

Exploring the Integration of Virtual Reality in Physical Education: A Comprehensive Review

Milena Kuleva

*Department of Language Learning and Information Technologies
National Sports Academy "Vassil Levski"*

Sofia, Bulgaria

milena.kuleva@nsa.bg

Abstract. Virtual Reality (VR) has emerged as a promising technology with diverse applications across various domains, including education. In the realm of physical education (PE), VR presents an innovative approach to enhance learning experiences, offering immersive environments and interactive simulations. This study provides a comprehensive review of existing literature to explore the integration of VR in PE, focusing on its efficacy, challenges, and potential outcomes.

A systematic search of academic databases, including ProQuest/Web of Science, EBSCO, DOAJ, and Gale databases, was conducted to identify relevant studies published between Jan. 2016 and Feb. 2024. Keywords such as "virtual reality" and "physical education" were used to filter the literature. Studies involving diverse research designs, including experimental trials, case studies, and qualitative analyses, were included in the review.

The review revealed a growing amount of literature exploring the integration of VR in PE, highlighting its potential to enhance engagement, motivation, and skill acquisition among students. Studies reported positive outcomes in various systems around the world. VR-based interventions demonstrated effectiveness in improving performance, knowledge retention, and adherence to exercise regimens. Moreover, immersive simulations enabled experiential learning, providing students with realistic scenarios. However, challenges such as equipment cost, technical limitations, and user discomfort were noted as barriers to widespread adoption. Additionally, concerns were raised regarding the potential isolation of students and the need for adequate supervision in VR environments.

In conclusion, the integration of VR technology in PE shows promise as a valuable tool to enrich teaching and learning experiences. With continued advancements in technology and pedagogy, VR has the potential to revolutionize PE education, providing students with immersive and interactive learning environments conducive to holistic development.

Keywords: *VR, Physical Education, Gamification, Immersion, Personalized Learning, Accessibility.*

INTRODUCTION

The integration of technology into Physical Education (PE) has gained significant momentum, driven by its potential to enrich the teaching-learning process and enhance student engagement and learning outcomes. Adopting Virtual Reality (VR) and Augmented Reality (AR) in PE is particularly noteworthy, representing a frontier in educational technology that combines digital and physical environments to offer innovative learning experiences. AR can magnify the user's visual field with data and information under an instant real-world environment [1]. These technologies enable the simulation of diverse physical activities and environments, providing students with interactive and immersive learning opportunities. The use of VR and AR in PE has shown positive impacts on students' understanding, cognitive motivation, motor skills performance, and physical activity levels. Such a positive impact could also be found for people with different disabilities. [2-6]. However, despite the growing interest and evident benefits, research in this area is still in its early stages, indicating a need for further exploration and evidence-based integration into PE curricula.

As Chen et al. [7] also confirmed in 2019, a significant amount of research exists on motion training systems and methodologies utilizing virtual reality. However, these studies have not provided detailed evaluations of user motion learning outcomes across different immersive environments nor offered thorough insights into the connection between users' learning achievements and their VR experiences. Such evaluations and analyses are crucial for developing upcoming immersive motion learning systems.

VR technology enhances sports science by boosting physical activity via exergames, advancing performance through training programs, and aiding injury recovery [8].

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The integration of VR and AR in educational environments is a new era, especially within the field of physical education. This new technological frontier offers unparalleled opportunities to improve teaching methods, engage students in immersive learning experiences, and address long-standing teaching challenges.

A. The Rise of VR/AR in Education

The adoption of VR and AR technologies in education has been progressively increasing, motivated by their potential to provide immersive, interactive learning environments that engage students in a manner traditional methods cannot. In the context of PE, these technologies promise to revolutionize how physical skills and health concepts are taught, learned, and assessed. Unlike conventional PE approaches that are limited by physical space, equipment availability, and safety concerns, VR/AR can simulate a wide array of physical activities and sports in a controlled, safe environment. This allows students to practice skills, understand complex concepts, and receive immediate feedback in an engaging and effective way.

It could be said that in the school programs of different countries, different sports are offered to students depending on the region. For example, countries around the Mediterranean do not practice the same sports as more northern countries, and vice versa. The implementation of VR technology effectively bridges this gap, allowing for a more inclusive and diverse range of sports from both regions to be integrated into the teaching content. [9].

B. Engagement and Motivation

One of the most significant advantages of integrating VR/AR into PE is the potential to increase student engagement and motivation significantly. By immersing students in virtual environments that simulate real-world sports scenarios or physical activities, VR/AR makes learning more compelling and enjoyable. This heightened engagement can improve attendance and participation rates, especially among students who may not be traditionally interested in physical activities or feel self-insecure in physical settings. [10-11]

Skill Acquisition and Performance

VR/AR technologies have shown promise in enhancing skill acquisition and performance in PE. Through the use of virtual simulations, students can practice specific skills repeatedly, with the technology providing instant feedback on their performance. This immediate feedback loop allows for rapid adjustments and improvements, potentially accelerating the learning process. Moreover, VR/AR can offer personalized learning experiences, adapting to each student's skill level and learning pace, thus optimizing skill development across diverse student populations. [12-13]

C. Possibilities for Introduction in PE Classes

Introducing VR systems in PE classes opens up many possibilities for educators and students. For instance, VR can simulate challenging environments or scenarios that are impossible or impractical to experience in a school setting, such as mountain climbing, kayaking, or even spacewalking. This not only enriches the curriculum but also ensures that students have access to a broader range

of physical activities, fostering a more inclusive and comprehensive approach to physical education.

Furthermore, AR applications can overlay digital information onto the physical world, offering a unique way to learn about anatomy, physiology, and the science of exercise through interactive experiences. For example, AR can project the muscular system on a student's body as they perform an exercise, providing a deep understanding of the mechanics involved.

D. Challenges and Considerations

Despite the promising potential, the integration of VR/AR into PE faces several challenges, including high costs of equipment, the need for technical support and training for educators, and concerns about equitable access for all students. Addressing these challenges requires strategic planning, investment in infrastructure, and ongoing professional development for educators. The value of creating VR environments is based on many hours of work by professionals - both technical and psychological-pedagogical.

II. MATERIALS AND METHODS

This study conducts a comprehensive literature review focusing on the integration of virtual reality in physical education and sports classes in schools and universities around the world. The articles part of this research are from January 2016 to February 2024, with a total of 3065 sources. By using digital library access to numerous scientific databases such as ProQuest/Web of Science, EBSCO, DOAJ, Gale databases, and others, the search was defined to include as many articles as possible for exact coverage. The keyword strategy encompassed combinations like "Virtual reality AND PE classes", "VR AND Sports education" and "VR AND Physical Education", among others. Due to the sheer volume of articles, the study was limited to making sure that both applied terms necessarily appeared either in the title of the publications or in the subject line. On this basis, the number of articles that were reviewed was 78. To be able to identify articles that would fall as close as possible to our study, the following criteria were set:

Inclusion Criteria:

- Explicit use of a virtual environment.
- Involvement of physical activity or sports with reported outcomes for a Physical education class.
- Publication in English.
- Minimum of 5 participants.
- Detailed results, preferably with tables and graphical representations.

Exclusion Criteria:

- Case studies.
- Absence of informed consent.
- Non-English publications.
- Studies without physical activity or sports participation or not in the educational process.
- Theoretical research only.
- Participants with diagnosed diseases or in hospital settings.

III. RESULTS AND DISCUSSION

After applying the inclusion and exclusion criteria, only seven publications were included in the analyzed articles. Of the total number of articles examined, 71 were dropped for the following reasons:

- The publication was not on the subject of physical education and sport - 25 pcs.
- There was no examination of research subjects in the publication - 16 pcs.
- The publication included researched persons with various diseases - 1 pc.
- The publication was a review - 11 pcs.
- The publication was theoretical - 18 pcs.

The review of the seven articles, as a whole, highlighted mainly the positive aspects of VR and its application.

The study by Chang et al. [14] that we will review found that AR-assisted learning with 3D models can improve performance in motor skills learning compared to video learning. However, there were challenges with the AR mobile carrier that needed to be addressed, and the satisfaction of students using AR-assisted instruction was generally higher than that of traditional methods.

The AR-PE class can be adapted to provide learning opportunities in athletic competitions and training experiences beyond individual motor skills training by incorporating virtual reality (VR) into the assistive system. This would enable situational learning, allowing learners to experience realistic athletic scenarios and training environments. Additionally, the integration of mixed reality, which combines augmented and virtual reality, can be explored as a research direction for athletic training aids. This approach would offer a more comprehensive and immersive learning experience for athletic competitions and training beyond individual motor skills training.

Building on the initial findings, further analysis through literature research, expert interviews, and questionnaire surveys explored the impact of VR technology on physical training teaching in college classrooms in the study of Wang et al. [15]. Their experimental results affirmed the validity of all research hypotheses, indicating a positive impact of VR technology on physical education. They reported that a significant portion of participants reported improvements in various aspects of learning due to VR technology. Specifically, 80% found that VR stimulated interest in learning, 75% observed that it attracted more attention, and 63% believed it improved learning efficiency. Such findings highlight VR's capability to make education more engaging and effective. They also conclude that VR technology has shown its potential to significantly enhance educational outcomes by a deeper understanding of physical training, increasing learning efficiency, and accelerating learning progress.

Chen's paper [16], which was published in 2022, on the use of Cross-Country Skiing Teaching, is interesting. Research has been done, but unfortunately, no particular conclusions stand out, and this probably means that research needs to be furthered in this direction. It is a sport that is not commonly practiced in physical education

classes but could be included, to some extent, to introduce it and spark learners' interest in doing it. Probably, a vast majority of the learners would not have come into contact with this sport had it not been for the opportunity created through VR.

Dong's [17] research, published in 2020, highlights the significant role that advancements in technology, specifically mobile communication and virtual reality, play in enhancing physical education and exercise. As living standards improve and the importance of fitness gains momentum, incorporating high-tech means such as 5G and VR into physical training has made sports more engaging, entertaining, and effective in improving physical quality. Their approach is mainly aimed at the younger generation, emphasizing the necessity of integrating their physical health into educational reforms. Smart physical education, facilitated by using 5G and VR for anytime, anywhere fitness exercises, not only raises exercise awareness among students but also fosters a healthy lifestyle by blending interest with physical activity. However, the study indicates a positive impact of intelligent physical education on students' physical performance. The future of physical education looks promising, with the potential for an integrated sports and entertainment project, underscoring the need for ongoing development in this field to organize the most effective teaching schemes for contemporary students.

An important study was conducted by the team of Geisen et al. [18] from Germany in 2023. The authors of the study implemented VR in dance-related sports activity classes. According to their research, the analysis of the VR rotation task reveals its potential to evoke unique perceptual experiences and unexpected behavioral responses among students, highlighting the complex interplay between physical and mental processes and modern technology. The integration of VR with an electric turntable introduced novel physical and mental rotational perceptions, though it also presented challenges that required effort and adaptation. Despite these challenges, the VR rotation task shows promise for diagnostic and training purposes in perceptual and attentional aspects, particularly in extracurricular dance classes. The task's difficulty suggests the need for extended training and adaptation across various learning environments and age groups, positioning it as a valuable tool for cognitively demanding tasks in various educational fields. Feedback from the study indicates that the VR rotation task can enhance motivation and promote independent, self-organized learning among students, fostering behaviors crucial to dance education, such as observation, communication, interaction, and synchronization. They conclude that the VR rotation task significantly contributes to dance practice's didactic and collaborative aspects, supporting the holistic development of young learners. The findings suggest a promising path for future research into VR-enhanced training tools in sports education and beyond, emphasizing the importance of further exploration and integration of technology in pedagogical strategies to enhance learning experiences and outcomes in sports education fields.

In the research of Chen et al. [7], presented in 2019, they make interesting findings. They developed research with Taichi, which is a special type of Chinese martial art

with particular motion features. They indicate that measuring or predicting learning quality proves more challenging than determining learning time. It was noted that an overly immersive VR environment, such as one provided by head-mounted displays (HMDs), while facilitating rapid learning, may negatively impact learning quality due to excessive immersion, such as the inability for students to see their bodies, potentially misrepresenting motion learning. Quite the opposite, environments that offer good sensory engagement and immersion without overdoing it, like the CAVE system, showed higher motion quality scores and quality of student performance ratings than both overly immersive HMDs and non-immersive PC setups. High presentation quality also plays a vital role in enhancing learning quality. They generally conclude that designing future immersive motion learning systems should balance several key factors: providing an engaging VR experience, ensuring visibility of the learner's body, avoiding motion impediments, delivering high-quality multimedia content, and maintaining a comfortable learning environment. These elements attract learners and significantly improve both the efficiency and quality of the learning experience, highlighting the nuanced relationship between immersion and educational outcomes in VR-based learning environments.

The environment showcased exhibits characteristics of effective immersion, high-quality presentation, ease of use, and separation from distractions, thereby establishing itself as the optimal learning setting despite its cost.

Lee and Oh [2] present a study in 2022 that contributes significantly in three key areas. Firstly, it expands the traditional Technology Acceptance Model (TAM) to include presence and flow, attributes specific to VR/AR media, enhancing understanding of user acceptance and participation intentions in VR/AR sports experiences. Secondly, by identifying experience economy factors as precursors to increasing user presence in VR/AR sports, the study empirically explores the causal link between these factors, providing a nuanced understanding of user engagement. Finally, it offers strategic insights for strengthening the VR/AR sports experience sector.

However, the study faces limitations, notably in its demographic scope, focusing primarily on university students with a sports major, which may not fully represent the broader population engaging with VR/AR sports experiences. Future research is encouraged to explore these findings across different age groups and incorporate qualitative analyses to deepen the understanding of VR/AR sports experiences among different user profiles.

Xiong [19] also concluded that a positive experience with the use of VR technologies was derived from their study in 2021. They focused on martial arts as the subject matter. The research utilized questionnaire surveys to identify the learning needs of martial arts students and the functional requirements of a martial arts teaching system. The system demonstrated a significant improvement in both the learning experience and efficiency for learners, showcasing the potential of integrating advanced technologies in PE teaching methodologies.

An interesting study with adding artificial intelligence to VR is presented by Yuehong Shi [20]. The study was published in 2024 and is one of the most recent studies in this paper, making both an interesting study and essential conclusions. The study investigates the impact of integrating big data technology and genetic algorithms within a VR-based intelligent teaching system for physical education. Through comprehensive research and system development, followed by data analysis on VR technology's application in physical education, they present several key findings:

Applying an AI-driven VR teaching system to aspects such as physical form, quality, and learning attitude does not show statistically significant effects, with p-values exceeding 0.05 in their study. This indicates that both traditional and VR-assisted teaching methods contribute to enhancing students' physical quality, albeit without significant differences between the two approaches.

A focused analysis of tennis technical skills assessment employing VR technology, which Shi [20] presents in their research, reveals a notable improvement in the experimental group's performance. The experimental group scored significantly higher in technical assessments than the control group, demonstrating that VR-assisted tennis teaching can effectively elevate students' tennis skills.

Their study also highlights a 19% to 20% increase in physical education efficiency attributable to VR technology, a significant enhancement in educational efficiency that underscores the effectiveness of VR-assisted teaching methods in physical education settings.

CONCLUSIONS

Based on the above analysis, several conclusions could be drawn.

With the development of VR technologies, more and more researchers are doing their research on the topic. According to the present study, the researches are mainly done by Asian researchers, with the most significant percentage of them being from China.

Instead, there is currently a lack of research investigating the effect of virtual reality in physical education and additional sports in extracurricular activities. The study lacks more in-depth, detailed, and sufficient examination and research on physical education that requires the application of virtual reality technology. However, an opinion may rather be formed that VR and AR in physical education present an exciting opportunity to redefine the learning experience, making it more engaging, inclusive, and effective. As these technologies continue to evolve and become more accessible, their potential to enhance physical education and promote a lifelong love of physical activity among students is boundless. The journey of integrating VR/AR into PE is just beginning, and it promises to pave the way for a future where education is not just about absorbing information but experiencing and interacting with knowledge in profound and meaningful ways.

It could be pointed out that the theory and technical mastery of virtual reality technology are not thorough enough, and there is a lack of comprehensive understanding of its application. This applies more to the

development of appropriate virtual reality environments as well as to specific pedagogical scenarios providing subject-specific knowledge and competencies.

Although not a part of the studied articles that met the inclusion criteria, research on the application of virtual reality in different, not-so-accessible sports that could not be applied in a regular physical education class is found. In this respect, using technology provides an opportunity to enrich the learners' knowledge in the sports that are "not applicable" in the class.

Regarding the financial aspect of virtual reality, it is noteworthy that many of the studies conducted with virtual reality have received funding from research projects or have received funding from an educational institution or a government. This is probably also due to the fact that the cost of developing and testing a virtual reality environment is time-consuming, which automatically makes it an expensive endeavor. It is not just the purchase of the technology - the various helmets - but the constant input of human labor and ideas that makes the product expensive.

The application of VR technology in physical training teaching shows promising results in enhancing learning outcomes, student engagement, and teaching methodologies, and there are opportunities for further research and development to overcome current challenges and fully realize VR's potential in education.

Understanding the current progress in this research area is crucial for its development, given that integrating technology into physical education classes can significantly enhance their quality. This enhancement could be achieved by creating enjoyable student experiences, ultimately aiming to instill lifelong physical sports habits. Therefore, this research holds huge promise for sports practice, offering educators innovative methods to elevate PE class quality through practical experiences and novel technological applications. Furthermore, it emphasizes the advantages these technologies offer students while providing guidelines for their effective implementation in educational settings. Doing so aims to motivate more PE teachers to incorporate technology into their teaching and ensure its proper application, thereby realizing the anticipated benefits highlighted throughout this study.

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