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The Mechanism and Realization Path of Digitalization to Empower the High-Quality Development of Physical Education in Colleges and Universities

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Abstract

As the national education digitalization strategy deepens, the digital wave has brought profound changes to school sports development, presenting both opportunities and challenges for the high-quality development of university sports teaching. This paper uses literature review and logical analysis to systematically explore the mechanisms, practical challenges, and implementation paths of digital technology in enhancing the high-quality development of university sports teaching. Digital technology can integrate teaching resources, optimize resource allocation, and promote educational equity; virtual reality technology can reshape smart teaching environments and innovate teaching settings; intelligent devices and platforms can analyze data to provide precise and personalized teaching guidance; artificial intelligence multi-modal evaluation systems can revolutionize teaching assessment; smart management platforms can enhance teaching management efficiency. While significant progress has been made in the digital transformation of school sports teaching, practical challenges remain, such as limitations of digital technology, security concerns, and obstacles to its widespread adoption. To enhance the effectiveness of digital technology in sports teaching, it is recommended to strengthen the construction of new infrastructure, create intelligent teaching spaces and resource integration platforms; enhance the digital literacy of physical education teachers and establish a training system that combines theory with practice; improve data security management systems, implement a tiered storage, approval, and dynamic audit mechanism, to promote the high-quality development of university sports teaching systems.

Keywords

Digitalization, Enabling, High-Quality Development of College Physical Education

1. Introduction

The 2022 Work Points of the Ministry of Education clearly stated: "Implement the digitalization strategy for education, promote the digital transformation and intelligent upgrading of education, and create new pathways for educational development." In 2023, during the fifth collective study session of the Central Political Bureau, President Xi Jinping emphasized that "the digitalization of education is a critical breakthrough for China to open up new pathways and shape new advantages in educational development." The National Education Development Plan for the 14th Five-Year Period lists "accelerating the digital transformation of education" as one of the six strategic tasks to shape new advantages in education (General Administration of Sport of China, 2021). The introduction of a series of strategic guidelines and policies demonstrates that China is actively implementing the digitalization strategy for education, stimulating the potential of digital education, and accelerating the realization of the strategic goal of building an education powerhouse. This study will explore how digitalization can drive the high-quality development of physical education in higher education institutions through internal mechanisms, propose practical paths for digital empowerment of high-quality development in higher education physical education, and provide actionable strategies for reforming physical education in higher education institutions.

2. Research method

This study employs the literature review method and logical analysis to explore the topic. In the literature review, keywords such as "digital empowerment" and "university physical education" were used to search through Chinese and English databases, including CNKI and Web of Science, as well as policy documents. The process involved initial screening by title and keyword, secondary screening by abstract and introduction, and final screening by full-text reading. From 2018 to 2025, 127 core articles were selected based on their relevance to the application and mechanisms of digital technology in university physical education. Non-academic or non-university physical education materials were excluded, and the literature was categorized using the SWOT framework. For the logical analysis, a combination of deduction and induction was used to derive the logic of empowerment based on educational digitalization theory. The conclusions of the literature were summarized to refine the research content. From a systems theory perspective, university physical education was analyzed as a complex system. The

positive and negative effects of technology were examined dialectically to construct the research framework.

3. The Mechanism of Digitalization to Empower the High-Quality Development of Physical Education in Colleges and Universities

3.1. Optimization of Teaching Resources

Digital technology integrates venues, faculty, and course resources, optimizing the allocation of teaching resources and promoting educational equity. Through intelligent management systems, universities can accurately track the distribution of sports teaching resources, including venues, equipment, and faculty, ensuring efficient resource allocation and utilization, avoiding waste and underutilization, and ensuring that every student has access to high-quality sports teaching resources. Digital technology achieves precise resource allocation through intelligent management systems. For example, after the smart venue system was installed at Chengdu Phoenix Mountain Sports Park, the venue usage rate increased to 87%, setting a record for seamless operations with six events in a single day. This achievement highlights the positive impact of the smart venue system on venue utilization efficiency. In higher education institutions, Peking University's "Smart Venue System" serves as an example. Since its launch, the system has comprehensively covered all sports venues on campus, enabling teachers and students to easily perform tasks such as venue search, real-time attendance check, one-click reservation, and QR code entry, significantly improving the efficiency of venue resource allocation, reducing resource idleness, and greatly shortening the waiting time for reservations.

The application of digital technology has not only improved resource utilization but also promoted the fairness of sports education, ensuring that students from different regions and with varying conditions have access to high-quality educational resources. For instance, China's MOOCs (Massive Open Online Courses) have surpassed 76,800 courses, serving 1.27 billion domestic learners, with sports courses being particularly popular. The course Sports and Society on XuetangX has attracted over 700,000 users, ranking it among the top courses on the platform. Since the launch of the "MOOC Western Tour Plan" in 2013, by April 2024, universities in the eastern region have provided 190,000 MOOCs and online courses to universities in central and western regions, facilitating 5.06 million blended learning sessions and reaching 530 million student participants. Feedback from many western universities indicates that the introduction of a large number of high-quality sports courses has significantly alleviated the shortage of course resources and greatly enhanced educational equity.

3.2. Reshaping Teaching Scenarios

Digital technology is reshaping the smart teaching environment on campus, innovating the sports teaching environment, and creating a conducive learning envi-

ronment. In the era of digital smart education, the digital transformation of school sports teaching has become an innovative driving force for the reform of physical education. By leveraging technologies such as virtual reality (VR) and augmented reality (AR), universities can create a smart sports teaching environment where students can learn and train in virtual settings, enhancing classroom engagement and learning outcomes. For example, Peking University offers a "digital sports" course that uses VR and other digital technologies to allow students to experience outdoor activities like mountain climbing, skiing, and rowing from indoors. The course is equipped with advanced intelligent sports equipment, including smart bicycles with swivel handles and a variety of real and virtual tracks, smart ski machines that use VR technology to recreate cross-country skiing scenes, and smart boxing platforms that use VR technology to enable students to compete against virtual opponents. This innovative "digital sports" course breaks the limitations of traditional sports teaching in terms of time, space, and equipment, allowing students to enjoy the fun of digital sports, stimulating their interest in sports, and improving their sports skills and health through immersive digital sports experiences. Zhu and Yang (2022) conducted a semester-long comparative teaching experiment with students from the tennis classes at Hefei Normal University and Anhui University of Science and Technology. After the experiment, both the experimental group and the control group showed improvements in various physical fitness tests, including the fan-shaped run, standing long jump, and long-distance running. The improvement in the experimental group was notably greater than that of the control group. Additionally, the experimental group demonstrated significant improvements in specialized skills, such as serving, forehand and backhand hitting, and baseline rallies, with even more pronounced enhancements compared to the control group. The results indicate that the VR-based teaching method is significantly more effective than traditional methods, greatly enhancing students' physical fitness and specialized skills (Zhu & Yang, 2022).

3.3. Reconstruction of Teaching Process

Digital technology is reshaping the teaching process, enabling precise and personalized instruction centered around students, thereby enhancing teaching effectiveness (Sun, 2023) Firstly, digital technology facilitates precise guidance. The algorithmic capabilities of digital technology can accurately analyze students' movement data, allowing for the creation of targeted training plans based on individual differences, thus providing personalized teaching guidance. Devices such as smart bracelets and motion sensors monitor students' heart rates and technical movements in real time. Teachers adjust their teaching strategies based on this feedback to ensure that each student progresses at a pace that suits them. Shenzhen University's School of Physical Education has developed an AI evaluation system that uses computer vision and learning algorithms. This system captures students' movements through high-definition cameras, analyzes the standardization of these movements, and provides real-time feedback. It offers scientific and person-

alized training guidance for golf and table tennis, enhancing classroom engagement and interaction, and improving teaching outcomes. Secondly, digital technology supports data-driven personalized teaching. Through data analysis from smart teaching platforms, teachers can identify students' sports levels and learning needs, allowing them to tailor learning plans. Students can access personalized teaching resources through the platform for self-study (Huang et al., 2021), while teachers track progress and provide feedback, adjusting the teaching content and strategies accordingly. The Department of Physical Education at Shanghai Jiao Tong University is exploring smart physical education classrooms. Teachers use students' sports data to implement precise interventions, designing personalized fitness improvement and extracurricular exercise plans, and providing targeted tutoring for exam content, which enhances teaching quality. Through personalized tutoring, students have seen significant improvements in both health and sports skills. Data-driven digital and personalized intelligent teaching enables students to teach according to their aptitude, improve their sports skills in personalized experience, enhance their independent learning ability, and cultivate lifelong sports habits; teachers optimize teaching plans through data analysis, realize mutual growth between teaching and learning, and promote the comprehensive development of physical education.

3.4. Innovation of Teaching Evaluation

Digital technology facilitates the reform and innovation of teaching evaluation by monitoring and assessing various aspects of teaching in real time. Data analysis technology can monitor and evaluate various aspects of physical education teaching in real time, including student learning, teacher quality, and resource utilization, providing technical support for teaching improvement. This helps universities identify and address issues, thereby enhancing the quality of physical education teaching. The AI classroom multi-modal evaluation system developed by Northeast Forestry University uses big data analysis, image recognition, semantic understanding, and speech recognition to collect classroom data without the teacher's awareness. This data includes images of teacher behavior, student behavior, and audio streams between teachers and students. After deep mining and analysis, the system provides a comprehensive and intelligent assessment of the teacher's teaching situation, presenting the results visually to help teachers improve their teaching effectiveness.

3.5. Improve Teaching Management Efficiency

Digital technology, through intelligent and automated management models, has significantly enhanced the efficiency of teaching management. In the wave of educational digital transformation, teaching management is continuously innovating and breaking new ground. By introducing digital technology, a smart examination platform has been established to boost the efficiency of teaching management. Compared to traditional methods, digital technology has transformed the

previously labor-intensive processes of preparing examination materials, entering scores, evaluating homework, and analyzing sports data, thereby avoiding low-level errors and inefficiencies in handling large volumes of data. This intelligent and automated approach to teaching management reduces the administrative workload for physical education teachers, freeing them from repetitive tasks and allowing them to focus on curriculum design and innovative teaching content, thus enhancing both management efficiency and teaching quality. The Department of Physical Education at Shanghai Jiao Tong University has integrated "Sports Profiles" into the smart examination platform. Through PDA terminal scanning or card swiping, student identities are recognized, and test results are immediately recorded by the system. Students can view their test results in real-time on the App. The system's intelligent, accompanying, and automatic collection, entry, statistics, and reporting of physical test data have enabled online automatic recording of test results for events such as 50-meter sprint, sit-ups, standing long jump, push-ups, and swimming. This change has eliminated the need to print nearly 20,000 identity codes annually before each physical test and manually enter the results after testing, thereby reducing the workload of physical education teachers, improving their work efficiency, and allowing them to focus more on the innovation and optimization of course content.

4. The Practical Dilemma of Digitalization Enabling High-Quality Development of Physical Education in Colleges and Universities

4.1. Inherent Limitations of Digital Technology

While the integration of digital technology with physical education holds great potential, it still faces limitations in practical applications. Firstly, the value of physical education extends beyond promoting students' physical health; it also involves fostering their mental health, cultivating sports ethics, and enhancing social adaptability, thereby achieving both physical and mental development. Currently, the data provided by artificial intelligence for physical education primarily focuses on quantifiable indicators such as physical health, skills, and fitness. Evaluating teaching effectiveness solely from a physical perspective fails to adequately reflect the cultivation of mental health, which is an inherent limitation of digital technology. School physical education should not only focus on these biological data points but should also leverage the comprehensive value of physical education to promote the all-round development of students' physical and mental well-being. Secondly, physical activities are systematic processes involving multiple senses, requiring the coordinated participation of all bodily senses to be fully realized. The intelligent sports teaching aids supported by digital technology typically provide partial assistance to bodily perception and sensory functions, making it challenging to create a complete and systematic body image. Thirdly, while virtual reality (VR) and augmented reality (AR) smart teaching scenarios can engage multiple senses, they also come with instability and safety concerns, which

can negatively impact the learning experience. For example, when users experience VR mountain climbing, the discrepancy between the virtual actions and the real body's static state can cause dizziness and imbalance, affecting the overall learning experience (Xiao et al., 2024). Lastly, digital teaching may lead to an increase in students' average daily screen time. According to a survey report on mobile phone usage among Chinese college students released by MyCOS Research Institute, over 80% of college students are "mobile phone dependent", spending an average of more than 5 hours per day on their phones. Digital teaching may further increase the daily screen time of students, thereby reducing their actual time for physical exercise, which can negatively impact their physical and mental health. To address this health risk, scientific preventive measures can be taken. For example, in terms of daily eye habits, the "20-20-20" rule should be followed: every 20 minutes of use, look at objects 20 feet away for 20 seconds to relieve visual fatigue. In course design, a 1:1 time ratio mechanism between digital teaching and physical exercise should be established to ensure sufficient time for physical exercise, promoting the development of students' physical functions and protecting their visual functions.

4.2. Security Risks of Digital Technology

When digital technology is applied to physical education, data security issues cannot be overlooked. The data collected and recorded by AI devices carries the risk of leakage. This data includes not only basic information about teachers and students, but also their sports preferences, health conditions, and teaching management data, among other vast amounts of information. As digital technology becomes more prevalent in physical education, the volume of data involved will continue to grow. How can we ensure its security? Typically, the intelligent carriers storing this data are developed and operated by outsourced digital technology companies. The educational data they collect and analyze is highly valuable for both economic and research purposes. Without strict data security measures, it is difficult to prevent these data from being leaked, leaked out, or illegally sold during transmission, which could lead to data security issues and harm the information security and personal rights of teachers and students. In fact, some schools have become targets of ransomware attacks due to the lack of a robust network security system and the large amount of valuable educational data stored in their management systems. According to a 2022 report by Sophos, 64% of higher education institutions and 56% of primary and secondary education institutions were hit by ransomware attacks in the past year. Therefore, universities urgently need to enhance data information management, improve data information security, and effectively protect the data privacy of teachers and students while utilizing digital technology.

4.3. The Promotion of Digital Technology is Hindered

The potential of digital technology in sports education is significant, but its wide-

spread adoption faces numerous challenges. Firstly, the uneven development of digital application capabilities and levels among schools in China means that some universities lack the funds to equip themselves with advanced digital smart teaching devices. This results in students not fully benefiting from the convenience and efficiency of digital teaching, which hinders the overall improvement of teaching quality (Shan et al., 2025). Secondly, the high barrier to entry for digital technology applications means that physical education teachers need systematic and professional training to effectively use these technologies. However, the limited availability of digital training resources makes it difficult for many teachers to effectively utilize advanced digital technologies, thus increasing the difficulty of promoting digital technology. Additionally, the talent cultivation system for sports education in China has not yet fully embraced digital concepts, leading to a shortage of "digital technology + sports" interdisciplinary professionals, which further limits the promotion and application of digital technology in higher education sports education.

5. The Realization Path of Digitalization to Empower the High-quality Development of Physical Education in Colleges and Universities

5.1. Strengthen New Infrastructure and Create a Digital Education Environment for Physical Education

The Ministry of Education has clearly pointed out the need to accelerate the construction of new education infrastructure. As the cornerstone of innovation and development in physical education, new infrastructure plays a core role in promoting digital transformation.

First, enhance the infrastructure for digital sports teaching environments to ensure that facilities meet standards and improve quality. Firstly, comprehensively optimize the configuration of digital sports teaching equipment, promoting the construction of digital smart sports teaching spaces in schools. These spaces should deeply integrate virtual reality systems, artificial intelligence technologies, and intelligent interactive devices, breaking down the barriers between online and offline learning, and merging physical and digital spaces. This will enable students to better learn sports skills in virtual settings. Currently, many leading digital technology companies are actively supporting the digital transformation of school sports, injecting new momentum into the development of school sports. For example, companies like iFLYTEK, Youdao, and Megvii Technology have developed intelligent application scenarios based on advanced technologies, providing technical support for sports teaching. For universities with limited resources, those that currently lack the conditions to build VR sports labs or equip with motion sensors are advised to adopt a "lightweight" solution, initially deploying low-cost motion data collection and analysis software, such as KEEP, Coolang Xiaoyu, Mustard, and other AI action analysis apps, before gradually advancing the construction of smart venues. Secondly, the research and development of digital in-

telligent teaching equipment should also expand non-quantitative data collection scenarios, develop emotionally interactive intelligent devices, and construct multi-modal behavior analysis systems to effectively integrate physical education with mental health education. By analyzing classroom video AI, we can identify students' social behaviors in sports activities, such as the frequency of mutual assistance among classmates and conflict resolution methods, as well as their adherence to rules (such as the frequency of rule violations). This forms a three-dimensional evaluation model that includes sports skills + psychological qualities + social adaptation. Additionally, a virtual emotional context moral education module is developed, embedding moral decision-making scenarios into VR sports courses, such as setting up scenarios for fair competition decisions in team matches and emergency rescue simulations. Through algorithms, the choices made by students are recorded, and their development of sports ethics is analyzed and evaluated. With the rapid advancement of digital technology, these applications will become feasible. Although these intelligent devices may not fully capture the "heart-nurturing" humanistic value of physical education, they provide valuable insights for the high-quality development of school sports teaching. Thirdly, by deeply applying big data, artificial intelligence, and other technologies, we explore the construction of data center cloud platforms and networked remote services, promoting the development of smart campus platforms, building a new digital educational environment, and achieving full-time and all-space coverage of learning scenarios.

Second, actively introduce and develop multi-functional service platforms to build a balanced and precise digital resource system for sports education. Universities should leverage the National Government Service Platform and the National Smart Education Platform to integrate high-quality digital sports educational resources, connect and aggregate scattered high-quality application cases and content, and enhance the utilization rate of teaching resources. Focus on core areas such as sports teaching, research, and evaluation, and develop new educational resource platforms like interactive digital textbooks, teaching resource libraries, and intelligent learning situation analysis systems. Utilize interactive live classrooms and remote delivery classrooms to complement resource advantages, expand the boundaries of resource sharing, meet students' personalized needs, alleviate the supply-demand contradiction of resources, and promote educational equity. Further advance the "MOOC Western Tour Plan" public welfare education initiative, fully utilizing digital technology and resource advantages represented by MOOCs, continuously delivering high-quality teachers and MOOC resources from the eastern regions to universities in the central and western regions. Through digital empowerment shared courses, achieve balanced educational resources, improve the quality of higher education in the central and western regions, establish a "1 + 1" technical assistance mechanism between universities in developed and underdeveloped regions, share virtual sports course resources, promote the sharing of educational resources, support the development of higher education in the

central and western regions, and promote higher quality educational equity.

5.2. Concepts Are King, and the Cultivation of Digital Literacy of Physical Education Teachers Should be Strengthened

Physical education teachers are the leaders in digital teaching in physical education. Enhancing their digital literacy is crucial for integrating digital technology deeply into teaching (Yang, 2022). Teacher training should be strengthened from multiple angles: training programs should combine theory with practice, covering both digital teaching theories and practical exercises. Schools and educational institutions should regularly organize specialized training to help teachers understand the principles of digital technology, software and hardware operation methods, and integration strategies. Through case studies and simulated classes, teachers can improve their ability to apply digital technology in classroom teaching. Seminars and academic lectures can guide teachers to stay updated with the latest developments in education. A platform for teacher collaboration and exchange should be established, along with a regular experience-sharing mechanism, to foster a cooperative learning environment and accelerate the digital transformation of the teaching team. The feedback mechanism for technology application should be improved, encouraging teachers to reflect and summarize, and regularly assessing the effectiveness of technology applications to optimize training content and methods.

5.3. Consolidate the Barrier and Establish a Sound Digital Management System

The widespread use of digital technology in sports education has led universities to face the challenge of collecting and processing vast amounts of data. Establishing a robust digital management system is crucial for ensuring information security (Yang et al., 2024). Firstly, it is essential to enhance the construction of data security systems. Universities should establish a stringent data management system, clearly defining the boundaries and details of data management policies, including the collection, storage, use, and destruction of expired data. Policies should align with national laws and regulations, and a regular data security audit mechanism should be established to regularly inspect the entire data management process, conduct simulated attack tests and vulnerability scans, address security risks, and dynamically optimize the management system. Secondly, schools should improve the data security literacy of teachers and students through systematic training, enhancing their awareness and responsibility for data protection. Regular specialized training sessions should be conducted: for teachers, focusing on data application in teaching scenarios, analyzing data leakage cases, explaining the application of laws in teaching settings, and helping teachers understand the compliance procedures for managing the entire data lifecycle; for students, using scenario simulations to popularize basic concepts of data security and enhance self-protection awareness. An open feedback channel should be established to collect

suggestions from teachers and students, dynamically optimizing management strategies to ensure that the data management system evolves in tandem with technological advancements and policy requirements.

6. Conclusion

Digital technology has provided a revolutionary impetus for the high-quality development of physical education in universities, but this transformation will not happen overnight. In the future, it is essential to support this transformation with technological innovation, breaking down the separation between physical and mental development, and building a more humanistic and intelligent teaching system. Data security must be the baseline, with improved management systems and technical protections to safeguard the information rights of teachers and students. The core focus should be on enhancing literacy, cultivating a composite faculty that integrates digital technology and physical education, and bridging the gap in technology application. Universities need to unite various forces under policy guidance, deepening the application of digitalization from a tool to the restructuring of the educational ecosystem, making physical education a vital domain for the comprehensive development of students' minds and bodies, and contributing to the construction of a strong educational nation through sports.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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