MAPPING RESEARCH ON LEARNING MEDIA IN PHYSICAL EDUCATION: BIBLIOMETRIC ANALYSIS OF PAST FINDINGS AND FUTURE RESEARCH AGENDA

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Abstract

The aim of this research is to map research literature on learning media in physical education over two decades. This study uses meta-data from the Scopus repository, retrieved using relevant keywords and extracted in terms of field development, productivity, collaborative networks and thematic structure in the field. We analyzed the data in VOSviewer and Biblioshiny software. A total of 265 documents/articles were published in the Scopus database in the period 2000-2022. Based on publications in the Scopus database, the findings show that: (1) academic interest in physical education learning media in the first decade tended to fluctuate and began to increase in the last decade; (2) Most publications are written by researchers spread across various countries, although most research is still published by a small number of authors and countries; (3) there is a noteworthy level of scientific collaboration in this field, where there is no collaboration between co-authorship clusters; (5) The conceptual dynamics of the literature reveal the multidimensionality of this topic of inquiry. Our significant contribution is the explanation of past findings relevant to current research that offers interesting insights into the evolution of the field of instructional media in physical education. These findings suggest the need for more interdisciplinary studies and broader collaboration of authors between countries.

Keywords: Learning media. Technology. Physical education. Bibliometrics

Introduction

Learning media in physical education has a contribution in encouraging the student learning process. This relates to aspects of skills such as acquiring complex movements or developing solutions to movement problems (Wibowo et al., 2022). However, learning media is also associated with interdisciplinary goals such as encouraging independence, motivation and the ability to collaborate (Talib, 2018; Sommier et al., 2022).

The impact provided by learning media makes selection, assessment and development attractive and urgent for research in physical education (Richards et al., 2012; Kennedy & Yun, 2019; Murtagh et al., 2023). Showing, learning media in physical education is a clear research desideratum in didactic research in subjects and special education.

The learning environment in physical education and sports classes indicates that facilities should be available for children who engage in outdoor activities such as climbing, jumping, hopping, kicking, throwing, skipping, and catching, and those who also engage in other basic motor skill activities in simple organizational games and various cooperative activities. Good learning occurs when many senses are involved (Mayer, 2003), instead of relying too much on verbal communication alone. Learning media is quite important for effective conflict teaching and conflict resolution. This makes learning media one of the backbones of Physical Education classes and supports students in getting maximum activity (Ningthoujam, Nongthombam & Sunderchand, 2017). Textbooks, balls or sticks and the like are the most basic learning tools in Physical Education classes. If no development or modification is carried out in selecting or its implementation, makes teachers treat the subject in an abstract way, depicting it as bland and uninteresting. Media, as a physical element, has a considerable influence on the teaching and learning process and can greatly condition its influence (García Montes & Ruiz Juan, 2005).

In the book *"Physical Education Futures"*, Kirk, (2011, p. 102) said that technology has dominated sports practices, including Physical Education and has penetrated so far into forms of physical culture in everyday life. It was about a decade before Kirk expressed his opinion, Hitchcock (2001), have suggested, access to digital information and communication technologies in flexible and easy learning will be pervasive and necessary to achieve the goals of full access, participation and progress by diverse Physical Education students. However, at that time the implementation of 'technology', in this case as a physical education learning medium, was only considered as a 'complementary' subject (Antoniou et al., 2003). Indeed, at that time the accessibility of hardware, operating systems, software applications, digital content, and networks was a significant issue in the general learning classroom (Hitchcock, 2001), and only a few schools, some teachers and students have the opportunity to benefit from their use. Meanwhile, media or learning tools are the primary element in supporting the learning process.

The growth of the Internet and related technologies has resulted in changes in education and society that have placed new demands on physical education teachers and presented a unique set of challenges in translating traditional face-to-face teaching to the digital space. In the last decade, research on Physical Education learning media has increasingly focused on the use of technological media and experiencing its benefits (Colasante, 2011; Meckbach et al., 2014; Baek, 2016; Zheng, ma & Lin, 2021). How the use of technology is conceptualized and how to understand its use and implications for teaching is a way of illustrating the school's adaptability and the role of the teacher. Many consider it a revolution of concrete learning resources and tools for the curriculum and some of us believe that it should be seriously rethought to give way to a more adaptative type of educational approach that focuses on the professional development of teachers and attention to student diversity. With special reference to Physical Education, various authors have pointed out the need to study the peculiarities of this field (Goad et al., 2019).

In general, there is considerable agreement that research on learning media in Physical Education has experienced extraordinary progress in recent years (Rodríguez et al., 2022; Sudarso & Setiawan, 2022 Mokmin & Mokmin, 2022). However, this progress is fragmented and developing in many different directions, making it extremely difficult to reconcile the diversity of existing theoretical, conceptual, and methodological approaches into a unified framework that will allow the field to move forward. Meanwhile, no research in the literature review has focused on learning media/tools in physical education. Attempts with similar methods vary in the physical education and sports literature on certain metadata sources (Gümüş et al., 2020; Tomanek & Lis, 2020), kurikulum penjas (Gazali et al., 2021), or directly lead to how technology is directly used in Physical Education (Calabuig-Moreno et al., 2020; Perdima et al., 2022; Zhou, 2023). In this context, we believe that a research review with bibliographic mapping, which synthesizes the accumulated knowledge about instructional media research in Physical Education will provide an overview of the development of this field and fill the gaps research by providing analysis Bibliometrics thus offers invaluable insights for researchers and practitioners alike.

This research aims to map research literature on learning media in Physical Education. More specifically, this study conducted a bibliometric review of the literature available in the Scopus database to provide a comprehensive picture of the evolution and condition of in the past and current research in the field of learning media in Physical Education which includes; productivity, collaborative networks, and intellectual structure in the field.

To guide the framework of this literature review, the following research

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questions were explored: (1) How is the productivity development of research publications on physical education learning media using the Scopus database? (2) What journals, authors and articles are the most influential in the field of learning media in physical education? (3) How do past findings and current overall trends in the field of physical education instructional media research become the subject of more publication in the Scopus database?

Method

This literature review research uses bibliometric methods, namely using bibliographic data from publication databases to create a structural picture of a scientific field (Zupic & Čater, 2015). In this study we used the database from Scopus (https://www.scopus.com), which includes high-quality scientific literature in more than 250 disciplines, including social sciences and humanities. (Cretu & Morandau, 2020), then Publish or Perish (PoP) is selected to determine more detailed citation metrics. To obtain metadata, researchers conducted a detailed search in the Scopus database in March 2023. This study used a general scientific mapping workflow method consisting of the following five rigorous steps: 1) Study design; 2) Data collection; 3) Data analysis; 4) Data visualization; and 5) Interpretation(Borner, Chen & Boyack, 2005) (Zupic & Čater, 2015).

Research design

The first step, to get metadata in Scopus, in the search column we select options (article title, abstract and keywords) with a time span of the last two decades, 2000-2022 and select the document type: article, conference paper, book chapter and review article. The phrase written in the search column is "instructional material*" OR "instructional tool*" AND "physical education". Because the research phrases/terms we examine contain a variety of meanings, we utilize the phrase options provided "Add search field", then the selected phrase is "learning material*" OR "learning tool*" OR "learning media*" AND "physical education" OR "teaching material*" OR "teaching tool*" OR "teaching media*" AND "physical education" OR "physical activity".

Second step: It is important to note that the bibliometric approach used in this research is to determine the number and type of publications taken for analysis of relevant journals, publications, researchers or countries that contributed to our research and the results are exported in Research Information Systems (RIS) format) to include all important article information such as paper title, author name and affiliation, abstract, keywords, and references from articles found. The third step, the RIS format is imported into Publish or Perish (PoP) to obtain data citation metrics more detailed ones, such as cites/year, cites/paper, cites/author, author/paper, h-index, g-index, hl_norm and hl_annual.

Data analysis

To visualize the bibliometric network of search results from Scopus metadata, we used Vosviewer software (Husaeni & Nandiyanto, 2022). VOSviewer is used for its ability to work efficiently with large data sets and provide a variety of interesting visuals, analyzes and investigations (van Eck & Waltman, 2010a). Vosviewer can also create publication maps, author maps, or journal maps based on co-citation networks or to build keyword maps based on co-citation networks. Researchers use several steps in VOSViewer to obtain article metadata, including: 1) Co-occurrence analysis, 2) All keywords, 3) Full calculation 4) Minimum number of author documents (Jeong & Koo, 2016; Ridwan et al., 2022). Biblioshiny is used to carry out data analysis in mapping the distribution of author affiliations between countries.

Results and discussion

Publication productivity and citation metrics

The research results presented are based on search output from the Scopus. com database and PoP software, analyzed using VOSviewer and Biblioshiny software to map the structure of scientific fields and determine the keywords that appear most frequently. The results we present here answer our research questions outlined in the introduction. Search results from the Scopus database in the initial stage with a range of 2000-2022 and without using document filters produced 308 data with a total of 2711 citations.Then we made improvements by selecting only articles, conference papers, book chapters and review articles and also sorting out documents that were not relevant to our research topic. A total of 265 articles were obtained as a result of improvements with 2030 citations (88.26 citations/year). This data has been well verified in the Scopus database from 2000-2022. Complete comparison results of metric data from the initial search and refined search can be seen in **Table 1**.

Researchers try to present the rate of research growth in Physical Education learning media based on trends in publication and citation data throughout the 2000-2022 period which is presented in **Figure 1**. A detailed examination of these trends reveals that the number of publications and citations in the first decade (2000-2011) did not show a significant increase, and instead tended to fluctuate in this field over time. As a result, the amount of literature available

Table 1: Comparison of learning media metrics in physical education.

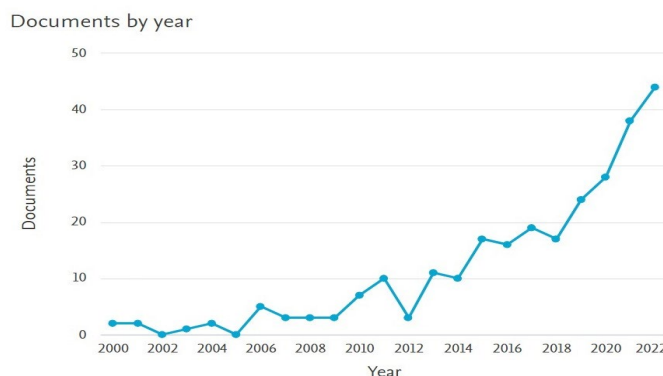| Metrics data	Initial search	Refinement search
Source keyword in Scopus	"instructional material*" OR "instructional tool*" OR "instructional media*" AND "physical education" OR "learning material*" OR "learning tool*" OR "learning media*" AND "physical education" OR "teaching material*" OR "teaching tool*" OR "teaching media*" AND "physical education" OR "physical activity"	"instructional material*" OR "instructional tool*" OR "instructional media*" AND "physical education" OR "learning material*" OR "learning tool*" OR "learning media*" AND "physical education" OR "teaching material*" OR "teaching tool*" OR "teaching media*" AND "physical education" OR "physical activity"
Publication year	2000-2022	2000-2022
Papers	308	265
Citations	2711	2030
Cites/year	117.87	88.26
Cites/paper	8.80	7.66
Author/paper	3.20	3.20
h_index	25	21
g_index	43	37
hl_norm	13	12
hl_annual	0.57	0.52

Figure 1: Growth rate of learning media research in physical education in the period 2000-2022 (source: Scopus metadata).

that is relevant to physical education learning media is only small, there are only 38 publications with a total of 473 citations (2057 citations/year). However, in the last decade it has increased significantly from 2012 to the present with a total of 226 publications with a total of 1574 citations (143.09 citations/year). The graph continued to increase in mid-2018-2022.

Journals, articles, authors, and countries as influential trans-disciplinary structures in the field of physical education learning media

Most of the research on physical education learning media appears to be published in several sources with 179 journals/sources identified. Table 2 presents the main research journals on the topics investigated ordered by number of publications. Theoryya I Politika Fizicheskoy Kultury stands out as the main venue for this research topic. Other publications on the list in the top 5 are spread across various journals, such as the Journal of Physics Conference Series, Movimento, Journal of Physical Education and Sport and Retos. Interestingly, of the top five journals whose contributions were identified, Teknologiya I Politika Fizicheskoy Kultury, which contributed the most documents (13), only had 4 (four) citations with h_index as (source local impact) with a score of 1 (one). Meanwhile, Retos, which produced 7 (seven) documents, had 38 citations with the highest h_index of 5 (five). Moreover, the articles published by Retos are mostly very relevant to the research topic we investigated, which includes material on first aid training programs in physical education using audio-visual media (Lago-Ballesteros, Basanta-Camiño & Navarro-Paton, 2018); integration of information communication technology (ICT) in physical education (Escola, 2018), and how to evaluate it (M. A. M. C. Rodríguez & Eirín-Nemiña, 2018); use of textbooks in Spanish for physical education (J. Rodríguez et al., 2022); analysis of the use of gymnastics

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facilities (equipment) in physical education (Rodríguez-Fernández, Abelairas-Gómez & Peixoto-Pino 2018); and linking the availability of physical education learning tools with gender perspectives (Lleixà, Soler & Serra, 2019). Other data presentations can be seen in Table 2.

To find out the most influential articles in this field, we list the most relevant and influential papers ordered by the number of citations in the articles (see Table 3). Of the top 10 articles identified, a topic that frequently appears in these publications is the examination of the use of multimedia and technology as a learning medium for physical education. Other influential publications discuss issues related to tools/instruments used for assessment of physical education or physical activity, views and experiences of teachers and students in hybrid learning environments, and the effectiveness of learning media. Publication of Thomas dan Stratton, (2006) which reviews what stakeholders can actually do regarding the use of ICT in physical education, which is the most influential article with the number of citations (71). The issue of ICT integration in physical education in the mid-2000s has become an interesting topic for researchers (Lau et al., 2011).

The total number of publications in the data set has been published by 854 authors in 54 countries around the world. In table 4, we present the authors who are most active and seen as the main 'actors' in the circulation of research publications on physical education learning media. This can be checked through the number of publications and citations of the author, as listed in Table 4. Rekik, G. and Darido, S. C. emerged as the most productive authors (4 articles/documents) however, Rekik, G was superior in citations (29

citations) while Darido, S. C. had 15 citations. Next in line is Papastergiou, M., Huang, C.H., Belkhir, Y., Suherman, A. Each of whom has 3 published articles/documents. Hastie, A. P. A., who comes from the USA, although it ranks 7th in terms of article/document productivity, has the highest number of citations (86 citations).

Meanwhile, Table 5 and figure 2 (map) show a list of a country's productivity in producing research in the field of physical education learning media. China stands out as the leading country in producing and disseminating knowledge about physical education learning media, with 48 articles/documents, followed by the USA (41 articles/documents) and Indonesia (23 articles/documents). In terms of citations, the USA is far ahead with 524 citations (22.78 cites/years), followed by Spain with 193 citations (19.30 cites/years) and the United Kingdom (UK) 150 citations (8.82 cites/years).If we look more closely at the geographic distribution of publications internationally, there is evidence that research on physical education learning media has been produced in many other countries and regions around the world, although with different levels of productivity (see Figure 2). It includes countries and regions in North and Central America, a small number of countries in South America and parts of Western Europe, Australasia, and countries in East and Southeast Asia, as well as some countries and regions in Africa.

Co-authored analysis was conducted through Biblioshiny to explore trans-disciplinary initiatives among the scientific community in the field of physical education instructional media. Collaborative publications show social ties in the scientific realm. Co-authorship analysis of such publications maps the

Table 2: Journals with the most publications, citations and h_index.

Journal	Documents	Citations	h_index
Teoriya I Praktika Fizicheskoy Kultury	13	4	1
Journal of Physics Conference Series (19)	9	19	3
Movimento (25)	8	25	4
Journal of Physical Education and Sport (136)	7	136	2
Retos (38)	7	38	5

Table 3: The most influential articles in physical education learning media.

Title	Authors	Source title	Year	Citations
What we are really doing with ICT in physical education: a national audit of equipment, use, teacher attitudes, support, and training	Thomas, A. & Stratton, G.	British Journal of Educational Technology	2006	71
The impact of video technology on student performance in physical education	Palao, J. M., et al.	Technology, Pedagogy and Education	2012	69
Suitability and readability assessment of educational print resources related to physical activity: Implications and recommendations for practice	Vallance, J. K., et al.	Patient Education and Counseling	2008	48
Economic evaluation of URMEL-ICE, a school-based overweight prevention programme comprising metabolism, exercise and lifestyle intervention in children	Kesztyüs, D., et al.	European Journal of Health Economics	2013	35
The effect of pedometer use in combination with cognitive and behavioral support materials to promote physical activity	Coocker, K. D., et al.	Patient Education and Counseling	2008	28
Active Learning: Educational Experiences Enhanced Through Technology-Driven Active Game Play	Mellecker, R. R., et al.	The Journal of Educational Research	2013	23
Use of Technology for Constructivist Learning in a Performance Assessment Class	Juniu, S.	Measurement in Physical Education and Exercise Science	2006	23
Can learning of basketball be enhanced through a web-based multimedia course? An experimental study	Marina, P. & Vassilis, G.	Education and Information Technologies	2013	21
Teaching undergraduate biomechanics with Just-in-Time Teaching	Riskowski, J. L.	Sports Biomechanics	2015	21
The Lieberman–Brian Inclusion Rating Scale for Physical Education	Lauren, L., et al.	European Physical Education Review	2019	19

Table 4: Top authors by number of publications in the database.

Author	Institution	Country	Documents	Citations
Rekik, G.	Tanyu Research Laboratory, Taipei	Taiwan	4	29
Darido, S.C	Universidade Estadual Paulista "Júlio de Mesquita Filho"	Brazil	4	15
Papastergiou, M.	University of Thessaly	Greece	3	49
Huang, C.H.	LungHwa University of Science and Technology	Taiwan	3	27
Belkhir, Y.	Université de la Manouba, Manouba	Tunisia	3	15
Suherman, A.,	Universitas Pendidikan Indonesia	Indonesia	3	3
Hastie, P. A.	Auburn University, Auburn	USA	2	86
Chin, S. L.	Tamkang University	Taiwan	2	23
Akhmetova, A.	K. Zhubanov Aktobe Regional University	Kazakhstan	2	4
Chen, Y. S.	University of Taipei	Taiwan	2	1

Table 5: Top countries by number of publications in the database.

Country	Documents	Citations	Cites/years
Tiongkok/China	48	79	4.62
USA	41	524	22.78
Indonesia	23	35	3.89
Spain	21	193	19.30
Rusia	18	8	0.80
Taiwan	16	68	4.00
United Kingdom	12	150	8.82
Australia	10	52	2.26
Brazil	10	40	3.33
Canada	10	146	9.73

Country Scientific Production
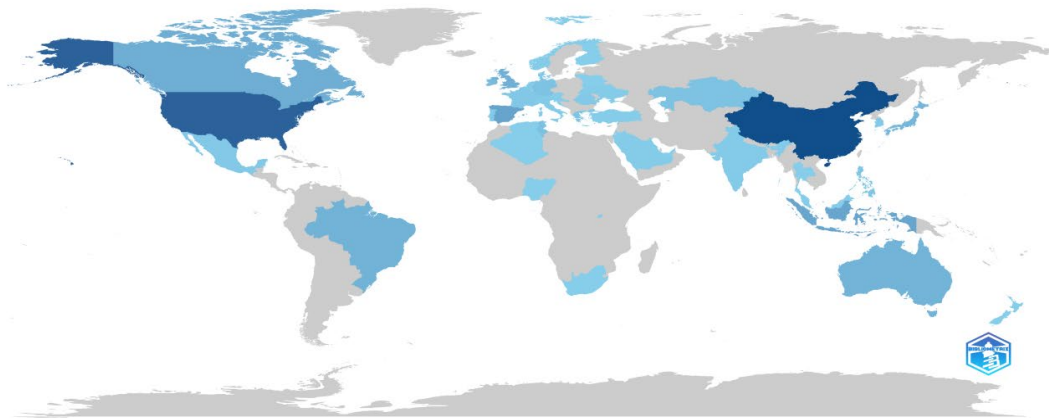
Figure 2: Map of the distribution of research on physical education learning media in various countries.
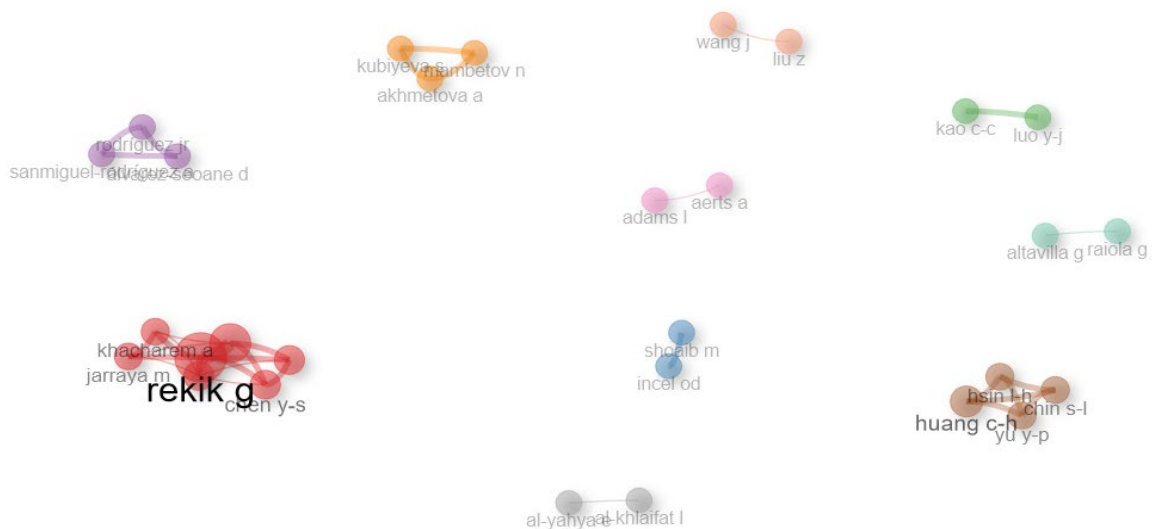

Figure 3: Collaboration network between authors in the physical education learning media domain.

research collaboration networks of researchers in a particular field (Abbasi, Altmann & Hossain, 2011). Such analyzes can examine research collaborations of individual researchers, institutions, and countries (Zupic & Čater, 2015). This research network gave rise to collaborations among authors presented in Figure 3. Of the 854 authors, 'only' 29 identified authors were grouped into 10 clusters (as shown in Figure 3), indicating the scarcity of collaborative research initiatives among researchers in the field physical education learning media. All authors included in the cluster have established good relationships through collaboration within the cluster, not outside the cluster. All identified clusters are relatively independent, which reinforces the boundaries of disciplines in the structural development of this knowledge domain. The two authors in network visualization, who wrote the largest number of articles, did not have a collaborative effort that could be called feasible. Whereas, Abbasi et al. (2011) confirmed that collaboration skills have a strong influence on the academic

performance of researchers.

Each of these networks can be interpreted as a relatively formal research group consisting of a number of authors who have written several publications on physical education learning media in the last 2 decades. In cluster one which is the main cluster, Ghazi Rekik who comes from Tunisia, currently affiliated with the Tanyu Research Laboratory (Taiwan) in Scopus metadata, has written 4 (four) documents which are available in the Scopus repository from 2019 to 2022, of which three papers some of them were written together. Where three publications maintain collaboration with his compatriot, Yosra Belkhir. Interestingly, the most cited author (86) (Hastie, P. A) was not included in this collaboration network, perhaps because there were only two papers and overall Hastie did not serve as first author (chief researcher). However, Marina Papastergiou (49 citations) who produced three papers, two of

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which were first authors, was also not included in the collaboration network. Research collaborations, especially remote and international collaborations, are now increasingly common throughout the world. Recent studies highlight the important role of research leadership in collaboration (He, Wu & Zhang 2021), Thus, it is important to critique the concept of leadership in research collaboration.

Figure 4 visualizes the collaborative research network on physical education learning media research at the country level. From 54 countries, the results of Biblioshiny's analysis gave rise to 34 countries with five clusters that have international research collaboration networks in the field of physical education learning media which are characterized by the relationships between researchers discussed in the previous section. China (48 documents with Total Link Strength (TLS) 5) and USA (41 documents with TLS 10) were the most productive and influential countries in physical education learning media research in our study, located at the heart of the map and showing collaborative relationships with most other countries and regions included in the analysis. China (China) in particular is rapidly emerging as a new global leader in science. There are two main reasons for the change. First, spending on research is increasing rapidly in China (Basu et al., 2018). Pada tahun 2018, research and development (R&D) expenditures in China increased from 2010. Second, the evaluation of research output in China is mainly based on quantitative measures such as the number of publications, journal impact factor, and number of citations. This emphasis on quantitative measures encourages the entire academic community to publish as many papers as possible.

Thematic structure of keywords in the research field of physical education learning media

Understanding the thematic structure of keywords in a scientific domain is a precursor to the distribution of knowledge in a scientific field. This includes past findings and more recent topics in certain scientific disciplines. Co-word analysis is carried out to achieve this goal. This analysis reveals the relationship between keywords and terms as the co-occurrence of keywords and terms in the same journal article with a network map (van Eck & Waltman, 2010; Zupic

& Čater, 2015). Nicolas, Valenzuela-Fernández and Merigó (2020) argue that the co-occurrence of keywords can facilitate understanding research trends of a knowledge domain and predict future research trends (Zhou, 2023). The analysis begins with the main focus on the terms "mesh" and "the primary search terms" in the VOSviewer software. We used VOSviewer to visualize the appearance of the co-occurrence network by keywords from 265 articles/documents and selected 93 keywords with at least 5 times the frequency of occurrence for visual analysis, as shown in Figure 5. In the figure, the larger the dots represent the more occurrences and the more they represent the hot spots in the field, and the dots are connected to represent the strength of association, and the more lines represent the more occurrences of two keywords in the same article. Different colors represent different clusters, i.e. research topics, and the time of occurrence is represented from blue to yellow.

Through Figure 5 Publications in the research sample provide 93 keywords, TLS 6014 which produces four clusters; a red one-color cluster, a green two-color cluster, a blue three-color cluster and a yellow four-color cluster. Analysis of the co-occurrence of high-frequency keywords reveals thematic groups (clustering) in the field of physical education learning media research. We can see that physical education, human, teaching materials, teaching, student, physical activity, article, female and others are representative high frequency keywords in this field at the moment. The results of this analysis help in building a conceptual map based on the areas of primary interest of the researchers. In addition, this analysis also highlights the main research trends in the field of instructional media in physical education.

The overlay visualization shows that most of the keywords with the latest publication date (visualized in yellow) are spread across all identified Clusters as shown in figure 6. In general, Cluster one appears to group keywords with the earliest average publication date (visualized in dark blue), while Cluster two is a collection of the most recent issues. Keyword analysis with the latest publication date with the year of appearance around 2019-2022 is manifested by keywords such as: 'mental health', 'machine learning', 'covid-19', 'big data', 'applications', 'artificial intelligence', 'student', 'information technology', and other keywords.
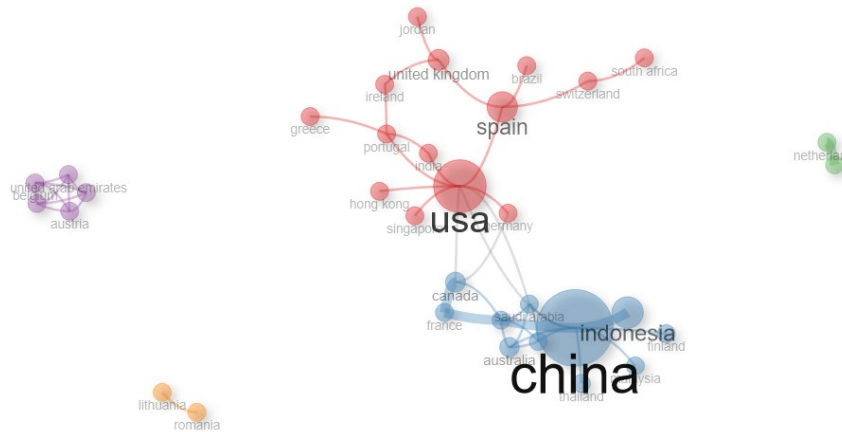

Figure 4: Collaboration network between countries in the physical education learning media domain.
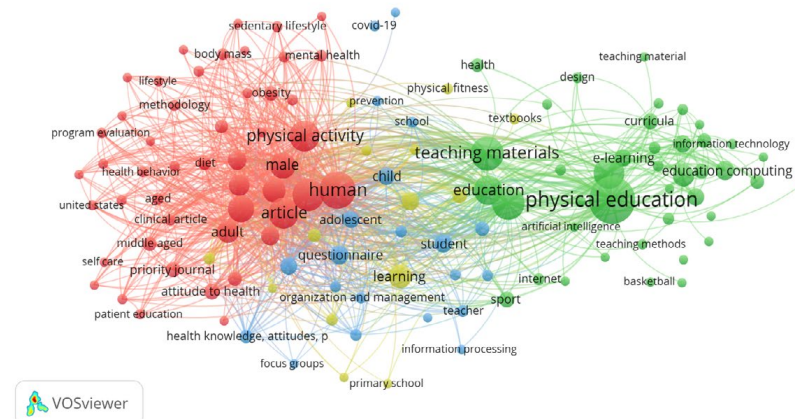

Figure 5: Focus of research topics on physical education learning media during the 2000-2022 period.
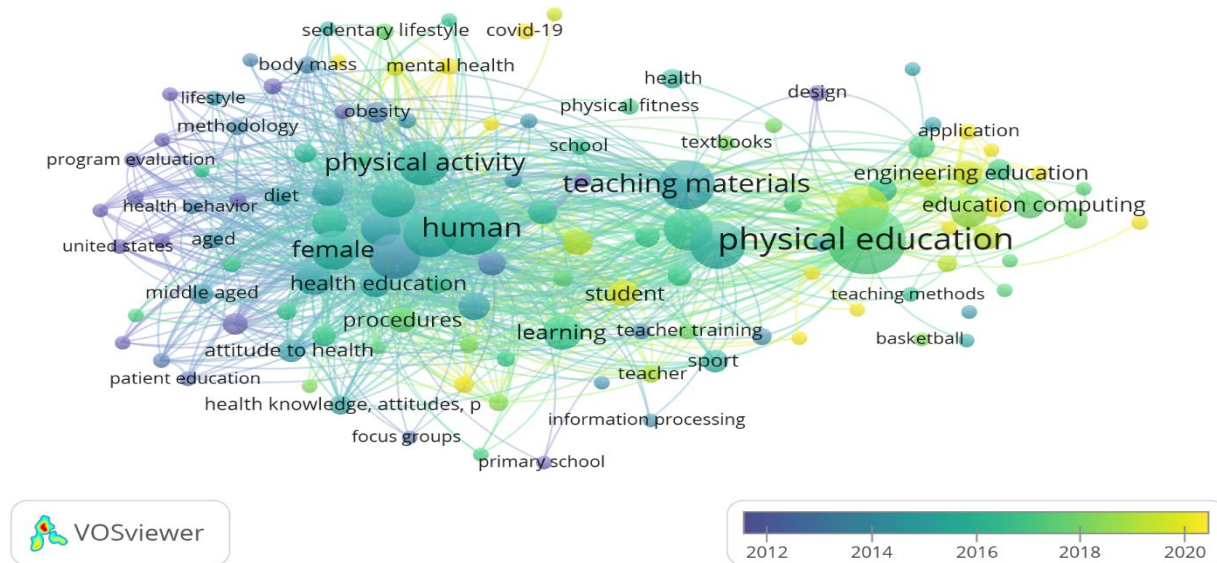
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Figure 6: Average date of publication of high frequency keywords in the field of physical education learning media research.

Discussion

The main aim of this research is to carry out bibliometric analysis of research articles on learning media in physical education, using relevant meta-data from the Scopus repository spread from 2000-2022. This study provides an overall picture of the development of the field of instructional media in physical education and offers relevant insights into past findings and its current state. The results of data analysis are organized into relevant subsections to meet specific research questions. In general, the pattern of publication and citation data shows an increase in academic interest in learning media research in physical education in the last decade, especially since 2018. Although, the first decade experienced fluctuating productivity.

The growth that has occurred in the last decade is most likely due to the evolution of teaching infrastructure and facilities that are integrated with technology and information, which has actually been mentioned by Hitchcock, (2001) about the accessibility of digital media and technology in physical education. As the use of technology increases; Calabuig-Moreno et al. (2020) reporting this growth can be seen from the number of articles published from 2017 onwards. Where also reported by Gómez García et al. (2019) yang juga menyoroti tahun yang sama sebagai puncak di bidang ini. Titik puncak dari produktivitas terlihat sejak tahun 2020. Penjelasan yang masuk akal untuk peningkatan publikasi pada tahun tersebut adalah bencana dari Pandemi Covid-19 yang berdampak nyata pada pendidikan jasmani dan memicu minat yang besar pada media pembelajaran pada aktivitas fisik dan olahragawhich also highlights the same year as a peak in this field. The peak point of productivity was seen in 2020. A reasonable explanation for the increase in publications in that year was the disaster of the Covid-19 Pandemic which had a real impact on physical education and sparked great interest in learning media on physical activity and sports (Zheng et al., 2021; D'Agostino et al., 2021; Campos-Mesa et al., 2022).

One of the main focuses of this research is to investigate how past research maps and current findings in the field of physical education learning media. The year range for our research starts from 2000-2022, but in Figure 6 the year range is shown as 2012-2020. So, with high precision, we re-explore the metadata in Scopus to investigate research in the past (2000s) that is considered relevant in physical education learning media. First, we found that digital and multimedia access was considered an important aspect in facilitating the physical education learning process (Antoniou et al., 2003; Lin & Tzeng, 2006; Zimbelman et al., 2007). However, the media used is still limited to physical visuals or digital multimedia and has not been integrated with the latest technology. In fact, at that time the use of technology in physical education classes was still rare (Thomas & Stratton, 2006; Kretschmann, 2015). Entering 2009-2010, e-learning or hybrid research emerged in physical education classes (Huang et al., 2009; Pang, 2010) where multimedia again takes an important role (Lei & Wei, 2009).

'Mainstream' keywords such as 'physical education', 'teaching materials', 'human', or 'student' dominate the co-occurrences produced by VosViewer analysis. However, the results of the analysis did not produce 'keywords' that actually characterize the spectrum of physical education, for example; balls, sticks, nets, nets or other facilities commonly used for physical activities or outside the classroom. So that raises questions from researchers; Is this set

of keywords really not the focus of research on physical education learning media? Or are these words not included in the title or abstract in the focus of this research? Or is it metadata from Scopus that is not detected by VosViewer machine learning due to language influences and so on. These questions have worried researchers.

Then, what is unique is the emergence of keywords such as 'ICT', 'internet', 'application', 'big data', 'education computing' and other words with the nuance of 'technology' since the last five years. Massive technological advances have encouraged the integration of more sophisticated technology into physical education learning media. Starting from using the website as a learning facility (Huang et al., 2011), and also a website developed as a sports science answer to future technological challenges (Papastergiou, 2011). The emergence of online education has also provided a new development platform for the preparation and development of physical education teachers through such networks (Ko, Boswell & Yoon, 2015) to increase cross-disciplinary learning and develop the diversity of physical education teachers.

Limitations and future research

The main limitation of this study is that the authors reviewed and performed bibliographic analysis only on metadata in Scopus. Scopus has a bias towards Social Sciences and Arts and non-English publications (Mongeon & Paul-Hus, 2016), which may have excluded some relevant publications in the field of physical education learning media. Other academic databases, such as Web of Science (WoS), EBSCO or ERIC to confirm the trends shown in this study. Future research with a comparable database is recommended to investigate the field of physical education instructional media research more thoroughly. Future international research that concentrates on physical education learning media needs to expand the collaboration of authors from developed countries with developing countries. Close collaboration between experts and educators is needed to improve pedagogy and curriculum. However, we consider that the bibliometric approach used in this study provides a novel approach that offers interesting insights into the evolution of this field and the challenges that hinder its progress.

Conclusion

Physical education as a system in social sciences has an important and active role in physical activity, physical exercise and community recreation, and is an important activity for bodily health. Overall, this research provides an overview of the current development and state of physical education learning media research since the beginning of the first millennium. The results of our research show that research on physical education learning media in the first decade experienced slow and fluctuating development, then in the second decade it experienced very rapid progress and has developed into a mature research area with leading actors contributing to the development of the field, structure solid social, intellectual, and knowledge base, and the potential to influence thinking.

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