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Review. Technology integration for Physical Education teachers: a bibliometric analysis
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Technology integration for Physical Education teachers: a bibliometric analysis

Integración tecnológica para profesores de Educación Física: un análisis bibliométrico

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Abstract
Rapid advancements in information technology have transformed physical education (PE), enabling digital platforms for innovative learning amid sociocultural shifts and COVID-19-driven online pivots, yet PE teachers face challenges like low digital confidence and competency gaps (pedagogical, personal, social, professional). This bibliometric study fills a research void by mapping Scopus trends (2019-2024) via VOSviewer (v1.6.19), addressing RQ1 (publication productivity), RQ2 (influential journals/authors/articles), H1 (2020-2021 peak then decline), and H2 (dominant "PE" and "educational technology" themes with digital literacy gaps); from 1,070 initial hits, 377 English documents were analyzed for co-authorship, citations, and keyword networks (7 clusters, min. 2 occurrences). Results confirm H1 with productivity surging from 25 (2019) to 115 articles (2021) before dropping to 20 (2024), highlight top influencers like Casey, A. (China, 4 docs), Varea et al. (2022; 68 citations on COVID-19 PE changes), and Sargent et al. (2020; 54 citations on flipped learning), plus keyword clusters ("physical education," "e-learning," "sports") revealing gaps in teacher literacy and geographic equity (China/US dominance), underscoring needs for targeted training, AI/VR integration, ASEAN studies, and policy frameworks to sustain post-pandemic gains.

Keywords: Physical Education teacher; Physical Education; technology; bibliometric analysis.

Resumen
Los rápidos avances en tecnología de la información han transformado la educación física (EF), permitiendo plataformas digitales para el aprendizaje innovador en medio de cambios socioculturales y cambios en línea impulsados por la COVID-19, pero los profesores de EF se enfrentan a desafíos como una baja confianza digital y brechas de competencias (pedagógicas, personales, sociales, profesionales). Este estudio bibliométrico cubre un vacío de investigación mapeando las tendencias de Scopus (2019-2024) a través de VOSviewer (v1.6.19), abordando RQ1 (productividad de publicaciones), RQ2 (revistas/autores/artículos influyentes), H1 (pico 2020-2021 y luego descenso) y H2 (temas dominantes de "PE" y "tecnología educativa" con brechas en alfabetización digital); de 1.070 resultados iniciales, se analizaron 377 documentos en inglés para coautoría, citas y redes de palabras clave (7 grupos, mínimo 2 ocurrencias). Los resultados confirman el primer semestre con la productividad subiendo de 25 (2019) a 115 artículos (2021) antes de caer a 20 (2024), destacando a los principales influenciadores como Casey, A. (China, 4 documentos), Varea et al. (2022; 68 citas sobre cambios en el EP por COVID-19), y Sargent et al. (2020; 54 citas sobre aprendizaje invertido), además de grupos de palabras clave ("educación física", "e-learning", "deportes") que revelan brechas en la alfabetización docente y la equidad geográfica (dominio China/EE. UU.). subrayando la necesidad de formación específica, integración de IA/VR, estudios de la ASEAN y marcos políticos para sostener los avances postpandemias.

Palabras clave: profesor de Educación Física; Educación física; tecnología; análisis bibliométrico.

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Introduction

The development of information technology into science and technology is growing rapidly (Bizel et al., 2023) and is towering so that it can influence world sectors, one of which is physical education (Werthi Queena K, Fredlina & Astuti, 2021). The strategies used in physical education based on digital platforms for innovative learning can be used as the main benchmark in curriculum development. That is why it can be a useful artifact (Regania Pasca et al ., 2022). Contemporary sociocultural developments have significant positive sides, such as making it easier for teachers to access and integrate student performance on digital platforms. In contrast, negative sides emerge, such as dependence on technology, so that books are no longer the main source sought (Karlsson I et al., 2023). Integrating physical education teachers (AlKasasbeh & Amawi, 2024) in developing technology-based learning methods is widespread (Widyaningsih et al., 2023). With creative thinking and technological support, this is a form of self-development regarding how the teacher's role will be to obtain relevant competencies. So, the four teacher competencies that must be understood include pedagogical, personal, social, and professional (Zhou, Xing, Yue, 2023). The wave of digital transformation in education and the emergence of global social challenges require partial digitalization of physical activities in schools. Physical education is the main milestone for systematic physical activity to improve cognitive, perceptual, neuromuscular, emotional, and mental systems (Tandiyo & Sugiharto, 2023). The benefits of technology in the world of education are very significant, such as increasing student motivation and learning outcomes. This causes the learning process to be interactive, inspiring, and fun (Sungeelee et al., 2024). Teacher reflection must be linked to professional reality, teacher thinking, and actions; for this reason, it is necessary to highlight technological development scenarios for physical education teachers (Botagariyev et al., 2022).

The contribution of teachers as the basis for revolutionary change from the past to the present generally means that physical education teachers have made regular progress in technology over the past few years. This is the biggest challenge, especially for physical education teachers, who must be more creative in this era of technological development (Xue & Li, 2024). The change in technology integration in physical education teachers is a clear research objective. Many physical education teachers are still

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unsure about existing technology; they feel they lack understanding and are not confident because this technology is suitable for entering the world of learning, especially in physical education (Wohlfart et al., 2023).

It is very important to find alternative solutions to overcome this problem. The technology involved in physical education continues to be upgraded every year, making education turn into a digital platform (He & Cao, 2024). The specific methods of various kinds of literature change, as do technological developments in physical education (Aprilo et al., 2023). Research has reported that technology, such as technology-based learning media, has been used widely to optimize the teaching and learning process (Knoke et al., 2024). Besides that, technology can also manage information about physical education (Tomanek & Lis, 2020). The context of educational technology is included in the physical education curriculum (Gazali et al., 2021). Technological developments provide an opportunity to search for research literature reviews that map bibliometrics about physical education teachers using technology (Marín-Suelves et al., 2023).

The productivity of researchers has been boosted by conducting studies that discuss technology and teachers. The majority of researchers use comprehensive methods that do not just focus on one research area, such as teacher technology competency (Burrows et al., 2021), technology practices around Technological Pedagogy Content Knowledge (TPAC) (Voithofer & Nelson, 2021), the impact of technology on stress (Fernández-Batanero et al., 2021), teacher anxiety about technology (Henderson & Corry, 2021), designing problem-based technology (Hutchins & Biswas, 2023), as well as factors influencing teacher technology integration (Ifinedo et al., 2020). However, no researchers have discussed bibliometric studies in technology studies related to physical education teachers (Belfiore et al., 2019). As a result, researchers are filling these gaps to open up future research. Researchers used bibliometric visualization to provide an objective picture of technology for physical education teachers. This research provides an overview to guide teachers to improve innovative formulas in physical education (Perdima et al., 2022).

This study is a comprehensive bibliometric analysis to review research trajectories, resulting in a broader research coverage (Cascella et al., 2024). In broad

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terms, many researchers have carried out analyses related to physical education, but none have focused on technology for physical education teachers. This is a gap that researchers need to analyze. VOSviewer is an element of visualizing data by viewing citation analysis (Jiang et al., 2024) with accurate and objective descriptions (Wu et al., 2024). Publication of bibliometric studies focused on physical education in the last five years, such as: Educational reform in digital technology (Wang et al., 2024), physical education in the context of the Association of Southeast Asian Nations (ASEAN) (Masangcay et al., 2023), physical education for people with disabilities (Karakaya et al., 2023), analysis of physical education leadership (Gazali & Saad, 2023a), the formation of sports education initials in the pedagogical model (Yessica Segovia et al., 2023), physical education learning media and the Education curriculum physical (Sahin et al., 2023a). This research aims to map research literature on the technology integration of physical education teachers. More specifically, studies that use bibliometric reviews are available in the Scopus database, providing a comprehensive picture of the past to present in physical education teacher technology integration. This research aims to map research literature on the technology integration of physical education teachers. More specifically, studies that use bibliometric reviews are available in the Scopus database, providing a comprehensive picture of the past to present in physical education teacher technology integration. To guide this literature review framework, the following research questions were explored: RQ1: What is the development of technology research publication productivity for physical education teachers using the Scopus database? RQ2: What journals, authors, and articles are the most influential in the technology field for physical education teachers? Based on preliminary trends in Scopus data, two hypotheses are proposed: H1: Publication productivity on technology integration in physical education teaching peaked during 2020-2021 due to COVID-19-driven digital shifts, followed by a decline post-pandemic. H2: Keyword co-occurrence networks will reveal dominant themes in "physical education" and "educational technology," with gaps in teacher-specific competencies like digital literacy. The objective of this study is to conduct a comprehensive bibliometric analysis using VOSviewer to visualize these trends, identify influential contributions, and highlight research gaps to guide future innovations in physical education teacher training.

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Methodology

Study design

This research employed a bibliometric analysis to evaluate research trends and patterns in scientific publications (Campbell et al., 2024). The bibliometric approach allows for a comprehensive and mechanistic review of literature data derived from objective sources (Huang et al., 2024;Cetindamar et al., 2019). The data were sourced from the Scopus database, which provides extensive access to high-quality scientific publications using advanced profiling algorithms (Baas et al., 2020). VOSviewer software was used to visualize bibliographic networks, including relationships among keywords, authors, journals, and institutions.

Eligibility Criteria

Document search used the Boolean keywords: ("teacher" OR "tutor" OR "in structure") AND ("physical education" OR "physical activity" OR "sports education") AND ("technology" OR "augmented reality" OR "virtual reality"). Searches occurred on December 26, 2023, in Scopus, targeting 2019-2023 publications. Only English-language journal articles, conference papers, and book chapters were included, yielding 377 documents after filtering (meeting the bibliometric threshold of ≥300; Donthu et al., 2021). Exclusion of non-English research was justified as Scopus metadata (titles, abstracts, keywords) for bibliometric visualization in VOSviewer requires English for accurate network mapping and co-occurrence analysis; non-English terms would fragment clusters and bias global trend interpretations presented in the abstract.

Procedure

Initial search yielded 1,070 documents; language/type filtering reduced to 377 English articles. Data exported in RIS (Mendeley management) and CSV (VOSviewer processing). Full texts screened for verification. VOSviewer (version 1.6.19, developed in the Netherlands by Nees Jan van Eck and Ludo Waltman at Leiden University, 2009-present) analyzed: (1) co-authorship networks (authors/institutions by collaboration links); (2) keyword co-occurrence (minimum 2 occurrences, creating 7 clusters visualized by color density in Figure 4); (3) citation patterns (top articles/authors by total links/strength, as in Tables 1-2, Figure 3); (4) publication trends (annual productivity

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from Scopus export, Figure 2). The results section presents: annual productivity (RQ1), top authors/journals/articles (RQ2), keyword networks, and geographic distributions.

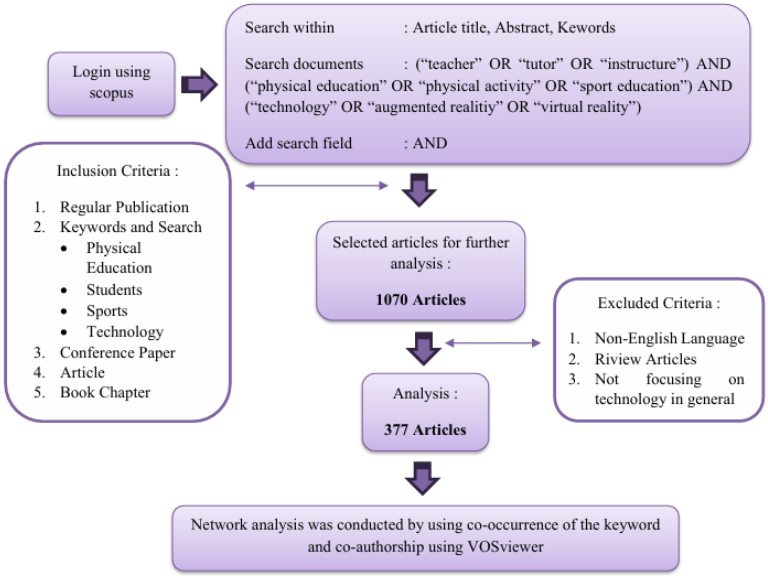

Figure 1. Selection process circuit

Results

The results of the bibliometric analysis related to the research questions are presented in this section. First, we conduct a literature survey on the evolution as well as contributions to the field by author, country, and document type. Second, we examined the most important authors, journals, and papers cited in scientific papers. Third, researchers conducted keyword analysis in the field of technology and physical education teachers.

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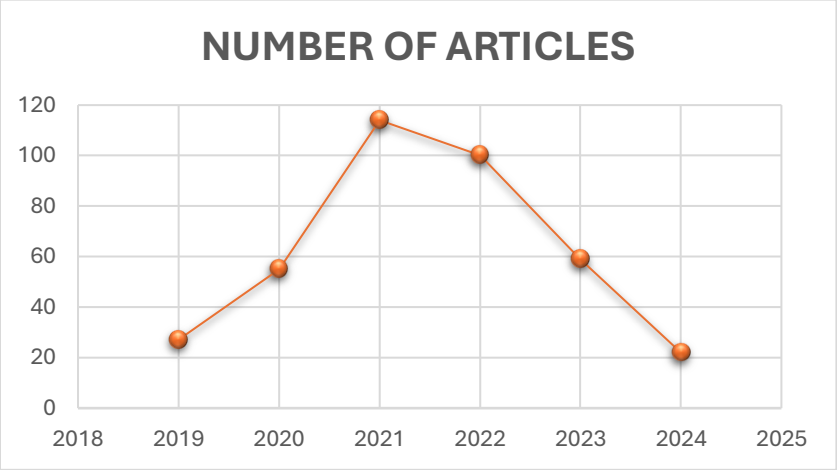

Figure 2. Production capacity of scientific publications entitled "technology" and "teachers" from year to year

Figure 2. Presents the dynamics of the production rate of research on technology for physical education teachers from the period 2019 – 2024. The number of literature relevant to technology for physical education teachers in the 2019 period was only around 25. However, the number of published articles increased to around 55 in 2020, and around 115 in 2021 will be the top stratum in the number of articles available. A very significant decrease occurred in 2022 with 100 articles, in 20223 with 60 articles, and in 2024 with 20 articles. This is likely due to teachers not being updated on technology until it gradually increased in 2021 due to COVID-19, where the learning process that was originally offline became online or distance learning. After that, it decreased due to the lack of further socialization regarding technology among teachers.

Based on the data above, the research results are presented based on search results from Scopus, which are exported in the export filter counts menu and then entered into Excel. From the data that appears, Table 1 presents a list of the names of the ten most active writers from several countries related to technology. Physical education teacher. The country China has (4 articles/documents) with the author Casey, A., which is the country that publishes the most documents in producing and disseminating knowledge, while the least is Ireland, with the author Baek, J.H. obtaining (2 articles/documents).

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Table 1. Most published authors in the fields of technology and teaching

Authors	Country	Document
Casey, A.	China	4
Fedorets, V.M.	United States	3
González-Víllora, S.	Spain	3
Klochko, O.V.	Australia	3
Moreno-Guerrero, A.J.	United Kingdom	3
Sargent, J.	Malaysia	3
Scanlon, D.	South Kore	3
de Araújo, A.C.	Ukraine	3
Almusawi, H.A.	Brazil	2
Baek, J.H.	Ireland	2

Based on Table 2 of the article recapitulation above, there are ten articles most cited in the field of technology and physical education teachers. These are articles that are relevant or very influential in this research. One of the top articles is Varea (Varea et al., 2022a), which received 68 citations with the title "Exploring the changes of physical education in the age of COVID-19," published by the Journal of Physical Education and Sports Pedagogy. Another influential article published in this research regarding technology for physical education teachers is by Sargent et al ., 2020) with the title Flipped Learning, pedagogy and Digital Technology: Establishing Consistent Practice to Optimize Lesson Time, with 54 citations in the European Physical Education Journal Reviews.

Table 2. Most cited articles by the Scopus database about technology and teachers

Title	Authors	Source Title	Citations	Year
Exploring the changes in physical education in the age of COVID-19	Varea V.	Physical Education and Sport Pedagogy	68	2022
Flipped learning, pedagogy, and digital technology: Establishing consistent practice to optimize lesson time	Sargent	European Physical Education Review	54	2020
Applying artificial intelligence in physical	Lee	Sustainability (Switzerland)	53	2021

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education and future perspectives				
Analysis of the Construction of a Personalized Physical Education Teaching System Based on a Cloud Computing Platform	Zhang	Wireless Communications and Mobile Computing 2	49	2020
Physical activity levels, game performance, and friendship goals using two different pedagogical models: Sport Education and Direct Instruction	Rocamora I.	Physical Education and Sport Pedagogy	41	2019
Re-thinking technology adoption in physical education	Wyant J.	Curriculum Studies in Health and Physical Education	41	2019
Innovation in physical education: Teachers' perspectives on readiness for wearable technology integration	Almusawi H.A.	Computers and Education	41	2021
Evaluation of Physical Education Teaching Quality in Colleges Based on the Hybrid Technology of Data Mining and Hidden Markov Model	Zeng Y.	International Journal of Emerging Technologies in Learning	41	2020
Integrating Technology in Physical Education Teacher Education: A Socialization Perspective	Gawrisch D.P.	Department of Kinesiology and Community Health	33	2020
Experiences of teaching and learning in K-12 physical education during COVID-19: an international comparative case study	Howley D.	Physical Education and Sport Pedagogy	29	2022

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The data above was taken from the VOSviewer software. The most visible top authors, namely Varea, Sargent, and Lee, are the top 3 most cited articles. This visualization is to make it easier to show the highest authors.

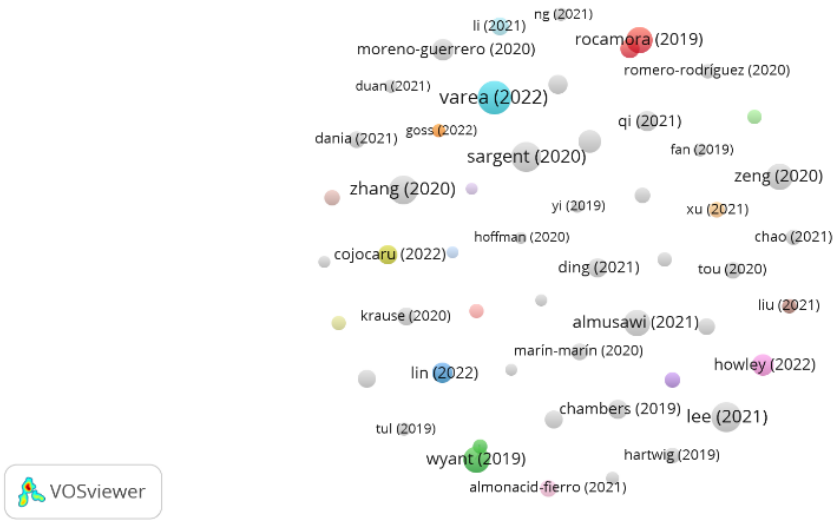

Figure 3. Visualization of the most cited articles in the Scopus database

This analysis helps us build a conceptual map and see the main topics of interest to researchers. It can also point to major trends in technology and teacher research. Identifying keywords and terms that appear together in the same article is called co-occurrence of keywords and terms. Researchers start the analysis by looking at the author's keywords and using VOSviewer. Of the 1070 article titles published in the Scopus database, 377 keywords were found, and only keywords with a minimum of two occurrences were included. Seven groups were created, and each group contained related keywords that appeared in students, technical education, education, learning, and humans. Figure 4 shows the density of high-frequency keyword items.

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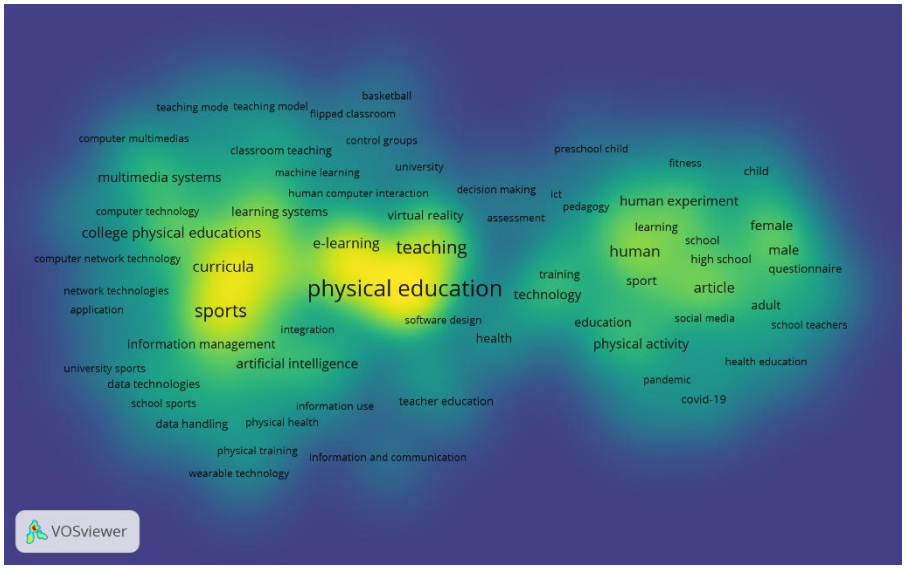

Figure 4. Author keyword network visualization map

The image above has three different colors; the yellow color indicates that fewer articles are being researched regarding topics such as physical education, sports, e-learning, and teaching. The green color indicates that more people are researching the topic, and the blue color indicates that more researchers are researching the topic. This research aims to analyze trending research literature, particularly relating to technology in physical education. To achieve this goal, bibliometric analysis is used. Based on the research findings, the following is an explanation of the discussion related to the research questions.

This research has the main objective, namely, to carry out a bibliometric analysis on research articles related to technology for physical education teachers. Metadata used from the Scopus repository is relevant from 2019-2024. This research provides an overall picture of technology for physical education teachers and produces relevant (Berekbussunova et al., 2024) insights regarding past findings and current conditions. The analysis results section is organized into subsections to meet specific research questions. The pattern of publication and citation data shows an increase in technology among physical education teachers in the decade since 2019.

In terms of growth in the early decades of this study, productivity was seen to fluctuate. This is possibly caused by changes in evolution that have been mentioned by Perdima et al., 2023) regarding the use of technology in the field of physical education,

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which is still very small in Scopus data. The increase in the use of technology among physical education teachers began to be seen in 2020 because, at that time, COVID-19 caused all learning to become online, which made technology start to be useful. The existence of technology makes learning active and innovative (Almusawi & Durugbo, 2024), and there are still many teachers who do not know more about the uses of technology (Aristovnik et al., 2023).

A list of analyses of articles that were very influential in this research can be seen (Varea et al., 2022b), with the title Exploring the changes of physical education in the age of COVID-19 with 68 citations taken from the journal Physical Education and Sport Pedagogy. This research discusses changes in physical education in the COVID-19 era, which have disrupted the educational process. This research focuses on pedagogy and information and communication technology (ICT) and ultimately encourages the exploration of distance learning, such as e-learning.

The keywords used in this research are teachers, physical education, and technology because they are the focus of this research. However, the keywords that dominate the VOSviewer analysis results are 'physical education,' 'sports,' 'learning,' and 'human.' However, in the results of the analysis, there are no 'keywords' that refer to the spectrum of physical education, such as physical education in the scope of the curriculum (Sahin et al., 2023b), leadership (Gazali & Saad, 2023b), instructional Media or Another scope that could be to solve the problem of physical education teachers who are technologically litereate. This raises the question that many of the existing keywords are not focused on physical education teachers. Alternatively, metadata taken from Scopus is not detected by VOSviewer because it is affected by words or something else. This incoming question creates a concern or gap for the researcher.

Discussion

This bibliometric analysis reveals fluctuating publication productivity on technology integration for physical education teachers, peaking at 115 articles in 2021 before declining to 20 by 2024 (Figure 2). This pattern aligns with COVID-19-driven digital shifts documented by Varea et al. (2022), who reported rapid pedagogy changes toward e-learning in physical education, mirroring the 2020-2021 surge from 55 to 115

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publications. However, the post-2021 decline contradicts sustained growth in general educational technology adoption (Burbules et al., 2020), suggesting physical education teachers face unique barriers like low digital confidence (Saiz-González et al., 2025), unlike broader fields where motivation gains persist.

Influential articles, such as Sargent et al.'s (2020) flipped learning framework (54 citations, Table 2) and Lee's (2021) AI applications (53 citations), corroborate top-cited works, emphasizing consistent technology practices to optimize lesson time. These align with TPACK models (Voithofer & Nelson, 2021) in co-authorship networks (Table 1), where multi-country collaborators like Casey, A. (China, 4 docs) dominate. Indicating underrepresentation of developing regions and confirming abstract-noted "distribución geográfica desigual (Amarante et al., 2022).

Keyword co-occurrence (Figure 4) highlights "physical education," "sports," and "e-learning" clusters but omits teacher-specific terms like "digital literacy," echoing gaps in teacher competency studies (Burrows et al., 2021; Zhou et al., 2023). This supports H1 (pandemic peak) but challenges H2 partially, as "educational technology" links exist yet lack curriculum integration depth (Gazali et al., 2021; Sahin et al., 2023b). Compared to (Østerlie et al., 2025), who noted minimal pre-2020 technology in physical education Scopus data, findings extend this by quantifying post-pandemic stagnation, attributable to insufficient training (Thorbecke, 2023).

Geographic and institutional imbalances in results (e.g., China/US dominance) relate to resource disparities highlighted by Fernández-Batanero et al. (2021) on technology stress, where affluent nations lead innovation while others lag. This validates the abstract's global gap call, differing from equitable trends in general bibliometrics (Jiang et al., 2024). Overall, findings reinforce technology's motivational benefits (Alé & Arancibia, 2025) but underscore the need for teacher-focused interventions, bridging literature gaps in bibliometric specificity for physical education (Portela Dos Santos et al., 2022).

Conclussion

This study achieved its objective of conducting a comprehensive bibliometric analysis using VOSviewer to map technology integration trends for physical education

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teachers from 2019-2024 in Scopus, addressing RQ1 (publication productivity) and RQ2 (influential journals/authors/articles).

For RQ1, results confirm H1: productivity peaked at 115 articles in 2021 amid COVID-19 online shifts (from 25 in 2019), then declined to 20 by 2024 (Figure 2), reflecting temporary digital adaptation rather than sustained growth. RQ2 identifies top influencers: authors like Casey, A. (4 docs, Table 1); journals such as Physical Education and Sport Pedagogy; and articles like Varea et al. (2022; 68 citations) on pandemic changes and Sargent et al. (2020; 54 citations) on flipped learning (Table 2, Figure 3). Keyword networks (Figure 4) reveal dominant clusters ("physical education," "e-learning") but gaps in teacher digital literacy, partially supporting H2.

These findings fill a bibliometric void in physical education technology (Belfiore et al., 2019), underscoring needs for teacher training and global equity. Projections include: rising AI/VR integration post-2025 (extending Lee, 2021); ASEAN-focused studies to balance US/China dominance; and policy-driven competency frameworks (per TPACK; Voithofer & Nelson, 2021) to sustain motivation gains (Sungeelee et al., 2024).

Limitations include the English-Scopus focus; future work should incorporate multilingual databases for longitudinal tracking beyond 2024.

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