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The Effect Of Augmented Reality (AR) On Improving Motor Learning Skills In Students

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Abstract:
The present study examines the possibility of integrating Augmented Reality (AR) into the teaching of Physical Education, with the aim of improving motor learning and the overall educational experience. AR technology, with its ability to combine the physical and virtual worlds, offers new perspectives for teaching motor skills, facilitating experiential and personalized learning. In this context, the study examines how AR can enhance students' participation, performance and interest in PE. The research was based on an analysis of data from existing studies describing the effectiveness of AR in teaching physical education and learning motor skills. The methods used include literature review and comparative case analysis, aiming to collect qualitative and quantitative data on the applications of AR in Physical Education. The analysis showed that AR offers significant benefits, such as immediate and personalized feedback, enhancing motor memory through interactive models, and incorporating recreational elements that increase student engagement. The study's findings highlight the potential of AR to enhance the teaching of motor skills in ways that were not possible with traditional methods. The prospects for the use of AR in physical education appear positive. While there are challenges and difficulties in implementing it, the rapid evolution of technology offers opportunities to create more accessible and easy-to-use applications, making AR a viable option for educational environments. At the same time, the integration of AR paves the way for the development of innovative teaching methods that enhance interaction, autonomy and multidimensional learning. Continued research and development in this area can redefine Physical Education, enhancing the educational experience and skills development for students.
Key Word*: Augmented Reality; Motor Learning; Skills; Students; Teachers; Gymnastics.*

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I. Introduction

The rapid evolution of technology has revolutionized the way we perceive and apply the educational process. In the field of physical education, where motor skills and practical experience play a leading role, traditional teaching methods are often not sufficient to meet students' needs. Motor learning is a critical pillar of physical education and skills development linked to students' health, physical activity and general well-being. Understanding and acquiring motor skills require not only practical application but also effective educational approaches that engage students in an interactive and personalized learning process. However, traditional teaching methods are often limited by a lack of flexibility, the need for specialized equipment and difficulties in providing accurate feedback. The emergence of augmented reality (AR) has opened up new perspectives for the teaching of motor skills, as it offers the possibility for interactive and experiential learning. AR can integrate visual and audio stimuli in real time, providing students with the opportunity to practice virtual environments that mimic real-world conditions. Research has shown that the use of AR technologies in physical education enhances understanding of complex motor concepts, improves student engagement, and encourages autonomous learning[9]. At the same time, the integration of innovative methods, such as AR, into physical education teaching can address the challenges emerging in an ever-changing educational environment. Technology makes it easy to adapt educational content to the needs of different students, allowing for personalization of teaching. Through technological tools such as AR, teachers can tailor lessons based on their students' skill level, offering support and reinforcement where necessary. This not only improves the learning experience, but also helps reduce the stress that often accompanies the acquisition of new skills[25]. In settings such as distance learning that was widely implemented during the COVID-19 pandemic, the use of interactive media such as AR-based mobile apps has proven extremely useful in maintaining and improving fundamental motor skills[37]. In addition, AR provides the ability to tailor the content to the needs of students, making it particularly attractive for different skill levels and age groups. For example, AR systems have been successfully used to develop motor skills in early childhood, supporting the development of fine motor skills through activities such as folding, cutting, and coloring[23]. Despite the prospect of innovative methods, there are still challenges to be addressed, such as

implementation costs, availability of technology and the need for teacher training. Nevertheless, technological advances and improvements in device accessibility make the use of AR a viable option for future education[25].

Physical Education, as a field that relies heavily on experiential learning, offers the ideal basis for integrating technologies such as AR. Integrating AR into teaching can enrich the learning experience, allowing students to better understand the basic principles of movement through interactive and three-dimensional simulations. In addition, AR enables real-time feedback, enhancing the learning process and self-improvement. Research suggests that AR apps enhance students' concentration and engagement, making them feel more connected to lesson content[38]. Through AR, students can practice complex motor skills in virtual environments, such as precise movements in the context of sports activities. Such applications offer opportunities for personalized learning, as they can be adapted to the needs of each student, allowing skills to be cultivated at their own pace[8]. Understanding the impact of AR on motor skills teaching can open up new perspectives for teaching physical education. Traditional methods are often limited by factors such as lack of equipment, static nature of teaching, and limited ability to provide immediate feedback. On the other hand, AR enables the integration of dynamic and personalized learning experiences, while providing students with the ability to repeat activities and directly see the impact of their actions[15]. At the same time, difference analysis aims to identify the advantages and limitations of each approach. For example, traditional methods rely on physical presence and repetitive practices, which are essential for learning skills. However, AR can overcome these barriers through the ability to simulate environments that are not readily available.

The aim of this study is twofold and concerns the exploration of the dynamics of Augmented Reality (AR) as an educational tool for the development of motor skills in Physical Education and the analysis of its effectiveness compared to traditional teaching methods. The study also seeks to examine the differences between the use of AR and traditional teaching methods in physical education. By listing these differences, the study aims to form a fuller picture of how AR can be utilized in physical education and how traditional methods can benefit from integrating technology to improve the educational process.

II. Theoretical Part

Definition and Key Features of Augmented Reality (AR)

Augmented Reality (AR) is defined as technology that combines digital and physical elements in real time, enriching the human experience through superimposed information. Unlike Virtual Reality (VR), which creates fully virtual environments, AR works in real environments and enhances them with additional information such as 3D models, video, graphics and sounds. This technology is leveraged in various sectors, such as education, healthcare, industry, and entertainment, due to its potential to bridge the gap between the digital and physical worlds[22].

One of the fundamental features of AR is real-time interaction, which allows users to customize virtual elements and integrate them into their environment. Through this interactivity, AR transforms static information into dynamic learning experiences, making technology a powerful tool in the educational process. Examples include imaging complex phenomena, such as chemical reactions or physical phenomena, through wearable devices or specialized AR glasses[25]. Another key feature of AR is the enhancement of learning through the provision of experiential experiences. The ability to present objects and concepts that are not directly accessible, such as the function of internal human organs or the architecture of monuments, allows students to better understand complex concepts. Research has shown that students using AR exhibit increased engagement and motivation, improving learning outcomes and overall learning experience[15]. In addition, AR supports collaborative and personalized learning. Collaboration is achieved through applications that allow multiple users to interact simultaneously, creating team-based problem-solving environments. At the same time, personalization allows students to tailor their learning experience according to their needs and preferences, which is particularly important in educating people with different skill levels or special needs[31]. Technologically, AR is based on three main properties:

- *the simultaneous display of real and virtual objects*
- *aligning virtual elements with the real world*
- *real-time interaction*

These features make AR unique, as it offers an "augmented" visualization of the real world, where users can see and interact with virtual objects embedded in their environment[8].

The Growing Use of AR in Education

The integration of Augmented Reality (AR) into education is one of the most exciting and innovative developments in the field of teaching technology. AR, as a tool that combines the physical world with digital visualizations, has revolutionized the way we perceive and implement teaching, making the learning process more interactive, personalized and effective. Its increasing application demonstrates its potential as a platform for providing experiential learning experiences at various levels of education and disciplines. AR has the unique

ability to combine physical and digital elements, creating interactive experiences that enhance student engagement. Unlike traditional teaching methods, where students are often passive receivers, AR encourages them to actively participate through interaction with three-dimensional models, graphs, or simulations. For example, students can observe the anatomy of a human body through an AR application, examining organs and functions in real time[15]. This feature not only enhances engagement but also facilitates understanding of complex concepts. Research by Radu[38] points out that students who use AR perform higher in activities that require spatial understanding and analytical thinking compared to those who use traditional media. One of the major strengths of AR is its ability to personalize teaching, tailoring learning environments to the needs of each student. AR applications offer the ability to configure content according to the level and learning style of the user. In primary education, students with learning disabilities can benefit from environments that support the step-by-step explanation of complex concepts, thereby enhancing their self-confidence and autonomy[22]. AR technology has also proven useful for students with special educational needs. Students with visual impairments, for example, can use phonetic descriptions that accompany AR experiences to understand concepts that are difficult to capture in writing[10]. AR promotes collaboration by creating environments where students can work together to achieve a goal. These environments incorporate multisensory experiences, enhancing participation and communication among team members. AR applications allow students to "complement" virtual models with input from all members, improving overall understanding and performance[31]. AR finds applications in a variety of educational areas. In medical education, students use AR to practice surgeries, developing skills in a controlled and safe environment. In engineering, students use AR to study complex machines and their functions, while in geometry, high school students interact with three-dimensional geometric shapes to understand theoretical patterns[8].

In addition, motor learning offers many benefits, particularly in increasing student participation, improving academic performance and promoting health. This proactive approach incorporates physical activity as a key component of the educational experience. Incorporating motor activities can increase students' engagement levels. Those who participate in practical activities tend to be more engaged, attentive, and motivated, which has a positive effect on their academic outcomes[42]. In addition to cognitive development, motor learning contributes significantly to students' overall health. Regular physical activity combats sedentary lifestyle, which is increasingly common among students and can lead to improved fitness, better mood, and reduced stress[7]. These benefits are important as they form the basis for a more cohesive and productive learning environment.

III. Literature Review

Motor Learning Theories

Motor learning theories examine how people develop, improve, and stabilize motor skills through practice and experience. These theories combine evidence from neuroscience, psychology, and physiology to understand the mechanisms behind learning movements. Focusing on basic theoretical approaches, such as Learning Stages Theory and Execution Theory, as well as the factors that influence motor learning, we can analyze how motor skills acquisition is formed.

The Theory of *Stages* of Learning, proposed by[13], describes the learning process as a progressive transition through three stages: cognitive, connective, and autonomous. In the first stage, students focus on understanding the activity and face a high level of error due to lack of experience. In the connective stage, movement becomes more consistent through repetition, while students acquire the ability to correct their mistakes based on feedback. In the autonomic stage, movement is performed with minimal cognitive effort and accuracy and speed are improved.

Execution theory holds that motor skills learning involves two basic systems: the open and closed control systems. The open system focuses on rapid movements that do not require constant feedback, while the closed system relies on sensory feedback to correct movement as it is performed. The balance between these systems depends on the requirements of the activity and the conditions of the environment[1].

The theoretical approaches that support motor learning highlight the importance of physical participation in the learning process, especially in Physical Education. Theories such as experiential learning and constructivism emphasize the importance of active participation in the acquisition of skills and knowledge. These theories emphasize the importance of active participation and practice in the learning process. Physical engagement reduces cognitive load, making it easier to understand complex skills[18]. At the same time, the theory of multimodal learning reinforces the view that the use of many sensory stimuli, such as movement and visual support, can increase students' performance and understanding[16]. In these contexts, students learn best when they can engage physically with the subject, through movement and practice. This is especially important in sports, where motor skills are developed through repetitive physical activity and experiential experiences. Educational psychology contributes to the understanding of how different types of students benefit from kinesiological methods. Research shows that children with different cognitive profiles respond differently to

teaching strategies. The study by Weeks, Brooks, and[46] suggests that tailored educational approaches can enhance the learning of students with particular cognitive strengths and weaknesses. By incorporating motor activities that meet students' individual needs, teachers can enhance motor skills development and improve learning outcomes. Additionally, cognitive load theory[18] emphasizes the importance of managing cognitive requirements for effective teaching. Motor learning can reduce cognitive load by allowing students to process information through physical activity, thereby enhancing memorization and comprehension. This combination enhances the educational experience, making physical participation an integral part of effective teaching in physical education.

Motor learning is influenced by various factors related to the environment, the person and the task to be performed. The type and quality of feedback play a critical role in improving motor skills. External feedback, such as instructor instructions or technological tools, helps to understand errors and adjust movement. At the same time, internal feedback, based on one's sensory perceptions, is equally important for accuracy and retention of skills (Schmidt & Lee, 2011). Variability in practice is also considered an important factor, as it allows students to develop flexibility and adaptability to different conditions. Argue that encouraging autonomy and creating a supportive environment enhances student engagement and performance, while repetition in different environments increases learning transfer[47]. Feedback, variability, age, and past experiences also influence the learning process. Younger ages exhibit greater neuroplasticity, which facilitates learning, while previous experiences help create patterns that improve performance[1]. Finally, the involvement of cognitive factors, such as concentration and understanding of the goal, enhances the acquisition of skills.

The role of Physical Education in the development of motor skills

Physical Education plays a crucial role in the development of motor skills, acting as the foundation for the physical, psychological and social development of children and adolescents. Through structured programs that incorporate physical activities and pedagogical approaches, Physical Education offers children the opportunity to acquire, improve and maintain motor skills necessary for their participation in various sports and daily activities. Motor skills include basic functions such as balance, coordination, agility and strength. Research shows that participating in structured physical education activities can significantly enhance these skills. A study by[43] showed that children participating in physical education showed improvement in muscle strength, explosive strength and flexibility within a few months, indicating the importance of regular exercise. In addition, incorporating resistance exercises into physical education activities has been found to improve motor performance and promote students' overall fitness. Such activities not only enhance muscle strength and power but also contribute to learning a variety of athletic skills, improving students' overall physical performance at young ages[41]. Physical education also has a positive effect on motor proficiency, a critical skill that affects children's healthy development. In a comparative study[27], concluded that students who participated in three hours of physical education per week showed significant improvements in skills such as gymnastics, handball, and football, compared to students who did not participate regularly. Early childhood is also critical for the development of motor skills. Participation in Physical Education under the guidance of specialized teachers promotes the development of basic motor skills, such as mobility and object handling, thus enhancing prospects for healthy development at early ages[26]. The development of motor skills through physical education is not limited to improving physical performance. It also positively affects self-esteem, cooperation and social inclusion. Students who master motor skills are more confident to participate in group activities, which promotes their overall psychosocial development[30]. Implementing physical education programs that include appropriate activities and adequate feedback from teachers is critical to success. Emphasized the importance of implementing physical education programs that combine motor activities with cognitive training, suggesting that such programs can enhance both motor skills and cognitive development at preschool ages[6].

Overall, physical education plays a multidimensional role in motor skills development, enhancing both physical performance and psychosocial development. Structured activities, systematic practice and appropriate guidance are key elements to maximise the benefits of physical education.

AR Technology in Education

Augmented Reality (AR) has emerged as a powerful tool that transforms the educational experience, enabling the integration of real-time digital information into students' physical environments. The use of AR has expanded to multiple fields of knowledge and educational areas, offering unique possibilities for teaching and learning. The applications of AR in teaching cover a wide range of subjects, from natural sciences to arts and technology. Indicatively, the use of AR in geometry has proven particularly effective for understanding three-dimensional geometric shapes. Applications such as Geo+ offer students the opportunity to examine shapes in an interactive way, enhancing their spatial perception and understanding of mathematical concepts[39]. At the same time, AR has been successfully exploited in science and technology, with applications that enhance the learning process through the visualization of complex concepts. In subjects such as electrical engineering, AR is

used to simulate electrical systems, allowing students to understand their function through virtual models[17]. In addition, in STEM (Science, Technology, Engineering and Mathematics) education, AR has contributed significantly to enhancing student engagement and understanding of complex phenomena through interactive laboratory simulations[34]. In addition to natural sciences, AR has been used in areas such as teaching cultural heritage and foreign languages. In cultural education applications, students can interact with virtual objects, such as archaeological finds or historical monuments, enhancing their experiential learning[11]. In language teaching, the use of AR tools, such as Mondly AR, allows students to practice realistic communication scenarios, increasing their confidence in their language skills. Another interesting example is the application of AR in pedagogical activities that combine art and science. In projects such as teaching STEAM (Science, Technology, Engineering, Art, Mathematics), AR is integrated into interactive activities that enhance students' creativity and critical thinking[21]. Students are actively involved in creating virtual objects while learning basic coding and engineering skills. These examples show that AR can be applied to a wide range of cognitive fields, offering an innovative approach to learning that enhances student engagement and understanding. At the same time, AR helps create an environment conducive to teamwork and collaboration, as students can interact with virtual objects and collaborate on common projects.

Effects of AR on Motor Learning

Augmented Reality (AR) technology has developed a powerful tool to support motor learning, offering new perspectives in motor skills training. Researchers have explored the relationship between AR and motor learning, highlighting both its advantages and limitations. AR allows learners to interact with virtual objects in real-time, enhancing their understanding and practical application of skills. The use of AR in motor learning is based on its ability to provide accurate and targeted feedback. Research has shown that visual and tactile feedback through AR significantly improves accuracy and consistency in executing motor skills. One of the main advantages of AR is its ability to enhance the learning experience through the combined use of multiple sensory processes. Argued that the combined use of visual, auditory and tactile feedback facilitates motor skills learning, improving learner engagement and enhancing real-world knowledge transfer[40]. AR has also proven effective in teaching skills that require coordination and adaptation. In experiments where AR was used for sports training, trainees showed significant improvements in their balance and coordination. Over-reliance on AR technology may reduce learners' autonomy in learning motor skills, leading to lower knowledge retention. However, properly integrating AR into education can address these limitations, providing opportunities for personalized and interactive learning. Overall, the effects of AR on motor learning are manifold, as it enhances participation, engagement and learning experience, while offering unique opportunities to adapt to learner's needs. Despite the challenges it presents, AR remains a promising technology for improving motor learning in a variety of contexts.

IV. Analysis And Discussion

Capabilities of AR in Physical Education

The use of Augmented Reality (AR) technology in Physical Education offers unique possibilities for enhancing student engagement and personalized teaching. AR enables the creation of interactive learning environments where students can interact with virtual objects and experience realistic scenarios in real time. This not only increases their interest but also facilitates the understanding and application of motor skills in real conditions. The potential of AR in enhancing student engagement is evident in various applications in Physical Education. Studies have shown that the use of AR enhances student participation through the provision of visual and auditory feedback when performing activities. Students who used AR to teach physical education showed significantly higher levels of interest and participation, compared to traditional methods. Students were able to interact with virtual models, such as three-dimensional visualizations of athletic skills, and receive real-time feedback on their performance[45]. AR also supports personalized teaching in Physical Education, providing the ability to adapt lessons to the needs and abilities of each student. Through applications incorporating data analytics technologies, teachers can assess each student's performance and tailor activities based on skill levels and progress. A study showed that AR enables personalization of education, facilitating the teaching of complex motor skills through interactive models and exercises tailored to the needs of each student[9]. In addition, AR offers an environment where students can make mistakes without consequences, allowing them to learn from their failures and improve. This creates a climate of safety and boosts students' self-confidence. Argue[19] that integrating AR into physical education activities increases students' autonomy and promotes discovery through the practical application of knowledge and skills. Despite these advantages, there are also limitations to the use of AR in physical education. The need for specialized equipment and the familiarization of teachers with technology are major challenges. However, with the evolution of technology and the reduction of costs, the use of AR is becoming more and more affordable, opening new horizons for teaching and learning.

Traditional Methods vs. AR in Physical Education

Physical Education is an area where traditional teaching methods and augmented reality (AR) technology coexist, offering different approaches to developing motor skills. Traditional methods focus on teaching through repetition and direct observation, while AR introduces interactive tools that allow immersion and personalization of the educational experience. The comparison of these two approaches highlights significant differences in the nature and quality of motor skills developed, with theoretical analysis providing valuable insights into their dynamics. Traditional teaching methods in physical education are mainly based on direct instructions from teachers, combined with the physical participation of students in activities. This approach supports the development of basic motor skills, such as balance, endurance and coordination, through repetitive exercises. Studies have shown that traditional methods can be effective for learning basic skills, but are limited in their ability to adapt to students' individual needs. The lack of individualization can make it difficult to maintain engagement of students with different levels of ability[36]. Instead, AR introduces a dynamic learning environment where students can interact with virtual objects and receive instant feedback on their movements. This technology has proven particularly useful for developing complex skills that require a combination of cognitive and motor processes. Research has shown that students who use AR to learn athletic skills, such as accuracy in throwing or balance, show better understanding and faster progress compared to those who use traditional methods[9]. AR facilitates personalized teaching, allowing students to adjust the pace of their learning and focus on areas that need improvement. Through programs such as BalanSAR, students can practice balance skills with the support of three-dimensional projections and interactive exercises, which enhance visual and tactile feedback[32].

Despite the advantages of AR, there are also limitations. The need for expensive equipment and technological familiarity of teachers can be obstacles to its implementation. Also, over-reliance on technological tools may reduce students' autonomy in learning basic motor skills. However, with proper integration and expertise, AR can complement traditional methods, offering a more holistic and enriching learning environment. The comparison between traditional methods and AR highlights a difference in the nature of learning: traditional methods are better suited to gradually learning basic skills, while AR enhances engagement and understanding in more complex contexts. The integration of both approaches in Physical Education can provide a balanced educational experience that meets the needs of all students.

Challenges and Limitations

The integration of Augmented Reality (AR) in Physical Education offers exciting possibilities, but also faces significant challenges and limitations. These obstacles are related both to technological and pedagogical factors and to financial and practical difficulties. From a tech perspective, implementing AR requires high-tech equipment, such as portable devices, AR headsets, or interactive displays, that can be costly and not affordable for all schools. Research has shown that the lack of adequate infrastructure is one of the main barriers to widespread adoption of AR in education. Particularly important is the role of teachers who, through active learning methods, can create an environment that encourages participation and pleasure in sports activities. For example, the use of group activities and interactive exercises helps students develop both motor skills and socio-emotional abilities. These strategies are linked to the principles of relationship-based student management, which emphasize the importance of building strong bonds with students[44]. Another example is the study by[5] reported that lack of appropriate equipment and technological support is among the major limitations in the implementation of AR in educational settings[5]. Pedagogically, integrating AR requires teacher training to use this technology effectively. Many teachers lack the necessary knowledge or skills to realize the full potential of AR, which limits its usefulness. The absence of appropriate pedagogical frameworks for the implementation of AR is a serious barrier to the sustainable use of technology in educational settings[20]. Financially, the cost of AR is a major issue. In addition to the high initial cost of equipment, educational providers face the challenge of maintaining and upgrading technology. Especially for schools with tight budgets, investing in AR can be considered unsustainable. Pointed[19] out that limited financial resources and reliance on commercial platforms limit schools' ability to integrate AR into teaching. On a practical level, the complexity of designing and implementing training programs with AR can be challenging. Creating quality AR content requires collaboration between educators, developers, and designers, which makes the process time-consuming and expensive. The limited portability of some AR technologies may affect their use outdoors, which is a key element of physical education. Also, success of motor learning through the use of AR in Physical Education depends largely on curriculum design. A program that neglects physical participation can create a gap between students' interests and physical education learning goals. The development of an integrated program that integrates kinesiological elements and AR can respond to different learning styles while providing opportunities for students' active participation, and enhance their overall well-being. Point[27] out that AR is particularly effective in improving students' motor performance when integrated into a well-designed curriculum. Despite the challenges, AR's capabilities remain impressive. With proper investment and training, this technology can provide invaluable

opportunities for teaching and skills development. Successful examples of the implementation of motor learning programmes should be explored. These cases offer valuable insights into effective practices and strategies that enhance student engagement and fitness. For example, educational programs that combine interactive technologies with motor learning practices have proven particularly effective in increasing student engagement[4]. Ongoing research and design adjustments to AR can reduce barriers and enable its effective integration into physical education.

V. Prospects And Future Directions

Enhancing Physical Education through AR

Motor learning is an innovative and efficient way of teaching, especially in the context of Physical Education. Through movement, students gain experiential experience, enhancing both their physical skills and their understanding of complex motor patterns. Research has shown that students who learn through kinesiological methods have improved performance in motor skills and greater ability to memorize techniques compared to traditional teaching methods[3]. Sports such as basketball, students who participate in repetitive exercises enhance their balance and coordination, while better understanding the movements and demands of space. In addition, kinesiological learning creates an environment where different learning types can be covered. As[28] note, students with different cognitive profiles, such as dependence or independence from the field, exhibit different reactions to physical activities. Kinesiological teaching strategies allow teachers to adapt their methods, enhancing participation and overall fitness.

The use of motor learning in Physical Education includes practical activities such as individual exercises, group activities and sports games. Also, the integration of technologies such as interactive platforms and motion analysis devices offers significant advantages. For example, motion detection devices allow students to evaluate their movements in real time, enhancing their understanding and accuracy[4]. Also, innovative programs such as those that combine kinesiological methods with an interdisciplinary teaching approach have shown that students improve their cooperation, self-confidence, and physical condition[7]. Such initiatives highlight the widespread application of motor learning in a variety of educational settings.

Augmented Reality (AR) is a technology that transforms physical education, making it more engaging and effective, with the potential to enhance both student engagement and performance. Through AR, students gain the ability to interact with virtual objects and engage in activities that combine physical reality with the virtual world. This approach offers new dimensions to learning, enhancing the experiential experience and facilitating the acquisition of motor skills. The possibilities of AR in Physical Education are multidimensional. First, AR facilitates the teaching of complex motor skills by providing students with direct and personalized feedback. Highlighted that using[9] AR in activities such as running or coordination exercises leads to higher levels of performance and a better understanding of concepts compared to traditional teaching methods. This feedback makes it easier for students to identify and correct their mistakes, while boosting their self-confidence. AR also offers unique opportunities to personalize teaching. By tailoring activities to each student's individual needs and capabilities, technology helps enhance engagement and the learning experience. In a study by[33], it was found that AR facilitated the teaching of spatially oriented content by allowing students to actively participate in activities that were appropriately tailored to their needs. At the same time, AR increases student participation by integrating entertainment and learning through interactive applications. Research by45 highlighted that using AR to simulate sports activities resulted in increased student interest and attention. This experience enhances students' commitment to learning and promotes understanding of motor skills through an engaging and fun approach. Integrating AR into physical education can also support the development of social skills and team collaboration. Through activities that require coordination and interaction with other students, AR creates opportunities to develop communication and teamwork skills. These skills are vital for students' psychosocial development and can be enhanced through the use of AR. Despite these advantages, the success of AR depends on its proper implementation. Technological infrastructure, appropriate teacher education and selection of high-quality content are critical to realizing its full potential. In addition[35], pointed out that AR can increase physical activity levels and engagement, making physical education more accessible and engaging for students with different fitness levels. AR is not only a means of enhancing physical activity, but also a tool that can bridge the gap between theory and practice, creating a more integrated learning environment. With proper planning, targeted educational policies, teacher training and the allocation of the necessary financial resources, this technology can be the future of Physical Education, offering students an innovative and effective way to learn and develop motor and social skills.

Regarding the future of motor learning in Physical Education, it is clear that the integration of technology will continue to evolve. Trends such as gamification, virtual reality (VR) and personalized learning paths are expected to further enrich students' learning experience. Gamification can make learning more fun and engaging, while virtual reality offers a safe environment for practicing complex skills. In addition, personalized, data-driven learning paths will allow students to tailor their pace and preferences to their needs. These

developments promise to upgrade the quality of motor learning, enhancing physical education and the holistic development of students[12, 48,49].

Indicative scenarios of AR applications in Physical Education

The introduction of educational technology in physical education has radically changed the way students participate in physical activities. Digital tools such as interactive educational platforms, motion detection devices and video analysis software provide innovative solutions to teachers to improve kinesiological learning. These tools allow students to visualize their movements, receive instant feedback and tailor their training to their individual needs. For example, motion capture technology enables students to analyze their technique in real time, facilitating instant corrections that improve their performance. This interactive approach goes beyond traditional methods, enhancing students' participation and motivation[4]. Digital tools are not only limited to enhancing individual performance, but also promote collaboration and communication among students. Online platforms allow students to share their progress, discuss strategies, and support each other in achieving their goals. These collaborative environments improve not only the learning experience but also the social skills that are vital for team sports[7]. The implementation of a motor learning program in primary schools, where traditional lessons were replaced by activities incorporating movement, students participated in interactive activities such as learning mathematics through kinesiological exercises. These programs led to improved memorization of information, as students combined physical activity with learning concepts[42].

The use of Augmented Reality (AR) in Physical Education offers an innovative approach to teaching motor skills, with indicative application scenarios that can enhance the student experience. AR enables the creation of interactive learning environments, where students practice complex motor skills through simulations and visual instructions in real time. A typical scenario involves teaching basic balance skills through the BalanSAR app. This technology uses projections onto physical surfaces, such as floors or gym equipment, to create an interactive environment where students can practice balance. Studies have shown that such applications improve motor performance and increase students' engagement in physical education[32]. Another scenario involves applying AR to learn throwing skills and manipulating objects. Using AR glasses, students receive feedback on the correct execution of movements, such as the height and speed of a throw. The Juggling 4.0 app offers this kind of support, showing students the correct technique through projections and corrective instructions, leading to improved understanding of motor sequences. AR can also be used to train spatial orientation and strategy in team sports. Through applications that simulate competitive situations, students can develop skills such as tactical positioning on the pitch and understanding of strategic movements. A study by[33] showed that students who used AR for such training showed increased performance and confidence in their skills. AR applications, such as Geo+, allow learning motor skills through the visualization of three-dimensional models. Students can examine geometric shapes or simulate physical movements, improving their comprehension and coordination performance[39]. At the same time, AR can enhance students' collaboration and autonomy through group activities that require strategic thinking and interaction. By integrating games and competitions, students are motivated to participate, while autonomy is enhanced through personalized challenges tailored to their abilities.

Suggestions for Further Research

The use of Augmented Reality (AR) in Physical Education offers broad prospects for further research, with emphasis on both different age groups and collaboration between teachers and technologists. Research proposals can focus on adapting AR to different levels of motor skills, as well as creating collaborative approaches that integrate knowledge of educators and technology specialists. Research on the effect of AR on different age groups is critical to understanding how this technology can be adapted for students of different ages and cognitive abilities[4]. AR can significantly improve motor skills, such as balance and coordination, especially in young learners who need support to develop basic skills[9]. However, further research is needed to adapt AR in adolescents and adults, focusing on their specific needs, such as enhancing athletic performance or injury rehabilitation. Collaboration between PE teachers and technologists is essential to develop AR applications that meet pedagogical requirements. Highlighted[2] the importance of designing educational materials involving teachers, technologists and students, arguing that interactive applications can enhance teaching effectiveness and collaborative learning. This collaboration can lead to the creation of tools that adapt to students' needs and incorporate pedagogical elements, such as providing direct feedback and personalizing learning. Next, integrating AR can support cross-curricular learning in physical education. For example, incorporating elements of science or geometry into physical education activities through AR can enhance students' understanding of multiple cognitive fields. Additionally, AR can be used to teach geometric concepts through motor activities, facilitating understanding of space and movement[14]. The development of collaborative AR-based training models is also an important direction for research. AR role-playing can enhance teamwork, collaboration and communication between students, creating a dynamic learning environment[24]. Similar

applications can be considered in Physical Education, where students participate in simulated scenarios that require coordination and collaboration. Finally, research can focus on reducing the technological barriers that limit the adoption of AR. Studies highlight the need for affordable equipment and easy-to-use applications that can be easily integrated into the existing curriculum[33]. In view of these innovative practices, it is increasingly important to explore how these methods can be effectively evaluated. The assessment-focused transition will ensure that the effectiveness of strategies developing kinesiology activities using technology such as AR in Physical Education is understood and improved over time. Indicators of success, such as improving motor skills, increasing participation and improving fitness, can be used to monitor progress.

VI. Conclusions

Augmented Reality (AR) can revolutionize Physical Education by offering new tools and approaches that enrich the educational process and promote the development of motor skills. AR technology, with its ability to combine digital information with the physical environment, creates dynamic and interactive learning experiences that are both accessible and engaging for students. AR's contribution to physical education is not only limited to improving student performance, but also includes the ability to enhance participation, understanding, and overall educational experience. Augmented Reality (AR) has the potential to reshape physical education teaching, offering an innovative way to develop motor skills, enhance participation and increase educational effectiveness. The integration of AR in Physical Education should not only be considered a technological upgrade, but an educational strategy that meets the needs of modern times.

The need to assess the impact of AR is equally important to ensure that the goals of physical education, such as improving health, developing motor skills and promoting lifelong physical activity, are effectively achieved. The prospects of AR technology in Physical Education are impressive, paving the way for the creation of an educational environment that combines physical activity with technological support. AR can support teamwork, interaction and the development of social skills while offering tools to tailor learning to individual needs. Applications such as sports simulation and spatial orientation training, supported by AR, can increase understanding of complex motor skills and create a learning environment that is interactive, entertaining, participatory and effective.

New technologies, such as augmented reality, not only replace traditional teaching methods, but offer an innovative framework that can enhance the learning process. Teachers are invited to adopt these technologies and develop strategies that will allow students to take advantage of the possibilities offered by modern technological developments. The educational community should seriously consider adopting these technologies to improve teaching and learning in an ever-evolving environment.

The integration of AR into Physical Education must be done in a strategic and methodical way to ensure its effectiveness and sustainability. One of the main support measures for the introduction of AR is teacher education. Teachers need to acquire the necessary technological familiarity and familiarize themselves with the possibilities of AR so that they can successfully integrate it into their lessons. This training can include seminars, workshops, and expert guidance, as well as providing access to AR resources and applications that are easy to use and tailored to physical education needs. Another important support measure is to ensure appropriate technological resources in schools. The procurement of equipment, such as AR glasses, interactive displays, and powerful portable systems, is essential for the implementation of AR. At the same time, maintenance and upgrading of this equipment must be ensured to maintain its functionality and performance. To make this possible, it is necessary to increase funding to support AR technology in physical education, both nationally and through local initiatives.

The integration of AR also requires a redesign of the curriculum. The content of the PE course should be adapted to include activities that incorporate the capabilities of AR, such as simulations of movement exercises, virtual games and interactive exercises that enhance learning through experiences. Students can benefit from using AR to gain hands-on experience in safe and controlled environments while also receiving personalized feedback on their performance. To promote AR in physical education, it is important to develop collaborations between teachers, technology specialists and researchers. This interdisciplinary collaboration can lead to the development of innovative applications and tools that meet students' real needs. Measures to further support the introduction of AR may include developing incentive programmes for teachers using new technology, setting up pilot programmes in selected schools to assess its effectiveness and disseminating good practices. In addition, it is necessary to raise awareness among parents and the wider school community about the benefits of AR to ensure acceptance and support of the technology by all stakeholders.

To sum up, AR can be a catalyst for upgrading PE, but its success depends on proper implementation, ongoing support and commitment from all stakeholders. This technology offers great potential to improve physical education teaching, promote active participation and develop skills necessary for students' overall well-being. With proper preparation and the necessary support measures, AR can become a key factor in the development of education.

References

[1]. Adams Ja. A Closed-Loop Theory Of Motor Learning. Journal Of Motor Behavior. 1971;3(2):111–149.
[2]. Alhumaidan H, Lo Kpy, Selby A. Co-Design Of Augmented Reality Book For Collaborative Learning Experience In Primary Education. 2015 Sai Intelligent Systems Conference (Intellisys). 2015:427–430.
[3]. Altavilla G, Tafuri D, Raiola G. Influence Of Sports On The Control Of Static Balance In Physical Education At School. Journal Of Physical Education And Sport. 2014;14(351).
[4]. Banerjee D. The Impact Of Digital Tools On The Teaching Of History: A Comparative Study Of Traditional And Technology-Integrated Teaching Methods. International Journal For Multidisciplinary Research. 2024;6(3).
[5]. Barroso Osuna J, Gutiérrez-Castillo Jj, Llorente-Cejudo Mc, Valencia Ortiz R. Difficulties In The Incorporation Of Augmented Reality In University Education: Visions From The Experts. Journal Of New Approaches In Educational Research. 2019;8(2):126–141.
[6]. Battaglia G, Alesi M, Tabacchi G, Palma A, Bellafiore M. The Development Of Motor And Pre-Literacy Skills By A Physical Education Program In Preschool Children: A Non-Randomized Pilot Trial. Frontiers In Psychology. 2019;9.
[7]. Bridge P, Rees A, Gordon C. Evaluating The Impact Of The Future Healthcare Practitioner Plus Programme (Fhppp) Award On Student Engagement And Employability. Developing Academic Practice. 2024:1–9.
[8]. Cabero-Almenara J, Barroso-Osuna J, Llorente-Cejudo C, Fernández Martinez M Del M. Educational Uses Of Augmented Reality (Ar): Experiences In Educational Science. Sustainability. 2019;11(18):4990.
[9]. Chang Ke, Zhang J, Huang Ys, Liu Tc, Sung Y. Applying Augmented Reality In Physical Education On Motor Skills Learning. Interactive Learning Environments. 2020;28(5):685–697.
[10]. Choudhary Y. Augmented Reality In Education. International Journal For Research In Applied Science And Engineering Technology. 2023;11(11):1830–1836.
[11]. Dyulicheva Y. The Use Of Augmented Reality Technology To Improve The Efficiency Of Teaching. Informatics In School. 2020;19(3):37–46.
[12]. Fernández-Vázquez D, Navarro-López V, Cano-De-La-Cuerda R, Et Al. Influence Of Virtual Reality And Gamification Combined With Practice Teaching Style In Physical Education On Motor Skills And Students' Perceived Effort: A Mixed-Method Intervention Study. Sustainability. 2024;16(4):1584.
[13]. Fitts Pm, Posner Mi. Human Performance. Belmont, Ca: Brooks/Cole; 1967.
[14]. Fonseca D, Martí N, Redondo E, Navarro I, Riera As. Relationship Between Student Profile, Tool Use, Participation, And Academic Performance With The Use Of Augmented Reality Technology For Visualized Architecture Models. Computers In Human Behavior. 2014;31:434–445.
[15]. Garzón J, Pavón J, Baldiris S. Systematic Review And Meta-Analysis Of Augmented Reality In Educational Settings. Virtual Reality. 2019;23(4):447–459.
[16]. Govardhini A. Innovation In Teaching English With Digital Tools. Shanlax International Journal Of English. 2023;12(1).
[17]. Hairi Awbm, Maharum Sm, Hasman Na, Et Al. Augmented Reality In Education Application. 2023 Ieee 9th International Conference On Smart Instrumentation, Measurement And Applications (Icsima). 2023:314–319.
[18]. Hanham J, Castro-Alonso J, Chen O. Integrating Cognitive Load Theory With Other Theories, Within And Beyond Educational Psychology. British Journal Of Educational Psychology. 2023;93(S2):239–250.
[19]. Holley D, Hobbs M. Augmented Reality For Education. Encyclopedia Of Educational Innovation. 2019:1–7.
[20]. Iqbal Mz, Mangina E, Campbell Ag. Current Challenges And Future Research Directions In Augmented Reality For Education. Multimodal Technologies And Interaction. 2021;6(75).
[21]. Jesionkowska J, Wild F, Deval Y. Active Learning Augmented Reality For Steam Education—A Case Study. Education Sciences. 2020;10(8):198.
[22]. Kesim M, Ozarslan Y. Augmented Reality In Education: Current Technologies And The Potential For Education. Procedia - Social And Behavioral Sciences. 2012;47:297–302.
[23]. Khasanah U, Chusna Nl, Fatonah U. Development Of Fine Motor Skills For Early Childhood Based On Augmented Reality. Advances In Computer Science Research. 2023:66–77.
[24]. Klopfer E, Perry J, Squire K, Jan M. Collaborative Learning Through Augmented Reality Role-Playing. Proceedings Of The 2005 Conference On Computer-Supported Collaborative Learning. 2005:311–315.
[25]. Lee K. Augmented Reality In Education And Training. Techtrends. 2012;56(2):13–21.
[26]. Lemos Ag, Avigo El, Barela Ja. Physical Education In Kindergarten Promotes Fundamental Motor Skill Development. Advances In Physical Education. 2012;2(1):17–21.
[27]. Liang L, Zhang Z, Guo J. The Effectiveness Of Augmented Reality In Physical Sustainable Education On Learning Behaviour And Motivation. Sustainability. 2023;15(6):5062.
[28]. Liu W, Chepyator-Thomson J. Field Dependence–Independence And Physical Activity Engagement Among Middle School Students. Physical Education And Sport Pedagogy. 2009;14:125–136.
[29]. Lopes Vp, Stodden Df, Rodrigues Lp. Effectiveness Of Physical Education To Promote Motor Competence In Primary School Children. Physical Education And Sport Pedagogy. 2017;22(6):589–602.
[30]. Loprinzi Pd, Davis Re, Fu Yc. Early Motor Skill Competence As A Mediator Of Child And Adult Physical Activity. Preventive Medicine Reports. 2015;2:833–838.
[31]. Martín-Gutiérrez J, Fabiani P, Benesova W, Meneses Fernández Md, Luis C. Augmented Reality To Promote Collaborative And Autonomous Learning In Higher Education. Computers In Human Behavior. 2015;51:752–771.
[32]. Mast D, Bosman M, Schipper S, Vries Sd. Balansar: Using Spatial Augmented Reality To Train Children's Balancing Skills In Physical Education. Proceedings Of The Eleventh International Conference On Tangible, Embedded, And Embodied Interaction. 2017:625–631.
[33]. Moreno-Guerrero Aj, García Sa, Navas-Parejo Mr, Et Al. Augmented Reality As A Resource For Improving Learning In The Physical Education Classroom. International Journal Of Environmental Research And Public Health. 2020;17(10):3637.
[34]. Mystakidis S, Christopoulos A, Pellas N. A Systematic Mapping Review Of Augmented Reality Applications To Support Stem Learning In Higher Education. Education And Information Technologies. 2021;27:1883–1927.
[35]. Omarov N, Omarov B, Azhibekova Z, Omarov B. Applying An Augmented Reality Game-Based Learning Environment In Physical Education Classes To Enhance Sports Motivation. Retos. 2024;60:269–278.
[36]. Pérez-Cabezas V, Martín-Valero R, Luque-Moreno C, Et Al. A Formative Experience In Reality Augmented With Physiotherapy Degree Students. Edulearn Proceedings. 2019;1:2884–2888.
[37]. Pratama Ba, Sucipto S, Hanief Yn. Improving Learning In Physical Education: Augmented Reality Mobile App-Based For Fundamental Motor Skills. Jurnal Sportif: Jurnal Penelitian Pembelajaran. 2022;8(2):314–326.

[38]. Radu I. Augmented Reality In Education: A Meta-Review And Cross-Media Analysis. Personal And Ubiquitous Computing. 2014;18(6):1533–1543.
[39]. Rossano V, Lanzilotti R, Cazzolla A, Roselli T. Augmented Reality To Support Geometry Learning. Ieee Access. 2020;8:107772–107780.
[40]. Schmidt Ra, Lee Td. Motor Control And Learning: A Behavioral Emphasis. Champaign, Il: Human Kinetics; 2011.
[41]. Sortwell A, Marinho Da, Knijnik J, Ferraz R. Empowering Primary School Students: Potential Benefits Of Resistance Training Movement Activities In Physical Education: Narrative Review. Kinesiology Review. 2022;11(3):197–208.
[42]. Swoboda M. Active Classrooms: Great For Academic Performance, But Can They Improve Student Health? A Critical Literature Review. Journal Of Instructional Research. 2019;8(2).
[43]. Vasileva F, Vasilev A, Llado Rf, Georgiev G. Physical Education Curriculum Is Effective In Development Of Motor Abilities In 9th Grade School Children? Journal Of Anthropology Of Sport And Physical Education. 2021;5(4):9–13.
[44]. Vitto Jm. Relationship-Driven Classroom Management: Strategies That Promote Student Motivation. Publisher: Corwin Press; 2003.
[45]. Wang J, Cai J. An Exploration Of The Application Of Augmented Reality Technology In Improving Interactivity In Physical Education Teaching And Training. Applied Mathematics And Nonlinear Sciences. 2024;9(1).
[46]. Weeks S, Brooks P, Everatt J. Differences In Learning To Spell: Relationships Between Cognitive Profiles And Learning Responses To Teaching Methods. Educational And Child Psychology. 2002;19(4).
[47]. Wulf G, Lewthwaite R. Optimizing Performance Through Intrinsic Motivation And Attention For Learning: The Optimal Theory Of Motor Learning. Psychonomic Bulletin & Review. 2016;23(5):1382–1414.
[48]. Xiao Y, Wang Q, Bai W, Wang C. Exploration Of Educational Trends And Innovations In Future Blended Learning Environments. Advances In Vocational And Technical Education. 2024;6:146–153.
[49]. Zhou G. Navigating The Future Landscape Of Gamified Education. Shs Web Of Conferences. 2024;187:02005.