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Pedagogical Challenges in Using Immersive Technologies for Physical Education: A Review

(Cabaran Pedagogi dalam Penggunaan Teknologi Imersif untuk Pendidikan Jasmani: Tinjauan Literatur)

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ABSTRACT

The integration of immersive technologies such as VR and AR is transforming the landscape of Physical Education by making learning more immersive, interactive, and learner-focused. However, Malaysian PE faces challenges in teacher readiness, infrastructure, and curriculum alignment. Limited training, unclear frameworks, and device access hinder implementation. This study explores pedagogical challenges to inform future instructional models and policy. This literature review aims to identify and synthesise the pedagogical challenges faced by PE teachers in implementing VR/AR technologies in Malaysian schools. A comprehensive search was conducted across Scopus, Web of Science, Taylor & Francis, and Google Scholar using Boolean combinations of keywords such as "virtual reality," "augmented reality," "physical education," "pedagogy," and "Malaysia". Criteria focused on empirical studies and reviews published between 2020 and 2025 that addressed VR/AR integration in school-based PE settings. The review highlights four dominant pedagogical challenges: (i) lack of teacher training and digital competence; (ii) inadequate infrastructure and costly equipment; (iii) restrictive school policies that hinder mobile or immersive technology use; and (iv) cognitive and physiological concerns, including VR-induced overload and cybersickness. Furthermore, existing literature lacks structured pedagogical models, teacher-driven frameworks, and localised data, revealing a gap between technological promise and classroom practice. Although VR/AR technologies offer transformative potential for PE in Malaysian schools, widespread adoption is constrained by pedagogical, infrastructural, and policy-related barriers. There is an urgent need for teacher-focused professional development, context-specific pedagogical models, and institutional support to ensure the equitable and sustainable implementation of these initiatives.

Key Words: Immersive technology; Physical Education; Pedagogical challenges; Teacher readiness; Virtual reality integration

ABSTRAK

Menggabungkan teknologi imersif seperti VR dan AR dalam Pendidikan Jasmani sedang mengubah landskap pendidikan menjadikan pembelajaran lebih imersif, interaktif, dan berfokus kepada murid. Namun begitu, pelaksanaan PJ di Malaysia masih berdepan pelbagai cabaran khususnya dari segi kesediaan guru, kekangan infrastruktur, dan penjajaran kurikulum. Latihan yang terhad, kerangka pedagogi yang tidak jelas, serta kekangan akses kepada peranti menjadi penghalang utama dalam pelaksanaan teknologi ini. Kajian ini bertujuan meneroka cabaran pedagogi yang dihadapi bagi memaklumkan pembangunan model pengajaran dan dasar pendidikan masa hadapan. Ulasan tinjauan literatur ini dijalankan bagi mengenal pasti dan mensintesis cabaran pedagogi yang dihadapi oleh guru PJ dalam melaksanakan teknologi VR/AR di sekolah-sekolah Malaysia. Carian menyeluruh telah dilakukan merentas pangkalan data Scopus, Web of Science, Taylor & Francis, dan Google Scholar menggunakan gabungan kata kunci Boolean seperti "virtual reality," "augmented reality," "physical education," "pedagogy," dan "Malaysia". Kriteria tertumpu kepada kajian empirikal dan ulasan literatur yang diterbitkan antara tahun 2020 hingga 2025 yang membincangkan integrasi VR/AR dalam konteks PJ berasaskan sekolah. Ulasan ini mengenal pasti empat cabaran pedagogi utama: (i) kekurangan latihan guru dan kompetensi digital; (ii) infrastruktur yang tidak mencukupi serta kos peralatan yang tinggi; (iii) dasar sekolah yang ketat yang menyekat penggunaan teknologi mudah alih atau imersif; dan (iv) kebimbangan kognitif dan fisiologi, termasuk isu beban berlebihan akibat VR dan cybersickness. Tambahan pula, literatur semasa masih kekurangan model pedagogi yang tersusun, kerangka yang berasaskan guru, dan data kontekstual tempatan, sekali gus menunjukkan jurang yang ketara antara potensi teknologi dan amalan bilik darjah. Walaupun teknologi VR/AR menawarkan potensi transformatif kepada pengajaran PJ di sekolah Malaysia, pelaksanaannya secara meluas masih terhad oleh halangan pedagogi, infrastruktur, dan dasar. Maka, terdapat keperluan mendesak untuk pembangunan profesional yang berfokuskan guru, model pedagogi yang sesuai dengan konteks tempatan, serta sokongan institusi bagi memastikan pelaksanaan yang adil dan mampan.

Kata Kunci: Teknologi imersif; Pendidikan Jasmani; Cabaran pedagogi; Kesediaan guru; Izntegrasi realiti maya

INTRODUCTION

Physical Education (PE) is a compulsory and foundational component of school curricula, essential for promoting students' physical health, motor skills, and psychosocial development (Martín-Rodríguez & Madrigal-Cerezo, 2025). In recent years, immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) have gained attention in educational settings due to their capacity to enhance engagement, motivation, and personalised learning. These technologies show promise in inclusive education, especially for learners with disabilities or diverse learning needs (Mokmin & Ridzuan, 2022; Mokmin et al., 2025). In global contexts, immersive technologies are increasingly applied in PE instruction to simulate realistic environments, promote motor learning, and foster experiential activities that traditional methods cannot replicate.

Despite the transformative potential of immersive technologies, their integration in Malaysian PE classrooms remains limited, inconsistent, and largely underexplored. PE teachers in Malaysia face significant challenges related to digital readiness and pedagogical preparedness. Many rely on trial-and-error approaches due to insufficient exposure, training, and guidance in using immersive technologies effectively (Hasan et al., 2023; Rahman & Yusof, 2024). These pedagogical issues are compounded by infrastructural limitations, including inadequate access to VR/AR devices, poor internet connectivity, and school policies that restrict the use of mobile or digital devices (Irwahand et al., 2022). Furthermore, teachers express confusion over the curricular relevance of immersive tools, particularly in highly exam-oriented or rigid curriculum structures (Kuleva, 2024).

Other barriers include learner-specific issues such as cognitive overload and cybersickness, which reduce user acceptance and hinder learning outcomes. Xie et al. (2025). More critically, there is a lack of structured, evidence-based pedagogical frameworks tailored to the PE domain for immersive integration (Stracke et al., 2025). Although international literature reflects increasing experimentation and success in immersive PE contexts (Bores-García et al., 2024; Kuleva, 2024), Malaysian research highlights a glaring need for localised instructional models that align with national curriculum standards, teacher competence, and school infrastructure realities (Mokmin & Ridzuan, 2022). This study addresses this gap by exploring the pedagogical challenges in immersive technology implementation, aiming to support future policy, training, and model development in PE.

RESEARCH OBJECTIVES

1. What are the key pedagogical challenges that Physical Education (PE) teachers face in integrating immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR), into their teaching practices in Malaysian schools?
2. How do PE teachers' perceived preparedness, skills, and the availability of professional development and pedagogical support influence their integration of immersive technologies in Malaysian schools?
3. What are the primary infrastructural and resource-related barriers, including equipment availability, cost, and institutional policies, affecting the integration of immersive technologies in PE lessons in Malaysian schools?
4. How do curriculum constraints, time limitations, and teachers' perceptions of the pedagogical value and benefits of immersive technologies influence their integration into PE instruction in Malaysian schools?

METHODOLOGY

SEARCH STRATEGY

To access relevant studies, the following electronic databases were searched: Scopus, Semantic Scholar, Google Scholar, and SciSpace. The following keywords were used: "immersive technology", "virtual reality", "augmented reality", or "mixed reality", combined with "physical education", "school-based PE", "movement education", and "pedagogical challenges", "instructional barriers", or "teaching constraints", along with "Malaysia" or "Malaysian schools". Advanced search features were applied, including Boolean operators and truncation, and results were limited to studies published between 2020 to 2025. Duplicates were removed manually, and only articles meeting the inclusion criteria were selected.

INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria for this scoping review encompassed peer-reviewed empirical studies, systematic reviews, and meta-analyses published between 2020 and 2025 that explored the integration of immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), or Mixed Reality (MR) within Physical Education (PE) contexts. Studies were eligible if they focused on pedagogical challenges, instructional applications, or teacher readiness and professional development for immersive tools. Only articles published in English or Malay, with accessible full-texts, and those that provided

clear pedagogical or instructional implications for school-based PE settings in Malaysia or comparable Southeast Asian regions were included.

Studies were excluded if they: (i) discussed technology use outside PE or unrelated to immersive technologies, (ii) were editorials, conceptual papers, or opinion pieces without empirical evidence, (iii) focused solely on technical development of immersive tools without addressing pedagogical integration, or (iv) involved clinical, rehabilitation, or non-school-based populations (e.g., hospital settings or sports therapy unrelated to school PE instruction).

DATA ANALYSIS

Data analysis was conducted systematically on the 14 articles that fulfilled the predefined inclusion criteria. These selected studies were thoroughly examined, involving a detailed review of titles, abstracts, and full texts to ensure a comprehensive understanding of their content and alignment with the research objectives. The focus was on identifying patterns related to pedagogical challenges, instructional strategies, and the integration of immersive technologies, specifically virtual reality (VR) and augmented reality (AR), in physical education (PE) settings.

A thematic analysis approach was employed, utilising an inductive coding process to identify recurring keywords, pedagogical barriers, teacher readiness issues, and institutional or infrastructural limitations. Coding was conducted iteratively, allowing for the refinement and consolidation of themes as new insights emerged throughout the review. Similar codes were clustered into broader thematic categories that reflected critical issues in implementing immersive technologies within PE instruction.

Subsequently, a comparative synthesis was conducted to identify convergences and divergences across studies, with a particular focus on educational levels, country-specific contexts, resource availability, and teacher competencies. This thematic synthesis yielded deep insights into the recurring challenges, practical gaps, and potential strategies for enhancing the effective use of immersive technology in physical education. These findings form a foundational basis for informed pedagogical recommendations and future instructional model development within the Malaysian PE context.

RESULT

The following is a summary of findings on pedagogical challenges in the use of immersive technologies in Physical Education, categorized into four key themes based on recent literature:

TABLE 1: Pedagogical Challenges and Opportunities in Immersive Technology Integration for Physical Education

Author (Year)	Theme	Finding Summary	Challenge / Opportunities
Kuleva (2024)	Instructional Adaptation and Curriculum Integration	Review highlights fragmented VR adoption and lack of standardised frameworks.	Opportunity to create structured VR integration models
Mokmin & Ridzuan (2022)	Instructional Adaptation and Curriculum Integration	VR/AR can assist students with learning disabilities if properly adapted.	Need for inclusive content and teacher support
Hasan et al. (2023)	Teacher Readiness and Professional Developmen	PE teachers lacked technological and pedagogical skills in Islamic schools.	Lack of training opportunities and digital exposure
Stracke et al. (2025)	Institutional Factors and Research Gaps	SLR found positive learning outcomes using immersive VR in HE.	Limited findings in primary/ secondary PE contexts
Xie et al. (2025b)	Instructional Adaptation and Curriculum Integration	Combining VR, AR, AI enhances engagement in university PE.	Lack of long-term empirical validation
Kuzminskyy (2023)	Teacher Readiness and Professional Development	Blended tools improve teacher training but lack VR specificity.	Potential to adapt for immersive-specific training
Martín-Rodríguez & Madrigal-Cerezo (2025)	Institutional Factors and Research Gap	Identified barriers like tech cost, policy gaps, and limited teacher support.	Curriculum update needed for immersive tech integration
Irwahand et al. (2022)	Resource and Infrastructure Limitations	Reported motion learning gains with IVR but issues with body visibility.	Cybersickness and design optimisation challenges

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AL-Sinani & Al Taher (2023)	Teacher Readiness and Professional Development	Augmented feedback improved teacher training effectiveness.	Scalability and cost of AR development
Mokmin et al. (2025)	Instructional Adaptation and Curriculum Integration	Gamified VR increased motivation in PE tasks.	Hardware dependency issues
Bores-García et al. (2024)	Institutional Factors and Research Gaps	VR seen as promising but underutilised; calls for more collaboration.	Need for interdisciplinary design in VR-PE
Hamizi & Mokmin (2022)	Resource and Infrastructure Limitations	VR tools were positively received in special education PE environments.	Limited access to suitable content and need for teacher upskilling.
Catama & Tejada (2024)	Teacher Readiness and Professional Developmen	Pre-service PE teachers faced instructional, emotional, and management challenges during internships.	Need for integrated mentorship, reflective practices, and fieldwork alignment.

This systematic review identified 14 articles that explored the pedagogical challenges and opportunities associated with implementing immersive technologies in Physical Education (PE). Through thematic analysis, four key themes emerged: (1) Instructional Adaptation and Curriculum Integration, (2) Teacher Readiness and Professional Development, (3) Resource and Infrastructure Limitations, and (4) Institutional Factors and Research Gaps. Each theme reveals interconnected issues that have critical implications for the adoption of immersive technologies, such as Virtual Reality (VR) and Augmented Reality (AR), in primary school PE classrooms, particularly in the Malaysian context.

A significant proportion of the reviewed literature emphasised challenges in adapting existing PE curricula to accommodate immersive technologies. Kuleva (2024) noted the fragmented implementation of VR across contexts, primarily due to the absence of standardised pedagogical frameworks. This gap presents a notable opportunity to design structured and scalable models for VR integration. Similarly, Mokmin and Ridzuan (2022) emphasised the potential of VR/AR in supporting students with learning disabilities, while also highlighting the urgent need for inclusive instructional design and enhanced teacher facilitation. Xie et al. (2025) further demonstrated how the integration of VR, AR, and AI could increase engagement in higher education PE. However, they cautioned that the lack of long-term empirical validation limits broader applicability. The findings by Mokmin et al. (2025) highlight that although gamified VR and immersive tools can enhance motivation and participation, their effectiveness is constrained without refined classroom management protocols and content alignment.

Several studies have highlighted teacher preparedness as a primary barrier to the integration of immersive technology. Hasan et al. (2023) reported a lack of both technological fluency and pedagogical competencies among PE teachers in Islamic school settings, pointing to insufficient exposure to digital tools and professional training. Likewise, Kuzminskyy (2023) and Al-Sinani & Al-Taher (2023) suggested that while blended and augmented feedback mechanisms showed promise in enhancing teacher learning, they often lacked specificity for immersive technologies and posed cost-related scalability concerns. Catama and Tejada (2024) added nuance by focusing on pre-service teachers, who encountered emotional, instructional, and classroom management difficulties during internships involving immersive tools. This suggests a broader need for integrated mentorship and reflective pedagogical frameworks that align with field-based realities.

Infrastructure and access remained pervasive concerns. Irwahand et al. (2022) identified barriers, including insufficient digital infrastructure, a lack of administrative support, and low teacher motivation, as hindrances to the adoption of ICT in PE. These limitations are particularly pronounced in under-resourced or rural schools, where the digital divide further hampers equitable access to immersive technologies. Hamizi and Mokmin (2022) observed similar findings in special education PE, where VR tools were generally well received, but the content remained limited, and teacher competency was insufficiently developed.

Lastly, the institutional dimension revealed systemic barriers and underexplored research avenues. Stracke et al. (2025) and Martín-Rodríguez & Madrigal-Cerezo (2025) identified gaps in policy, high technological costs, and minimal institutional support as core impediments. Bores-García et al. (2024) reinforced this view, arguing that while VR in PE holds transformative potential, its implementation is often ad hoc and lacks interdisciplinary collaboration. These observations collectively point to a

pressing need for cross-sector policy reform and strategic investment in infrastructure, teacher development, and content co-design among educators, technologists, and curriculum developers.

Taken together, these findings indicate that while immersive technologies offer promising avenues for enhancing PE instruction, their effective integration is constrained by pedagogical, infrastructural, and institutional challenges. Addressing these barriers requires the development of context-sensitive models, comprehensive teacher training, inclusive content design, and collaborative policy-level strategies. The evidence supports a shift toward a holistic, system-wide approach to immersive education, particularly within Malaysian primary PE, where localised needs, teacher realities, and technological capabilities must be harmonised for sustainable implementation.

DISCUSSION

The integration of immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) into Physical Education (PE) is increasingly recognised for its potential to transform pedagogy through enhanced engagement, motivation, and motor learning (Bores-García et al., 2024; Martín-Rodríguez & Madrigal-Cerezo, 2025). These technologies can offer dynamic and adaptive learning environments, but their pedagogical application remains constrained by multiple interrelated challenges.

One of the most persistent barriers is the lack of digital competence and pedagogical readiness among PE teachers (Irwahand et al., 2022; Hasan et al., 2023). Studies have shown that many educators lack confidence or sufficient training in immersive technologies, often resorting to basic applications like video projection rather than utilising the full affordances of AR/VR platforms (Mokmin & Ridzuan, 2022). Additionally, a resistance to change is common, fuelled by fear of failure and uncertainty regarding the effectiveness of these tools (Martín-Rodríguez & Madrigal-Cerezo, 2025). The pressure to meet academic benchmarks and examination targets also leads to deprioritisation of technology-based instruction, particularly when it is perceived as time-consuming or burdensome (Irwahand et al., 2022). Teachers are also challenged with adapting instruction for diverse physical abilities and ensuring classroom management in VR contexts, skills not typically covered in standard teacher training (Hasan et al., 2023).

Economic and infrastructural barriers often limit the implementation of immersive technology. High costs associated with VR headsets, AR equipment, and ongoing system maintenance pose significant constraints, especially in developing nations (Martín-Rodríguez & Madrigal-Cerezo, 2025; Bores-García et al., 2024). Moreover, technical issues such as blurry graphics, lag, and interface errors disrupt learning and create a negative user experience (Mokmin & Ridzuan, 2022). Digital inequity further exacerbates access gaps many schools lack adequate devices, internet access, or technical support (Irwahand et al., 2022). In addition, logistical challenges such as inadequate classroom space, restrictive mobile device policies, and the absence of standardised frameworks for evaluating immersive learning outcomes limit large-scale adoption (Kuleva, 2024).

Though immersive experiences enhance engagement, they also present risks. Learners have reported issues like motion sickness, visual distortion, and cognitive overload in high-immersion environments (Martín-Rodríguez & Madrigal-Cerezo, 2025). These design issues can negatively affect concentration and motor learning if not addressed through careful instructional planning. For students with learning disabilities (SLDs), AR has shown potential to improve clarity and comprehension of motor tasks. Mokmin and Ridzuan (2022) emphasise that AR can facilitate inclusivity, provided that content is accessible, adjustable, and designed with diverse learners in mind.

System-level barriers include an outdated curriculum that emphasises conventional outcomes over innovation and lacks emphasis on digital media as a pedagogical language (Martín-Rodríguez & Madrigal-Cerezo, 2025). School systems still frame digital tools as add-ons rather than transformative elements of learning, contributing to tokenistic adoption. Kuleva (2024) also notes that despite the expanding body of research, few PE programs in schools have systematically adopted immersive technologies due to fragmented policy direction and minimal investment in educational infrastructure for AR/VR integration.

The promise of immersive technologies in PE is compelling, yet their potential remains unrealised without addressing significant pedagogical and systemic barriers. Solutions must begin with sustained teacher training, equitable resource allocation, and inclusive instructional design. Policy reforms, institutional leadership, and ongoing research into best practices are vital to ensure immersive tools enrich, rather than merely extend, the value of physical education for all learners (Bores-García et al., 2024; Irwahand et al., 2022; Martín-Rodríguez & Madrigal-Cerezo, 2025).

CONCLUSION

In terms of identifying pedagogical challenges, this review highlights that immersive technologies, such as VR and AR, in Physical Education are promising but face significant barriers related to teacher competence, infrastructure, and curriculum rigidity. Most studies have

reported that while immersive technologies improve engagement and skill acquisition, their integration remains minimal due to insufficient training, a lack of resources, and the absence of supportive policy environments. Regarding teacher readiness, many studies pointed to low digital literacy and a lack of pedagogical training tailored to PE, with additional issues such as cognitive overload, poor infrastructure, and high device cost complicating implementation. Furthermore, few studies focused on inclusive design for students with learning disabilities, and even fewer provided empirical data from primary school settings.

The conclusion drawn is that immersive technologies in PE remain underutilised despite strong potential to enhance motivation and learning outcomes. Research implications include the urgent need to embed immersive tech training in PE teacher education programmes, strengthen school infrastructure, and develop curriculum models aligned with immersive pedagogy. Institutional support and equitable access also remain key factors for successful integration. However, this review is limited by its reliance on secondary sources and the predominance of qualitative findings, which lack strong experimental designs. Additionally, most reviewed studies originate from higher education or international contexts, with limited focus on Malaysian primary PE settings. Recommendations for future research include field-based interventions in local schools using mixed-method or experimental designs, and the development of inclusive, scalable teaching models that respond directly to teacher capacity and student diversity.

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