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ARTICLE

Emerging Technology in Primary Physical Education in Last Decade: A Bibliometric Analysis

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Abstract

Physical education has great potential to be integrated with technology during the implementation. This paper reports bibliometric research on emerging technology in primary physical education during 2015-2024. This study utilizes Dimensions database. We found it consistent last five-years rising in TiP-PE publications; the most document type on Tip-PE was journal articles; Indonesia is the country with highest publication on Tip-PE; and the highest occurrences keyword along with total link strength is the 'Education'. Moreover, the cited performance articles of the TiP-PE covered to the Quartile 1 on Scopus, which implies it has good reputation and credibility. These insights offer a thorough basis for scholars, teachers, and decision-makers to enhance their grasp of TiP-PE, steering upcoming efforts toward creative and meaningful advancements at the pedagogy-technology combination.

Keywords: Bibliometric, Education, Primary School, Physical Education

1. Introduction

The rapid advancement of civilization has brought humanity into the era of Society 5.0, characterized by a human-centered approach to technological innovation. This era emphasizes the responsible use of technology to enhance well-being, efficiency, ethical accountability, and environmental sustainability [1]. Consequently, all aspects of human life have become increasingly integrated with technology, including the field of education. Within this context, the concept of Education 5.0 refers to the fifth revolution in education, which harnesses digital technologies to remove barriers to learning, improve pedagogical approaches, and promote holistic well-being [2].

The subject of physical education (PE) holds significant potential for integration with technology in the learning process. The digitalization of PE learning resources has become a growing trend, and block chain technology—with its features of decentralization and data traceability—offers new opportunities for innovation in this field [3]. The use of various smartphone applications can assist teachers in effectively implementing the PE curriculum while simultaneously enhancing students' physical fitness [4]. Moreover, the incorporation of tablets and mobile fitness applications has been

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shown to positively influence students' intrinsic motivation in PE lessons [5, 6]. The application of such digital devices for pedagogical monitoring in PE facilitates the efficient collection of accurate and objective data, thereby supporting more valid and evidence-based assessment practices [7]. Wearable devices, in particular, can record comprehensive data on students' physical activity, providing teachers with valuable insights into student performance and contributing to the overall effectiveness of PE instruction [8]. However, several barriers and challenges remain in the implementation of digital technologies in PE classrooms [9].

The era of Education 5.0 emphasizes the convergence of advanced technologies—including artificial intelligence (AI), big data analytics, and immersive virtual reality—with collaborative learning strategies and experiential practice [1, 2]. Previous bibliometric studies have primarily focused on the use of virtual and augmented reality in physical education [10] with some examining educational technology in PE learning based on data from the Scopus database [11, 12, 13]. Nonetheless, to date, there has been a lack of bibliometric research specifically addressing the implementation of technology in physical education, particularly at the elementary education level.

Therefore, this study aims to conduct a bibliometric analysis of emerging technologies in primary physical education over the past decade. The objective is to identify publication trends, influential authors, key themes, and existing research gaps within this evolving field.

2. Methods

This study utilized the Dimensions database (http://app.dimensions.ai/) because it provides free access to a comprehensive collection of scholarly publications. Moreover, Dimensions offers approximately 25% greater coverage than Scopus [14, 15]. Bibliometric analysis is an effective method for identifying enduring research trends over time accordingly, this study employed bibliometric techniques using both quantitative and qualitative approaches to examine patterns in publication growth, productive authors and their collaborations, institutional affiliations, publication sources, and the countries of origin of contributing authors. In addition, science mapping was conducted through bibliographic coupling and co-occurrence analyses to identify emerging research themes. The research procedure followed several systematic steps: (1) formulating the study plan, (2) defining the objectives for data analysis, (3) processing the collected data, and (4) summarizing and presenting the findings [16]. The flowchart presented in Figure 1 illustrates the research process undertaken to identify emerging technologies in primary physical education.

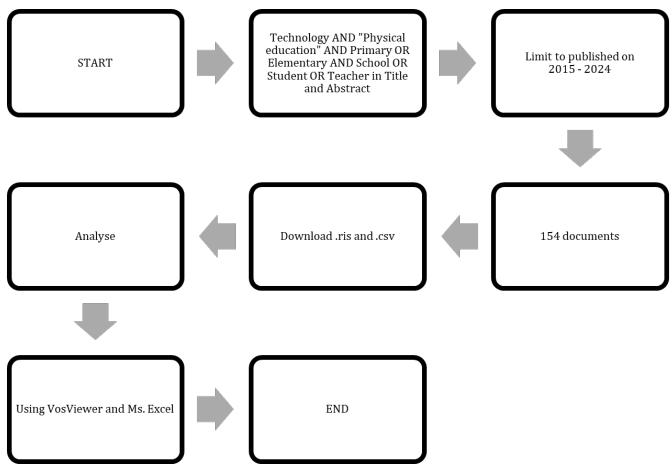

Figure 1. Flowchart of study.

Data collection commenced on March 22, 2025, by searching article titles and abstracts in the Dimensions database using the following keywords: "Technology" AND "Physical Education" AND (Primary OR Elementary) AND (School OR Student OR Teacher). The initial search yielded 178 publications, which were subsequently reduced to 154 after limiting the publication years to the period between 2015 and 2024. To facilitate data analysis, the search results were downloaded from the Dimensions database in both .ris and .csv formats. The data were then imported into VOSviewer and Microsoft Excel for further analysis to identify publication trends, influential authors, and key research themes.

3. Results And Discussion

3.1 Results

3.1.1 Publication Years, Types of Documents, And Top Countries in Technology in Primary Physical Education (TiP-PE)

Figure below depicts the trend of (TiP-PE) during one decade (2015-2024).

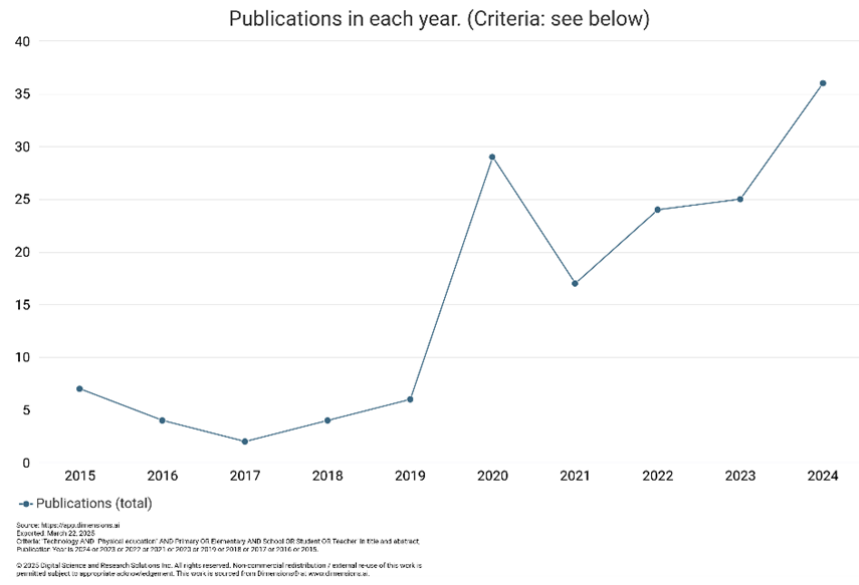

Figure 2. Number Publications of (TiP-PE).

The publication trend in TiP-PE consists of various document types, regardless of their accessibility status. The gathered data reveals the several types of documents published during 2015 to 2024, providing valuable insights for future research. Figure 3 displays the different document types published in TiP-PE.

Based on figure above, the most widely used documents on TiP-PE Publication are article by 120 documents. In addition, book chapters and conference proceedings represent the second and third most common form of documents in the TiP-PE publication, with 23 and 8 documents, respectively. Figure 4 further illustrates the leading countries contributing to TiP-PE publications.

Figure 4 indicates the couples of productive countries in TiP-PE publications. Dimensions records data from 15 countries. According to this information, Indonesia (25) is the leading country in TiP-PE publications from 2015 to 2024 [11, 12, 13].

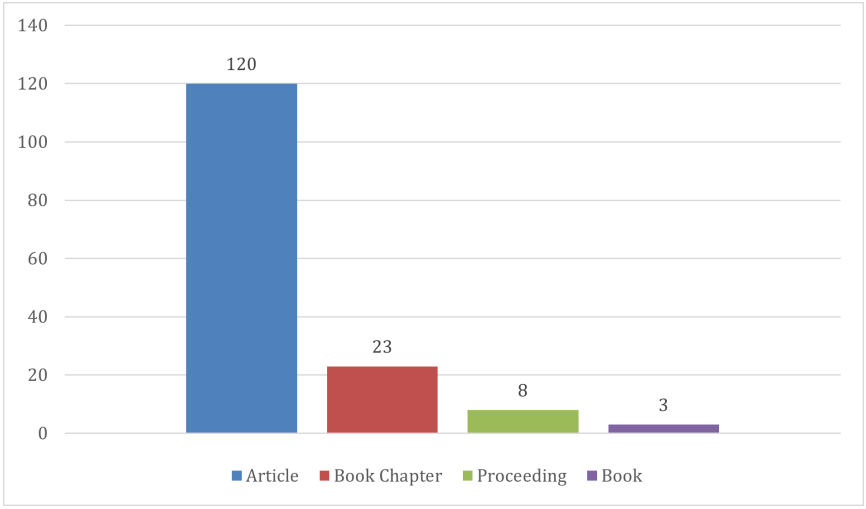

Figure 3. Various Types of TiP-PE Publication Documents.

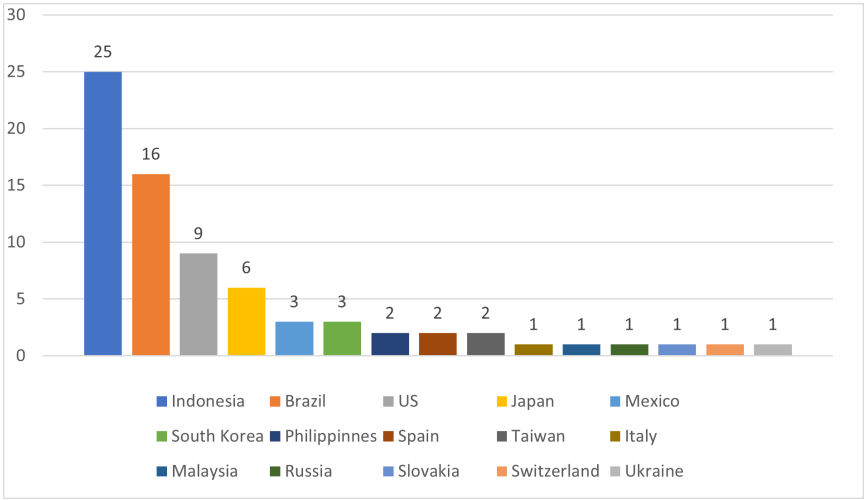

Figure 4. Leading Countries in TiP-PE Publication during 2015-2024.

3.1.2 Visualization of TiP-PE Publication Trends During 2015-2024

Prior to mapping the occurrence of keywords in TiP-PE publications from 2015 to 2024, the most frequent keywords were analyzed, as shown in Table 1. It is evident that the keyword 'Education' has the leading total link strength (15.943) and appears mostly (318 times).

Table 1. Top 20 Occurrence Keyword in TiP-PE Publications.

Keywords	Occurrences	Total Link Strength	Keywords	Occurrences	Total Link Strength
Education	318	15.943	Theory	125	8.779
Physical education	261	10.359	Learning	122	8.962
Student	252	11.560	Child	116	4.451
Technology	225	10.034	Class	99	3.742

Teacher	212	11.517	Practice	97	6.826
Study	201	9.373	Responsibility	96	7.035
Research	143	6..873	Use	93	3.881
Development	135	7.752	Activity	91	2.938
Administrator	130	9.356	Level	89	4.751
School	129	6.185	Game	84	2.255

Metadata keywords are mapped to highlight recommendations for the use of technology-based learning in TiP-PE publications. Research recommendations can be found by analyzing the relationships between rarer or smaller keywords, as shown in Figure 5, which displays whole connected keywords.

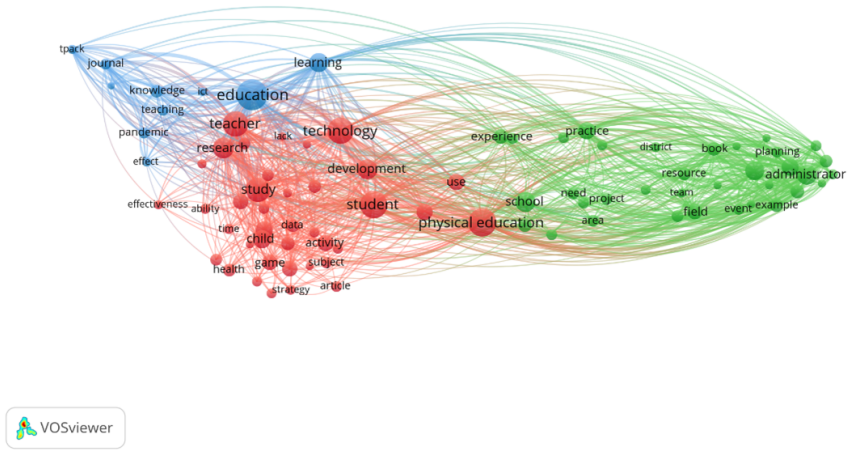

Figure 5. Visualization of Keyword Mapping on TiP-PE Publications in a decade.

Therefore, In order to discover new insights for future TiP-PE research, keywords are narrowed down to the least and most meaningful links, as shown in Figures 6 and 7. The metadata mapping visualization analyzes the relationships between less common or smaller keywords to uncover research novelties from the mapping results.

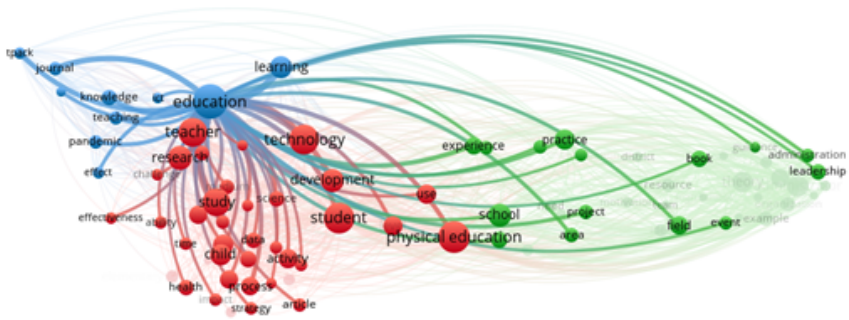

Figure 6. The Top Connected Keyword.

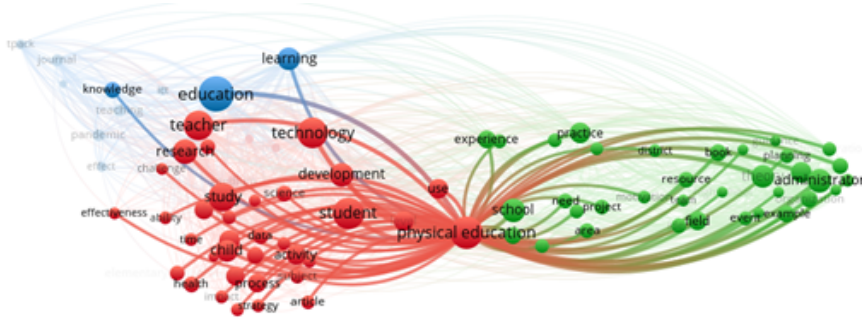

Figure 7. The Top Connected Keyword.

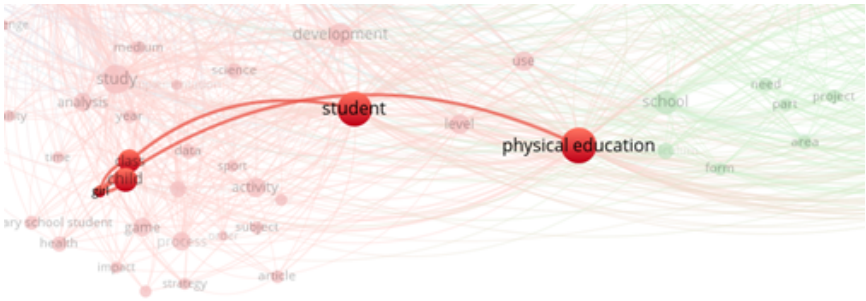

Figure 8. The Least Linked Keyword.

Figure 9. The Least Linked Keyword.

3.1.3 Authors and Their Affiliations

Table 2. Top Authors and their Affiliation in TiP-PE Publications.

Authors	Affiliations	Total
J.D. Greenberg	SHAPE America (Society of Health and Physical Educators)	8
Edgar Omar López-Caudana	Monterrey Institute of Technology and Higher Education, Mexico	3
Hari Yuliarto	Yogyakarta State University, Indonesia	3
Nancy Mazón	National Autonomous University of Mexico, Mexico	2

The list of leading authors and their affiliations in TiP-PE publications from 2015 to 2024 is shown in Table 2, providing guidance for future researchers to undertake, collaborate on, or expand research. Author relationships can be investigated through Vosviewer, are clearly presented in Figure 8.

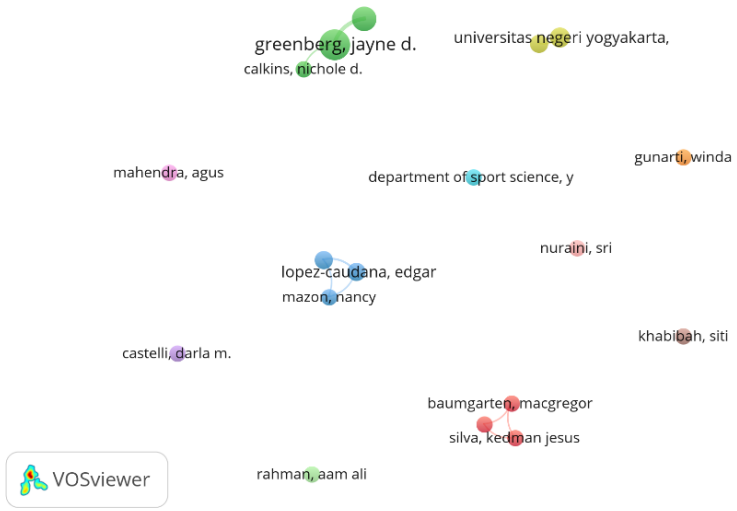

Figure 10. Author Network Visualization in TiP-PE Literature.

3.1.4 Top Subject Areas and Sources of TiP

The analysis of the top subject areas and source titles aims to identify potential domains for the further expansion of TiP-PE research. Several thematic areas within TiP-PE should be broadened, along with related disciplines that require stronger integration to enhance the field's overall development. Table 3 presents the primary subject areas and journal sources of TiP-PE publications from 2015 to 2024,

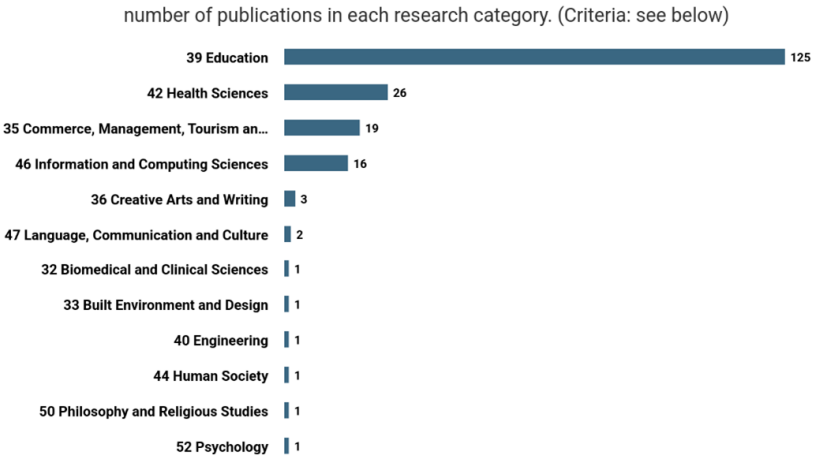

Figure 11. The Most Subject Areas.

Table 3. Journals Source of TiP-PE Publications.

Source Title	Total
Organization and administration of physical education	17
International journal of multidiciplinary research and analysis	7
Scientific Journal of National Pedagogical Dragomanov University Series 15 Scientific and pedagogical problems of physical culture (physical culture and sports)	6
JPUD - Jurnal Pendidikan Usia Dini	5
Retos	4
Caderno de Educação Física e Esporte	3
Journal of Physical Education Recreation	Dance
2	
PLOS ONE	2
Physical Education and Sport Pedagogy	2

3.1.5 Distribution of Top Cited Publication TiP-PE During 2015 to 2024

Table 4 shows the distribution of publications on TiP-PE publication during 2015-2024. ACPP is known as Average Citation Per Paper, the highest rank of the paper distribution noted by the *.

Table 4. Overview of TiP-PE Publications by Year (2014–2025).

Year	Total Publication	Cited	ACCP
2015	7	1	1.43
2016	4	3	26.50
2017	2	3	1.50
2018	4	9	11.75*
2019	6	10	3.50
2020	29	26	4.76
2021	17	60	3.59
2022	24	104	2.29
2023	25	103	0.68
2024	36*	128*	0.22
Total	154	447	2.4875

3.1.6 Publication State of The Art of TiP-PE During 2015 to 2024

In Table 5, previous research is reviewed based on the TiP-PE publications with the highest citations from 2015 to 2024. The chosen publications are related to the education field, identified according to Titles, Abstracts, and Keywords.

Table 5. State of the Art Analysis of TiP-PE Publications During 2015-2024.

Author(s)	Citation	SJR-Percentile (2023)	Findings	Recommendation
[17]	96	1.493 (Q1)-91st on Education Subject area	Using the RO2 wearable device in PE lessons led to more efficient learning, greater player engagement, and elevated heart rates	Exergames combined with wearables device can address several challenges encountered in physical education.

[18]	46	1.312 (Q1)-124th on Education Subject area	Mobile devices, including smartphones and wearables, play a significant role in advancing physical education and professional training, promoting the growth of both physical and social fitness. Despite this, the overall use of wearable technologies is still somewhat limited.	Most of the attention has been given to university communities, but there is a need for more focus on students in junior high, senior high, and elementary schools. At this point, the types of sports included in mobile learning are limited, with a predominant focus on dynamic physical education. The application of mainstream mobile learning strategies in physical education is also constrained. Consequently, several research directions for mobile technologies in physical education are recommended.
[19]	37	1.273 (Q1)-129th on Education Subject area	App-integrated PE classes over a two-week period were ineffective in reducing children's sedentary behavior and improving light PA, MVPA, or PA-related beliefs.	Teachers are encouraged to ensure that iPads and apps are integrated with the goals of physical education. The selection of apps and the strategies for using them should be carefully planned to prevent reducing children's physical activity in favor of efficient management or focusing too heavily on other subjects.
[20]	35	0.839 (Q1)-19th on Multidisciplinary Subject area	Both boys and girls experienced improvements in mood and self-esteem after engaging in exergames, with girls demonstrating greater positive acute effects.	The creation of a task-centered environment in class is important for encouraging positive experiences for both sexes, facilitating student development, and promoting more active behaviors that contribute to better mental health in children.
[21]	26	0.839 (Q1)-19th on Multidisciplinary Subject area	Despite the challenge of separating the effects of gamification and exergaming, gamification appeared to generate more overall positive feelings and motivation among most students. Exergames, however, were more effective in making the experience enjoyable and improving motor learning. Although there is scientific interest in understanding their separate effects, the combination of gamification as a method and exergaming as a tool holds considerable value in terms of pedagogy.	A future research opportunity could involve examining how these interventions affect different genders. Additionally, incorporating other key participants in the school community, such as group tutors or parents, would be an interesting research focus.

3.2 Discussion

As illustrated in Figure 2, the number of publications on TiP-PE exhibited fluctuating trends between 2015 and 2024. The lowest number of publications was recorded in 2017, with only two articles, followed by a sharp increase in early 2020, reaching 29 publications. This upward trend was largely driven by the global COVID-19 pandemic, which accelerated the adoption of new educational formats centered on online learning and the integration of information and communication technologies (ICT) [22]. Along with this phenomenon, the trend of TiP-PE publications has also increased [23]. Despite experiencing a decrease in the number of publications in the following year in 2021

[24], Tip-PE publications experienced a consistent increase from 2022 to 2024 [25].

In recent years, the use of technology in learning in Indonesia has experienced very significant growth [26]. In the last decade, Indonesia has become the country that has conducted the most research on Tip-PE with 25 publications and 29 citations. The results of the Vosviewer on Countries Bibliographic coupling analysis show that there are 3 Clusters including: Cluster 1 (4 items) Including Brazil, South Korea, Spain, and Taiwan; Cluster 2 (3 items) Including Indonesia, Malaysia, and Philippines; And the cluster 3 (3 items) Including Japan, Switzerland, and US.

According to Table 1, 'Education' become the top keyword of TiP-PE publications. In addition, 'Physical Education' take the second order with total link strength of 10.359 and occurrences 261. Furthermore, it followed by Student, Technology, Teacher, Study, Research, Development, Administrator, School, and others. This pattern reveals the trends in TiP-PE publications over the past decade: 1) as a part of physical education theory; 2) Related to whole learning components including primary school student, teacher, study, and administrator; 3) Research and development on various technology can be implemented on PE; 4) Implementing practice using physical activity-game based [27, 28, 29, 30].

The mapping visualization on figure 5 shows that there are three main clusters of term co-occurences throughout all TiP-PE documents. Cluster 1 (red node) with total of 39 items, contain of ability, activity, analysis, article, challenge, child, class, data, development, elementary school, and the others. Cluster 2 (green node) with total of 35 items, including addition, administration, administrator, area, book, communication, curriculum, district, event, experience, and the others. Cluster 3 (blue node) with total of 10 items contain of education, effect, ict, international journal, journal, knowledge, learning, pandemic, teaching, and tpack.

Figure 6 illustrates the keywords most frequently linked in TiP-PE publications, the keyword 'Education' and 'Physical education' has the highest occurences with another subject area identified on Tip-PE. In contrast to Figure 7, it shows that 'girl' and 'robotic' are the least linked keywords with 'Physical Education'. Therefore, It is essentials for researchers focusing on leading trends in TiP-PE, there's still significant scope for exploration. There are various ways TiP-PE can support and advance education; for example, adopting a hybrid teaching model may boost physical activity levels among adolescent girls during lessons [31]. Another recommendation can be given Using robotic technology in PE lessons helps engage children more effectively, increasing their enthusiasm for class activities [32, 33].

Illustrated on Figure 10, J.D. Greenberg is the most productive author (8 publication), followed by E.O. Caudana (3 publication), H. Yuliarto (3 publication) And N. Mazon (2 publication). However, the most cited author is Lindberg by 1 only document (96 citation). Based on analysis, many authors are not linked to each other. Relate to authors data before, SHAPE America (Society of Health and Physical Educators) is the top affiliation conducted publication on TiP-PE, followed by Monterrey Institute of Technology and Higher Education, Yogyakarta State University, and National Autonomous University of Mexico.

According to Table 3, the top subject areas are Education, with total of 125 subject area. Health Science are second, followed by Commerce, management and tourism, Information and Computing Science, Creative Art and Writing, and so on. The top source title, namely the Organization and administration of physical education by 601 documents then followed by International journal of multidiciplinary research and analysis, Scientific Journal of National Pedagogical Dragomanov University Series 15 Scientific and pedagogical problems of physical culture (physical culture and sports), JPUD - Jurnal Pendidikan Usia Dini, Retos, Caderno de Educação Física e Esporte, Journal of Physical Education Recreation & Dance, PLOS ONE, Physical Education and Sport Pedagogy. To

examine the innovative focus of TiP-PE publications, the subject areas and source titles were strategically analyzed through mapping [10].

As shown in Table 4, we found that 2024 had the highest number of publications (36). Relate to data before, in the same year has the most cited paper (128). However, 2018 is the highest ACPP. In contrast, the fewest papers can be found during 2017 (2). The total number of papers on a decade is 154, with 447 citations and 2,4875 ACPP. According to Table 5, State of the Art Analysis of TiP-PE Publications During 2015-2024 found that using the RO2 wearable device in PE lessons led to more efficient learning, greater player engagement, and elevated heart rates. However, the overall use of wearable technologies is still somewhat limited. In contrast, App-integrated PE classes over a two-week period were ineffective in reducing children's sedentary behavior and improving light PA, MVPA, or PA-related beliefs. Another top cited research on Tip-PE shows that gamification provided a greater overall positive feeling and more motivation in most students on PE class, but exergames practice showed higher positive mood and self-esteem effects in girls [20, 34, 35].

The findings suggest that TiP-PE research is heading toward emerging technologies like engineering education, guided by key terms. Additionally, linking TiP-PE with robotics integration appears promising for boosting primary students' engagement in PE [36, 37, 38]. These potential research paths in educational fields are illustrated in Figure 10.

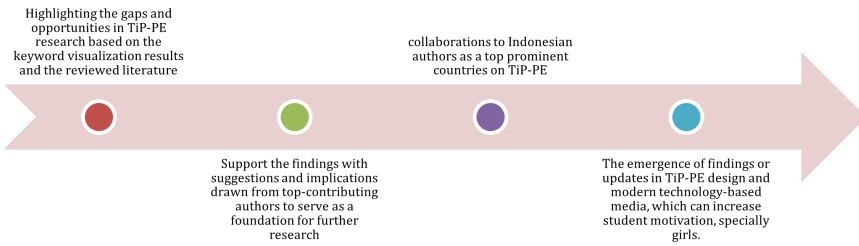

Figure 12. Research Roadmap to TiP-PE for Future Research.

Based on the Figure 10, Future research on TiP-PE is encouraged, guided by keyword visualization results and potential collaboration with Indonesia, the country showing the strongest link strength in TiP-PE publications. Alternatively, researchers may also consider referencing the work of Greenberg and Caudana for the top author according to number of publications on TiP-PE. Also, it is recommended to collecting reference on top source about TiP-PE namely Organization and administration of physical education; and International journal of multidiciplinary research and analysis. Based on the Table 5, several research issues for mobile technologies in physical education are recommended. However, selection of apps and pedagogy of app use need to be carefully thought out to prevent compromising children's PA for the sake of efficient management or emphasis on other learning domains. It could also be valuable to investigate how these interventions affect different genders as a potential area for future research [39, 40].

Based on discussion above, the integration of technology into elementary physical education (PE) has accelerated over the past decade, driven by the dual imperatives of enhancing motor skill development and fostering lifelong engagement in physical activity. Unlike general educational technology (EdTech) or traditional PE research, TiP-PE research is uniquely situated at the intersection of developmental pedagogy and application of technological tools. When viewed from the perspective of the pedagogical strategies used, research on Tip-PE often employs Design-Based Research (DBR) to develop digital pedagogical strategies with a focus on gamification and virtual environments [21,

41]. Research in the field of educational technology (EdTech) also uses the DBR pedagogical approach, but often lacks context specificity due to its broader objectives and scope [42]. Meanwhile, research in physical education (PE) generally uses pedagogical strategies that emphasize curriculum innovation and teacher collaboration, but lacks focus on digital aspects [41].

Another comparison that can be identified is based on the application of the technological tools used. Most of TiP-PE research using wearable device to provide real-time motion monitoring to optimize physical and health outcomes. Some of them also use smartphones and AI to enables personalized teaching plans, adapting content and standards to individual student needs [18, 43, 44]. Meanwhile, EdTech uses a wider variety of devices, including mobile devices, VR/AR, cloud computing, and social media, but lacks focus on the development of physical/motor skills [45]. In contrast, digital tools are less used for assessment and instruction on traditional physical education [41].

Elementary PE technology research is marked by its context-specific, leveraging interactive tools and pedagogical models to enhance both physical and motivational outcomes. However, digital inequality, teacher preparedness, and ethical concerns remain significant barriers to widespread adoption. In the end, more research on TiP-PE is expected to provide more practical implications and recommendations in the fields of technology, physical education, and elementary education.

4. Conclusion

The comprehensive bibliometric analysis of Technology in Primary Physical Education (TiP-PE) publications over the past decade (2015–2024), utilizing the Dimensions database, VOSviewer, and Microsoft Excel, provides significant insights and establishes a foundation for future research. The findings reveal several noteworthy trends, including a steady increase in TiP-PE publications over the last five years, the predominance of journal articles as the primary document type, and Indonesia's leading contribution to the field. Furthermore, the identification of key contributors such as Greenberg, Caudana, and Linberg, along with their institutional affiliations, underscores the collaborative nature and international scope of TiP-PE research.

Based on these results, several recommendations for future research can be proposed. First, researchers are encouraged to explore emerging themes identified in this study, such as the integration of robotics technology and mobile-based applications in primary physical education classes, as well as the differential effects of these technological interventions across genders. Additionally, the observed temporal patterns and the strong reliability of TiP-PE publications highlight the importance of sustained collaboration and the exploration of more specialized or niche areas within the field. Cross-institutional and cross-national partnerships are particularly valuable for advancing academic discourse and promoting interdisciplinary innovation.

In summary, the conclusions and proposed research directions derived from this study provide a meaningful foundation for deepening understanding and advancing the development of TiP-PE within both academic and policy contexts. These insights are expected to shape future research and practical applications, fostering meaningful innovations at the intersection of technology and pedagogy, particularly in the context of primary education.

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