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Virtual and augmented reality applications in sport and physical education learning: systematic literature review (2021–2026)

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ABSTRACT

Immersive technologies are becoming popular tools in sport and physical education. But the evidence for their teaching effectiveness is scattered across many fields. This systematic review looked at the design, implementation, effectiveness, and moderating factors of VR, AR, MR, and XR interventions in this area. The review followed PRISMA 2020 guidelines with a predefined protocol. We searched only Scopus because of its wide coverage and standardized metadata. That helped make the search transparent and reproducible. The search found 403 records. After removing duplicates and screening, 18 studies met the criteria. Two reviewers independently handled selection and data extraction. Their agreement was excellent, with Cohen's κ = 0.87. Methodological quality was checked using the Mixed Methods Appraisal Tool (MMAT 2018). Both reviewers did thematic synthesis separately before reaching consensus. Four main themes came out: (1) tactical and cognitive learning, (2) motor skill acquisition through augmented feedback, (3) curricular integration of immersive technologies, and (4) communication, socialization, and inclusion. Overall, these technologies boosted learner engagement, real-time feedback, motor skills, and tactical understanding. But their effectiveness depended on learner expertise, visuospatial ability, instructional design, and teacher competence. Still, using only Scopus and excluding grey literature might have caused publication bias and limited the evidence. Future work should focus on longitudinal studies, transfer of learning to real sport performance, and strong comparative trials across different educational settings.

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Introduction

Movement, performance, and physical learning are being taught, measured, and experienced differently now thanks to digital transformation. In schools and universities, sport and physical education instruction increasingly relies on sensors, cloud platforms, and simulation environments rather than just direct demonstration (Fu et al., 2021; Wang, 2023). The broader sports sector has followed a similar path, digital tools are now used in preparation, monitoring, and governance, raising concerns about wellbeing and competitive integrity (Qi et al., 2024). Immersive technologies hold a unique place in this shift because they don't just record or transmit movement; they rebuild the perceptual world where learning happens. Research across economic sectors suggests that virtual reality has reached a technical maturity and cost point where institutions can realistically adopt it, not just dream about it (Durojaye et al., 2023; Chen et al., 2023). For sport and physical education, that turns the question from a technical one into a pedagogical one: when does immersion actually boost learning?

The specific problem this review tackles is the evidence behind that question. Immersive systems often get introduced into sport and physical education because they seem engaging, are novel, or carry institutional prestige, not because their instructional impact has been proven (Vako et al., 2023; Liu et al., 2025). Physical education involves learning that's physical, situated, and social, so moving from a mediated environment to real performance isn't straightforward. In classroom subjects, the literature can rely on fairly stable outcome constructs, but sport pedagogy has to handle motor execution, tactical thinking, emotional responses, and social interaction all at once. That means evidence from fields like health professions education or engineering instruction can't simply be borrowed without careful checking (Orsega-Smith et al., 2023; Zhang, 2024). A domain-specific synthesis is needed.

So far, research on immersive technology in sport-related learning has developed along three mostly separate tracks. The first is technological: building prototypes and platform architectures with evaluations focused on feasibility, latency, and user experience (Zhang et al., 2022; Biał ecki et al., 2024). The second is psychological and motor-behavioural: looking at perception, decision-making, and skill acquisition under manipulated visual conditions (Grady, 2023; Romero-Naranjo, 2025). The third is pedagogical: dealing with curriculum integration, teacher competence, and classroom feasibility (Asi & Sabbah, 2025; Almusawi & Durugbo, 2024). These traditions publish in different journals, use different outcome language, and rarely cite each other, which fragments the overall picture and makes it hard to tell whether reported gains are pedagogical, perceptual, or just motivational.

Recent tech advances have made this fragmentation worse. Standalone head-mounted displays, mixed-reality projection, 360-degree mobile content, digital twins, and federated learning architectures have expanded what can be simulated and how cheaply it can be distributed (Amm et al., 2024; Budnarowski et al., 2025). At the same time, developments in wearable sensing, artificial intelligence, and information and communication technologies make it possible to close the loop between learner movement and system response in real time (Huang & Li, 2026; Chen et al., 2021). The metaverse conversation has widened the frame even more, covering spectatorship, event marketing, and identity along with instruction (Li & Jia, 2025; Jang et al., 2021). Each advance opens up the design space faster than the evaluation literature can keep up with its instructional consequences.

The first gap is about specifying outcomes. A lot of the existing work reports system performance, satisfaction, or perceived usefulness rather than actual learning, and only a few studies compare immersive delivery against a reasonable non-immersive control (Zhang et al., 2022; Kim et al., 2025). When learning is measured, it's usually right after the intervention, so retention and transfer are mostly unexamined. That matters because immersion might create short-term engagement effects that fade, or it might impose a cognitive cost that lowers immediate performance while helping later transfer. Without consistent outcome specification, the field can't tell these possibilities apart.

The second gap is theoretical and methodological. Much of the literature assumes an additive model where more immersion equals more learning, but that assumption doesn't match aptitude, treatment interaction accounts of instructional design (Liu et al., 2025). Sample sizes tend to be small, randomisation is rare, and learner characteristics like prior expertise or visuospatial ability are seldom treated as moderators, even though theory strongly suggests they should be. Method reporting often isn't detailed enough for replication, and qualitative evidence about teacher capability, which determines whether any technology is used well, remains thin (Asi & Sabbah, 2025; Almusawi & Durugbo, 2024). The result is a literature that's empirically active but theoretically underdetermined.

A synthesis is urgent right now because institutional adoption is happening fast. Universities and school systems are investing in immersive infrastructure today, while the evidence that should guide those investments is still scattered and sometimes contradictory (Weng et al., 2021). Making adoption decisions without synthesis risks locking in expensive setups that help some learners and hurt others, especially in resource-limited systems where opportunity costs are high (Zhu, 2022). So a systematic review that consolidates outcomes, identifies moderators, and specifies design conditions has immediate practical value as well as scholarly value.

With that in mind, this review first asks how immersive technologies have been designed and implemented in sport and physical education learning environments. Answering that gives a structured picture of the technologies used, the populations studied, the instructional purposes served, and the research designs employed to evaluate them, which builds a shared descriptive vocabulary for a fragmented field.

The review then asks what learning, performance, and psychosocial outcomes have been reported for these interventions. This question produces an integrated outcome map that separates motor and tactical learning from affective, communicative, and social effects, and that distinguishes actual instructional gains from feasibility or acceptance findings often reported in their place (Rash et al., 2022; Musick et al., 2021).

This study employed a PRISMA 2020-guided systematic literature review to synthesize empirical evidence on immersive technologies in sport and physical education. Learning outcomes were operationalized as improvements in motor skill acquisition, tactical understanding, cognitive learning, learner engagement, affective responses, and instructional effectiveness.

Finally, the review asks which factors moderate the effectiveness of immersive technologies in these settings. This tackles the field's central unresolved issue and is the main novelty of the review: instead of just deciding whether immersive technology works, it specifies for whom, under what instructional setups, and with what supporting teacher competencies it works, drawing where relevant on evidence from adjacent immersive-learning domains (Khoruzhaya & Moranski, 2026).

Method

Research Design and Framework

The study is set up as a systematic literature review which the researchers have decided for the reasons that their questions revolve around putting together and assessing a wide but fragmented empirical literature instead of conducting primary research to create new data. The steps of the process have been based upon Tranfield et al.'s (2003) evidence-based review methodological framework which, to name but a few, outlines unobtrusive formulation of questions, protocol-governed literature search, explicit eligibility criteria, and synthesis that can be tracked. To report findings, PRISMA 2020 statement (Page et al. 2021) and the original explanatory version by Liberati et al., (2009) are used as guiding standards. There is no physical registration of the review on a public registry, but the researchers have conceptually identified it and the detailed protocol that follows in the paragraphs below will make it easier for anyone to redo the review.

Search Strategy

A single Boolean expression was executed against the TITLE-ABS-KEY field, combining three conceptual blocks joined by the AND operator: immersive technology, sport and physical education, and learning. Truncation was applied to capture morphological variants, and quotation marks were used to preserve multi-word phrases.

("virtual reality" OR "immersive technolog" OR "augmented reality" OR "mixed reality" OR "extended reality" OR metaverse OR "head-mounted display") AND (sport* OR "physical education" OR athlet* OR coach* OR "motor skill*") AND (learn* OR teach* OR train* OR instruction* OR pedagog*)*

Field limiters restricted the result set to journal articles, to the English language, and to the publication window 2021–2026. No restriction was placed on subject area at the search stage in order to capture the interdisciplinary dispersal of the literature; disciplinary relevance was instead enforced at the screening stage.

Database and Information Sources

We only used Scopus, a bibliographic source that, besides being a database of sports and education science, covers the publications in IT venues too through a uniform metadata structure, enabling export reproducibility and the unambiguous removal of duplicates. The results of the search were retrieved on 20 July 2026, and the full set was output as a structured metadata file including authors, title, year, source, volume, issue, pagination, document object identifier, abstract, and keywords. We do not use other databases, gray literature sources, or citation-chaining techniques. In fact, this shortcoming has also been stated as one of the main limitations of our study. Restricting the search to a single bibliographic database may have excluded relevant studies indexed exclusively in Web of Science, PubMed, ERIC, or IEEE Xplore. Consequently, publication bias and database selection bias cannot be completely ruled out. Scopus was selected because it provides one of the broadest multidisciplinary coverages of peer-reviewed literature across sport sciences, education, engineering, computer science, and educational technology. In addition, its standardized metadata structure facilitates transparent search strategies, reproducible data export, and reliable duplicate identification, making it particularly suitable for systematic literature reviews.

Eligibility Criteria

Eligibility criteria were defined according to a PICOS template, resulting in a set of unambiguous inclusion and exclusion conditions that are shown in Table 1. The target populations are learners, athletes, students, and instructors who are involved in sport, physical education, or sport-related professional learning. The intervention refers to any digital immersive environment whether virtual, augmented, mixed, or extended reality that was used to support teaching or training. A reference group or comparator could be the traditional face-to-face methods that are not using any kind of augmented/immersive media. The results of the studies were measured in various aspects like physical and tactical motor learning skills, overall performance level, affective and psychosocial outcomes, and instructional feasibility of a given method. Different types of studies such as experiments, quasi-experiments, research-and-development (R&D), qualitative, as well as design-and-validation-of-a-system are acceptable study designs.

Table 1 <PICOS-based Inclusion and Exclusion Criteria>

Criterion	Inclusion	Exclusion
Population (P)	Learners, students, athletes, or instructors in sport, physical education, or sport-related professional learning	Clinical patient populations with no sport or physical education learning purpose
Intervention (I)	Virtual, augmented, mixed, or extended reality environment applied for instruction or training	Non-immersive digital tools only (video, wearables, or analytics without an immersive environment)
Comparison (C)	Conventional instruction, non-immersive media, or within-subject baseline (comparator optional)	Not applicable
Outcome (O)	Motor or tactical learning, performance, affective or psychosocial response, instructional feasibility	Purely engineering benchmarks (latency, throughput) with no learner-referenced outcome
Study design (S)	Experimental, quasi-experimental, research and development, qualitative, or system design and validation	Editorials, commentaries, conference papers, book chapters, and reviews
Language	English	Any language other than English
Publication period	2021–2026	Published before 2021
Accessibility	Full text retrievable	Abstract only or full text inaccessible

Study Selection Process

The selection was made through three consecutive phases. The first phase entailed deduplication with regard to the document object identifier and the normalized title which deleted 14 duplicate entries. 389 records were then filtered at the title and abstract level against the eligibility criteria with a deliberate choice to set the level of inclusiveness to the maximum degree in order not to discard ambivalent records too early but rather send them for full text evaluation. Ninety nine articles proceeded to final text evaluation; at this step each record was compared against every PICOS category and each time when the record was excluded a primary reason was stated. Two reviewers separately performed the screening. Discrepancies in a few cases relating to which type of intervention the work concerned were settled by referring back to the definition of immersion which was used in the study. Two reviewers independently screened all titles, abstracts, and full texts. Inter-rater agreement was assessed using Cohen's kappa coefficient ($\kappa = 0.87$), indicating excellent agreement according to Landis and Koch (1977). Disagreements were resolved through discussion until consensus was achieved.

Quality Assessment - FICO Framework

The methodological quality was evaluated by the research team through the FICO model. This approach covers four aspects: 1. Focus whether the research goal was very clear and specific; 2. Information whether data collection and reporting were sufficient and transparent; 3. Context whether the setting, participants, and technology had been explained thoroughly; and 4. Outcome whether and how well the results were understood to the audience. The FICO model was applied by assigning each study to zero (if lacking or deficient), one (if only partially met), or two (if fully accomplished) for each of the dimensions, giving a total score of eight as the maximum one could reach. It was specified that only studies scoring at least a five would be eligible for synthesis. In addition to having a quality score problem, they also were disqualified for a substantive reason, six full-text reports were excluded, and all of the 18 remaining studies obtained a score of five or more.

Data Extraction Procedure

The same form for data extraction was used throughout all included studies to record the information of bibliographic citations, corresponding author country, research paper type, research group/s, sample size, characteristics of the sample, sport or activity domains, immersive technology and hardware, instructional purpose, comparator, outcome measures, and the main results. A study's data, if not present in the article, was recorded as not available instead of assuming or inferring the answer. Data extraction results have been presented mainly in Table 2 and Table 3.

Network and Bibliometric Analysis

A descriptive bibliometric approach was utilized at a very basic level to understand how the included papers evolved over time and where they came from. Number of works for each year was simply counted and the countries involved were figured out by checking the corresponding authors' affiliations. Keyword co-occurrence was merely studied descriptively to support, but not to guide, the theme coding to be done later. Because a total of only 18 studies were the outcomes, we decided not drawing a co-authorship or co-citing network map because there definitely was a too low density to derive any conclusion from such a network analysis

PRISMA 2020 Flow Diagram

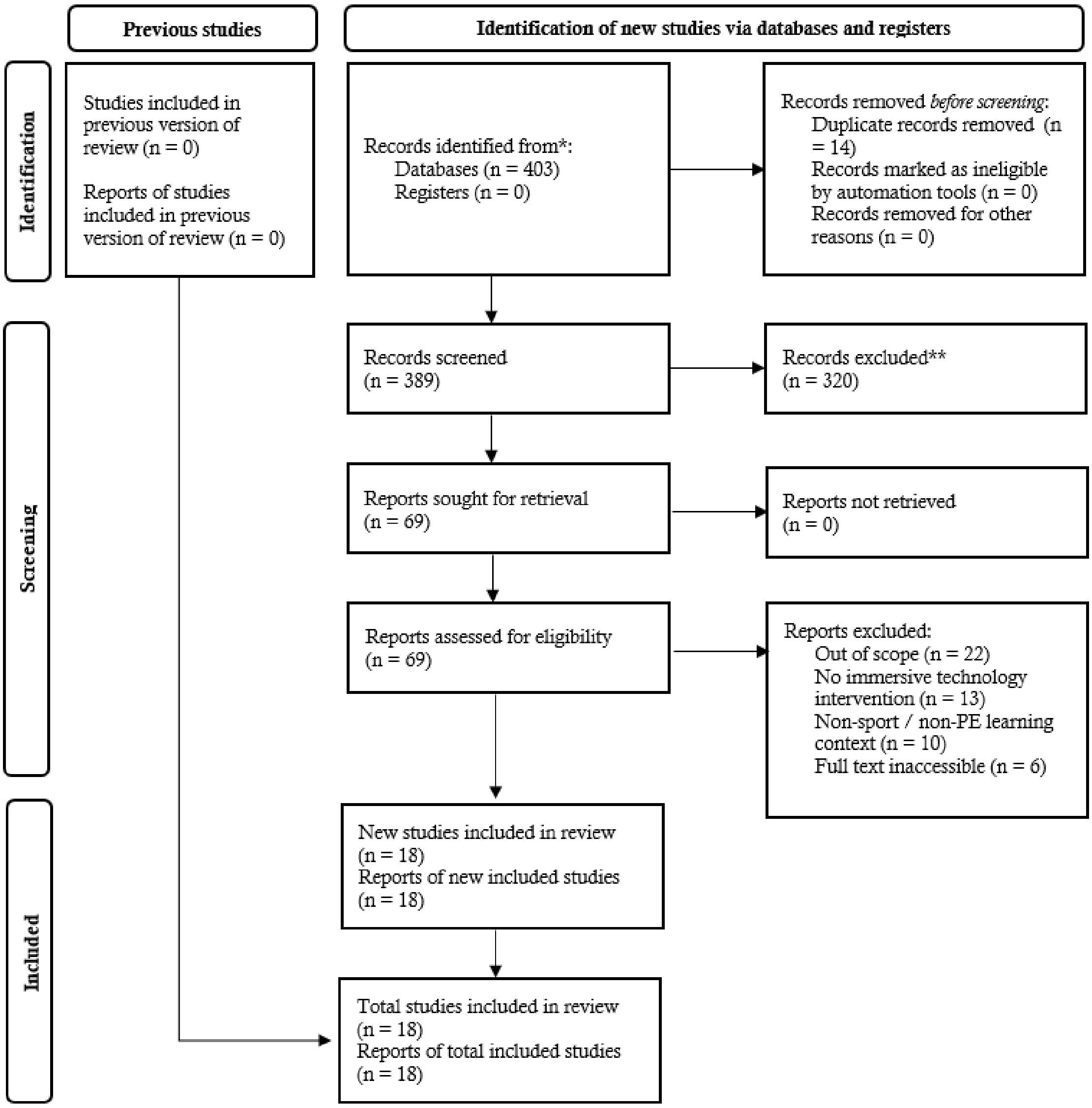

Figure 1 <PRISMA 2020 Flow Diagram Of the Identification, Screening, Eligibility Assessment, and Inclusion of Studies (Adapted From Page et al., 2021>

Figure 1 describes the complete selection procedure. Through the Scopus search, a total of 403 records were identified. Fourteen records were excluded prior to screening as duplicates. The remaining 389 records were filtered at the title and abstract level, from which 320 were rejected because they didn't tackle the application of immersive technology in a sport or physical education teaching setting. Sixty-nine full-text articles were examined with regard to their eligibility, and 51 of them have been rejected mainly on the following basis: 22 were outside the scope, 13 failed to include an immersive technology intervention, 10 were set in a context that differs from sports or PE and finally, 6 could not be obtained as they were only available in the abstract form. Eighteen articles were completely in line with the selection criteria and have therefore been incorporated into the present synthesis.

Data Analysis and Synthesis

We synthesised the available evidence following the procedure of thematic synthesis as outlined by Thomas and Harden (2008). Coding was independently conducted by two reviewers using a predefined coding framework. The initial coding results were compared and discussed until complete agreement was achieved. Any disagreements were resolved through consensus, ensuring thematic consistency and strengthening the credibility and trustworthiness of the thematic synthesis. First, we generated descriptive codes through a line-by-line coding of the findings and abstracts sections of the included papers. Next, codes were grouped into descriptive themes and then translated into analytical themes that relate to the three research questions. Four analytical themes identified from the study are: tactical and cognitive learning; motor-skill acquisition and augmented feedback; curricular and instructional integration; and communication, socialisation, and inclusion. To assure the thematic integrity of the coding frame, recirculation across the whole corpus of the coding frame was done and the result showed that all the included papers were successfully classified into a primary theme. To enhance analytical rigor, the final thematic framework was reviewed independently by both reviewers and compared with the original study findings. The final themes were retained only after consensus was achieved, thereby ensuring the validity and reliability of the thematic interpretation.

Reporting and Documentation

The review complies with the 27-item PRISMA 2020 checklist and reports the selection cascade in the flow diagram presented in Figure 1 (Page et al., 2021). All counts reported in the abstract, in this section, in the flow diagram, and in the results are drawn from a single audit trail and are arithmetically consistent.

Results and Discussions

Study Selection Results

The database search resulted in the retrieval of 403 records a number which is in line with the popularity of the topic but still limited to a specialist audience. Deduplication removed 14 items, a number that amounts to 3.5% of the starting number which, being so low, can be explained by having used only one database. After removing duplicates, 320 out of 389 selected articles were further discarded by title and abstract screening, which amounts to a low survival rate of about 22.85%. It is clear that the retention rate is so low because it was decided quite deliberately to use a broad Boolean formula to prevent filtering prematurely. Whereas, the full-text screening stage proved to be much more selective: among all 69 records, 51 articles were rejected at this stage and the most typical reason was that the study referred to either sports or immersive technology, but did not concern their pedagogical intersection. The final sample of 18 primary studies is only about 4.5% of the initial number of articles and 26.1% of the complete texts that were read in depth by researchers.

The relatively low inclusion rate (18 of 403 records; 4.5%) demonstrates that, although immersive technologies are increasingly discussed in the literature, only a limited number of empirical studies specifically investigate their pedagogical application within sport and physical education. This finding indicates that the field remains in an early stage of evidence development and highlights the need for more rigorous educational intervention studies.

Descriptive Characteristics

A total of 18 studies, which cover eight countries, published between 2021 and 2026 form part of the studies referred to in the text. They involve various activities from sports like soccer and rugby, to basketball, golf, karate, pencak silat and others, such as Tai Chi, swimming, athletics, dragon boat racing, and adapted boxing. Research designs of the selected articles are varied. These are controlled/ quasi-experimental comparative designs, research-and-development studies, interview-based qualitative studies of researchers and system design and validation research. The descriptions of features and outcomes per study are given in Table 2 while Table 3 provides the classification of the corpus of the studies, by design, theme, technology, and outcome domain.

Table 2 <Summary of the 18 Included Studies>

Full title of study	Author(s)	Country	Method	Key findings
College Physical Education Teaching Aided by Virtual Reality Technology	Meng., 2021.	China	Quasi-experimental design with sensor-based data collection in a virtual teaching environment	A VR-supported college physical education environment increased students' interest in sport and improved the measured quality of teaching relative to traditional delivery.
Development of Three-Dimensional Virtual Reality Technology for Learning Languages in Pencak Silat Curriculum	Rohayati, Hodiyah, & Marwan., 2022.	Indonesia	Research and development with 30 junior secondary students; expert validation by media and physical education specialists	A validated 3-D VR audio-visual model was successfully integrated into the pencak silat curriculum and proved feasible for supporting language learning alongside martial-arts instruction.
Exploring Virtual Reality-based Teaching Capacities: Focusing on Survival Swimming during COVID-19	Shin & Kim., 2022.	South Korea	Qualitative study using in-depth interviews with survival swimming instructors	Effective VR-based instruction depends on three teacher capacities: skilled operation of the equipment, clear communication of objectives, and structured pre-class preparation.
Synchrony in Triadic Jumping Performance under the Constraints of Virtual Reality	Naito, Go, Shima, & Kijima., 2022.	Japan	Experimental study of triadic jumping synchrony in an immersive virtual workspace	Ordered synchrony patterns reproduced in virtual space were qualitatively equivalent to those in real space, although temporal rigidity was partially reduced, supporting VR as a shared workspace for physical education.
Effect of Perspective and Visuo-Tactile Feedback in Virtual Reality-Based Posture Learning	Hanashima, Tokuda, Mochimaru, & Ohyama., 2023.	Japan	Controlled experiment (N = 24) manipulating avatar perspective and feedback modality	Third-person perspective produced more accurate learning of head position than first-person perspective, and visuo-tactile feedback improved subjective ease of learning.
Extended Reality as a Training Approach for Visual Real-Time Feedback in Golf	Geisen, Nicklas, Baumgartner, & Klatt., 2024.	Germany	Three-group controlled trial (N = 32) with pre-test, post-test, retention, and transfer tests over three weeks	XR-delivered real-time visual feedback on club alignment and velocity supported golf putt learning without reliance on an external perspective or delayed feedback.
Adaptive Mobile Cloud Computing on College Physical Training Education Based on Virtual Reality	Hong, Wang, & Li., 2024.	China	System design and simulation-based validation of a VR-assisted convolutional	Integrating VR with mobile cloud computing and biosensing enabled real-time augmentative communication and interactive physical

Full title of study	Author(s)	Country	Method	Key findings
			neural network framework	training for learners with physical impairments.
The Utilization of Virtual Reality in Training Tactical Decision-Making in Argentinian Rugby	Martínez & Ramirez., 2024.	Argentina	Secondary data analysis with descriptive statistics and equality-of-means testing	VR simulation of realistic match conditions was significantly associated with improved tactical decision-making without the physical load of on-field practice.
Memorizing Soccer Tactics through Immersive and Non-Immersive Visualizations: The Moderating Effect of Visuospatial Abilities	Mahfoudh & Zoudji., 2024.	France	Experimental within-subject comparison with 52 adult male soccer beginners	Beginners with high visuospatial ability memorised tactical scenes more efficiently through non-immersive animation than through VR, supporting an ability-as-compensator interpretation.
Application of Immersive Virtual Reality in the Training of Wheelchair Boxers: Evaluation of Exercise Intensity and Users Experience Additional Load	Polechoński, Langer, Akbaş, & Zwierzchowska., 2024.	Poland	Pilot exploratory study with physiological monitoring of exercise intensity	Immersive VR boxing generated exercise intensity sufficient to confer health-related physical activity benefits for wheelchair users, with hand-held weights modifying the load.
Enhancing Tai Chi Training System: Towards Group-Based and Hyper-Realistic Training Experiences	Tian, Ni, Zhang, Chen, Zhu, Xu, & Li	China	System development with comparative evaluation across coach-guided, VR, and mixed-reality conditions	VR produced the highest training accuracy, whereas mixed reality delivered a superior social experience with comparably high accuracy, indicating a trade-off between precision and sociality.
Effective Motion Self-Learning Genre Using 360° Virtual Reality Content on Mobile Device: A Study Based on Taichi Training Platform	Wang, Gai, Jiang, Chen, Bian, Luan, Huang, & Yang., 2024.	China	Platform development with user evaluation of 360° mobile VR motion learning	Mobile 360° VR content supported effective self-directed motion learning, extending immersive instruction beyond dedicated laboratory hardware.
The Use of Virtual Reality for Tactical Learning: The Moderation of Expertise and Visuospatial Abilities	Ben Mahfoudh & Zoudji., 2025.	France	Experimental comparison of immersive VR and non-immersive animation with 104 novice and expert players	Non-immersive animation outperformed VR overall, except for expert participants with high visuospatial ability, who alone derived benefit from the immersive condition.
Development of Karate Learning Media Based on Virtual Reality Digital Technology Applications	Septri et al., 2025.	Indonesia	Research and development with staged design validation, revision, and product trials	A VR-based karate movement guide was developed and validated as instructional media that helps students retain basic

Full title of study	Author(s)	Country	Method	Key findings
				karate techniques in coursework.
Design of an Immersive Basketball Tactical Training System Based on Digital Twins and Federated Learning	Lv, Tao, Zhang, & Xue., 2025.	China	Four-tier system design with experimental validation against a control group	The immersive digital-twin system raised tactical execution accuracy by 35.2%, shortened decision time by 1.8 s, and improved team coordination efficiency by 47%.
Assessment of Team Skills during Dragon Boat Training Using VR Devices	Le & Wang., 2025.	China	Two-group comparison with 344 athletes using self-report teamwork assessment instruments	VR-based training was more effective than conventional training in developing synchrony, with weaker differentiation for perspective-taking and communication.
The Value of Athletics Class with the Use of Virtual Reality Games for Better Communication and Socialization of Students	Niu, Dong, Zhang, Zhang, & Cao., 2025.	China	Experimental–control design with 100 first-year students using the Small Group Socialization Scale	Athletics classes supplemented with VR games improved measured socialisation and communication among students relative to conventional classes.
Comparing the Effectiveness of Immersive Virtual Reality and Non-Immersive Video in Memorizing Soccer Tactics: The Influence of Visuospatial Abilities	Ben Mahfoudh & Zoudji., 2026.	France	Experimental within-subject comparison with 52 soccer beginners	Beginners memorised tactical scenes more effectively through conventional video than through immersive VR, and visuospatial ability significantly conditioned the outcome.

Table 2 demonstrates that the collection is methodologically eclectic though in terms of results quite rich for each contribution learners are the ones providing evidence, without the authors merely comparing their work statistically. This is exactly one of the requirements from Table 1 that is an outcome.

Across the included studies, virtual reality (VR) represented the dominant immersive technology, whereas augmented reality (AR), mixed reality (MR), and extended reality (XR) were considerably less represented. Most studies adopted experimental or quasi-experimental designs, reflecting the emphasis on evaluating instructional effectiveness rather than technology development alone. The majority of interventions focused on motor skill acquisition, tactical decision-making, and learner engagement, while only a limited number examined long-term learning retention or transfer of learning to authentic sport performance.

Table 3 shows a corpus arranged according to four analytical themes of the same weight, where studies on tactical and cognitive learning and motor-skill acquisition have each been counted five times, and for studies on curricular integration and communication-oriented applications four each have been accounted.

Figure 2 shows that the main activity (in terms of results and products) is from 2024 and 2025 these two years alone cover twelve out of eighteen pieces. The relatively low outputs from the years 2021 and 2023; and the incomplete coverage in 2026; indicate that the field underwent rapid consolidation after the normalisation of remote and technology-mediated instruction post-pandemic rather than simply expanding linearly during the entire period.

Table 3 <Classification of Included Studies by Design, Theme, Technology, and Outcome Domain>

Author(s)	Country	Research design	Theme	Technology	Outcome domain
Meng., 2021.	China	Quasi-experimental	Curricular integration	VR teaching environment with sensor data capture	Teaching quality; student interest
Rohayati, Hodiyah, & Marwan., 2022.	Indonesia	Research and development	Curricular integration	3-D VR audio-visual module	Media validity; language learning support
Shin & Kim., 2022.	South Korea	Qualitative interview	Curricular integration	VR and simulator-based swimming instruction	Teacher capacity; instructional feasibility
Naito, Go, Shima, & Kijima., 2022.	Japan	Experimental	Communication and sociality	Immersive shared virtual workspace	Movement synchrony
Hanashima, Tokuda, Mochimaru, & Ohyama., 2023.	Japan	Controlled experiment	Motor skill and feedback	Avatar-based VR with visuo-tactile feedback	Posture accuracy; ease of learning
Geisen, Nicklas, Baumgartner, & Klatt., 2024.	Germany	Controlled trial	Motor skill and feedback	Extended reality with head-mounted display	Putt performance; retention; transfer
Hong, Wang, & Li., 2024.	China	System design and validation	Curricular integration	VR with mobile cloud computing and biosensing	Augmentative communication; accessibility
Martínez & Ramirez., 2024.	Argentina	Secondary data analysis	Tactical and cognitive	VR match simulation	Tactical decision-making
Mahfoudh & Zoudji., 2024.	France	Experimental	Tactical and cognitive	Immersive VR versus animation	Tactical memorisation; visuospatial moderation
Polechoński, Langer, Akbaş, & Zwierzchowska., 2024.	Poland	Pilot exploratory	Inclusion and participation	Active VR exergame application	Exercise intensity; user experience
Tian, Ni, Zhang, Chen, Zhu, Xu, & Li	China	System development and evaluation	Motor skill and feedback	Multi-user VR and mixed reality	Action accuracy; social experience
Wang, Gai, Jiang, Chen, Bian, Luan, Huang, & Yang., 2024.	China	Platform development and evaluation	Motor skill and feedback	360° mobile VR content	Self-directed motion learning
Ben Mahfoudh & Zoudji., 2025.	France	Experimental	Tactical and cognitive	Immersive VR versus animation	Tactical memorisation; expertise moderation
Septri et al., 2025.	Indonesia	Research and development	Motor skill and feedback	VR karate movement guide	Technique retention; media validity
Lv, Tao, Zhang, & Xue., 2025.	China	System design with	Tactical and cognitive	Digital twin with federated learning	Tactical execution;

Author(s)	Country	Research design	Theme	Technology	Outcome domain
		controlled validation			decision speed; coordination
Le & Wang., 2025.	China	Two-group comparison	Communication and sociality	VR team training devices	Synchrony; perspective-taking; communication
Niu, Dong, Zhang, Zhang, & Cao., 2025.	China	Experimental–control	Communication and sociality	VR games in athletics classes	Socialisation; communication
Ben Mahfoudh & Zoudji., 2026.	France	Experimental	Tactical and cognitive	Immersive VR versus video	Tactical memorisation; visuospatial moderation

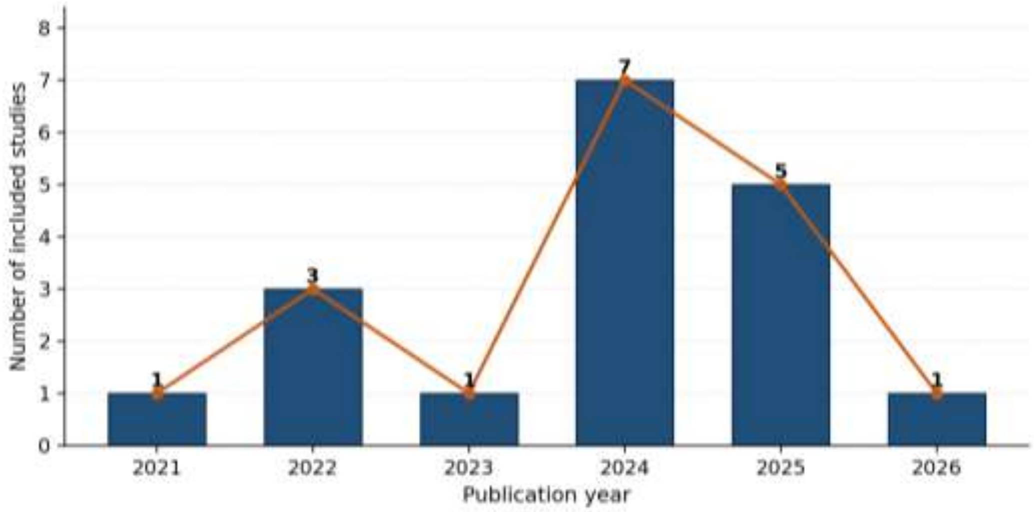

Figure 2 <Annual Distribution of the 18 Included Studies (2021–2026)>

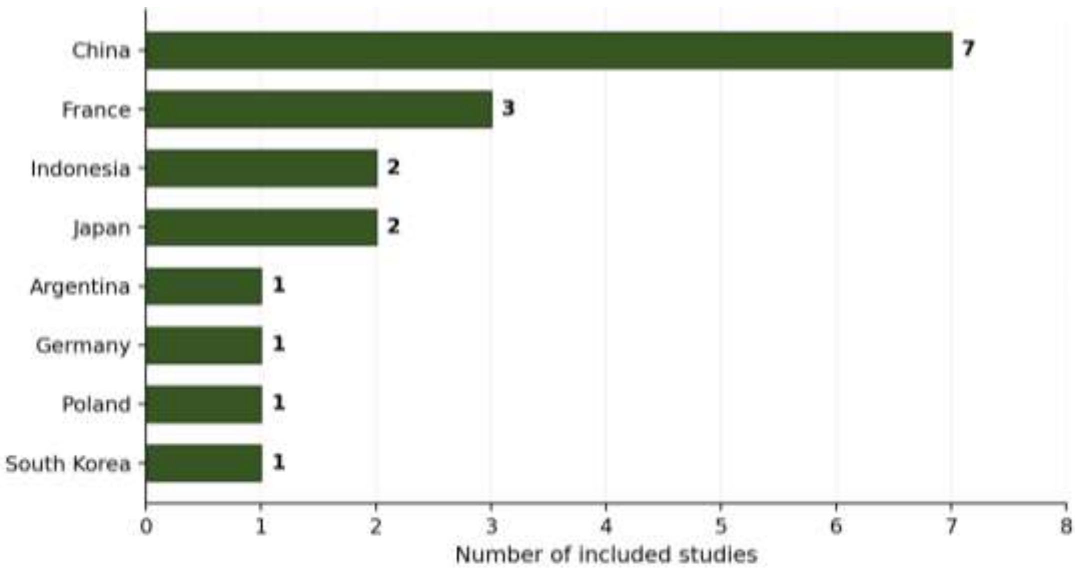

Figure 3 <Geographic Distribution of the Included Studies by Country of the Corresponding Author>

Figure 3 depicts a China dominance, as seven of the eighteen studies were from China alone. France followed as a contributor with three studies. Indonesia and Japan gave two studies each. In comparison, Argentina, Germany, Poland, and South Korea offered one study each. Since the almost total absence of evidence in Africa, South Asia, and several parts of Latin America is a characteristic feature of the data that limits the scope of a cross-study summary.

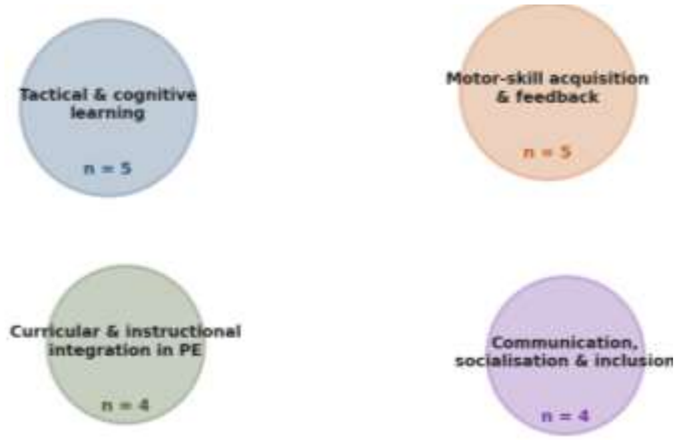

Figure 4 <Thematic Clusters Derived from the 18 Included Studies, with Bubble Area Proportional to the Number of Studies in Each Theme>

Figure 4 describes the four major topics of thematic synthesis. The fact that the number of studies per cluster was relatively equal demonstrates that the researchers have not yet focused mainly on one single area of application. Instead, the immersive technology is simultaneously being explored as four different applications: cognitive training, feedback device, curricular material, and social platform.

Findings for RQ1: Design and Implementation

The studies reviewed here use immersive tech following four main design logics. First up is reconstructing decision environments. Realistic scenarios play out here, letting learners practice their perception and decision-making minus the physical demands. Martínez and Ramirez (2024) applied this to Argentinian rugby. Lv et al. (2025) took it further, mixing a four-tier digital twin setup with federated learning and multi-agent reinforcement learning to build adaptive game scenarios for college basketball. The second logic enhances perceptual feedback. Geisen et al. (2024) showed this by projecting a virtual club and real-time alignment data into a physical training space using a head-mounted display. Hanashima et al. (2023) took a different approach, adjusting avatar perspective and visuo-tactile cues for posture learning.

The third logic is about weaving immersion right into the curriculum. Here, the tool works more like teaching material than a strict training device. Rohayati et al. (2022) built and tested a 3D VR module for pencak silat classes in Indonesian junior secondary schools. Septri et al. (2025) followed a similar development path, producing a validated karate movement guide for university coursework. Both Meng (2021) and Hong et al. (2024) placed their tools within institutional systems. Meng used a sensor-loaded virtual teaching environment, while Hong developed a mobile cloud architecture to support learners with physical impairments. The fourth and final logic turns immersion into a shared social space. Naito et al. (2022) reconstructed triadic jumping synchrony in a virtual environment. Tian et al. (2024) built a multi-user Tai Chi platform using standalone devices, specifically to preserve group interaction.

Across all these approaches, hardware choices differ a lot, and those choices carry real pedagogical weight. Several studies relied on dedicated head-mounted displays with controllers. But Wang et al. (2024) deliberately targeted 360-degree content on ordinary mobile devices. Polechoński et al. (2024) simply adopted a commercially available exergame application. This split highlights a key unresolved tension in the field: high fidelity versus easy accessibility. The participant groups are just as varied. They span junior secondary pupils, university students, novice and expert athletes, wheelchair users, and instructors. Sample sizes swing wildly too. One tightly controlled lab experiment had just 24 participants, while a field-based comparison involved 344 athletes. The study designs reflect that range, blending rigorous controlled trials alongside developmental and secondary-analysis work.

The reviewed studies demonstrated considerable diversity in immersive technology implementation across educational settings. Virtual reality was the most frequently adopted technology because of its capability to create controlled and repeatable learning environments. AR and XR applications were generally employed to provide real-time feedback during motor learning. Most interventions targeted university students and novice athletes, whereas only a few studies involved elite athletes or school-aged participants.

Findings for RQ2: Reported Outcomes

There are four families of outcomes here. In the tactical and cognitive family, the results are genuinely mixed. On one hand, Martínez and Ramirez (2024) and Lv et al. (2025) report substantial gains. Lv's team quantified a 35.2% improvement in tactical execution accuracy and a 1.8 s reduction in decision time. But then you have the exact opposite finding from Mahfoudh and Zoudji (2024), Ben Mahfoudh and Zoudji (2025). They consistently found that non-immersive animation or video was actually better for tactical memorisation than immersive VR for most learners. This isn't just some artifact of bad measurement. It reflects a real divergence between system-level tactical execution and individual-level scene memorisation as outcome constructs.

The motor-skill and feedback family is a different story. The findings here are much more aligned. Geisen et al. (2024) showed that real-time XR feedback really helps with putt learning across post-test, retention, and transfer. It's probably the most complete outcome chain in the whole corpus. Hanashima et al. (2023) found something very specific and useful: a third-person perspective is better for head-position accuracy. Tian et al. (2024) add that VR beats both coach guidance and mixed reality for action accuracy. Wang et al. (2024) and Septri et al. (2025) back this up in self-directed and curriculum settings. So the benefit of immersive feedback seems to hold up pretty well across different delivery setups.

The psychosocial family is the most uniformly positive group. Niu et al. (2025) saw better socialization among first-year PE students after VR-supplemented classes. Le and Wang (2025) report that VR beats conventional dragon boat training for building synchrony, even if the effects on perspective-taking and communication were weaker. Tian et al. (2024) note that mixed reality actually gave a better social experience than fully immersive VR. Naito et al. (2022) offer a mechanism here. They show that ordered interpersonal synchrony patterns can survive the move into virtual space, even if they lose some temporal rigidity. Lastly, we have the feasibility and inclusion family. Polechoński et al. (2024) found that immersive boxing can give wheelchair users a health-relevant workout. Hong et al. (2024) showed it can help with augmentative communication for learners with physical impairments. And Shin and Kim (2022) identified the teacher capacities that make any of these outcomes possible in the first place.

Overall, immersive technologies positively influenced motor skill acquisition, tactical understanding, learner motivation, engagement, and communication. Studies employing augmented feedback consistently reported improvements in movement accuracy and skill execution. However, evidence regarding long-term retention and transfer of learning remained limited because most interventions evaluated only immediate post-test outcomes.

Findings for RQ3: Moderating Factors

Learner aptitude is the most consistent moderator across all the studies. A trio of studies by Mahfoudh and Zoudji (2024), Ben Mahfoudh and Zoudji (2025), really shows how visuospatial ability and prior expertise together decide if immersion works or not. In the 2025 experiment, only experts with strong visuospatial skills gained from VR over non-immersive animation. Novices and low-ability learners actually did worse under immersion. That's a classic aptitude, treatment interaction with real practical weight, and it directly challenges the additive idea that more immersion always brings more learning.

Then there's the level and setup of immersion. Tian et al. (2024) found that full VR and mixed reality optimize different things: VR boosts accuracy, while mixed reality enhances social experience. That suggests the right amount of immersion depends on what you're trying to teach, not on some fixed feature of a good system. Hanashima et al. (2023) spotted a similar effect at a finer scale: the angle from which a learner sees an avatar changes what gets learned. Geisen et al. (2024) added timing into the mix, since the advantage they reported came specifically from real-time feedback, not delayed delivery.

A third moderator is instructional and institutional capacity. The clearest evidence comes from Shin and Kim (2022). They pinpoint equipment fluency, communicative clarity, and structured preparation as the key factors in whether VR swimming lessons actually work. Meng (2021) and Hong et al. (2024) highlight infrastructure problems: both setups assume a network and sensing capacity that many places just don't have. Wang et al. (2024) propose a partial fix using mobile 360-degree delivery, which cuts the hardware requirement but sacrifices some fidelity. Put together, these three categories of moderators show that effectiveness in this field isn't something built-in; it's conditional and adjustable.

Four principal moderators emerged across the reviewed literature. First, learner expertise influenced instructional effectiveness, with novice learners generally benefiting more from immersive environments. Second, visuospatial ability affected users' capacity to process immersive visual information. Third, teacher competence determined the successful integration of immersive technologies into educational practice. Finally, instructional design characteristics, including feedback timing, task complexity, and session duration, substantially influenced learning outcomes.

Comparative and Critical Analysis

Methodologically, the corpus splits into two traditions that almost never talk to each other. The experimental tradition comes mainly from European and Japanese studies. It uses controlled comparison, explicit moderator modeling, and at its strongest, retention and transfer testing (Geisen et al., 2024; Hanashima et al., 2023; Ben Mahfoudh & Zoudji, 2025). The developmental and systems tradition shows up more often in Chinese and Indonesian studies. It focuses on building artifacts and showing feasibility rather than making counterfactual comparisons (Meng, 2021; Hong et al., 2024; Rohayati et al., 2022; Septri et al., 2025). Neither tradition is bad on its own, but because they stay separate, the most advanced systems tend to get the least rigorous evaluation, while the most carefully tested interventions are usually pretty simple on the tech side.

Three methodological issues keep coming up. One is that follow-up is short. Only Geisen et al. (2024) report retention and transfer, so the durability of reported gains is mostly unknown. Another problem is inconsistent control conditions. They range from no training at all to conventional instruction to non-immersive media, which makes effect sizes hard to compare across studies. A third issue is that self-report measures dominate the psychosocial family, even in the largest study in the corpus (Le & Wang, 2025). That leaves socialization and communication outcomes open to expectancy effects. Still, you can see a clear shift over this window. The 2021 and 2022 studies were mostly about feasibility. But from 2024 to 2026, studies increasingly model moderators and report quantified performance differences.

Immersive Technologies Improve Motor Learning

The findings consistently demonstrate that immersive technologies facilitate motor skill acquisition through enhanced visualization, immediate augmented feedback, and repeated practice opportunities. These findings are consistent with previous systematic reviews, which reported that immersive environments improve psychomotor learning by integrating perception, action, and feedback within realistic learning contexts.

Tactical Learning. Beyond motor performance, immersive environments also promoted tactical understanding by enabling learners to repeatedly experience realistic game situations without physical fatigue or injury risk. These findings reinforce the role of immersive technologies in supporting decision-making and game intelligence development.

Learner Engagement. Increased learner engagement emerged as one of the most consistent findings across the included studies. The immersive characteristics of VR, AR, and XR environments appear to enhance learner motivation, enjoyment, and active participation, although novelty effects may partly explain short-term improvements.

Teacher Competence. Successful implementation depends not only on technology but also on teacher competence. Effective instructional design, pedagogical integration, and teacher facilitation determine whether immersive technologies contribute meaningfully to learning outcomes.

Explaining Inconsistent Findings. Although most studies reported positive outcomes, several investigations demonstrated limited or inconsistent effects. Such discrepancies may be attributed to differences in learner expertise, intervention duration, hardware quality, cognitive load, outcome measures, and instructional support.

Interpretation of Findings

We can't conclude from this evidence that immersive technology generally boosts learning in sport and physical education. Instead, it points to something more specific and useful. Immersive environments work well when the instructional goal needs either real-time perceptual feedback you can't get from an outside view, or a shared space where people can practice moving together. When the goal is memorizing tactical setups, standard two-dimensional media often beat immersion, likely because the extra perceptual and navigational load in a virtual environment eats up processing power the task needs. This fits with broader findings on immersive learning, where telepresence, emotion, and cognition interact rather than just add up (Liu et al., 2025; Chen et al., 2023).

Looking closer at the corpus, the key mechanism seems to be informational, not motivational. When immersive delivery works, it's because it makes information available right when the action happens that would otherwise be inaccessible. Things like how an implement aligns with its intended path, where your head sits compared to a model posture, or the timing between your movement and two other performers'. Each of those is something a learner can't get from an external observer without a delay that kills its instructional value. On the flip side, when immersion fails, the needed info is already fully present in a 2D representation, and immersion just adds navigational and perceptual demands without adding anything informationally. Framing the evidence this way resolves the apparent contradiction in the tactical findings. It gives us a design rule that's both simple and testable. Immersion makes sense only when it uniquely provides action-relevant information. Otherwise, it's probably a net cost.

There's another point to note about engagement. Several studies found that participants were more interested, enjoyed the experience more, or were more willing to take part, alongside the main outcomes (Meng, 2021; Niu et al., 2025). It's tempting to take that as proof of instructional benefit, but the corpus doesn't support that conclusion. Engagement effects turned up in some studies with learning gains and in some without. And none of the included studies modeled engagement as something that mediates learning. This matches broader evidence that novelty-driven emotional responses to immersive media fade with repeated exposure (Liu et al., 2025; Durojaye et al., 2023). So engagement is worth measuring on its own, especially in compulsory physical education where just getting students to participate is already a goal. But we shouldn't treat it as a stand-in for learning.

Theoretical Implications

There are three theoretical consequences here. First, immersion should be seen as an instructional variable with an inverted-U relationship to learning, not a monotonic one. The exact same feature that enriches perceptual information also piles on extraneous load. Second, aptitude, treatment interaction needs to be reinstated as a central construct in sport pedagogy. What the Mahfoudh and Zoudji programme shows is that omitting learner aptitude doesn't just make the model imprecise. It steers you toward conclusions that are wrong in direction. Third, the finding that mixed reality can beat full immersion on social outcomes (Tian et al., 2024) challenges the implicit hierarchy that treats fidelity as the design target. That same hierarchy has already been questioned in other immersive-learning fields (Amm et al., 2024; Budnarowski et al., 2025). The present review extends previous systematic reviews by integrating technological, pedagogical, and psychological perspectives into a unified framework for immersive sport learning. Rather than considering immersive technologies as universally effective, the findings suggest that instructional effectiveness depends on interactions among learner characteristics, technological affordances, and pedagogical design.

Practical Implications

For practitioners, the real takeaway is to adopt selectively, not wholesale. Immersive delivery works best for real-time technical feedback and for team coordination tasks. For tactical memorisation in novices, though, it falls short compared to conventional media. Teacher preparation isn't just a small implementation step, it directly shapes outcomes. Shin and Kim (2022) make that clear, and broader research on physical education teachers' tech readiness backs them up (Asi & Sabbah, 2025; Almusawi & Durugbo, 2024). When resources are tight, the mobile 360-degree approach from Wang et al. (2024) offers a sensible starting point. And the accessibility data from Polechoński et al. (2024) and Hong et al. (2024) suggest adapted and para-sport contexts might see especially large gains, a finding that fits with tech-enabled Paralympic coaching.

Implementation sequencing also matters. The research says institutions trying to adopt everything across an entire curriculum at once are unlikely to succeed. Why? Because the teacher capacities Shin and Kim (2022) highlight develop through repeated use, not from a single training session. A staged approach works better: start with one activity domain where immersive feedback has a proven edge, then expand only once instructors have built real fluency. That aligns with the evidence. Procurement should be governed by instructional intent, not by specs. If the goal is group coordination, the mixed-reality configuration Tian et al. (2024) reported beats a higher-fidelity but socially isolating alternative. If the goal is individual technique, the opposite holds. Monitoring arrangements need to be in place from the start. The same system that enables adaptive feedback also generates learner data, and that data requires clear governance (Qi et al., 2024). For educators and coaches, immersive technologies should complement rather than replace traditional instruction. Teacher training, curriculum alignment, and appropriate learner support are essential for maximizing instructional benefits. Educational institutions should also consider cost-effectiveness and accessibility when implementing immersive learning systems.

Comparison with Prior Reviews

Earlier reviews on using immersive tech for education mostly came to positive overall findings, yet they also pointed to heterogeneity (Chen et al., 2023; Liu et al., 2025), and analyses at a sector-level have put their focus on the transformative possibilities (Durojaye et al., 2023). Because of the narrow focus on the subject - sport and physical education- of present review, its conclusion has to be much more nuanced than a blanket statement. Sport & PE involve performance through physical means, which in most cases are not required in classroom applications. Similar caveats were made by reviews of digital tech in sport in general, namely that measuring a performance using equipment does not automatically equate to improved performance (Qi et al., 2024; Vako et al., 2023). The unique feature of this study is that it points out that aptitude determines effectiveness, while previous reviewers have mentioned this but haven't emphasized.

Contradictions in the Literature

A clear tension exists in the literature. Martínez and Ramirez (2024) and Lv et al. (2025) report tactical gains from VR. But the Mahfoudh and Zoudji programme finds tactical disadvantages instead. Three plausible explanations are mutually compatible. The outcome constructs are not the same: execution accuracy in an adaptive adversarial system is not identical to recalling a static configuration. The populations differ; the positive studies used trained players while the negative used beginners. And the methodologies differ in rigour, as secondary data analysis and developer-conducted validation are more prone to optimistic estimates than controlled within-subject comparisons. A second contradiction relates to sociality. VR enhances synchrony, according to Le & Wang (2025) and Naito et al. (2022), yet underperforms mixed reality on social experience (Tian et al., 2024). This suggests coordination and connection are separate outcomes. This distinction also appears in team cognition research in virtual competitive environments (Musick et al., 2021; Biał ecki et al., 2024).

Research Gaps

We see three gaps. Temporal gap: only Geisen et al. (2024) even asks whether learning from immersion lasts or carries over to real competition. The rest of the corpus just does not look at that. Then there is a demographic and geographic gap. The studies are mostly from East Asia and Western Europe, and they use mostly young male participants. None come from low-income education systems. That is a big miss, because those are the settings where the decision to adopt immersive tech carries the highest opportunity cost (Weng et al., 2021; Zhu, 2022). Third gap is conceptual. The field has not developed measures that clearly tell apart immersion, presence, and instructional load. Without those, it is hard to build up comparable evidence. Some related fields have started using physiological tracking of learners, and that gives us a partial template to follow (Khoruzhaya & Moranski, 2026).

A fourth gap is the teacher's role in these immersive environments. In the corpus, the teacher shows up as an equipment operator, a task designer, or sometimes not at all in self-directed setups. But no study has actually compared these roles. And none has looked at how teaching talk changes when learners cannot see each other or the instructor. Teacher readiness and tech skills are known to matter a lot for educational technology in general (Almusawi & Durugbo, 2024; Asi & Sabbah, 2025). Plus, structured debriefing is a central part of effective simulation training in professional fields (Orsega-Smith et al., 2023). So the lack of research on how teachers orchestrate learning in immersive sport settings is a real gap. Then there is a fifth gap about cost. Not a single study reported how much it costs to implement, what the cost per learner is, or whether it is cost-effective compared to traditional methods. That means the practical question that most concerns decision-makers gets zero attention from the evidence. Despite rapid technological development, relatively few studies have investigated long-term retention, transfer of learning, teacher readiness, or cost-effectiveness of immersive technologies in sport education. Furthermore, comparative studies involving VR, AR, MR, and XR under standardized instructional conditions remain scarce.

Limitations of This Review

We should be upfront about four limitations. One, using a single database means we probably missed relevant work indexed elsewhere. This includes regional scholarship from Indonesia and Latin America. Two, we only looked at English journal articles. That left out conference proceedings. In human, computer interaction, conferences are a primary venue for exactly this kind of system. Three, the final set of 18 studies is defensible method-wise. But the studies are heterogeneous in design and outcome. So we couldn't do meta-analytic pooling. We had to rely on narrative synthesis, which gives us some interpretive leeway. Four, the FICO appraisal tool was applied systematically. Still, it involves judgment that might be different with another review team. Also, one study lacked a document object identifier in the source export. This limits independent verification of its bibliographic record.

Two additional factors influence the strength of our conclusions. Technological change is rapid in this domain. The hardware from early studies is no longer representative of what's available. So negative findings from older equipment may not generalize to current systems. Positive findings might reflect novelty conditions that have since normalized. Also, in the developmental tradition, the evaluation team is often the same as the developing team. That creates an optimism bias. This review can identify it but can't correct it. Both points argue for periodic updates of this synthesis instead of treating our conclusions as settled. And independent replication of the most consequential system-level findings is needed.

Future Research Agenda

Based on the gaps we found, four concrete directions stand out. First off, longitudinal designs need to become the standard. They should include delayed retention checks and ecologically valid transfer tests, following the model Geisen et al. (2024) used. Without that, the field can't separate learning from performance. Second, every comparative study should measure and model learner aptitude as a moderator. That means looking at visuospatial ability and prior expertise instead of treating them as background noise. Third, we ought to develop and test adaptive systems that adjust immersion level in real time to each learner's aptitude. The aptitude findings make it clear: no single immersion setting works for a mixed class. With AI-supported movement analysis already out there, the technical foundation is ready (Romero-Naranjo, 2025; Huang & Li, 2026). Fourth and finally, low-cost implementations should be tried in resource-constrained settings. Report the cost-effectiveness alongside the learning outcomes, so adoption choices depend on evidence, not on the prestige that immersive sport environments are getting these days (Li & Jia, 2025; Kim et al., 2025; Jang et al., 2021). Future investigations should prioritize longitudinal randomized controlled trials, standardized learning outcome measures, AI-supported adaptive immersive systems, low-cost VR solutions, and transfer of learning to authentic competitive performance.

Summary Answers to the Research Questions

The answer for RQ1 goes like this: immersive technologies use four design logics to work. They are decision-environment reconstruction, perceptual feedback augmentation, curricular embedding, and shared social space. The hardware spans from dedicated head-mounted displays to regular mobile devices. This all happens across eight countries and eleven activity domains.

As for RQ2, the outcomes are positive and pretty consistent for real-time motor feedback, interpersonal synchrony, socialisation, and accessibility. But things get contradictory when it comes to tactical learning. For novice learners, immersive delivery often ends up worse than non-immersive media in that area.

RQ3's answer shows that effectiveness is shaped mostly by learner aptitude. That means visuospatial ability and prior expertise matter a lot. Second come the level and setup of immersion, plus when feedback is given. And third, teacher competence and institutional infrastructure also play a role.

Limitations

This review has several limitations. First, only Scopus-indexed journal articles were included, potentially excluding relevant studies available in other bibliographic databases and grey literature. Second, heterogeneity in study design, intervention characteristics, and outcome measures prevented quantitative synthesis. Third, publication bias cannot be entirely excluded because studies reporting significant positive findings are generally more likely to be published than studies reporting null results.

Conclusions

A systematic review of 18 studies published between 2021 and 2026 found that immersive technologies in sport and physical education follow four distinct design logics. These cover decision-environment reconstruction, perceptual feedback augmentation, curricular embedding, and the construction of shared social space. The technologies are used across a wide range of activity domains and hardware configurations. Outcomes are relatively consistent and positive for real-time motor feedback, interpersonal synchrony, student socialisation, and accessibility for learners with physical impairments. But when it comes to tactical learning, the results get contradictory: immersive delivery is repeatedly outperformed by non-immersive media, especially among novice learners. What moderates effectiveness most? Learner aptitude, particularly visuospatial ability and prior expertise. The configuration and timing of immersion matter too, along with teacher competence and institutional infrastructure. So the core contribution of this review is a conditional account. Instead of a broad claim about how well immersion works, it specifies for whom, for which objectives, and under which configurations immersion is actually warranted. On a practical level, this supports selective deployment that's sensitive to aptitude, deliberate investment in teacher preparation, and the use of low-cost mobile implementations in resource-constrained systems. But the review does have limitations. It used a single database and English-language search only. The included designs are heterogeneous, and narrative synthesis always involves some interpretive latitude. Future research should focus on longitudinal retention and transfer testing, routine measurement of learner aptitude as a moderator, adaptive systems that modulate immersion based on the learner's profile, and rigorous evaluation in under-represented educational settings. Findings were synthesized through thematic analysis conducted independently by two reviewers with excellent inter-rater agreement (κ = 0.87). Positive outcomes were classified when immersive interventions demonstrated statistically or qualitatively superior learning performance relative to conventional instruction or baseline conditions.

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