

Research article

The role of pre-service physical education teachers in physical education – A bibliometric and systematic review

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ABSTRACT

Pre-service physical education teachers (PSPTs) have long been an important area of specific development in physical education and have become a significant force in the field of physical education and research over the past two decades. However, exploratory research on pre-service teachers remains relatively scarce, and lack a comprehensive scientific exploration of the scope of their role. Therefore, this study provides a comprehensive overview of pre-service physical education teacher education (PETE) from both a broad and specific perspective. Specifically, it includes the current state of PETE, the most influential authors, countries, journals, and literature, as well as specific research topics and future directions within PETE. Following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, a total of 340 articles were included, with 84 of them being empirical studies. The findings reveal that teacher training, diversity, equity, and inclusion in education, educational attitudes and beliefs, educational quality, educational methods and technology, career motivation, teaching models and strategies, and teacher assessment and reflection are major research themes. Visual analysis of the application of pre-service physical education teacher research highlights teacher training, diversity, equity, and inclusion in education, as well as instructional technology, as key areas of future focus. These insights contribute to the reasonable application of bibliometrics in the field of pre-service physical education teacher research.

1. Introduction

Pre-service physical education teachers (PSPTs) serve as a vital reserve force for school physical education (PE), destined to become future coaches and physical education instructors. In the context of an ever-increasing emphasis on the quality of PE in schools and student physical activity, playing a crucial role in the realm of school education. PE holds significant importance in international society for education and physical health, particularly the training of pre-service teachers, such as PSPTs [1,2].

PE courses, as a means to promote students' understanding of health and cultivate a positive lifestyle, satisfy intrinsic needs through high-quality PE. The pivotal factor in achieving these outcomes lies in the hands of PE teachers [3]. Through classroom education, teachers not only enhance students' health but also develop their teamwork, leadership skills, and self-discipline. The effectiveness of this instruction is contingent upon the teachers' qualifications and the teaching methods at their disposal [4]. Consequently, there is a significant call among researchers to investigate how PSPTs can enhance their teaching capabilities and learn to utilize PE effectively [5,6]. However, the process of preparing PE teachers faces several challenges. Besides possessing a certain level of sports knowledge and skills, teachers must also exhibit flexible teaching methods and a keen sense of educational innovation [7].

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The training of PSPTs necessitates a comprehensive educational approach that combines classroom learning with practical teaching [8]. Through PE classes, students enhance their cognitive abilities, health, motor skills, self-esteem, social skills, and academic achievements [9–11]. As future PSPTs, they need to possess the skills required to effectively convey this knowledge and competence, ensuring that students are influenced by the right values in PE [12]. Moreover, they should understand the current trends, concepts, and models in PE [13], as well as the psychology and characteristics of students at different age levels [14]. However, cultivating prospective physical education teachers is no easy task, as they need to possess not only sports knowledge and skills but also flexible teaching methods and a keen awareness of educational innovation [15]. However, all of this necessitates a deep understanding of the current research landscape to identify specific directions and content improvements in the development of pre-service physical education teacher education.

Current research indicates that there are certain issues in the training of PSPTs including the lack of comprehensiveness and modernity in the content and methods of training courses, which fail to meet the inherent needs of students [16,17]. Furthermore, it is imperative to gain an understanding of the training programs and practices in different countries and regions to better facilitate the development of PSPTs [18]. Specifically, this pertains to enhancing the fundamental qualities and capabilities of PSPTs, enabling them to better meet the educational needs of students and gain the trust of parents, thereby promoting the development of PE [19]. Cretu and Morandau [20] conducted a bibliometric analysis of over 250 primary teacher education disciplines in accordance with international education requirements, addressing the intersection of teacher education with Inclusive Education (IE), there remains a gap in understanding the dynamic trends concerning PSPTs. The aim of this paper is to systematically analyze and explore the research dynamics in the field of preparing physical education teachers, revealing the challenges and opportunities in their training. Through an in-depth examination of current research related to PSPTs, we hope to gain a better understanding of the changes in this field and provide targeted recommendations for future training.

2. Literature review

2.1. Role of PSPTs

PSPTs typically denote students or educational professionals undergoing training to specialize in PE. As the guides, leaders, and knowledge transmitters in PE classrooms, physical education teachers significantly influence students' lives [21]. The training of PSPTs goes beyond educational competence, emphasizing the use of effective teaching methods and the implementation of PE activities in diverse contexts [22]. Sevimli-Celik [15] research explores changes in the attitudes and knowledge of PSPTs working with young children during the development of physical skills and examines their methods in actual teaching. In a study by Lijuan Wang and Ha [23] 20 PSPTs were interviewed, revealing that the majority of young PSPTs preferred using the Teaching Games for Understanding (TGfU) instructional model. They found this approach, grounded on game activities, increased student engagement, stimulated critical thinking, and proves applicable to students with varying skill levels.

2.2. Current status of PSPTs

Research suggests a rising trend among young PSPTs in embracing the TGfU model in the field of PE [24]. However, it is crucial to recognize that this inclination may, in part, stem from a lack of guidance and collaborative opportunities with in-service teachers, leading them to prefer a skill-based TGfU approach [16]. Consequently, the training of PSPTs becomes pivotal. The configuration of course and training programs plays a significant role in influencing the development of knowledge and skills among PE teachers [25, 26]. Herold and Waring [27] underscore the considerable impact of various practice communities on the development of PSPTs, emphasizing the need to optimize and refine school PE internship departments and university-based internship communities.

The teaching methods adopted by PSPTs during actual education, including teaching strategies, curriculum design, student engagement, and assessment methods, all impact the physical development of students [28–30]. Thus, learning and optimizing teaching methods are conducive to PE teachers enhancing teaching quality [31]. Calderón, Scanlon, MacPhail and Moody [32] recommend introducing blended learning methods into PETE programs and staying in tune with the times. They encourage learning and applying digital technologies to promote learning in different environments and ensure the sustainable development of teacher education and training.

The attitudes and teaching abilities of PSPTs change during their teaching tenure [33]. Research has found that PE teachers at different career stages perceive and cope with stress differently. Schäfer, Pels, von Haaren-Mack and Kleinert [7] conducted a stress perception questionnaire test on 256 in-service teachers, 120 PSPTs, and 259 PE students. They found that PSPTs had significantly higher stress perception values compared to teachers and students, with avoidance coping positively correlated with stress perception. Furthermore, Abakay, Alincak and Demir [34], through a 13-week microteaching practice, measured the attitudes of PSPTs and in-service teachers toward the teaching profession. The results indicated that pre-service teachers held a higher attitude toward the teaching profession, and microteaching practice had a positive impact on teachers' professional attitudes.

2.3. The critical role of PSPT

PSPTs often exhibit a lack of confidence in applying their acquired knowledge in classroom teaching, and they struggle to integrate theoretical knowledge with practical teaching [35]. This results in a lack of confidence among prospective teachers in educational practice, necessitating more training and learning in physical education teaching knowledge to truly enhance the quality of education

and confidently tackle challenges. For instance, through video assessments of classroom pedagogy, prospective teachers show higher acceptance of intuitive teaching behaviors compared to in-service teachers, but their practical skills are lower. Addressing this challenge emphasizes the importance of strengthening cooperation and instructional guidance between in-service and prospective teachers [36]. Therefore, the flexible use of teaching methods and effective guidance are key aspects of prospective teacher training.

2.4. The value of bibliometrics

Based on the previous research on PSPTs, this study opts for a bibliometric review. Bibliometrics is a quantitative analysis discipline that employs mathematical and statistical methodologies to uncover the development and characteristics of a particular academic field through various aspects of papers and academic journals (authors, content, topics, research method, citations, etc.) [37]. Quantitative analysis can objectively evaluate performance and be used without bias since it relies on semi-automated and quantitative data and tools [38]. Bibliometrics can scrutinize existing literature specific to each field [39] and provide in-depth information analysis, including keywords, journals, countries, references, etc. Modern computer science technologies allow for graphical and visual results, as well as reverse interpretations through bibliometric literature reviews [40].

Up to the present, previous studies have systematically analyzed the satisfaction of physical education teachers in aspects such as leadership, professionalism, self-efficacy, and retention [41]. However, research on the inclusive attitudes of PSPTs [42], explorations of teaching methods [43], and the investigation of students with special education needs in the training of PSPTs has not been thoroughly organized and summarized [44]. Given this gap, our current study is deemed essential. In summary, within the field of research on prospective physical education teachers, we have observed a lack of systematic reviews, with most studies focusing on specific aspects of PSPTs independently. Therefore, this study aims to conduct an in-depth analysis of research on PSPTs over the past 30 years (1995–2023) by examining research topics, influential publications and authors, as well as variations in geographical sources. Specifically, this paper will explore the following three research questions.

RQ1. What is the current status of PSPTs?

RQ2. Who are the most influential authors, countries, journals, and publications related to PSPTs?

RQ3. What are the specific research topics of PSPTs and what are the future research directions?

3. Method

To assess the current research status of PSPTs, a systematic review was conducted from 1995 to the end of March 2023, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles as described by Ref. [45]. The PRISMA guidelines consist of 27 items and a four-phase flow diagram. The flow diagram is a visual representation of the process for selecting studies, including how many records were identified, screened, assessed for eligibility, and included in the review (see Table 1.).

3.1. Data collection

Relevant literature was retrieved by searching the core database Web of Science (WOS). WOS is widely recognized as one of the most authoritative and reputable publishers' databases [20,46]. The period selected for the database search was from 1995 to the end of March 2023, and it was limited to studies published in English in peer-reviewed journals. Given that the first article related to PSPTs dates back to 1995, so we have chosen 1995 as the starting point.

3.2. Identification of search terms and inclusion criteria

Search strategies were formulated according to the specific requirements of the database. The search strategy used was TS= ((Pre-Physical Education Teachers) OR (Preparatory Physical Education Teacher) OR (Pre-Service Physical Education Teachers)). The search criteria aimed to identify articles associated with the current research status of PSPTs. In alignment with the research objectives, inclusion and exclusion criteria were applied, as summarized in Table 1.

Table 1
Summary of inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
1. Research primarily focused on pre-service physical education teachers.	1. Research sourced from conference proceedings, books, magazines, news, and posters.
2. Studies must report on research involving pre-service physical education teachers in physical education.	2. Research unrelated to pre-service physical education teachers (including duplicate articles).
3. These studies should be published in peer-reviewed journals.	3. Simple reports should be excluded.
4. Research articles must be in English.	
5. Full-text availability is required.	

3.3. Data analysis

All selected articles underwent an analysis for their publication volume using bibliometric packages and VOSviewer software (see Fig. 1.). The initial search, employing the aforementioned search terms, resulted in 548 articles. Following a review of article types, with a primarily focusing on research papers, 473 articles remained, of which 433 were in English. Subsequently, duplicates were removed, reducing the number of articles to 340 based on title and abstract. This reduction was achieved through manual screening, involving two individuals independently reviewing and comparing articles to ensure the study’s reliability [47]. The agreement between the two reviewers was assessed using the widely employed inter-rater reliability calculation in educational statistics and measurement. Comparing the literature selected by two individuals and conducting an analysis using the inter-rater reliability commonly used in educational statistics and measurement, the results reveal that the number of completely identical articles selected by both individuals is 338 (with M being 335 and the total N being 340). Further discussion led to the inclusion of all 340 articles. These articles were included for the final analysis, and the average inter-agreement was calculated as well as the Newcastle-Ottawa Scale (NOS) to calculate the consistency.

The inter-rater reliability (agreement) was calculated as follows:

$$K\text{value(averageinter-agreement)}k = \frac{M}{N} * 100\%$$

$$\text{Reliability (R)} R = \frac{n * k}{1 + (n - 1) * k}$$

The K value is 98.5%, and the reliability (R) is 0.9967, which is greater than 0.9. This indicates that the agreement between the two reviewers is excellent, as a reliability value above 0.9 is considered highly reliable [47].

For data analysis, various sustainable graphing techniques were employed to understand the current research status of PSPTs. The analysis initiated with a systematic examination of the primary keywords in the current research, clustering them to identify overarching research themes. Furthermore, a network of exchanges between countries involved in this field of study and the core centrality of primary research authors were plotted and analyzed, emphasizing collaborative patterns. Descriptive and bibliometric analysis was conducted utilizing Bibliometric packages and VOSviewer software [48].

4. Results

Current publication trends for PSPTs are illustrated in Fig. 2. Examining the overall scenario, the first research related to PSPTs emerged in 1995. Starting from 2008, publications exhibited a continuous growth trend, reaching a peak of 42 articles in 2022. Educators and researchers in the field of PE have increasingly directed their focus toward the role of PSPTs.

For data collection, this study utilized 340 articles authored by 776 researchers across 47 countries, published in 106 journals. These articles cited 12,684 references from 5756 journals, with 104 journals having individual articles cited more than 20 times. This underscores the significance and influence of these journals in the realm of research on PSPTs.

4.1. RQ1: research topics in PSPTs

To identify the research topics, a keyword clustering analysis was performed on the collected data. This analysis revealed six main research themes in the field of PSPTs, represented by different colours (red, purple, dark blue, light blue, green, and yellow) in Fig. 3.

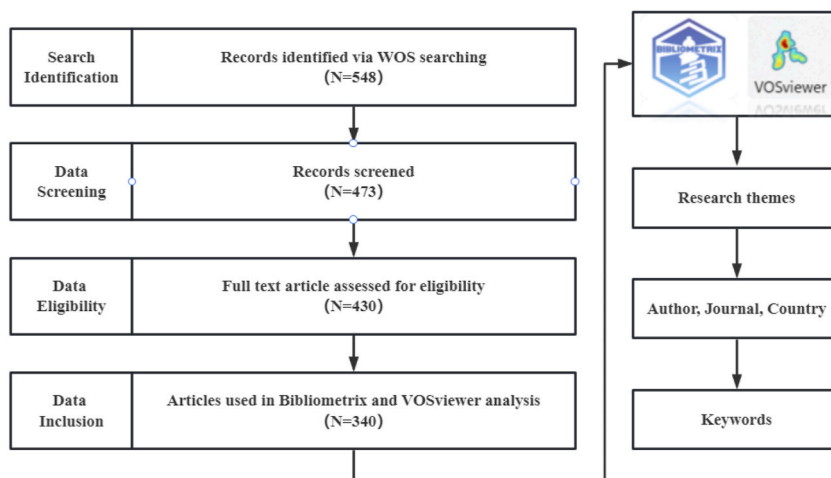


Fig. 1. Flowchart of analytical steps.

co-occurrence network analysis allows us to understand the interrelationships between authors, journals, and publications in the field of PSPTs [50]. In this section, we conducted a co-citation analysis to identify the most influential authors, journals, and publications in the PSPTs field.

4.2.1. Author co-citation network analysis

Author co-citation analysis helps identify influential authors in a particular field, revealing scholars who have made a significant impact in that area. The number of co-citations an author receives signifies their influence within a specific field [51]. In this study, we conducted an author co-citation network analysis using VOSviewer (see Fig. 4.) and identified the top 11 influential authors based on their co-citation frequency (see Table 2.). The results highlight these 11 scholars as highly influential figures in the PSPTs field, providing theoretical and practical foundations for the continued development and exploration of PSPTs. Among these authors, Ann Macphail has the highest co-citation count at 355, signifying her significant contributions to the field of PSPTs. Following her are Valeria Varea (218) and Tim Fletcher (165). Therefore, these authors are among the most influential in the field of PSPTs.

4.2.2. Country analysis

Fig. 5 reports the top 10 countries ranked by the number of published papers and illustrates the relationships between these countries. The United States (USA) has the highest number of published papers (76), followed by Australia (69), Ireland (40), Spain (33), the United Kingdom (30), Canada (27), China (16), Turkey (15), South Korea (11), and Germany (11). The results show that North America and Australia hold a prominent position in the PSPTs field compared to other regions and countries. These regions are economically developed, aligning with previous research findings such as those of McEvoy, MacPhail and Heikinaro-Johansson [52].

4.2.3. Journal co-citation network analysis

Co-cited journals refer to articles that simultaneously cite at least two journals in the same piece, and the number of co-citations can effectively reflect a journal's professionalism in a particular field [53]. In this study, journal co-citation network analysis using the Bibliometric package. The top 10 co-cited journals based on the number of co-citations, journals' Impact Factor (IF) and Journal Citation Index (JCI) in Table 3. JCI is used to measure a journal's average category-normalized citation impact in the last three years, with a value of 1 indicating the field's average [54]. It is evident that most journals have a JCI greater than 1, signifying their significant influence and ensuring the quality of the studies included in the analysis. *European Physical Education Review* had the highest number of citations in the PSPTs field (80), followed by *Physical Education and Sport Pedagogy* (73) and *Sport Education and Society* (41).

4.2.4. Journal co-citation network analysis

References are a crucial part of any research, and co-citation of references is a widely used method to understand the knowledge structure within a specific field. In Fig. 6., the size of the circles represents the number of citations, and the connecting lines between two nodes represent co-citation relationships between two articles. The color-coding represents clusters within the same category [48]. Table 4 presents the top 10 highly co-cited literature in the PSPTs field. These 10 papers have had a significant impact on PSPT research. Specifically, Shulman [55] has been cited 34 times, followed by Curtner-Smith et al. (2008) and Richards et al. (2014) with 32 and 24 citations, respectively.

4.3. Specific research directions in PSPTs

In the selected studies, it was found that research on the participants was conducted in a total of 151 studies (44.4%), including 83 (24.4%) quantitative studies, 65 (19.1%) qualitative studies, and 3 (0.9%) mixed methods studies in Fig. 7. Quantitative research is the dominant research method in this field. These 151 studies included a total of 24,748 participants, with sample sizes ranging from 1

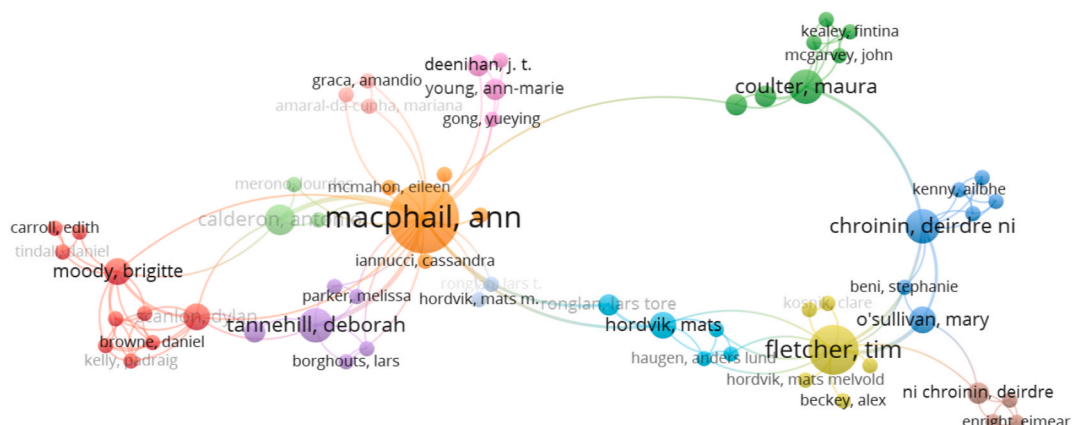


Fig. 4. Co-citation network of authors.

Table 2
The top 11 influential authors based on the number of citations.

Rank	Author	Publications	Citations	Average citations
1	Macphail. Ann	22	355	16.1
2	Varea. Valeria	8	218	27.25
3	Fletcher. Tim	10	165	16.5
4	Wrench. Alison	8	114	14.25
5	Garrett. Robyne	5	98	19.6
6	Tannehill. Deborah	5	97	19.4
7	Luguetti. Carla	5	72	14.4
8	Herold. Frank	5	65	13
9	Chroinin. Deirdre Ni	5	52	10.4
10	Wang. Lijuan	5	50	10
11	Coulter. Maura	5	46	9.2

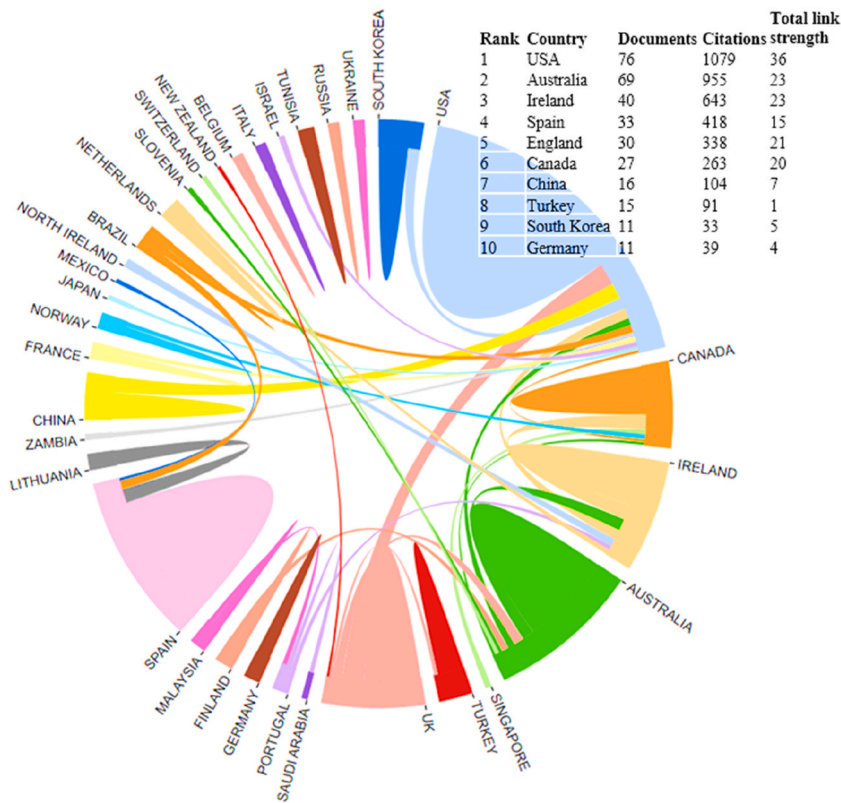


Fig. 5. Relationships between the number of papers published by countries.

Table 3
Top 10 key journals ranked by number of citations.

Rank	Journal	IF	JCI	Articles	Citations	Average Citations
1	<i>European Physical Education Review</i>	3.4	1.67	47	80	1.7
2	<i>Physical Education and Sport Pedagogy</i>	3.6	1.96	47	73	1.55
3	<i>Sport Education and Society</i>	2.9	1.19	31	41	1.32
4	<i>Quest</i>	2.8	0.99	11	23	2.09
5	<i>Asia Pacific Journal Teacher Education</i>	2.3	1.07	7	20	2.86
6	<i>Teaching and Teacher Education</i>	3.9	2.00	11	17	1.55
7	<i>Journal of Teaching in Physical Education</i>	2.8	1.45	9	16	1.78
8	<i>Sustainability</i>	3.9	0.68	11	9	0.82
9	<i>Journal of Curriculum Studies</i>	2.1	1.00	1	9	9.00
10	<i>Plos One</i>	3.7	0.91	3	4	1.33

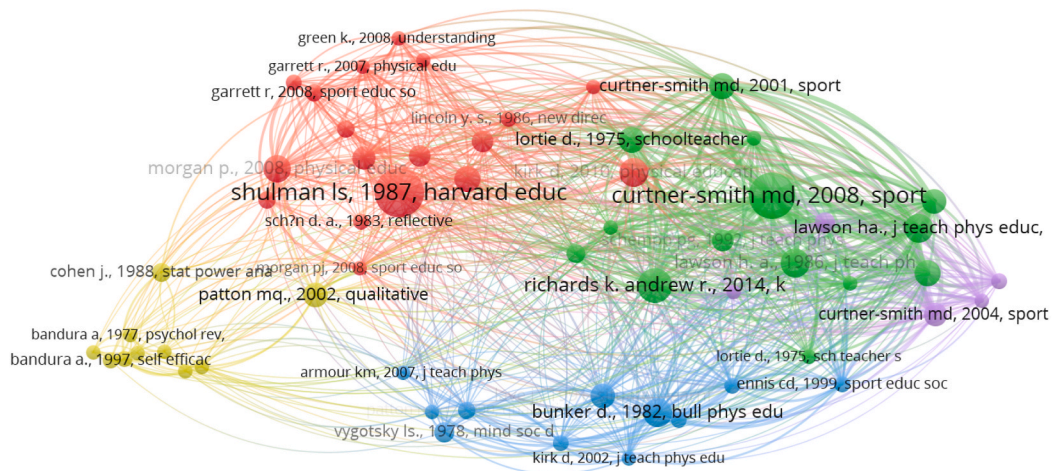


Fig. 6. Network of co-cited literature.

Table 4
Top 10 Key literature according to the number of co-citations.

Rank	Articles	Citations	Journal
1	[55]	34	Harvard Educational Review
2	[112]	32	Sport, Education and Society
3	[113]	24	Kinesiology Review
4	[89]	20	Journal of Teaching in Physical Education
5	[90]	20	Journal of Teaching in Physical Education
6	[114]	20	Bulletin of Physical Education
7	[91]	19	Movimento
8	[115]	18	Research Quarterly for Exercise and Sport
9	[116]	18	Journal of Teaching in Physical Education
10	[117]	18	Sport, Education and Society

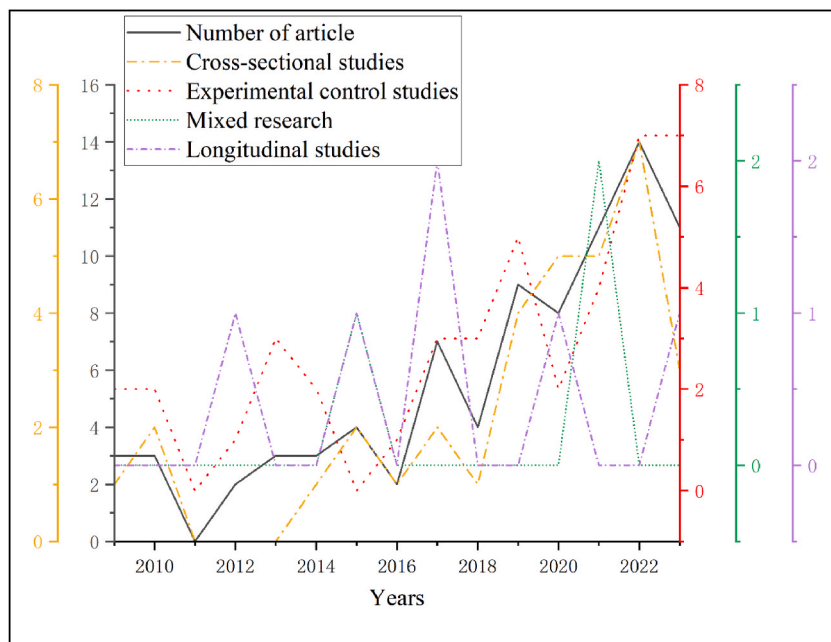


Fig. 7. Usage of research methods in the 84 studies.

[56] to 4242 [57]. Among these, 109 (32.1%) studies had sample sizes of 200 or fewer, 22 (6.5%) had sample sizes between 201 and 400, 9 (2.6%) had sample sizes between 401 and 600, and 11 (3.2%) had sample sizes exceeding 600. Through manual review and categorization, 84 empirical studies were further analyzed and summarized in detail in the supplementary material.

Upon analysing the results of the 84 empirical studies, the following research topics were identified: teacher training in 12 (14.3%) studies, multicultural and inclusive education in 6 (7.1%) studies, teaching methods and technology in 13 (15.5%) studies, educational quality in 4 (4.8%) studies, educational attitudes and beliefs in 25 (29.8%) studies, teacher professional motivation in 3 (3.6%) studies, scale development and validation in 7 (8.3%) studies, teaching models and strategies in 6 (7%) studies, teaching assessment and reflection in 5 (6%) studies, and physical health in 3 (3.6%) studies in Fig. 8. The results indicate that research on teacher educational attitudes and beliefs is the most prevalent, followed by teaching methods and technology, and teacher training.

4.3.1. Teacher training

Teacher training in PE has a positive impact on teachers' self-efficacy [2]. Ongoing improvements and developments in teacher training programs aim to enhance teacher commitment to the profession [58]. For instance Ref. [59], found that pre-service teachers' self-efficacy increased after participating in e-learning-supported training courses. Additionally, Adamakis and Zounhia [60] conducted research in three Greek sports schools and found that pre-service teachers faced challenges in the teaching methods module and school internships. Teacher training in PE often emphasizes teachers' physical literacy and encourages them to integrate it into their lives [2].

4.3.2. Multicultural and IE

IE is equally crucial for individuals with disabilities in PE. Thaver and Lim [61] conducted a survey with 1538 participants and found that the majority did not support the inclusion of students with disabilities in mainstream educational settings due to concerns about potential negative effects on regular teaching. Moreover, the study found significant differences in attitudes towards intellectually disabled children among PSPTs based on gender, age, class variables, and disability status [62]. However, Alhumaid, Khoo and Bastos [63] found that after a 6-week intervention training, PSPTs in Saudi Arabia had increased self-efficacy when it came to integrating students with disabilities into regular physical education classes.

4.3.3. Teaching methods and technology

The extent to which PSPTs use teaching methods and embrace teaching technologies directly affects the quality of PE classes [64]. Musard, Bezeau and Wallhead [65] found that teachers and students were able to discover in situ content learning tasks, narrowing the gap between teachers' and students' planned actions and actual actions through situational teaching methods. Feu, García-Rubio, Ibáñez and Antúnez [66] compared the effectiveness of tactical game teaching models for handball in a primary school setting and found that the game-based teaching method was more effective. They also noted that PSPTs tend to use various teaching methods, including student-centered teaching [67], game-based teaching [66], and blended teaching methods [32]. However, Greve, Weber, Brandes and Maier [68] found that there was no significant change in teaching effectiveness among 11 PSPTs in their learning of teaching technology. Nevertheless, with the advent of the AI era, mastering new teaching technologies, such as artificial intelligence-assisted teaching, is essential [69].

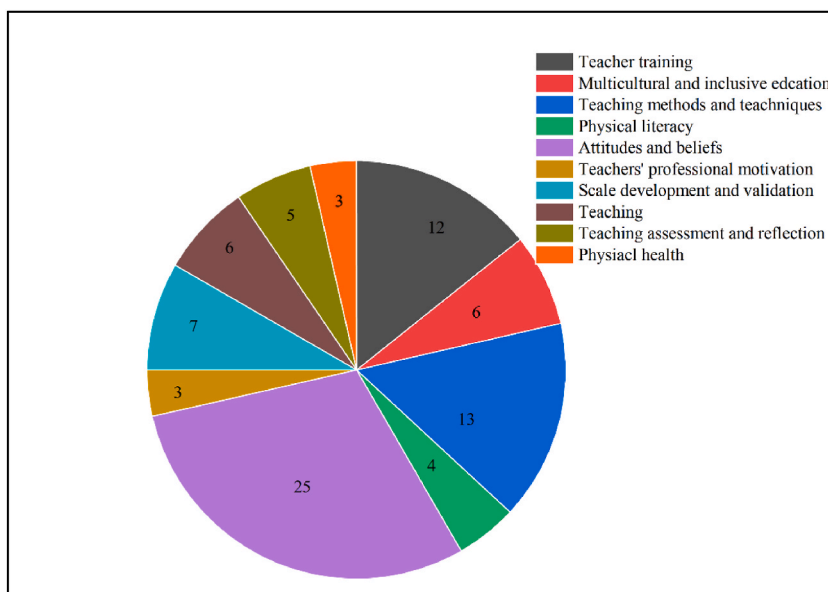


Fig. 8. Specific research areas in PSPTs.

4.3.4. Teacher qualities

Enhancing the educational qualities of PSPTs are crucial [70]. Especially when facing various stressors, teachers need to develop the ability to cope with and perceive stress [7]. It is essential for novice physical education teachers to improve their leadership and curriculum analysis skills [71]. The moral standards and personal qualities of teachers directly impact their teaching effectiveness [72].

4.3.5. Educational attitudes and beliefs

Students are profoundly influenced by teacher attitudes during the learning process [73]. In the self-efficacy of teachers, attitudes and beliefs play a critical role in determining whether PSPTs can successfully complete their training. Teachers' attitudes towards teaching methods [74], different types of learners [60], and their own confidence [75] can significantly impact their teaching abilities. Soini, Watt and Sääkslahti [76] conducted a survey with 274 pre-service teachers regarding their perceptions of cognitive abilities, and they found that raising awareness of practical skills is necessary.

4.3.6. Teacher career motivation

For individuals motivated to become PE teachers, their motivation typically stems from personal psychological needs and career desires [77]. Spittle, Jackson and Casey [78] found that intrinsically motivated individuals have greater interpersonal service motives, whereas motives related to participation in sports and physical activities are associated with extrinsic motivation.

4.3.7. Scale development and validation

Several scales measuring teaching confidence and motivation have been developed and validated for PSPTs [79]. Furthermore, scales assessing students' perceptions of teaching abilities have been translated [80] and cross-validated in different settings [81].

4.3.8. Teaching models and strategies

Teaching models and strategies are essential competencies for all teachers [82]. Roux and Dasoo [80] found that PSPTs could enable the permeation of values in PE lessons through role-play, games, and modeling as primary strategies for creating a favorable and safe learning environment for core values and basic human rights. Various teaching models can be challenging for PSPTs to combine theory and practice [83]. Cohen and Zach [84] explored the effectiveness of Cooperative Learning (CL) on teachers' teaching effectiveness and planning skills. They suggested that PETE programs focus on no more than two to three teaching models over three years of study and provide thorough practice until mastery is achieved.

4.3.9. Teaching assessment and reflection

Teacher assessment and reflection are tools for self-improvement and enhancing the quality of the curriculum [85]. These tools generally involve self-assessment by teachers [86] and student assessment [87]. Lee and Choi [88] investigated pre-service physical education teachers' perceptions of peer-guided reflection as a tool for reflection and their reflection process during microteaching peer-guided experiences. The results revealed that reflection can help them address and overcome barriers to reflection, link planning, teaching, and reflection, and provide a comprehensive three-dimensional perspective.

5. Discussion

To better promote the sustainable development of PSPTs, this study conducted bibliometric analyses on 340 articles and carried out an in-depth examination of 84 specific empirical studies. It aimed to address the following three questions: (1) the overall status of PSPTs, (2) the most influential authors, countries, journals, and publications related to PSPTs, and (3) specific research topics and future directions in PSPTs.

5.1. General state of PSPTs

The trend in the volume of publications in PSPTs from 1995 to 2023 shows an overall upward trajectory, experiencing three phases: an early development phase (1995–2008), moderate growth (2009–2017), and a high growth phase (2018–2023). Two-thirds of the total number of articles are in the high-growth phase, indicating a rising interest in pre-service physical education teachers. This aligns with the exploration of primary education teachers by Cretu and Morandau [20] projecting a peak in research on PETE in 2023. The research themes in PSPTs encompass the pre-service teachers' teaching abilities, teacher inclusivity, teachers' physical health activities, challenges and reflections faced by teachers, teaching methods and technologies, and future developments.

5.2. Most influential authors, countries, journals, and publications in PSPTs

Visual analysis of PSPTs information was conducted, resulting in the creation of a knowledge map. The most influential author is Macphail, Ann. The primary research groups in PSPTs come from the United States, Australia, Spain, Ireland, and the United Kingdom. The *European Physical Education Review* is the leading journal in the field of PSPTs. In core article reviews, it was found that Lawson [89] was among the earliest researchers to introduce the socialization model of PE teachers, leading to increased attention from researchers. Subsequently, Lawson [90] delved into issues related to professional socialization and the design of teacher education programs, uncovering challenges within the process of physical education socialization. This included the relationship between the

socialization of physical education teachers and their cognitive understanding of roles and teaching behaviors. Shulman [55] contributed to pedagogical reform by emphasizing the concepts of understanding, reasoning, transformation, and reflection. This reform aimed to address the disconnect between theory and practice [91]. Moreover, a significant concern was highlighted, emphasizing the lack of research focus on the relationship between PETE and the dominance of school sports, leading to increased attention on the training of physical education teachers.

5.3. Specific research topics and future directions in PSPTs

Upon further review, the research specific to PSPTs can be categorized into nine areas: teacher training, diversity, and inclusive education, educational attitudes and beliefs, teacher qualities, teaching methods and technology, career motivation, teaching models and strategies, and teacher assessment and reflection. In this section, each of these topics will be discussed as they relate to the field of PSPTs.

Teacher training and development. Over the years, research in PE has shown that traditional teaching methods have been predominant [86]. However, these traditional methods have certain limitations in stimulating students' intrinsic motivation and improving learning efficiency, which can negatively impact students' athletic performance [92]. Therefore, it becomes crucial to provide training to physical education teachers to equip them with various teaching methods, ultimately enhancing the learning experience of students [93]. Therefore, a key aspect in teacher training is to enable teachers to flexibly employ teaching methods. Research should focus on how to train PSPTs so that they can adeptly utilize various teaching methods.

Multicultural and IE. The importance of inclusive education is widely recognized among PSPTs of different ages and educational backgrounds [94]. Research indicates that teachers' attitudes toward inclusive education are not influenced by gender, age, or educational qualifications [61]. Nevertheless, more research is needed to delve into the intrinsic needs of learners from various cultural, socioeconomic, and ability backgrounds to develop more inclusive educational plans [95]. Inclusive education is crucial for students at different levels and for prospective teachers across various educational levels, influencing the sustainable development goals of education.

Educational attitudes and beliefs. Attitudes and beliefs in education play a pivotal role in shaping teacher efficacy [96]. By engaging in adaptive physical activity programs and reflection, PSPTs can transform their attitudes and beliefs related to working with children and youth with disabilities, thereby influencing the needs of the students [97]. Therefore, a critical focus for future development lies in bolstering the self-confidence and cognitive levels of PSPTs [98].

Educational quality. PSPTs, compared to their in-service counterparts, lack practical teaching experience. Continuous learning is crucial for enhancing teaching quality [99]. Strengthening educational qualifications emerges as a key factor in improving teaching quality. Compared to in-service teachers, PSPTs face greater challenges because they lack experience in specific teaching environments [36]. Therefore, enhancing educational qualifications and reflecting on teaching techniques to adapt to the ever-changing educational environment becomes particularly important [26,100].

Teaching methods and technology. Traditional learning methods have become less effective in meeting students' intrinsic needs [101]. With the innovation of teaching methods and advancements in technology, teachers must acquire new technological skills to support and enhance teaching quality [69]. Hyndman and Harvey [102] stimulated the potential in PE by taking a look at social media platforms such as Twitter, which helps educators to improve their educational decision-making skills and collaboration on social media, which can improve the ability to collaborate on education globally. Teaching methods and techniques also need to keep up with the times.

Career motivation. Embarking on a career as a PE teacher is grounded in personal intrinsic needs and career aspirations [77]. Motivation plays a significant role in determining the teaching efficacy of PSPTs, with their individual essential skills, values, beliefs, and viewpoints holding equally important [103]. Therefore, further scrutiny is required to better understand the intricate relationship between motivation and teaching efficacy [104].

Teaching models and strategies. This is a fundamental competency for every teacher. Some studies underscore the significance of refining preparations for the future by focusing on teaching methods, attitudes, and educational qualifications [16]. Strengthening collaboration and support between the internship community and established PE teachers can enhance teaching methods and educational qualifications, addressing cognitive imbalances and service learning challenges for PSPTs [105,106]. The amalgamation of diverse teaching modes and practices presents challenges for pre-service teachers [107]. Therefore, there is a need for teacher training to equip teachers with the pedagogical methods, attitudes and educational qualities to meet the educational challenges of the future.

Teacher assessment and reflection. Teacher assessment and reflection play a crucial role in enhancing self-awareness and the quality of courses, making them imperative. Recent studies highlight the significance of teacher training, particularly in the facing challenges like COVID-19. Teachers must continually acquire new teaching techniques to adapt to unforeseen circumstances and the dynamically evolving educational landscape. This includes addressing challenges posed by events like COVID-19 and incorporating artificial intelligence technology in education, as outlined by Darling-Hammond and Hyler [108].

Crisis response and challenges. Through teacher assessment and reflection, teachers are able to improve their self-awareness and the quality of their programs. PE teachers in the field of education typically need to handle challenges and learners' crises [109]. Research indicates that PSPTs need the ability to adapt to various learning environments and needs when facing these situations [16]. Teacher responses and support levels are crucial for students' mental health and development during crises [110]. Teachers should be prepared to handle challenges at any time [111].

This section has shown that there are limited evidence and empirical examples of teacher training, teacher assessment and reflection, multicultural and inclusive education in physical education. However, the new findings do suggest that there is a reliance on

teacher training programs for the full development of PSPTs, and these findings warrant further exploration of research on teacher training for PSPTs in physical education.

6. Conclusion and limitations

In summary, research in the field of PSPTs encompasses various aspects, including teacher training, multicultural and inclusive education, educational attitudes and beliefs, educational qualities, educational methods and technologies, professional motivation, teaching models and strategies, teacher assessment and reflection, as well as crisis response and challenges. These aspects collectively constitute crucial components of the sustainable development of PSPTs. In the conclusion, we emphasize the necessity of training, particularly in educational qualities and emerging technologies, to adapt to the ever-changing educational environment. Furthermore, attention to multicultural and inclusive education, along with the adjustment of educational attitudes and beliefs, is pivotal for future development.

However, this study has some limitations. Firstly, the sources and quantity of literature in the study may have influenced the results. Secondly, the research focuses on specific areas, possibly overlooking some related topics. Additionally, due to the dynamic nature of disciplinary development, certain emerging issues and trends may not have been fully explored. Finally, limitations in space and time may have constrained in-depth exploration of some topics. Despite these limitations, this study holds positive implications for promoting the sustainable development of PSPTs. By delving into various aspects of needs and challenges, it offers substantial recommendations for future training programs and policies. It underscores issues that the education sector needs to pay more attention to, such as the application of multiculturalism, the use of emerging technologies, and crisis response capabilities. This holds significant practical relevance for enhancing the quality and adaptability of the education system.

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Data availability statement

All data required to support this study is already mentioned in the manuscript.

CRedit authorship contribution statement

Tong Zhou: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

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