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Research on the Optimization of Smart Physical Education Teaching Paths from the Perspective of Digital Education

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Abstract

In the context of the strategic direction of accelerating the construction of a sports power and deepening the digitalization of education in the "15th Five-Year Plan", smart sports teaching is presented with new development opportunities. This study takes 492 valid documents collected in the CNKI database from 2015 to 2026 as samples and conducts a visual analysis using CiteSpace 6.4.R1. The research finds that the current research hotspots are mainly concentrated in three clusters: technology application, teaching models, and teacher development. However, there are still deep-seated problems such as superficial integration of technology, absence of process evaluation and data governance, incomplete teacher development mechanisms, and weak support systems. To systematically address these challenges, this study constructs a closed-loop optimization path of "competency support - resource guarantee - teaching implementation - governance escort", and embeds a data ethics framework, providing a new paradigm for the systematic implementation of smart sports teaching.

Keywords

Smart sports teaching, Digitalization of education, Path optimization, Digital literacy CiteSpace

1. Introduction

The "15th Five-Year Plan" explicitly proposed to "coordinate the development of mass sports and competitive sports, and accelerate the building of a sports power", and positioned educational digitalization as the strategic engine for high-quality education development. Based on this judgment, this paper uses CiteSpace, a scientific knowledge graph analysis tool, to conduct a quantitative analysis and visual mining of domestic research literature on intelligent physical education teaching over the past decade. It systematically organizes the research progress and hot issues in this field, identifies the main development bottlenecks, and on this basis, we attempt to construct a comprehensive, collaborative, and operational "four-one" optimization path. We hope that this will provide certain academic references and practical guidance for the standardized and systematic development of intelligent physical education teaching in China.

2. Study Design

In order to systematically grasp the research trends of intelligent physical education teaching in China, this study employs the bibliometric method for empirical analysis.

2.1 Data Sources

The data for this study came from the CNKI academic journal database. We searched using the terms “Smart Physical Education Teaching”, “Intelligent Physical Education Teaching”, and “Digital Physical Education Teaching”, and restricted the discipline to “Physical Education”. At the same time, the literature screening criteria were established: non-academic documents such as meeting notices, news reports, and publication statements were excluded, and low-value documents with download volume less than 5 and citation count of 0 were also excluded. The time span was defined as from January 1, 2016 to March 2026, to comprehensively cover the critical ten years from the beginning to the rapid development of this field. A total of 781 articles were initially retrieved, and after manual elimination of non-academic documents such as meeting notices, news reports, and publication statements, 492 valid journal articles were finally obtained as the research sample. All the documents were exported in Refworks format for subsequent analysis.

2.2 Research Technique

Data analysis was conducted using the scientific knowledge graph tool CiteSpace 6.4.R1. The research hotspots were identified through keyword co-occurrence analysis; the core research topics were summarized using cluster analysis; and the evolution process of the research hotspots was examined through the timeline view. The parameter settings are as follows: Time slicing is set from 2016 to 2026, the slice length (Year Per Slice) is 1 year, and the top 50 keywords with the highest occurrence frequency within each time slice are selected (Top N = 50). The node type is set as "Keyword", and the network pruning algorithm is set as Pathfinder. The keyword co-occurrence network graph, cluster graph, and trend graph in this paper were all generated based on the above parameter settings and analysis process.

3. Analysis of the Hotspots and Evolution of Smart Physical Education Teaching Research

3.1 Analysis of Bibliometric Characteristics

The annual publication volume is an important indicator for measuring the activity level of a field. Figure 1 shows the average annual number of published papers over the years. From the data, it can be seen that from 2015 to 2018, the average annual publication volume was less than 50, indicating that this discipline was still in its infancy. From 2019 to 2021, the average annual publication volume was more than 50, marking the entry of this discipline into a period of rapid development. After 2023, the average annual publication volume was more than 100, showing an explosive growth characteristic. This trend fully demonstrates that under the guidance of the national education digitalization strategy, related research has received increasing attention.

3.2 Cluster Analysis of Research Hotspots

Keyword Collinearity and Analysis

Through the analysis of keyword co-occurrence, it can be seen that the nodes related to "physical education and teaching", "intelligent sports", "intelligent classroom", "teaching mode", and "artificial intelligence" are relatively larger. This indicates that these words appear more frequently in the selected academic papers. When conducting keyword co-occurrence network analysis using the CiteSpace software, when setting the parameters, set the time window (Time Slicing) to 2016-2026, and set each time period (Year Per Slice) to 4 years. The node type (NodeTypes) is selected as "keywords", and the pruning method (Pruning) is set to "path filtering". According to the above settings, the keyword co-occurrence graph (Figure 1) is obtained.

Figure 1. Co-occurrence Network Map of Keywords in the Field of Smart Physical Education Teaching

The keyword co-occurrence network map is shown in Figure 2. After processing with the clustering algorithm, 13 valid clustering labels were obtained (Figure 4), including #0 Physical Education Teacher, #3 Smart Sports, #5 Artificial Intelligence, #6 Physical Education Teaching, #8 Information Technology, #10 Smart Classroom, #13 Teaching Reform, etc. These clusters clearly reveal the three core sections of the current research: the first is the technical support layer, focusing on how artificial intelligence and information technology can empower physical education teaching; the second is the model application layer, exploring specific practical models such as smart classrooms and teaching reforms; the third is the key element layer, paying attention to the development and challenges of the core role of physical education teachers.

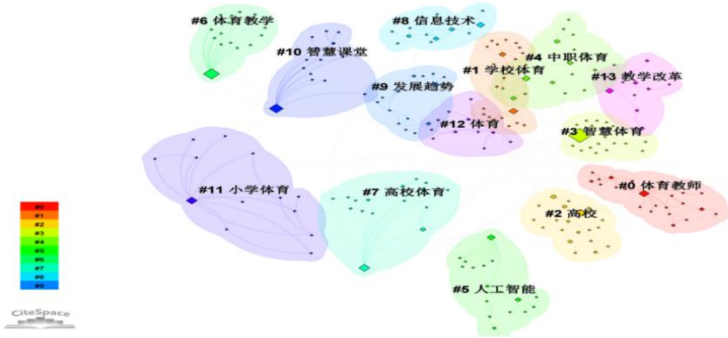

Figure 2. Clustering Map of Key Words in the Field of Smart Physical Education Teaching

4. The Current Problems in the Development of Intelligent Physical Education Teaching

Based on the in-depth interpretation of knowledge graphs and literature content, this study has identified the following four core challenges that currently face the development of intelligent physical education teaching:

4.1 Technical Integration is Superficialized and the Platform Ecosystem is Lacking

Currently, "the application of technology is in a 'scattered' state, and its integration with the teaching process remains at the level of 'tool substitution'. The underlying causes include two aspects: First, there is an information barrier between the technology providers and the demand side of physical education teaching. The technical tools developed by enterprises do not match the embodied characteristics of the physical education discipline; second, there is a lack of a technical integration framework oriented towards 'teaching objectives', resulting in advanced technologies such as AI, VR, and wearable devices becoming isolated displays of functions". The underlying mechanism lies in the lack of a technical integration framework oriented towards 'teaching objectives', leading to advanced technologies such as AI, VR, and wearable devices becoming isolated displays of functions. At the same time, the construction of smart sports platforms has fallen into the misconception of "emphasizing functions but neglecting the ecosystem", due to the lack of unified data standards and open interfaces, platforms form "data islands", resources are difficult to flow and share, and ultimately, it is impossible to build a virtuous digital ecosystem that supports personalized teaching.

4.2 The Absence of Process-based Evaluation and the Insufficiency of Data Governance Capabilities

Teaching evaluation still heavily relies on end-of-term skills and physical ability tests. The process data collected by intelligent technologies, such as classroom participation and the sequence of skill acquisition, have not been effectively utilized. The root cause lies in the systematic absence of the data governance system: from the collection norms and quality standards of data to the analysis models, none have been established, leaving a large amount of data in a "dormant" state. Moreover, the absence of data security and privacy protection mechanisms has made schools overly cautious in data application, unable to convert the data into precise teaching feedback and management decision-making bases.

4.3 Weak Digital Literacy among Teachers and an Incomplete Development Mechanism

At present, the development of digital technology in our country has reached a very intense stage. However, due to the lack of profound understanding of digital technology by many sports education professionals, they do not have a deep understanding of the digital technology used in sports teaching evaluation. On one hand, they may regard digital technology as an auxiliary means, without realizing the fundamental changes it has triggered. For example, some sports education professionals, when using digital technology, are still bound by traditional evaluation concepts and fail to fully utilize the innovative advantages brought by digital technology. They tend to only focus on the surface data while ignoring the deeper meaning and value behind it. On the other hand, some sports education professionals, although recognizing the importance of digital technology, lack the corresponding digital skills and cannot effectively use digital technology to conduct sports teaching evaluation, including data collection, analysis, visualization, etc. In addition, when applying digital technology, issues such as data security and privacy protection should also be paid attention to. Some teachers and students have concerns about using digital technology, fearing that personal information will be leaked or abused.

4.4 The Implementation of the Guarantee System is Weak and there is a Mismatch between Supply and Demand

Among the current smart education policies, only 12% of the provisions specifically target the physical education discipline, and no special funding for smart physical education has been set for rural schools, making it difficult for weak schools to implement these measures. This broad provision of the guarantee system fails to precisely address the actual difficulties of weak schools, becoming a key bottleneck restricting the widespread promotion of smart physical education teaching.

5. Construction of the Closed-loop Path for Intelligent Physical Education Teaching

This study integrates core elements such as teachers' digital literacy, digital resource ecosystem, and data governance norms, and constructs a closed-loop smart physical education teaching path centered on "sufficiency of literacy, guarantee of resources, implementation of teaching, and escort of governance", aiming to achieve precise, personalized and sustainable development of physical education teaching.

5.1 Overall Framework Design: "Three Layers and Four Stages" Closed-loop Path for Intelligent Physical Education Teaching

Based on the technical characteristics and teaching principles of intelligent physical education, integrating the industry standard of "Teacher Digital Literacy" and the core connotation of the "Four-in-One" optimization path, a three-layer architecture of "Foundation Support Layer - Core Implementation Layer - Evaluation Optimization Layer" is constructed. At the same time, the four steps of "Pre-class Diagnosis - In-class Implementation - Post-class Expansion - Whole-process Evaluation" are connected, forming a complete data-driven teaching loop. The details are as follows:

Foundation Support Layer: As the bottom-level guarantee for path implementation, it covers four modules: intelligent teaching environment setup, multi-dimensional data collection system, teacher digital literacy cultivation, and high-quality digital resource supply. The intelligent environment includes hardware such as smart playgrounds, wearable devices, and AI motion capture systems. Data collection covers various types of data such as students' physical health, sports skills, and classroom participation. At the same time, the teacher ability assessment and improvement are carried out based on the digital literacy scale for primary and secondary school physical education teachers, and teaching resource support is provided based on the differentiated resource matrix to lay the foundation for the entire teaching process.

Core Implementation Layer: This is the core implementation stage of intelligent physical education, corresponding to the three stages of "Pre-class - In-class - Post-class" teaching process. It achieves precise teaching through diagnostic assessment, immersive teaching, and personalized expansion, while embedding data ethics norms and home-school collaboration mechanisms to ensure the scientificity and inclusiveness of the teaching process.

Evaluation Optimization Layer: It undertakes the functions of teaching effectiveness diagnosis and path iteration. With multi-dimensional digital portraits as the core, it builds a combined evaluation system of process and outcome, and uses evaluation data to feed back to teachers' teaching innovation and resource optimization, forming a "Teaching - Evaluation - Improvement" closed-loop iterative mechanism.

5.2 Based on the Specific Optimization Strategies of the "Four Steps"

5.2.1 Before Class: Intelligent Diagnosis of Learning Situation and Personalized Lesson Preparation

1. Intelligent Diagnosis of Learning Situation Based on Multi-source Data Fusion

Obtain the historical data of students' health records, physical skills test scores, and extracurricular exercise trajectories over the past three years. Utilize the AI assessment system to conduct a comprehensive analysis of students' physical fitness, sports skills deficiencies, and health risks, generating a preliminary description of their learning situation. At the same time, supplement the school and family data interfaces with information such as students' extracurricular exercise habits and family support conditions to enhance the diagnostic dimensions. Based on the digital literacy scale, evaluate the assessment results of primary and secondary school physical education teachers, and carry out specialized pre-class preparation guidance to improve the teachers' data application ability, enabling them to proficiently convert learning situation data into teaching strategies.2. Personalized Lesson Preparation and Resource Recommendation Based on Layered and Classified Approach

Based on the results of learning situation diagnosis, formulate differentiated learning goals for students of different ability levels. At the same time, precisely match suitable resources from the intelligent sports resources matrix. For example, push specialized training micro-lessons for students preparing for the middle school entrance examination in sports, customize basic endurance training plans for students with weak physical abilities, and match professional rehabilitation guidance resources for students with rehabilitation needs. Establish a lesson preparation model of "teacher's independent design + platform's intelligent generation", allowing teachers to obtain high-quality lesson example templates through the virtual teaching room, improve teaching design based on school-specific characteristics, and automatically generate personalized group plans and teaching risk warning plans using platform tools.

5.2.2 During the Class: Immersive Teaching and Real-time Feedback Control

1. Creation of immersive teaching scenarios enabled by technology

For high-risk or high-cost sports such as skiing, swimming, and gymnastics, VR/AR technology is used to build virtual simulation training scenarios, allowing students to complete action perception and basic practice in a safe environment. For regular sports, a digital twin system is used to construct multi-angle action demonstration models to help students understand the technical essentials.

Equip rural and under-resourced schools with "5G + AI" lightweight intelligent teaching devices, such as portable motion cameras and simple motion capture devices. Utilize cloud computing power to achieve basic immersive teaching, thereby bridging the digital teaching gap between urban and rural areas.

2. AI-driven precise action guidance and correction

By using AI visual analysis and motion capture systems, real-time data of students' movement postures, force angles, etc. are collected, and after comparison with standard action models, immediate feedback is generated. Through slow-motion playback, dynamic marking, etc., precise error correction guidance is provided to students. At the same time, combined with professional judgment of teachers, teaching decision deviations caused by technical dependence are avoided.

Customized movement guidance plans are developed for special student groups, such as adjusting the standard threshold of movement for students with physical disabilities to ensure the inclusiveness and fairness of teaching.

3. Data-supported classroom organization and load regulation

Based on physiological data such as heart rate and energy consumption collected by wearable devices, a movement load monitoring and warning system is constructed. When students' load exceeds the standard, the system automatically reminds teachers to adjust the training intensity. At the same time, based on data on the mastery of movement skills, dynamic grouping is carried out to achieve personalized organization, where "those with sufficient ability expand and improve, and those with weak foundations receive targeted reinforcement".

Embed data security and ethics norms, clearly define the collection scope and usage rights of classroom movement data, and eliminate the risk of student physiological data leakage.

5.2.3 After Class: Consolidation and Expansion in Collaboration with Home, School and Community

1. Personalized after-class consolidation and expansion training

Based on the performance data during the class, customized home exercise plans are pushed to students, along with action demonstration videos, training check-in tasks, and difficulty advancement mechanisms. At the same time, an AI self-interaction training module is developed, using virtual competition PK and fun challenge game forms to enhance students' participation enthusiasm. A regional digital sports community is established, organizing cross-school sports check-ins and online skill challenges, etc., to promote interaction among students and expand the sports learning scenarios.

2. Data-driven home-school-community collaborative upbringing

Relying on the smart sports platform, a data interface for parents is established, synchronizing students' classroom performance, physical health changes, and after-class training completion status, providing family sports guidance suggestions for parents, forming a home-school-collaborative upbringing loop; at the same time, strictly following the "Campus Sports Data Security and Ethical Governance Measures", protecting students' data privacy. Linking community sports venues and public sports organizations, providing students with after-class offline sports practice venues and guidance resources, constructing a "school-family-community" three-in-one sports support network.

3. Evaluation: Comprehensive and multi-dimensional digital profiling

Based on the core functions of the evaluation optimization layer, a comprehensive and developmental evaluation system is constructed to achieve precise diagnosis of teaching effectiveness and iterative improvement of teaching paths. The specific strategies are as follows:

5.2.4 Construction of a Multi-dimensional Comprehensive Evaluation Index System

A five-dimensional evaluation system is established, including "movement skill data (action standardization, completion quality), physical fitness data (heart rate, endurance, strength, etc. physiological indicators), participation attitude (classroom interaction, frequency of after-class check-ins), healthy behavior (daily exercise habits, regularity of rest and sleep), and competition results (performance in school and extracurricular sports events)". At the same time, process data (such as movement trajectories, skill acquisition sequence, changes in classroom load) are fully included in the evaluation scope to make up for the shortcomings of traditional terminal evaluations. Differentiated evaluation thresholds are set for rural schools and weak schools, taking into account the scientific nature and educational fairness of the evaluation.

1. Digital portrait of students' sports growth and teaching iteration

Integrate students' sports learning data throughout their entire academic stage to generate a dynamic sports growth digital portrait, visually presenting the trajectory of changes in students' movement ability and health status, providing a basis for teachers to carry out targeted teaching interventions and for parents to formulate family exercise plans.

2. The evaluation data is fed back to teachers' professional development and resource optimization: On the one hand, provide teachers with diagnosis reports on teaching shortcomings, and conduct special research through virtual teaching rooms and cross-school workshops; on the other hand, update the digital resource library based on evaluation feedback, eliminate low-quality resources, and supplement compatible resources to achieve continuous optimization of teaching paths.

6. Conclusion and Prospect

This study conducted a systematic review of the research history of smart physical education teaching in China over the past decade through bibliometric and visualization analysis. The conclusion indicates that this field has shifted from the initial introduction of technologies to a deep integration with teaching practice. The research hotspots are widely distributed across dimensions such as technology, model, and teachers. However, it also faces systematic challenges such as insufficient technology integration, lagging teacher quality, a single evaluation system, and weak guarantee mechanisms. In response to this, the "sensitivity support - resource guarantee - teaching implementation - governance escort" four-in-one closed-loop optimization path constructed in this study provides a systematic solution to the current predicament. "Future research should further focus on the implementation paths of smart physical education teaching in weak areas such as rural schools and special education groups to promote educational equity and systematic development."

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