information

Systematic Review

A Systematic Review of the Use and Effect of Virtual Reality, Augmented Reality and Mixed Reality in Physical Education

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Abstract: New technologies are tools that are present in daily life on a regular basis. In order to improve the didactic process, education must take into account these new technologies. In the field of physical education, the significance of these technologies is reflected in the existence of applications that can be carried out within the field, both for educational purposes and for physical fitness and health. This is due to the potential presented by virtual reality, augmented reality and mixed reality. The objective of this study was to examine the utilisation and impact of AR, VR and MR technologies in physical education at the compulsory stage. In order to achieve this objective, a design based on the PRISMA methodology for conducting systematic reviews was employed. The databases of WOS, Scopus, PubMed and Google Scholar were subjected to analysis. The results indicate that there has been a notable increase in research activity in this field in recent years. The analysis yielded four principal areas of focus, namely the utilisation of pedagogical methodologies, the enhancement of motor and health-related competencies, and moreover, the facilitation of optimal integration of students in physical education. The utilisation and consequences of novel technologies represent a suitable instrument for enhancing the educational experience of students enrolled in physical education programmes.

Keywords: technology; physical education; virtual reality; augmented reality; mixed reality; bibliometric analysis

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1. Introduction

Currently, the utilisation of technological devices is pervasive in a multitude of daily activities performed by individuals. This phenomenon can be attributed mainly to the integration of technology in the advancement and implementation procedures in many fields [1–3]. Consequently, it is important to consider the impact of new technological devices and tools in the field of education [4–6]. In order to develop a current, novel and innovative teaching approach, it is essential to take these new technologies into account [4,6].

Consequently, the educational process must be continuously adapted to align it with the requirements of a dynamically evolving market in today's society. In this context, information and communication technologies (ICTs) play a pivotal role as an instrumental medium that has transformed various aspects of everyday life [4–6]. Furthermore, the integration of educational technology has been demonstrated to enhance student engagement, resulting in enhanced academic performance and motivation [7,8]. This is evidenced by numerous studies conducted with students in compulsory education [9,10].

Although it is true that many teachers exhibit a lack of motivation for the incorporation of new technologies, this should prompt them to reconsider their stance and adapt their pedagogical approach to align with the evolving educational and social landscape, which is increasingly aligned with the realities of the students [11,12]. This shift could potentially

enhance motivation and, more importantly, address the pervasive boredom that students often experience in the classroom. New technologies offer a powerful educational tool in various domains, including physical education in primary education [6].

In this context, physical education is an instrumental subject characterised by its high applied and motor content. It is therefore evident that physical education is a fundamental discipline in the integral development of students, as it not only promotes health and physical well-being but also fosters social, emotional and cognitive skills [13,14]. In recent decades, the integration of new technologies has profoundly transformed the field, offering new tools and methods to improve teaching and student learning [6].

One of the technological tools that are beginning to be included in the field of physical education are virtual reality (VR), augmented reality (AR) and mixed reality (MR) [3,6,15,16]. These technologies facilitate the exploration of alternative realities within the virtual space, which would otherwise be inaccessible. The first of these, VR, is an immersive technology that creates simulated environments in which users can interact [3]. The second, AR, is the technology with the greatest effect on education in recent years. It superimposes digital information on the real world, enhancing the user's perception [6,9,17]. Finally, MR combines elements of VR and AR, allowing interaction between the real and virtual worlds in real time [16,17].

In the specific case of physical education, these resources can be used for different objectives, demonstrating interesting results in compulsory education students. They not only allow the improvement of physical abilities but also allow the creation and application of new innovative teaching methods that involve students and motivate them. This creates a more effective and enjoyable learning experience [18], as well as creating individualised activities adapted to the needs of the students, which is a fashionable approach nowadays. This provides better experiences, which in turn are more attractive and effective [19].

For instance, AR has been employed to enhance sports activities with real-time information, such as providing guidance for exercises, correcting various body postures or even displaying real-time performance data of students [19]. Furthermore, the integration of AR with video enhances the efficacy of motor skill training [13]. In the case of VR using sports simulators, students can experience and learn various techniques of various sports without the risk of injury or injury-related complications. This can be achieved by avoiding the actual practice of the sport itself, such as injuries, falls, etc. [20]. Additionally, it can be used to improve recovery with interactive environments and, of course, being more attractive to the subjects [21]. Furthermore, it can be used to improve the physical fitness of students, with special relevance to those who have suffered from COVID-19. Finally, in the case of MR, students will be able to participate in various activities and games of a motor nature, combining real and virtual environments, competing through various challenges [22]. These challenges, according to some studies, improve motivation and engagement, with special reference to those students who flee from traditional physical education. Furthermore, they allow the creation of specific immersive training programmes that are adapted to the needs and different abilities of students [18–20,22].

In general, the data indicate the potential of these technologies in the field of education, with a particular focus on physical education. Therefore, it is essential to examine the application of these tools in this field at the compulsory education stage. This analysis focuses on the last 10 years, during which extensive research and studies have been conducted. In particular, no other studies have been identified that examine the use of these three technologies in relation to their use and the effect that their implementation has had in compulsory education. This lack of existing research represents an opportunity to offer better information and training to teachers. The dearth of existing research provides an opportunity to furnish educators with more efficacious information and training by offering a more comprehensive, direct and lucid perspective on the utilisation of these devices. A more comprehensive, direct and lucid perspective on the utilisation of these

devices in physical education, such as in the context of students with disabilities, their benefits for education with improvements in physical fitness, learning of motor skills and health-related elements, is warranted. The objective of this study is to analyse the utilisation and impact of AR, VR and MR technologies in physical education (PE) at the compulsory education level.

2. Materials and Methods

The objective of this study is to conduct a systematic review of the scientific literature on the use and effect of AR, VR and MR in compulsory education, with a specific focus on the subject of physical education.

In order to achieve the objective, the following questions were formulated to seek answers:

1. This study aims to ascertain whether AR, VR and MR technologies are being applied in the field of physical education.
2. Has the quantity of research published in this field increased over the past two decades?
3. What are the research objectives that have been analysed?
4. Does the research present the fundamental elements of scientific enquiry?

In order to complete the systematic review process, it was carried out in accordance with the following statement featuring in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [23].

The initial stage of the process, the identification phase, entailed a comprehensive search of relevant literature across a range of databases, including Web of Science, Scopus, PubMed and the academic search engine Google Scholar. These databases encompass a vast array of scientific publications from diverse academic fields. In this context, the field of AR, VR and MR technologies is included in the search.

It is necessary to filter the information in order to meet the defined objective. Consequently, a search string was created comprising the keywords "AUG-MENTED REALITY", "VIRTUAL REALITY" and "MIXED REALITY" in conjunction with "PHYSICAL EDUCATION". Furthermore, the search format was limited to the years 2004–May 2024, and only articles were selected as the document type.

Once the articles were selected, they were subjected to analysis according to the following criteria: title, abstract, method and results.

With regard to this matter, Figure 1 presents a flow diagram that graphically represents the process carried out in the systematic review based on PRISMA.

The diagram illustrates that a total of 325 articles were registered in the scientific databases of Web of Science, Scopus and PubMed. In addition, seven records were identified through a Google Scholar search.

However, upon completion of the search for studies, a screening was conducted to eliminate duplicate articles, resulting in a total of 287 research studies. Following a second screening of the 287 articles, 15 were excluded. Consequently, a total of 272 articles were subjected to evaluation (Figure 1).

Eligibility Criteria

Subsequently, the suitability phase was conducted, during which the inclusion and exclusion criteria were applied to select or discard the articles according to the established characteristics.

In this context, the inclusion and exclusion criteria for the present study are detailed in Table 1.

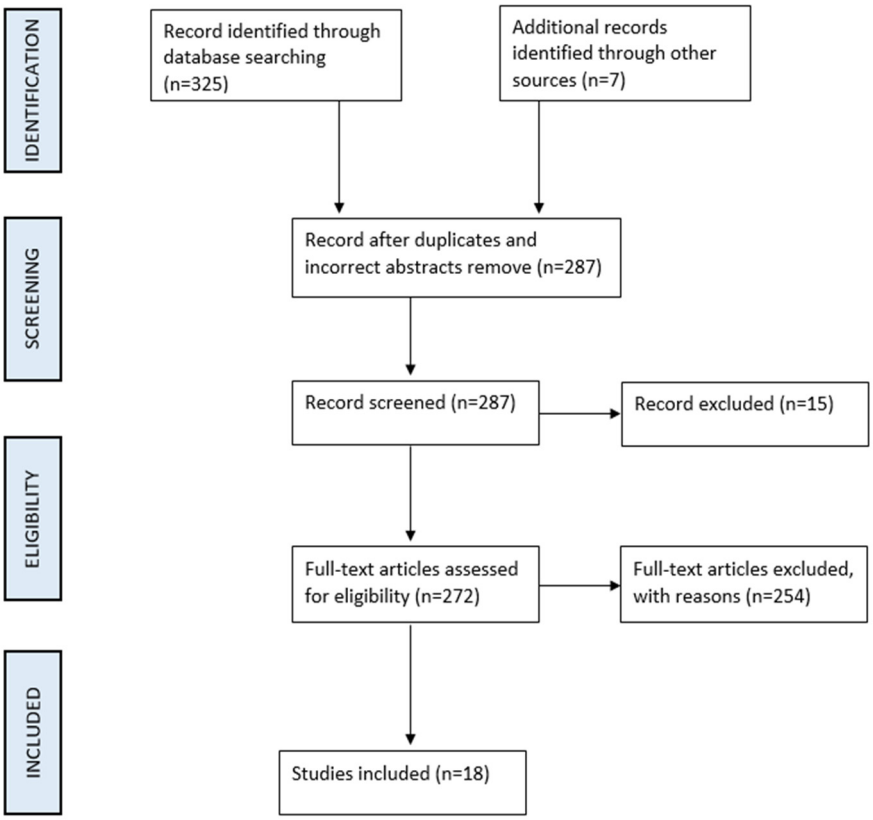

Figure 1. PRISMA-based selection flow chart.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Articles that come from an international peer-reviewed journal	All documents other than articles, such as lectures, book chapters, etc.
The study uses AR, VR and MR as technologies	Augmented reality, virtual reality and mixed reality are not the main technologies
The study uses augmented reality, virtual reality and mixed reality in primary education or secondary education	The study uses augmented reality, virtual reality and mixed reality to be applied at another educational level
The study uses augmented reality, virtual reality and mixed reality in primary education or secondary education in the subject of physical education	The study uses augmented reality, virtual reality and mixed reality to be applied in another educational field (mathematics, English, chemistry, physics, biology, etc.)
It was published between 2004 and May 2024	Articles outside the established period

3. Results

Subsequently, a more comprehensive examination was conducted, resulting in the exclusion of 254 articles that did not meet the inclusion criteria. This was due to the fact that not all research was directed at the field of physical education and its relationship with AR, VR and MR technologies (Figure 2).

Figure 2. Historical developments in research over the last 20 years.

Figure 2 illustrates the temporal distribution of articles published on this topic, demonstrating that the initial publications emerged in 2005. Subsequently, the number of articles remained stable until 2017, when there was a notable increase. The year in which the greatest number of articles on this topic were published was 2020. The results are presented in Figure 2 below.

Consequently, 18 studies that met all eligibility criteria were subjected to a comprehensive analysis (Figure 3). Of these, 12 articles focused on primary education, 4 on special education and 8 on secondary education. With regard to the type of research methodology employed, ten studies were qualitative in nature, while eight were quantitative.

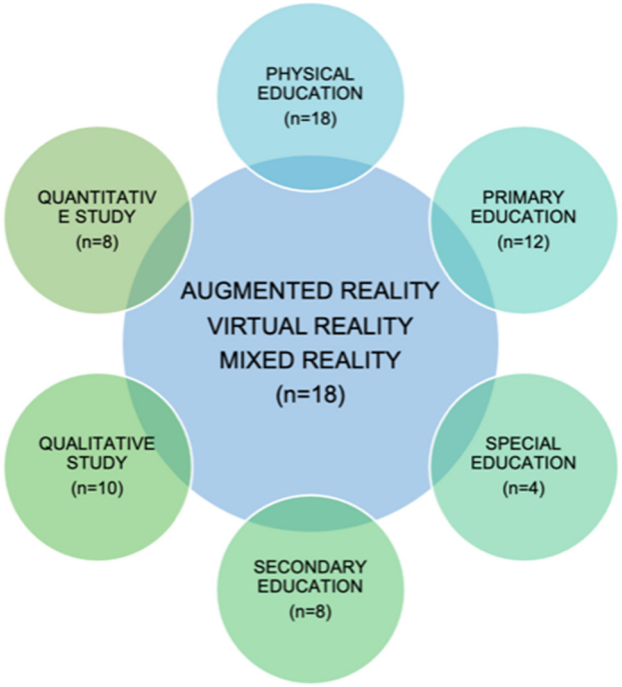

Figure 3. Research analysed by eligibility criteria.

The highest percentage of studies was observed between the years 2004 and 2024, with a similar percentage (22%) observed in both 2022 and 2023. The years 2021 and 2020 exhibited 19% each, while 2024 showed 11% (although only up to May). Finally, the years 2021 and 2015 demonstrated 6% and 5%, respectively (Figure 4). The results demonstrate a progression over recent years in the context of related research on the subject matter. This phenomenon may be attributed to the significant advancement of new technologies within the educational domain. The proliferation of novel educational methodologies that are predicated upon the utilisation of these technologies, coupled with the potential they afford students, may be the underlying causes.

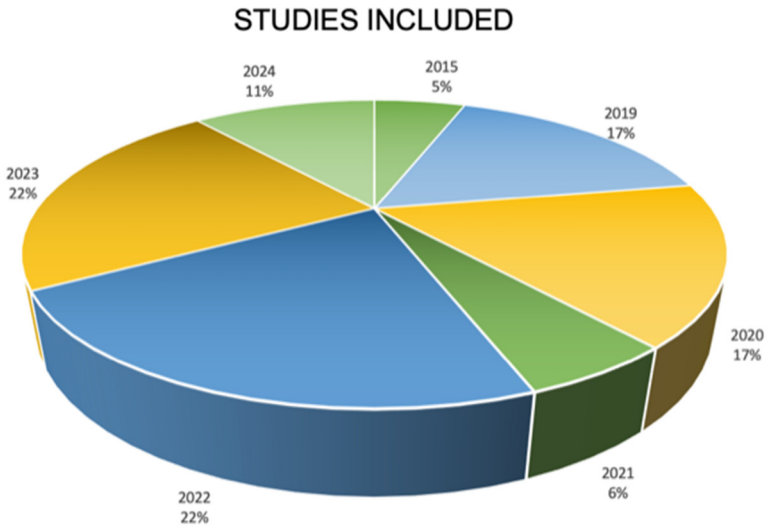

Figure 4. Percentage of investigations analysed by year.

The principal findings indicate that of the research methodologies examined, ten are qualitative studies, and eight are quantitative studies. In more specific terms, the studies by Chien-Yu and Yu-Ming [24], Kang and Kang [25], Fridhi and Bali [26] and Mohamed-Mokmin and Pasca-Rassy [27] examine the impact of the utilisation and integration of novel VR, AR and MR technologies among students with disabilities, demonstrating the efficacy of the disparate research methodologies employed. The studies with the greatest number of studies are those that examine the educational impact on pupils, both in primary and secondary education. The studies in question are those by Chang et al. [28], Moreno-Guerrero et al. [29], Peñarrubia-Lozano et al. [30], Binti-Ariffin et al. [31], Liu et al. [32], Pratama et al. [33], Liang et al. [14], Myeong-Hun [34], Bores-García et al. [35], Mohamed-Mokmin and Pasca-Rassy [27]. Other studies focus on motivational and health aspects, such as those by Yang and Meng [36], Budi-Darmawan [37] and Wu et al. [38]. In all of them, the effects are positive due to the implementation of these new technologies in the educational environment, with improvements in physical fitness, motor skill learning and health-related elements (Table 2).

Table 2. Research on AR, VR and MR in physical education: type of study, stage, objective and results.

Author	Year	Type of Study	Educational Stage	Purpose	Results
Chien-Yu, L. and Yu-Ming, C. [24]	2015	Qualitative study	Primary	The study aims to analyse whether participants with disabilities improve their physical strength and motivation to engage in sports activities through an AR game called Scratch 2.0	The results indicated that participants with disabilities exhibited greater motivation to engage in sports activities following the intervention
Gómez-García, G. et al. [39]	2019	Qualitative study	Primary and Secondary	The objective of this research is to analyse the scientific documentation on the use of VR in physical education	It is notable that there has been a notable increase in scientific production in recent years in relation to VR and other subjects on the curriculum

Table 2. *Cont.*

Author	Year	Type of Study	Educational Stage	Purpose	Results
Kang, S. and Kang, S. [25]	2019	Qualitative study	Primary and Secondary	The objective is to apply and integrate VR in the field of sports and physical education for individuals with disabilities with the aim of enhancing their sporting abilities	The implementation of VR is effective in participants with disabilities, provided that it is adapted to the specific type and degree of disability
Yang, Y. and Meng, L. [36]	2019	Qualitative study	Secondary	The objective of this study is to implement VR in order to analyse and correct the postures and movements of athletes in the field of physical education	The results demonstrated that the use of VR technology enhances the efficacy of training, as it facilitates the rapid correction of movement skills in real time and facilitates a more comprehensive learning and comprehension process compared to traditional methods
Calabuig-Moreno, F. et al. [40]	2020	Qualitative study	Primary and Secondary	The objective of this study is to analyse scientific publications related to VR and AR in the context of physical education	The data indicate that since 2015, there has been a notable increase in publications on AR and VR in relation to physical education. Spain has emerged as a leading country in this field
Chang, K.E. et al. [28]	2020	Quantitative study	Primary	The objective of this study is to ascertain whether students' knowledge of motor skills could be enhanced by integrating AR as a supplementary resource to traditional textbooks	The findings indicated that the application of AR significantly improved students' understanding of motor skills and proved to be an effective teaching aid in the field of physical education
Moreno-Guerrero, A.J. et al. [29]	2020	Quantitative study	Secondary	The use of AR to enhance spatial orientation and attitude towards PE is a promising avenue for future research	The incorporation of technological resources, in particular AR, has been shown to enhance the perception of PE among students
Peñarrubia-Lozano, C. et al. [30]	2021	Qualitative study	Primary	The primary objective is to assess the level of satisfaction derived from the integration of AR in a pedagogical approach to the natural environment	Students demonstrated a high level of interest in the utility and intrigue associated with AR

Table 2. *Cont.*

Author	Year	Type of Study	Educational Stage	Purpose	Results
Binti-Ariffin, U.H. et al. [31]	2022	Qualitative study	Primary and Secondary	A systematic review is conducted to assess the application of AR in physical education with a view to identifying innovative technologies with educational potential	The findings indicated that integrating AR into education is a crucial step
Fridhi, A. and Bali, N. [26]	2022	Qualitative study	Primary	The objective is to demonstrate the veracity of AR in relation to adapted physical activity for children with autism spectrum disorder (ASD)	Through various experiences, the capacity for memory and control in children with ASD can be observed
Liu, Y. et al. [32]	2022	Quantitative study	Secondary	The objective is to apply AR as a technological resource for teaching spatial orientation in physical education	The use of AR improves student performance in learning and training dimensions
Pratama, B. A. et al. [33]	2022	Quantitative study	Primary	The objective of this study is to ascertain whether students improve their motor skills through AR by administering the Gross Motor Development-2 (TGMD-2) test	The results demonstrated that the integration of AR technology enhances the motor skills of students enrolled in physical education programmes
Budi-Darmawan, G.E. [37]	2023	Quantitative study	Primary	The objective of this study is to investigate the potential impact of AR on students' motivation in the context of physical education	The utilisation of AR in physical education sessions has been found to positively impact student motivation, with greater effects observed than in traditional practice
Liang, L. et al. [14]	2023	Quantitative study	Secondary	The objective of this study is to investigate the potential effects of AR on the physical and cognitive performance of students enrolled in physical education courses	Following the implementation of AR, students demonstrated enhanced performance in motor skill acquisition, exhibited positive attitudes and displayed increased confidence, satisfaction, motivation and attention in the classroom
Myeong-Hun, B. [34]	2023	Quantitative study	Primary	The objective of this study is to assess the efficacy of VR in enhancing the fundamental physical abilities in the field of physical education	The utilisation of VR in PE sessions has been demonstrated to enhance students' physical fitness

Table 2. *Cont.*

Author	Year	Type of Study	Educational Stage	Purpose	Results
Wu, Q. et al. [38]	2023	Quantitative study	Secondary	The study aims to evaluate the impact of VR on physical and psychological changes in students with overweight and obesity when engaging in sports activities	The results demonstrate that student participation increases as a result of VR sports practice, as well as improvements in the quality of life and interpersonal relationships
Bores-García, D. et al. [35]	2024	Qualitative study	Secondary	The objective of this study is to gain an understanding of the experiences and perceptions of participants when using VR in an educational context	The findings indicated that there were positive perceptions regarding motivation, effort and motor skills, among other factors, when using VR
Mohamed-Mokmin, N. A. and Pasca-Rassy, R. [27]	2024	Qualitative study	Primary and Secondary	The primary objective is to conduct a comprehensive review of scientific publications on the utilisation of AR in special education as a teaching tool in physical education	The findings indicated that the integration of AR technology enhanced motivation and facilitated the acquisition of firearm-related skills. Consequently, the application of this technology is beneficial to children with learning difficulties

4. Discussion

The objective of this study was to examine the utilisation and impact of AR, VR and MR technologies in physical education at the compulsory stage. In this context, the scientific literature has been expanding over recent years, with the findings of the past decade being particularly noteworthy. These data are also reflected in another research work [41,42].

In general, we concur with other research works indicating that the utilisation of technologies is a complex process that necessitates greater adaptation by educators and that the types of utilisation are diverse [43].

The status of this research in the field of PE is presented below, answering each of the research questions posed in this study.

To what extent are AR, VR and MR technologies employed in the field of physical education?

In this context, the results indicate that these technologies are employed in diverse ways and elicit varying outcomes. However, in this instance, the impact of new technologies, including virtual, augmented and mixed reality, on the teaching methodologies is perceived to be positive, particularly in terms of enhancing motor and health aspects [7,8,22,28,29,31,32], as well as physical fitness [14,33,35,37,38].

In this context, studies indicate that there has been a significant evolution in recent years, with a notable increase observed in the last four years and particularly from 2017 onwards, in alignment with other research findings [24,25,32,40,44]. This phenomenon can be attributed to the considerable advancement of new technologies in the field of education. In the contemporary social context, where technological advancement and its associated benefits are pervasive, it is imperative that educational institutions do not remain detached from this phenomenon [39]. The advent of new educational methodologies that rely on the use of these technologies, together with the potential they offer to students in terms of increased motivation and improved health [14,30,35–38], motor learning [26,28,33,34] and performance [32], may be considered some of the underlying causes of the high proliferation

of studies in this field in recent years, as well as the greater accessibility to technologies related to VR, AR and MR.

The principal objective of the studies analysed was to ascertain the impact of the new methodologies, incorporating new educational technologies, on educational outcomes. This was achieved by examining the implementation of these methodologies and the positive effect they have on students in the fields of education and physical education. This is in accordance with the conclusions of other studies in this area [22,35,45]. Indeed, numerous studies have been conducted on students with disabilities, with a particular focus on the creation of environments and the implementation of new actions for this specific group of students with difficulties [24–27]. Furthermore, research has been conducted in the field of health, with a specific focus on the influence of these actions on postural, psychological and general health outcomes. In this context, the principal objective is multifaceted, as evidenced by other research works. It is evident that the impact of these novel technologies in the field of education must be considered from a comprehensive standpoint, encompassing both their utilisation and the beneficial outcomes they impart upon learners. This makes their implementation in the classroom a highly pertinent area of interest for educators, as well as for the physical, psychological and social development of students [14,28,30,33,46].

Similarly, the study's objective is multifaceted, and the results address a range of topics. Nevertheless, all studies indicate that the implementation of VR, AR and MR in the field of physical education has a beneficial impact on students. Such benefits include improvements in physical condition, physical performance, skills, motivation and social relationships, as well as enhanced outcomes when used with students with disabilities. Furthermore, another group of studies has sought to highlight the increase in the number of studies in recent years. It is evident that a significant proportion of the studies demonstrate improvements in physical condition and motor skills [14,21,33,35,37,38]. Others indicate enhancements in the domain of teaching and learning, including perception and interest in physical education [28,29,31,32]. Additionally, there are indications of positive outcomes in the realm of health, such as elevated motivation, enhanced quality of life and improved interpersonal relationships [27,38,47,48]. These findings align with those of other studies that have examined the relationship between physical education and health [49,50], and they corroborate the conclusions of another research work [51]. However, this does not align with other research work that indicates there are studies focusing on teacher training [52], an aspect that was not analysed in the research under study.

After analysing the use and effects of these technologies, namely AR, VR and MR, we concur with other research works that demonstrate their potential to enhance physical education (PE) in compulsory education [39]. These technologies can be employed to create more immersive learning environments, facilitate the integration of diverse students and improve the overall atmosphere in the classroom [18,19,26,39,51].

It is evident that despite the enhancements outlined, further investigation is required to elucidate the diverse applications and to elucidate the resistance that this technology engenders in physical education teachers [30,39]. Furthermore, there are several limitations to the study, including the need to extend it to a larger number of databases and to increase the age range of the analysis in order to gain a more comprehensive understanding of the effects and uses of these technologies across all educational stages. A content analysis should be conducted in order to determine the effect and use of the implementation of AR, VR and MR in a broader context. It is recommended that the study is broadened to include a greater number of subjects, uses and effects in other subjects that are part of the curriculum for students in various fields. It is also important to consider how this trend might be implemented in educational and school physical education settings and to address any potential resistance and difficulties that it may generate.

5. Conclusions

The research findings suggest that there has been a significant increase in the number of studies conducted in the field of physical education in recent years. This growth can be attributed to the emergence of new technologies, both at the social level and within educational institutions, including augmented reality, virtual reality and mixed reality. Moreover, this type of study can be regarded as an invaluable tool for assessing the current state of research on the topic, outlining potential avenues for further investigation and identifying challenges associated with integrating physical education into the school curriculum.

The principal research topics were classified into four principal categories. The first category concerns the application of new methodologies in the field of physical education. The second category addresses the impact of these methodologies on teaching and enhancing physical fitness. The third category focuses on the utilisation of these methodologies as an integrating element for students with disabilities. The final category examines the influence of these methodologies on positive health outcomes, including the quality of life, health, motivation and interpersonal relationships. It can thus be concluded that the utilisation of these novel technological instruments within the domain of physical education is an efficacious methodology for enhancing the quality of life, motivation and physical fitness of those engaged in physical education.

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