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Investigating popular topics for the integration of the internet of things in physical education: A content analysis in higher education

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ABSTRACT

Background Problems: Advanced technologies, such as the Internet of Things (IoT), have played an increasingly important role in the development of physical education in higher education. **Research Objectives**: This study aims to conduct a content analysis of the use of IoT technology in physical education in higher education. **Methods**: Scopus and Web of Science databases were used to collect and analyse data for this study, with a total of 178 articles obtained, consisting of 104 articles (Scopus) and 74 articles (Web of Science). The final data used for this study consisted of 20 articles, as it only targeted the top five topics related to the internet of things (IoT) in physical education after being analysed using ScientoPy. **Findings and Results**: The analysis identified five main topics related to the application of the internet of things in physical education in higher education, including cloud, artificial intelligence, deep learning, big data, and virtual reality. The implications of these findings for the development of physical education in higher education are discussed in this study, emphasizing the importance of IoT technology integration in creating a more adaptive and responsive learning environment. **Conclusion**: The contributions of this research include providing deeper insights into how IoT technologies can be applied in physical education in higher education, as well as highlighting the potential to improve the effectiveness of learning and teaching in this area. The conclusions of this study emphasises the importance of continuing to develop innovations in the application of IoT technology in physical education in higher education in order to achieve a more efficient and competitive learning environment.

Keywords: Internet of things; physical education; higher education; content analysis

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INTRODUCTION

The Internet of Things (IoT) is one of the popular internet performance information technologies (Lei et al., 2021), coined by Kevin Ashton in 1999 (Kassab et al., 2020), to refer to uniquely identifiable objects and their virtual representation in internet-like structures (Han, 2011; Uzelac et al., 2015). The concept of IoT

became popular when the International Telecommunications Union presented the publication "The Internet of Things" (Szum, 2021). Today, IoT has evolved into a multi-layer technology platform that includes hardware, software, connectivity, and user interfaces to manage data flow, communication, application functionality, and device automation (Aazam et al., 2018; Lombardi et al., 2021). IoT is based on three basic functions of smart objects, namely traceability, communication, and interaction (Miorandi et al., 2012). These three basic functions of smart objects play an important role in underlying the development of the Internet of Things, which can be seen through current technological advances, such as the ability of one of the features on the Google Maps electronic machine to interact with humans to provide directions (Keerthana et al., 2020) and track children's activities (Sravani & Ghosh, 2020).

In fact, more broadly, this technology has proven useful for both small and large-scale networks, resulting in a large portfolio of enabling hardware and software at various complexities (Buratti et al., 2015; Garcia-Sanchez & Garcia-Haro, 2011). IoT applications have been utilised in various fields, such as agriculture (Ayaz et al., 2019), medical (Asghari et al., 2019; Wang et al., 2018), retail (Đurđević et al., 2022), security system (Pinggui & Xiuqing, 2017), customer service (Jie et al., 2015; Yerpude & Singhal, 2021), smart house (Lee et al., 2016; Sung & Hsiao, 2020), environmental monitoring (Behera et al., 2020; Guerrero-ibanez et al., 2015), and industrial internet (Bahga & Madisetti, 2016; Wan et al., 2016). IoT has also made its way into education and has provided benefits to students, teachers, instructors, and the entire education system. For example, it is used to monitor student attendance and classroom activities (Alotaibi, 2015; Jiang, 2016), provide a more engaging learning environment for students (Marquez et al., 2016), and improve accessibility for students with disabilities (Bright, 2021).

The Internet of Things (IoT) is a fascinating and stimulating topic that will intrigue students, teachers, and lecturers while also providing an excellent platform in the field of physical education. Physical education is a very important subject studied in schools (Green, 2014; Stormoen et al., 2016), as it makes a significant contribution to the spiritual, moral, social, and cultural development (Cale et al., 2016; Harris, 2018) and the development of students (Akhter & Ahmed, 2021). The traditional mode of teaching physical education is gradually being abandoned, and physical education has begun to change direction towards intelligent forms (Ding et al., 2021; Meng, 2021; Yu, 2021), such as the use of MOOCs in physical education learning at the higher education level in football materials (Tian et al., 2022), basketball learning through network information technology through images, words, sounds, videos, and animations (Chen & Zhou, 2022), procurement of smart sports in universities as a resource for smart sports teaching, smart sports facilities, online competitions, and virtual sports for college students (Deng et al., 2022), and the use of AI and metaverse through the mobile internet (Li et al., 2022). In addition, the development of the Internet of Things for physical education teaching towards smart forms can also be observed, especially during the COVID-19 pandemic, and proven to help in online learning (Bucea-Manea-Ţoniş et al., 2022), by being oriented towards actual classroom teaching (Cai et al., 2019; Nosova et al., 2015; Turton et al., 2016), such as the use of Google Classroom, Moodle, and other information technology (Shmeleva et al., 2021). Some of these studies provide evidence that the Internet of Things (IoT) has been developed for teaching methods in physical education practice (Cheng, 2021; Wang et al., 2021).

Internet of Things (IoT) devices also incorporate 5G communication network technology and began to emerge in the past 2 years related to physical activities (Chen & Liang, 2020; Du et al., 2022) and the proposed 5G martial arts learning system (Chen & Liang, 2020). Several empirical studies in this period also proved that the 5G internet-based physical education teaching system can improve students' understanding of tennis knowledge and tennis skill test performance (Chen et al., 2022), further stimulate students' learning enthusiasm, improve students' learning efficiency, and cultivate good learning habits (Huang & Wang, 2021). In addition, physical education management also proposed a 5G-oriented VR CPS (Child Protective Services) (Wei, 2020). Therefore, with several studies that have been presented, it shows that every aspect of life in modern times, like today, has the potential to be inseparable from the influence and impact of technological growth and development, especially in the world of physical education.

While there have been several studies that reveal the benefits and advancements of Internet of Things (IoT) technologies in the context of physical education, there is a gap in the literature regarding in-depth content

analysis related to the integration of IoT in physical education. While previous research tends to focus on the technical aspects and practical benefits of IoT implementation in learning (Cojocaru et al., 2022; Wang et al., 2021; Yang et al., 2021a), few have explored an in-depth understanding of the content resulting from the use of these technologies in the context of physical education. Thus, there is an urgent need to conduct a more detailed content analysis related to the use of IoT in physical education to better understand its impact and implications on learning processes and student learning outcomes.

This research offers a fresh approach by using content analysis to explore the integration of the use of the Internet of Things (IoT) in the context of physical education in higher education. While there have been several previous studies trying to uncover the benefits of this technology, none have used a content analysis approach in this context. Previously, this topic has been investigated through a scientometric approach (Gazali et al., 2023), but now the focus shifts to an in-depth understanding of the types of data and information generated by IoT in physical education in higher education. It is hoped that, by applying the content analysis method, this research will open up new insights into how the information generated by IoT can significantly affect the learning process and student learning outcomes.

With a deeper understanding of the content generated by IoT and its impact on the learning process, we can design more effective and efficient learning approaches in the context of physical education. This study aims to conduct a content analysis of the use of IoT technology in physical education in higher education. As such, it is expected that this research will provide a better understanding of how IoT technologies can be optimised to enhance the learning experience within the field of physical education. In addition, the research questions to be answered through this study include: What are the main topics that dominate the literature on IoT technologies in physical education in higher education?.

METHOD

The Scopus and Web of Science (WoS) databases were used to collect and analyse the data for this study. These bibliographic databases contain information on high-quality, multidisciplinary research published in scientific journals with meaningful global impact and allowed consolidation of the data set to contribute to this study (Santamaria-Granados et al., 2021), as well as the databases most frequently visited by previous researchers worldwide (Sweileh, 2020; Yang et al., 2021a).

Dataset Collection

Initially, a paper-only search of the WoS and Scopus databases was conducted. The search keywords were (“internet of things” OR “IoT” OR “internet 4.0” OR “internet of everything” OR “web of things”) AND (“physical education” OR “physical and health education” OR “sport education” OR “sport pedagogy”). On the same subject, Gazali et al. (2023) had already used these keywords.

Eligibility Criteria

The eligibility criteria for studies included in this research included studies that explored the concept of the internet of things (IoT) in physical education. The data considered for this study was collected on December 12, 2023, and analyses were conducted for the period covering the years 2014 to 2023. This timeframe ensures a comprehensive picture of the evolution and trends in the field of internet of things (IoT) research in physical education over the past decade.

Database Abstraction

During the identification stage, a total of 239 results were extracted from the databases and sources mentioned above. Then, the researcher filtered the document types, limited to journal articles, book chapters, and conference papers, and restricted the search to English-language documents. Next, 61 duplicate entries were removed, and abstracts and citation information were imported into citation management software (Mendeley). After that, the authors reviewed the titles and abstracts and excluded 178 articles because they weren't pertinent to the current research topic. Thus, the final data used for this study consisted of 20 articles, as it targeted only the top five topics related to the internet of things (IoT) in physical education after being analysed using ScientoPy and then

analysed using content analysis. Figure 1 shows the flow of steps involved in the identification and screening of articles.

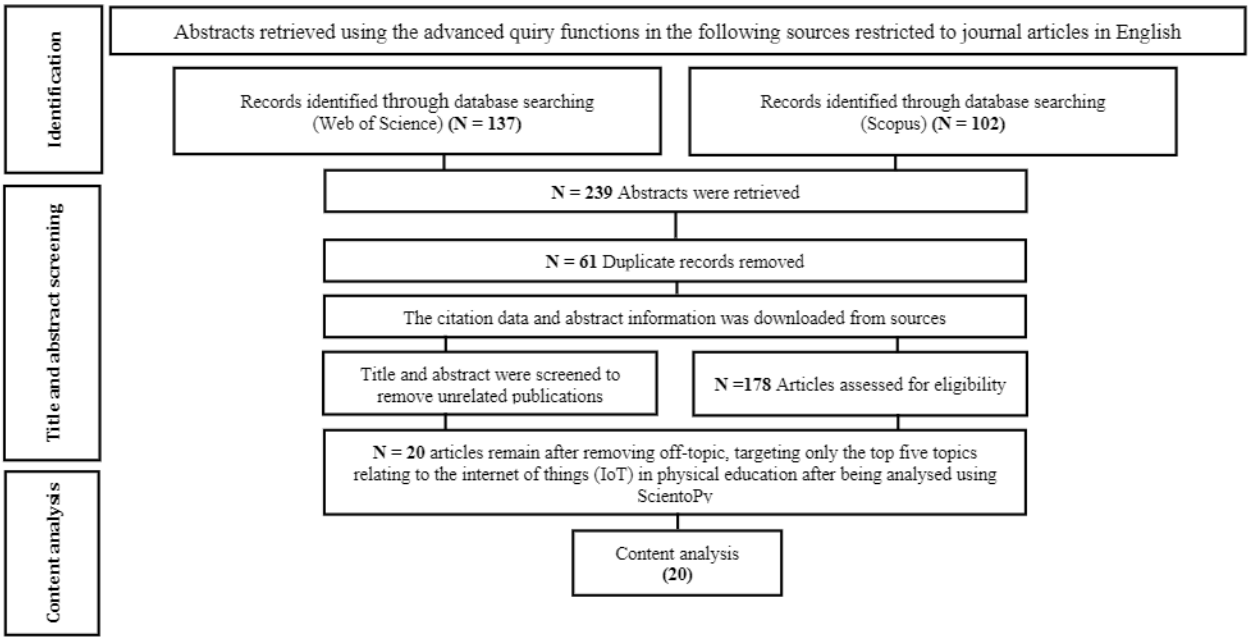

Figure 1. Flowchart of Selected Studies Using PRISMA Guidelines

RESULTS AND DISCUSSION

Results

In the exploration of the literature on the integration of the internet of things in physical education in higher education, several key topics stood out, and this study will deepen the understanding of its evolutionary journey. Cloud, artificial intelligence, deep learning, big data, and virtual reality are the five main topics identified, as shown in Table 1 and Figure 1.

Table 1. Five Main Topics of Content Analysis

Topic	Total	Authors	Country
Cloud	5	Ding, Y.; Li, Y.H.; & Cheng, L.	China
		Che, Y.; Sivaparthipan, C.B.; & Daniel, J.A.	China; India
		Hu L.; Liu C.; Cengiz K.; & Nallappan G.	China; Turkey; Japan; United Arab Emirates
		Guo, J.B.; & Sun, C.X.	China
		Wang, C.; & Wang, D.	China
Artificial Intelligence	5	Che, Y.; Sivaparthipan, C.B.; & Daniel, J.A.	China;India
		Fu X.	China
		Sun Q.	China
		Lei L.; Li J.; & Li W.	China
		Yu, H.T.; & Mi, Y.	China; South Korea
Deep Learning	4	Zong, X.X.; Lipowski, M.; Liu, T.F.; Qiao, M.; & Bo, Q.	Poland; China
		Dong, A.X.	China
		Zhang, L.; Sengan, S.; & Manivannan, P.	China; India
		Hu, R.	China
Big Data	3	Wang B.	China
		Zhang J.; & Gao X.	China
		Cao, L.; & Zhou, J.	China
Virtual Reality	3	Ding, Y.; Li, Y.H.; & Cheng, L.	China
		Feng, Y.H.; You, C.; Li, Y.B.; Zhang, Y.; & Wang, Q.X.	Indonesia;China
		Wang F.	China

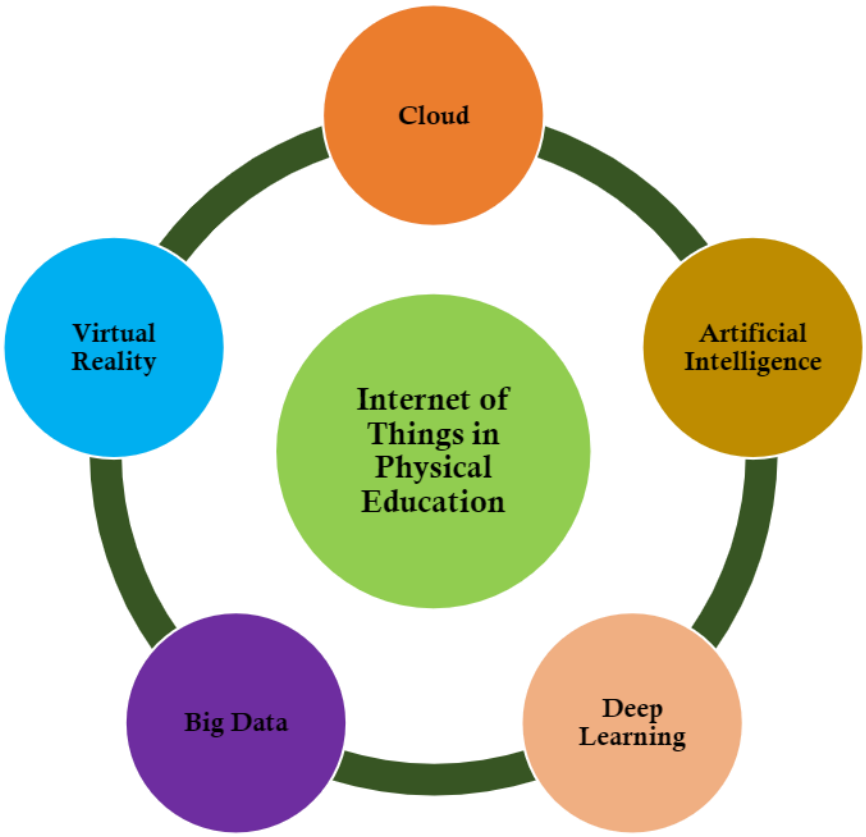

Figure 1. Five Main Topics of Content Analysis

Cloud

In the context of Internet of Things (IoT) integration in physical education, cloud technology plays a crucial role. The article written by Ding et al. (2020) describes the application of Internet of Things (IoT) and virtual reality (VR) technologies in physical education in higher education. This research aims to overcome the obstacles of limited teaching methods and the lack of distance teaching capabilities in physical education in higher education. By utilising virtual reality technology, this research designs a virtual reality system for physical education in higher education consisting of IoT, a cloud platform, and a mobile client. The system enables interactive experiences through mobile terminals by rendering virtual scenes through the cloud. Through requirements analysis and system framework design, as well as system testing, this study shows that the designed virtual reality system has good application effects and provides scientific reference for the reform of physical education in colleges.

On the other hand, the article by Che et al. (2021) discusses the interaction between humans and computers in physical education in IoT-based colleges. This research highlights the development of an artificial intelligence-based AI-IoTS system to enhance the interaction between humans and computers in the context of physical education. By utilising wearable technology and a cloud platform, this AI-IoTS system enables teaching and monitoring physical activities independently without the assistance of a physical instructor. Through simulation methods, this research proves that the proposed system can collect and teach students independently with better performance than conventional methods. Not only that, research by Hu et al. (2021) introduced an Internet of Things (IoT) framework in the physical education system by proposing an IoT-based Physical Activity Recognition (IPAR) model. In this model, physical activity recognition is performed using data from a single tri-axial accelerometer, which is then processed through a cloud platform and transferred to the physical activity instructor's mobile phone. This research shows that the proposed physical activity recognition model has a high degree of accuracy and efficiency, as well as low time complexity.

In addition, the article by Guo and Sun (2021) discusses real-time monitoring of physical education classrooms in colleges based on IoT and cloud computing. This research aims to improve teaching effectiveness through the use of artificial intelligence systems in physical education. By utilising IoT technology and cloud computing, this research developed a real-time monitoring system for physical education classrooms in colleges. Through the collection and processing of field data, this research shows that the developed system has a positive effect on improving teaching and classroom management. Finally, the article by Wang and Wang (2023) proposed the integration and management of teaching resources for physical education in colleges using cloud computing and edge computing. This research highlights the importance of the management and integration of teaching resources in physical education in higher education. Through the use of cloud computing and virtualization technologies, this research develops a resource management strategy to ensure balanced load distribution and improved utilisation of computing resources. This article provides a clear picture of how cloud computing can help manage and integrate teaching resources more effectively in a college physical education environment.

Artificial Intelligence

The development of physical education in higher education has become a key focus in an era where technology is advancing at an exponential rate thanks to the integration of artificial intelligence (AI) and Internet of Things (IoT) technologies. Articles by Che et al. (2023) and Fu (2020) extensively discuss the application of AI-IoT technology in this context, highlighting its crucial role in improving the interaction between humans and computers. By using wearable technology and an AI-based cloud system, this research shows great potential for improving the effectiveness of self-directed learning in the field of physical education. Simulation results show that the proposed system can collect data and teach students independently, which is a positive step in improving learning efficiency and independence in academic environments.

On the other hand, the article by Sun (2021) describes an IoT and AI-based school intelligence system developed to improve management and assurance mechanisms in physical education at the school level. This research optimises the use of data from various sources, such as class physical exercises, physical examinations, and sports competitions, to improve teaching quality and promote the physical quality of adolescents more scientifically. While the article by Lei et al. (2023) highlights the role of artificial intelligence technology in caring for the mental health of teachers and students, especially in the context of sports education, through a comprehensive analysis of various intelligent approaches, this study shows the potential to improve academic performance as well as skills by reducing stress or depression levels.

Finally, the article by Yu and Mi (2023) explores an application model for innovative sports teaching practices in higher education by utilising IoT technology and artificial intelligence. Through an innovative approach, this research highlights the great potential of AI and IoT technologies in improving the efficiency and quality of teaching in sports education environments. Overall, the articles provide valuable insights into various approaches and strategies for integrating artificial intelligence and Internet of Things technologies in physical education. Through this research, we can see how advanced technologies can be used to improve learning effectiveness, promote physical and mental health, and create a more adaptive and responsive educational environment. By understanding the potential and challenges of implementing these technologies, we can develop more innovative and effective approaches to physical education in the future.

Deep Learning

In the context of physical education development, research by Zong et al. (2022) proposed a new method that uses deep learning algorithms and the Internet of Things (IoT) to improve psychological education in college physical education courses. The results showed that this new approach significantly affected the psychological quality of college students, improved their emotional control abilities, and increased their self-challenge and adaptability to difficulties. In addition, the integration of technology also had a positive impact on learning quality and overall academic performance. This research makes an important contribution to the innovation of physical education teaching methods in higher education, leading to significant changes in the integrated psychological education approach.

Meanwhile, research by Dong (2023) also highlights the application of deep learning technology in analysing and evaluating physical teaching measures in physical education classes. Using smart devices connected to the internet, this study designed a deep learning-based evaluation system to monitor student actions in physical education classes. The experimental results demonstrate the effectiveness of the system in identifying risky movements and evaluating students' learning levels. However, the study also highlighted some challenges that need to be addressed, such as expanding the use of the technology for wider teaching purposes and ensuring the reliability and accuracy of the evaluations generated by the system. In conclusion, the application of deep learning technology in physical education offers great potential to improve students' learning experiences, but further research is needed to understand and overcome the obstacles that may arise in its implementation.

In the study by Zhang et al. (2022), the authors created a deep learning-based system for evaluating student actions in physical education classes. This method utilises a convolutional neural network (CNN) for the classification of risky actions and the evaluation of student learning levels. This research makes an important contribution to bringing innovative solutions to improve the efficiency of teaching and evaluation in the physical field. However, it also underscores the importance of paying attention to the reliability and validity of the evaluations generated by the system, as well as the need for further research to optimise the use of deep learning technologies in the context of physical education. Furthermore, the article by Hu (2023) explores the application of Internet of Things (IoT) technology and artificial intelligence in analysing the behaviour of tennis players. By utilising these technologies, this research created an intelligent system to detect and classify tennis serve motions. Experimental results show that the proposed approach achieves high classification accuracy, validating the great potential of the integration of IoT and deep learning in improving sports analysis. However, this research also highlights challenges that need to be addressed, including further development of the algorithm and optimisation of the system for actual on-court use. In conclusion, the application of IoT and deep learning technologies in sports behaviour analysis offers great benefits to the understanding and development of athletics but also raises questions that need further consideration in future research.

Big Data

In the context of big data and physical education, a study conducted by Wang (2021b) aimed to improve physical education teaching skills in preschool majors by utilising a big data approach. The study highlighted weaknesses in children's physical education and the shortage of professional teachers in this field. By analysing the preschool education curriculum and through standardised skills training, this study shows that an approach integrated with big data can improve students' skills across five different dimensions. As a result, this article provides more scientific guidance for the development of teaching skills in the field of children's physical education.

The article by Zhang and Gao (2021) discusses the implementation of massive open online course (MOOC) systems for improving the effectiveness of physical education in higher education. This research highlights the important role of MOOC technology in enriching course resources, reducing operational costs, and providing a more interactive online learning experience for students. Through literature analysis and a comparative approach, this study shows that MOOC-based curricula have brought about a fundamental transformation in teacher education and students' learning patterns. Therefore, this article provides insights into how the integration of MOOC technology can enhance the learning experience in the field of physical education.

The study by Cao and Zhou (2023) describes the challenges and strategies in dealing with online sports teaching under the background of big data and the Internet of Things (IoT). This study highlights the impact of the integration of IoT and big data technologies in online sports teaching, especially in overcoming the challenges arising during the COVID-19 pandemic. Through surveys and data analysis, this study shows a significant increase in the effectiveness of online sports teaching after implementing the enhanced strategies. As such, this article provides insights into how advanced technologies can be used to enhance the student sports learning experience in an ever-changing educational environment.

Virtual Reality

The use of virtual reality (VR) technology in physical education in higher education shows great potential for improving learning and teaching effectiveness. The first article by Ding et al. (2020) highlighted the importance of introducing a virtual reality system based on the Internet of Things (IoT) to enrich the physical learning experience in higher education. By incorporating these technologies, the designed system is able to provide a more interactive learning experience and provide valuable data for curriculum evaluation and development. The results show that the implementation of this kind of VR system has a positive impact on students' participation and their learning outcomes and contributes to the reform of physical education at the college level.

Meanwhile, the second article by Feng et al. (2022) highlights the role of VR technology integration with physical learning in higher education. The research highlights that the integration of VR in physical learning not only provides a more engaging learning experience for students but also increases their interest in and enthusiasm for sports. However, the research also identified some drawbacks, such as differences in teaching stages and objectives that may affect students' learning enthusiasm. Therefore, this study emphasises the need for continued improvement to find a stable way to increase students' learning interest. Thus, the analysis results from both articles confirmed that the use of VR technology in physical education in higher education is promising but also highlighted the importance of further development to optimise its impact on the learning process and student learning outcomes.

The third article by Wang (2021a) discusses the application of computer virtual reality (VR) technology in modern sports training. This research highlights that VR technology has become an important tool in the sports industry, assisting athletes in training, analysing athletes' physical conditions, enhancing fairness in sports matches, and driving the development of modern sports. By considering VR applications in various aspects of modern sports, this article provides important insights into how VR technology has changed the way training is conducted in sports, as well as its impact on improving athlete performance and spectator experience.

Discussion

In the analysis of the results and findings from this journal article, the integration of the Internet of Things (IoT) in physical education is shown to have significant implications. Various studies, such as those described by Ding et al. (2020), Che et al. (2021), Hu et al. (2021), Guo and Sun (2021), and Wang and Wang (2023), highlight various aspects of using IoT technologies in enhancing physical learning experiences, activity monitoring, classroom management, and teaching resource management. This integrated approach not only facilitates interactive learning but also assists in improving teaching efficiency and classroom management, as well as promoting innovation in curriculum and resource management. Other research shows that the combination of artificial intelligence (AI) and the Internet of Things (IoT) can make human-computer interaction, mental health, and the efficiency of teaching and grading much better. Examples include studies by Che et al. (2023), Fu (2020), Sun (2021), Lei et al. (2023), and Yu and Mi (2023). The integration of AI-IoT technologies offers great potential to increase the effectiveness of self-directed learning, improve academic performance, and create an educational environment that is more adaptive and responsive to student needs.

In addition, the use of deep learning technologies in physical education, as reviewed by Zong et al. (2022) and Dong (2023), shows great potential for enhancing students' learning experiences through analysis of exercise behaviour, evaluation of physical actions, and management and integration of teaching resources. However, challenges such as evaluation reliability and data validity, as well as ensuring widespread and accurate use of the technology in teaching, need further attention to maximise its benefits. Finally, the use of virtual reality (VR) technology in physical education, as described by Ding et al. (2020), Feng et al. (2022), and Wang (2021a), offers a more interactive and engaging learning experience, as well as a contribution to modern sports training. However, challenges such as differences in teaching stages and objectives and ensuring further development to optimise its impact on the learning process and student learning outcomes need to be overcome to harness the full potential of VR technology in physical education.

In the analysis of the results and findings from this journal article, it should be recognised that some of the studies mentioned may have methodological limitations that may affect the validity and generalizability of the findings. For example, some studies may use unrepresentative samples or have sample sizes that are too small to produce statistically reliable results. In addition, there may be constraints in the measurement of variables or in the control of uncontrollable factors, such as environmental or social factors, that may affect the results of the study. These weaknesses need to be critically considered in interpreting the results of the study and paying attention to the level of confidence that can be placed in the findings.

Although the integration of the Internet of Things (IoT) in physical education in higher education has been shown to be beneficial in improving the learning and teaching experience, it is possible that the research results may be interpreted in different ways depending on the point of view taken. For example, while IoT technologies can improve access to and efficiency of learning, some alternative interpretations might highlight that the use of these technologies can also increase the digital divide or reinforce inequalities in access to education. A more critical and holistic interpretation could lead to a deeper understanding of the implications of technology in the context of physical education. For future research, it is recommended to bridge the gap in the literature with more in-depth research on the effects of IoT integration in physical education in various contexts, including less accessible or remote environments. In addition, research can focus more on the contextual factors that influence the implementation of this technology, such as organisational culture, technological infrastructure, and the availability of trained human resources. Thus, future research can provide more comprehensive insights into ways to optimise the use of IoT technologies in physical education while minimising the risks and imbalances that may arise.

CONCLUSION

This research describes the results and discussion on the integration of advanced technologies such as the Internet of Things (IoT) in the context of physical education in higher education. The studies presented highlight the crucial role of these technologies in enhancing the learning experience, teaching efficiency, classroom management, and the management of educational resources. Overall, this research confirms that advanced technologies have great potential to change the paradigm of physical education in higher education. However, technical and methodological challenges need to be overcome, and further research is needed to understand and optimise the impact of these technologies in the context of physical education. With a deeper understanding of the potential and challenges of integrating these advanced technologies, we can develop more innovative and effective approaches to improving learning and teaching in the field of physical education in the future.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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