, prompts, serious games, primary education, and cognitive abilities. The topics of process mining, hypermedia systems, media, and emotions have been trending in 2019. As the year of 2020, the topics of learning outcomes, learning management systems, Clinical Application of Information (CMI), and Experience API are once again popular.

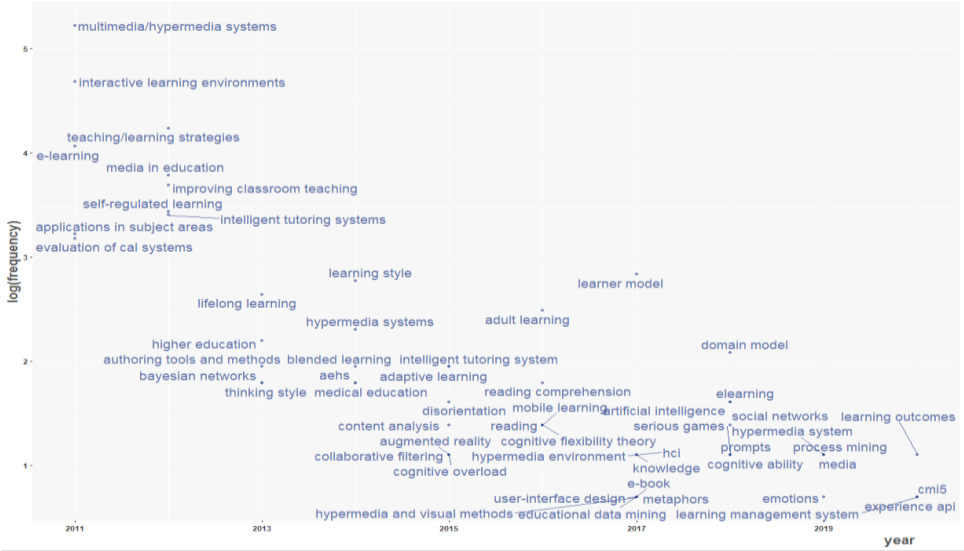

Figure 10

Trend Topics On Hypermedia Learning Research.

Collaboration WorldMap

The global collaborations showed in Figure 11. The blue color on the map reflects research collaboration between nations. Besides, the pink border connecting the states shows the degree of cooperation between the authors. It is exciting to see if countries with the highest number of hypermedia learning publications have participated in such partnerships. Based on the analysis, the United States has collaborated with China, Germany, Canada, Korea, Turkey, and Australia. Besides, France has already partnered with Algeria seven times. China has collaborated or worked with Canada five times. Note that Australia and Spain have collaborated three times. Finally, the Canada has collaborated with France three times.

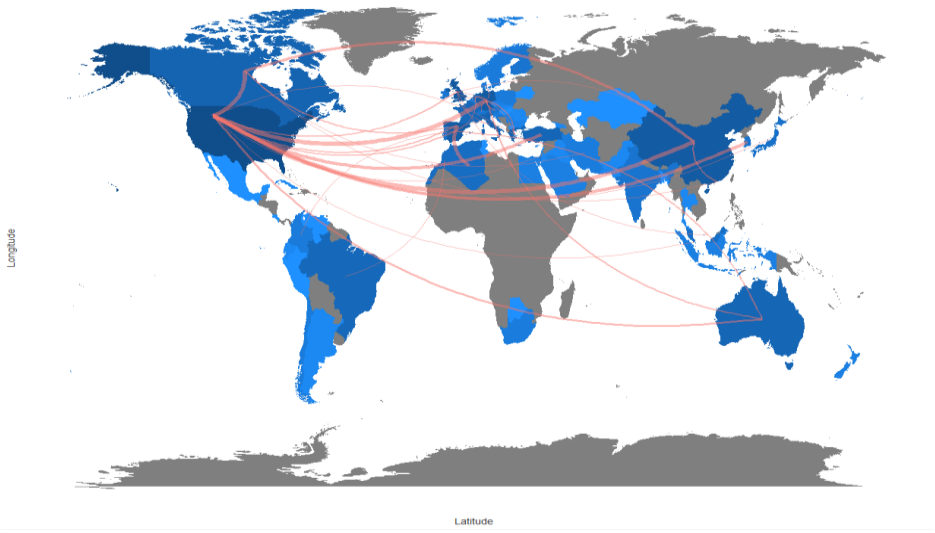

Figure 11
Country Collaboration Map (2 Min Edges).

Table 5
The top ten country collaboration.

Rank	From	To	Frequency
1	United States	China	10
2	United States	Germany	10
3	United States	Canada	9
4	France	Algeria	7
5	United States	Korea	6
6	United States	Turkey	6
7	China	Canada	5
8	United States	Australia	4
9	Australia	Spain	3
10	Canada	France	3

*Analysis by Biblioshiny for Bibliometrix.

CONCLUSION

This research offers a thorough overview of the hypermedia learning domain, integrating bibliometric analysis with systematic content analysis. We gathered bibliography data from 1,224 publications in the Scopus database, compiled by 2,584 authors published in 443 scholarly outlets. In the following sub-section, we summarize the main results of the four goals set out in the Research Questions section.

Key Journals, Articles, Countries, Universities, and Authors

There are basically three major high-quality journals that report on hypermedia learning including Computer and Education, Computers In Human Behavior, and Journal of Educational Computing Research. Based on TGCS, the most influential articles in the last two years are Alemdag & Cagiltay (2018), Davis et al. (2018), and Castro-Alonso et al. (2018). In terms of the number of publications, Brunel University and the University of Memphis are the most active institutions. Based on country scientific production, the United States has published the highest number of contributors, followed by China and the United Kingdom. The central authors, ranked by the number of publications, are Azevedo R. (28), Moos D. C. (16), and Liu M. (12). There are two different university collaboration networks in which the largest concentration is at Brunel University, and another network around the University of Memphis. Sometimes, authors need to collaborate with one another, and Azevedo R. is the author in this study most often collaborating with others researcher.

Future Research Avenues

The research and meta-analysis have expanded our understanding of hypermedia learning. However, limited to the number of research perspectives and research activities that have been conducted on the focus of each review, there is a lack of comprehensive overview of hypermedia learning trends and issues that have been the focus of current empirical investigations. Although keywords and terms are potentially the most relevant topics and results of the research, it is possible that several of the significant trends and issues discussed throughout the full text are insufficient from our research.

Despite the valuable viewpoints set out in this study, the researcher should consider a range of disadvantages. In the first place, the study used unique keywords to locate the initial list of research articles published as indexed by Scopus. However, this approach was very popular in previous bibliometric related studies. Although Scopus is one of the largest databases to cite scholarly articles, not all available sources are covered. These results are common with the exclusions applied to the analysis. Regardless, the most ideal search query could not put all the scholarly articles in this area. Despite these limitations, this paper explains the panoramic knowledge of trend topics in hypermedia learning literature. Besides, future research should consider relevant research clusters with hypermedia learning terms.

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