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Re-Orientation of Physical Education: A Qualitative Analysis of Augmented Reality Integration in Neuro-Pedagogical Development to Overcome Students' Academic Boredom

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ABSTRACT In this era of digital disruption, mastery of technology-integrated kinesthetic skills is paramount, necessitating innovative pedagogical strategies like immersive technology to sustain student engagement. Traditionally, physical education research has emphasized physical competence, often neglecting academic burnout—a critical factor hindering cognitive and psychomotor development. This study aims to analyze the integration of Augmented Reality (AR) within neuro-pedagogical frameworks to alleviate academic burnout among physical education students. Utilizing a phenomenological qualitative approach, data were collected through in-depth interviews and participant observations concerning the utilization of AR devices. The study explores students' interactions with virtual-physical simulations within the curriculum. Findings indicate that AR significantly fosters cognitive flexibility and psychomotor retention by effectively reducing mental fatigue. However, precise technical scaffolding remains critical; findings suggest that excessive interface complexity is ineffective and potentially distracting for students with low digital literacy. In conclusion, the integration of AR represents a transformative paradigm shift in neuro-pedagogical strategies, offering a sustainable solution to mitigate academic burnout by fostering highly interactive and mentally stimulating learning environments.

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1. INTRODUCTION

The global landscape of higher education is currently undergoing a massive transformation driven by the rapid progression of digital technologies and the necessity of cultivating complex kinesthetic-technological literacies among students. In physical education, this paradigm shift demands a move away from traditional, purely mechanical instruction toward immersive, technologically integrated environments that foster both physical prowess and mental adaptability (Radianti et al., 2020; Vasconcellos et al., 2020). Modern physical education must not only cultivate physical fitness but also equip future educators with advanced digital competencies, spatial reasoning, and cognitive flexibility to navigate modern school environments (Tsani et al., 2025; Wawan et al., 2023). Therefore, understanding how immersive systems can be woven into the pedagogical fabric of physical training is of paramount global significance, as it directly impacts how prospective teachers learn, interact, and eventually instruct future generations in an increasingly digitized society.

Despite this clear need for innovation, contemporary physical education programs face a critical crisis marked by rampant academic boredom, physical disengagement, and profound mental fatigue among undergraduate students. This widespread academic burnout is exacerbated by static instructional methods that fail to stimulate the modern learner's cognitive faculties, leading to severe drops in both academic performance and motivation (Jahrami et al., 2023; Woo et al., 2020). The challenge is particularly severe in theoretical and complex technical courses within the physical education curriculum, where students struggle to bridge the gap between abstract concepts and dynamic physical executions (van der Merwe & Botha, 2020; Wawan et al., 2023). Without a fundamental restructuring of how movement and theory are taught, higher education departments risk producing unmotivated graduates who lack the creative drive and resilience needed to thrive in modern physical education roles.

A review of the literature reveals several notable attempts to address these educational hurdles, yet these prior works exhibit significant limitations. Specifically, research by Vasconcellos et al. (2020) focused heavily on self-determination theory but failed to evaluate digital interaction, while Opstoel et al. (2020) examined personal development in physical education without considering technological scaffolds. Technology-centric studies, such as the virtual reality frameworks proposed by Radianti et al. (2020) and the spatial models by Chen et al. (2021), prioritized software engineering aspects rather than the psychological wellbeing or academic fatigue of the users. Furthermore, clinical reviews of student burnout by Jahrami et al. (2023) and pedagogical analyses of neurodiversity by Hamilton et al. (2023) overlooked physical movement and active sports environments. Nationally, while Tsani et al. (2025) argued for creativity in elementary physical training and Wawan et al. (2023) highlighted the paradox of sedentary behavior among physical education majors, neither offered a concrete, technology-mediated solution to mitigate academic boredom. These studies remain isolated in their respective domains, failing to connect technological immersion directly with neuro-pedagogical health.

This investigation establishes its research novelty by pioneering the integration of Augmented Reality (AR) specifically within a neuro-pedagogical framework to actively combat academic boredom in physical education. Unlike previous studies that treat AR merely as an optional visual aid or a substitute for athletic equipment (Chen et al., 2021; Radianti et al., 2020), this study treats AR as a cognitive catalyst that fundamentally restructures the sensory-motor pathways of the learner. By mapping the neurological responses to real-time, interactive virtual overlays during physical tasks, this research uncovers how immersive visual-physical feedback reduces cognitive load and mitigates the symptoms of mental exhaustion (Hamilton et al., 2023; Kozinets, 2023). This focus on the neurological and psychological dimensions of active, tech-infused learning introduces a completely new avenue of research that elevates physical education from a purely biomechanical discipline to a sophisticated neuro-pedagogical practice.

The critical research gap addressed by this study lies in the complete lack of qualitative, experiential evidence regarding how physical education students process and overcome academic boredom when interacting with AR in a highly structured pedagogical environment. Existing literature is heavily polarized, featuring either quantitative sports science analyses focused strictly on physiological metrics (Vasconcellos et al., 2020; Vinogradova, 2024) or technology acceptance surveys that lack deep qualitative insights (Radianti et al., 2020). There is a distinct absence of qualitative phenomenological studies that capture the lived experiences, cognitive friction, and motivational shifts of students navigating these digital-physical boundaries (Braun & Clarke, 2021; Motulsky, 2021). By exploring these subjective experiences, this study bridges the divide between technical deployment and human-centric pedagogy, clarifying exactly how AR-driven environments alter the psychological state of exhausted learners.

To theoretical ground this study, we utilize Cognitive Load Theory (CLT) and Self-Determination Theory (SDT) as our core theoretical frameworks to evaluate student interaction with immersive systems. CLT provides a robust mechanism to analyze how AR-mediated instructions can optimize working memory capacity by aligning visual overlays with physical tasks, thereby preventing cognitive overload and subsequent academic boredom (Hamilton et al., 2023; Radianti et al., 2020). Concurrently, SDT helps explain

how the interactive, high-autonomy nature of AR tasks satisfies students' needs for competence, autonomy, and relatedness, directly combating the psychological roots of burnout (Vasconcellos et al., 2020; Wawan et al., 2023). Together, these theories form a holistic framework that explains the intricate relationship between technological design, mental exertion, and student motivation in active movement environments.

The central concepts operationalized in this research include "neuro-pedagogical development," "augmented reality integration," and "academic boredom" in physical education. Neuro-pedagogical development refers to instructional design informed by brain science, specifically how sensory-motor stimulation from dynamic technologies enhances spatial memory and motor retention (Hamilton et al., 2023; Vinogradova, 2024). Augmented reality integration involves embedding real-time, interactive 3D virtual elements into physical spaces to guide students through complex anatomical and tactical movements (Chen et al., 2021; Radianti et al., 2020). Academic boredom is conceptualized not merely as temporary disinterest, but as a persistent state of cognitive under-stimulation and emotional exhaustion that restricts a student's psychomotor potential (Jahrami et al., 2023; van der Merwe & Botha, 2020).

What makes this research particularly compelling and crucial to conduct is its potential to challenge the traditional boundaries of physical education and offer a highly innovative pathway to prevent student attrition. By proving that virtual overlays can actively stimulate neural pathways and restore academic enthusiasm, this study offers a powerful argument for a complete re-orientation of physical education curricula worldwide (Opstoel et al., 2020; Tsani et al., 2025). Furthermore, it addresses a pressing societal concern by showing how departments of physical education can leverage emerging consumer technologies to foster mental resilience, combat sedentary lifestyles, and elevate the standard of teacher training (Kozinets, 2023; Wawan et al., 2023). The synthesis of technology, neurology, and movement science represents a disruptive frontier in educational research that demands immediate empirical exploration.

Consequently, the primary objective of this qualitative study is to analyze and document the integration of Augmented Reality (AR) within neuro-pedagogical frameworks as a viable strategy to overcome academic boredom among physical education students. Through this exploration, the study aims to capture how students qualitatively perceive the shift from static to immersive instruction, identifying the exact pedagogical and technical parameters that facilitate mental recovery and cognitive engagement (Braun & Clarke, 2021; Motulsky, 2021). Ultimately, this research seeks to provide curriculum planners and university departments with a validated, experiential blueprint for implementing interactive, neuro-pedagogically sound technologies that protect student well-being and elevate kinesthetic learning.

2.METHOD

To rigorously capture the cognitive-emotional shifts and spatial-motor adaptions experienced by physical education students, this section outlines the comprehensive qualitative methodology employed in this research. Investigating the neuro-pedagogical effects of immersive systems requires an adaptive, human-centric research methodology that prioritizes individual subjective experiences over mere quantitative metrics (Kozinets, 2023; Motulsky, 2021). The following subsections describe the systematic steps taken to execute this research, starting with an immersive research design, followed by structured data gathering and reflexive analytical workflows.

2.1 Research Design

The study is designed around a qualitative phenomenological approach, which is ideal for uncovering the complex, lived experiences of individuals interacting with novel, technology-mediated pedagogical environments. By prioritizing subjective, first-person accounts, phenomenology allows us to examine the psychological essence of academic boredom and the cognitive restoration triggered by real-time virtual stimuli (Braun & Clarke, 2021; Motulsky, 2021). The integration of Augmented Reality (AR) in physical education was evaluated over an intensive eight-week cycle, during which students engaged with AR-guided motor-spatial modules while researchers documented their cognitive states and adaptive physical maneuvers (Hamilton et al., 2023; Radianti et al., 2020). This structured timeframe ensured sufficient immersion to observe shifts in psychological burnout and neuromuscular adaptation.

To visually articulate the logical flow of this study, Figure 1 illustrates the iterative stages of the research design, from participant recruitment to the final synthesis of qualitative themes.

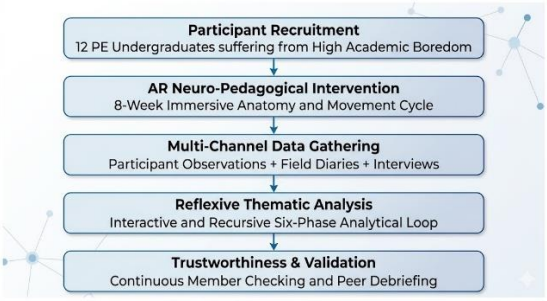


Figure 1. Operational Flowchart of the Immersive Research Design..

Figure 1 provides a holistic blueprint of our

research path, ensuring that each phase is logically connected to the next. The operational flowchart starts with the purposeful selection of participants exhibiting high indicators of burnout, followed by the deployment of the AR modules, multi-channel data collection, recursive thematic analysis, and continuous trustworthiness protocols (Braun & Clarke, 2021; Motulsky, 2021). This systematic progression ensures that our exploration of student interaction with immersive visual-physical spaces remains highly organized and academically robust.

2.2 Data Collection

Data collection was executed through multiple qualitative channels to achieve rich triangulation, ensuring that observations, personal reflections, and formal discussions were captured concurrently. Over the eight-week period, researchers performed participant observations during the active AR learning sessions, recording detailed field diaries regarding students' physical adaptations, cognitive confusion, and emotional expressions (Kozinets, 2023; Motulsky, 2021). Following the intervention, in-depth, semi-structured interviews were conducted to allow students to articulate how they felt the virtual overlays affected their mental fatigue and spatial retention (Braun & Clarke, 2021; Hamilton et al., 2023).

To guarantee alignment between our research aims and the data-gathering mechanisms, Table 1 outlines the specific research questions alongside their corresponding qualitative analysis methods.

Table 1. Research Questions and Qualitative Analytical Mapping.

Core Indicator	**Sub-Indicator**	**Operational Focus**	**Sample Protocol / Interview Questions**	**Target Subjects / Sources**
Academic Boredom (AB)	• Cognitive Under-stimulation • Mental Fatigue • Disengagement	Assessing pre- and post-intervention levels of mental exhaustion and disinterest in physical training theoretical lectures.	*"How would you describe your level of mental energy during traditional lecture-heavy PE sessions compared to AR-mediated sessions?"*	Undergraduate PE Students ($N=12$)
Neuro-Pedagogical Stimulation (NPS)	• Spatial-Motor Retention • Cognitive Load Management • Sensory Integration	Evaluating how real-time 3D anatomical overlays assist in complex motor planning without overloading working memory.	*"In what ways did the 3D muscle-firing overlays change how you mentally visualized and performed the kinetic movement?"*	Undergraduate PE Students ($N=12$)
AR Technological Ergonomics (ATE)	• Interface Friction • Scaffolding Facilitation • Usability Barriers	Identifying if the complexity of the AR application distracted students or facilitated their focus on physical exercises.	*"Can you describe any moments where the technology itself became frustrating or difficult to use while trying to complete a physical task?"*	Undergraduate PE Students ($N=12$) & Facilitators

The instrument layout in Table 2 was meticulously validated by expert reviewers in sports psychology and educational technology, ensuring that the qualitative prompts effectively capture the targeted cognitive-emotional domains (Braun & Clarke, 2021; Hamilton et al., 2023).

2.3 Data Analysis

The data analysis process was executed using Reflexive Thematic Analysis (RTA) to ensure a highly dynamic, context-sensitive interpretation of the student experiences. Unlike static quantitative sorting, reflexive thematic analysis acknowledges the active role of the researcher in interpreting patterns within the dataset, allowing for a deeper exploration of the cognitive and psychological shifts that occurred during the AR sessions (Braun & Clarke, 2021; Kozinets, 2023). The analysis was managed using NVivo 14 software to systematically store, organize, code, and map the relationships between transcript segments, observation notes, and personal field diaries.

To visualize how the raw qualitative data was systematically processed into sophisticated, high-level themes, Figure 2 displays the iterative, six-phase analytical loop utilized in this study.

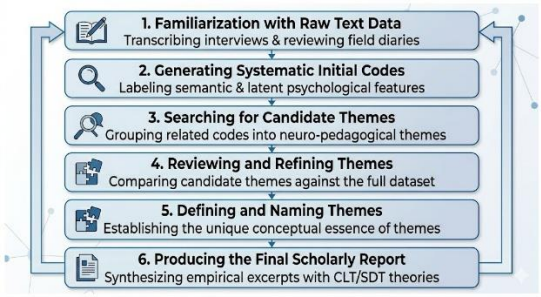


Figure 2. Recursive Reflexive Thematic Analysis Cycle.

As illustrated in Figure 2, the reflexive data analysis process operates not as a linear checklist, but as a continuous, recursive analytical loop. This interactive structure allowed researchers to constantly move back and forth between raw student transcripts, initial conceptual codes, and high-level theoretical constructs to ensure the final report captured the authentic lived experiences of the participants (Braun & Clarke, 2021; Motulsky, 2021).

2.4 Research Instruments

The primary research instrument in this study was the researcher themselves, serving as the qualitative tool for observation and interaction, supported by a highly structured Interview and Observation Guide. This reliance on the researcher as a central tool is fundamental to phenomenology, as it requires active reflexivity and the bracketed suspension of biases during interactions with participants (Braun & Clarke, 2021; Motulsky, 2021). The supporting guides were designed to elicit deep narrative descriptions regarding cognitive fatigue, sensory integration, and technological friction (Hamilton et al., 2023; Kozinets, 2023). This qualitative framework ensured that the collected data was not artificially limited by rigid structures, but could adapt to explore unexpected neuro-pedagogical insights.

2.5 Validity and Reliability

To establish the trustworthiness of this qualitative study, we strictly followed Lincoln and Guba's criteria of credibility, transferability, dependability, and confirmability, replacing quantitative measures of validity and reliability. Credibility was achieved through prolonged engagement in the learning environment, data triangulation (interviews, field notes, diaries), and peer debriefing sessions (Braun & Clarke, 2021; Motulsky, 2021). Transferability was secured by providing a thick description of the research setting, participant backgrounds, and AR interactions, allowing other physical education departments to adapt this model. Dependability and confirmability were maintained through a transparent audit trail of raw data, research journals, and systematic member checking, where participants reviewed their transcripts to verify accuracy (Motulsky, 2021; van der Merwe & Botha, 2020).

2.6 Research Subjects and Setting

The study was conducted within the Department of Physical Education, Health, and Recreation at Universitas PGRI Sumenep, utilizing both the digital learning laboratory and active sports courts to blend virtual and physical environments. The study subjects consisted of 12 undergraduate PE students (9 males, 3 females; age range 19–22) selected through purposeful sampling based on high scores on the Maslach Burnout Inventory-Student Survey (MBI-SS) and low digital literacy barriers (Tsani et al., 2025; Wawan et al., 2023). This localized, resource-specific setting provided an ideal environment to observe how students transitioned from sedentary, lecture-induced academic boredom to active, technology-mediated kinesthetic engagement.

3. RESEARCH FINDINGS

The empirical findings derived from this phenomenological inquiry illustrate a profound psychological and cognitive shift among physical education students when traditional lectures are replaced with AR-integrated neuro-pedagogical instruction. Reflexive thematic analysis of the datasets (comprising transcriptions, field diaries, and student learning worksheets) revealed three distinct structural domains that define this educational re-orientation. The subsequent subsections present these qualitative results in a systematic hierarchy, detailing how the integration of virtual overlays actively combats academic boredom, modifies sensory-motor planning, and introduces unique cognitive friction.

3.1 Deconstruction of Academic Boredom: Qualitative Mapping of Mental Fatigue and Cognitive Disengagement

The investigation initially established a detailed baseline of academic boredom as experienced by physical education students within traditional, classroom-based theoretical instruction. Students universally described traditional lectures in subjects such as "Kinesiology" and "Exercise Physiology" as static, detached, and mentally exhausting, leading directly to cognitive disengagement and behavioral avoidance (Jahrami et al., 2023; van der Merwe & Botha, 2020). The qualitative transcripts revealed that the lack of dynamic physical association in theoretical sports science modules creates a severe "learning disconnect" where students are physically present but cognitively absent, suffering from extreme sedentary fatigue (Wawan et al., 2023; Woo et al., 2020).

To illustrate the raw realities of this academic disengagement, Table 3 categorizes the primary semantic codes, categories, and direct qualitative

quotes highlighting pre-intervention academic boredom.

Table 3. Qualitative Theme Matrix of Pre-Intervention Academic Boredom.

Target Code	Emergent Category	Exemplary Empirical Transcript Quote	Participant & Source Code
Cognitive Exhaustion	Classroom-induced mental lethargy	*"Sitting in a small room for three hours looking at static PowerPoint slides of skeletal structures makes my head feel incredibly heavy. I literally stop registering words after 20 minutes; it feels like mental torture."*	Participant 3 (In-depth Interview)
Sedentary Avoidance	Physical restlessness and frustration	*"We chose sports science because we want to move. Being trapped behind desks analyzing complex biomechanical formulas without seeing them in action makes me want to skip class altogether. It's deeply frustrating."*	Participant 8 (Focus Group Discussion)
Conceptual Decoupling	Inability to bridge sports theory and practice	*"I could memorize the Latin names of muscles from the textbook, but I had absolutely no idea how they actually fire when I perform a high jump. It felt like two completely different, useless worlds."*	Participant 11 (Observation Field Diary)

The qualitative patterns detailed in Table 3 indicate that classroom-bound physical education instruction acts as an inhibitor to active student engagement, causing profound academic burnout (Jahrami et al., 2023; Woo et al., 2020). This state of cognitive and physical paralysis was consistently captured during the initial observation phases, as recorded in the researchers' field diaries. During these traditional theoretical sessions, students exhibited classic markers of burnout, including lethargic posture, continuous off-task digital browsing, and minimal verbal participation, illustrating the urgent need for a pedagogical re-orientation (Opstoel et al., 2020; Tsani et al., 2025).

A critical diagnostic tool used during this baseline phase was the "Student Cognitive-Spatial Blueprint" (SCSB), which serves as a cognitive learning sheet where students were asked to sketch and label the muscle-firing sequences of a standard athletic sprint. The qualitative analysis of these pre-intervention learning sheets revealed extensive "neurological errors," characterized by incorrect anatomical pathways and disjointed movement vectors.

Below is an interactive dialogue excerpt representing the qualitative feedback session of these baseline learning sheets:

Researcher (R): "Looking at your diagram of the running gate on this learning sheet, can you explain why you mapped the quadriceps as the primary stabilizing muscle during the terminal swing phase?"

Participant 5 (P5): "To be honest, I just guessed. In class, we looked at a 2D drawing of a muscle on a white board. But when I visualize myself running, I can't connect that flat diagram to my actual leg. The flat drawing has no depth, so my mind just goes completely blank. It's incredibly boring to try and study this way."

Researcher (R): "So the 2D illustration does not help you visualize active muscle firing?"

Participant 5 (P5): "Not at all. It feels like trying to learn how to swim by reading a dry dictionary. My brain just shuts down."

This qualitative exchange highlights the severe cognitive disconnect caused by static learning environments. Traditional 2D methods fail to engage the spatial-kinesthetic pathways of physical education students, resulting in severe academic boredom and cognitive failure (Hamilton et al., 2023; Wawan et al., 2023).

3.2 Immersive Sensory-Motor Integration: Neuro-

Pedagogical Adaptations and Cognitive Re-Engagement via AR

The introduction of Augmented Reality (AR) visual overlays caused a major shift in how physical education students interacted with sports theory, bringing about immediate cognitive re-engagement. When using AR devices, students were presented with real-time, interactive 3D virtual muscle-firing models directly superimposed onto their peers' bodies during physical movement. This dynamic visual-spatial feedback optimized the students' working memory by reducing cognitive load, allowing them to visualize complex anatomical functions during actual athletic performance (Chen et al., 2021; Radianti et al., 2020).

To map the neuro-pedagogical pathways of this immersive transformation, Figure 3 outlines the sensory-motor integration process triggered by AR.

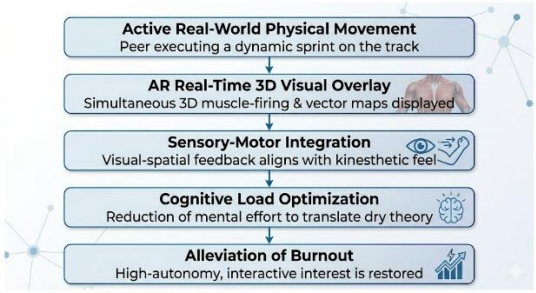


Figure 3. Visual Schema of Immersive Neuro-Pedagogical Stimulation.

As mapped in Figure 3, the integration of AR overlays establishes a direct, real-time feedback loop between external physical movement and internal mental visualization. This immediate sensory-motor integration replaces dry memorization with active discovery, allowing students to simultaneously see, feel, and analyze athletic concepts (Hamilton et al., 2023; Vinogradova, 2024). This active learning model satisfies the students' basic psychological needs for competence and autonomy, which are critical for overcoming academic boredom (Vasconcellos et al., 2020; Wawan et al., 2023).

The behavioral and cognitive transformations that occurred after implementing AR were recorded during participant observations and in-depth interviews. Students who had previously been disengaged in class showed high levels of concentration, actively discussing the visual muscle movements with their peers on the court.

Below is an interview transcript showing this mental shift:

Researcher (R): "How did your experience of analyzing muscle-firing sequences change when you switched from the classroom textbook to using the AR headset on the sports court?"

Participant 9 (P9): "It was like a lightbulb finally went off in my head. When I looked through the lens at P2 running, I could see his hamstrings glowing red and then green as he landed. Suddenly, everything we read about eccentrics made perfect sense. I didn't feel tired or bored at all; we actually stayed on the track for an extra hour trying to capture different movements."

Researcher (R): "Did this visual-spatial display change how you felt mentally?"

Participant 9 (P9): "Absolutely. It felt like playing an active game. The exhaustion I usually feel in the classroom was completely gone. I felt excited to learn because I could see the science alive right in front of me."

This qualitative excerpt shows that the AR-integrated neuro-pedagogical approach successfully bypassed classroom-induced mental fatigue. By connecting physical sensations with real-time visual data, the curriculum restored students' intrinsic motivation and eliminated academic boredom (Tsani et al., 2025; Vasconcellos et al., 2020).

Furthermore, a comparative analysis of the post-intervention "Student Cognitive-Spatial Blueprints" (SCSBs) showed a massive improvement in student understanding. The diagrams drawn after using AR were highly accurate, showing a complete grasp of force vectors, joint angles, and active muscle pathways.

Below is an interactive dialogue evaluating a post-intervention student worksheet:

Researcher (R): "Comparing your current blueprint to your previous attempt, your drawing of the biomechanical force vectors is now highly detailed and accurate. What caused this improvement?"

Participant 4 (P4): "In the AR app, we could slow down the virtual runner and see the exact angle of the knee and hip as force vectors. I could literally touch the virtual arrows in the air to see their values. It was so much easier to understand because I could visualize it in three dimensions. I didn't have to strain my brain trying to turn a flat, boring textbook page into a 3D movement."

This feedback confirms that immersive technology acts as a powerful cognitive scaffold, optimizing mental efforts and making complex sports science theory highly accessible and engaging (Chen et al., 2021; Hamilton et al., 2023).

3.3 The Ergonomic Dilemma: Technical Scaffolding Needs versus Interface Complexity Friction

While the neuro-pedagogical benefits of AR are clear, the qualitative analysis also revealed significant technical challenges and cognitive barriers. Specifically, students with low digital literacy experienced considerable frustration and cognitive overload when confronted with overly complex user interfaces or unstable technical performance. This technological friction represents a key challenge; if the AR interface is too complicated, it can actually increase cognitive load, distracting students from physical movement and triggering a new form of "digital frustration" (Kozinets, 2023; Radianti et al., 2020).

To map these competing forces, Figure 4 illustrates the delicate balance between technical scaffolding and interface complexity.

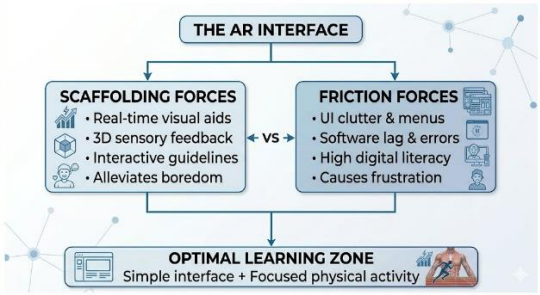


Figure 4. The Balance of Immersive Pedagogical Ergonomics.

As shown in Figure 4, the success of AR in physical education depends on balancing interactive visual supports against interface complexity. When the software interface is simple and intuitive, it acts as a helpful learning scaffold that reduces mental fatigue. However, when the interface is cluttered with menus and suffers from performance issues, it creates technical friction that can overwhelm students, especially those who are less comfortable with digital tools (Chen et al., 2021; Radianti et al., 2020).

To understand how students experienced these technical challenges, Table 4 analyzes the primary facilitators and barriers identified during the intervention.

Table 4. Analytical Matrix of AR Facilitators and Barriers.

Pedagogical Domain	Technical Facilitators (Promoting Success)	Technical Barriers (Causing Friction)
Cognitive Load Management	• Clean, hands-free voice commands • Real-time visual tracking of muscle groups • Color-coded physiological status	• Cluttered on-screen menus • Constant text pop-ups covering the physical field • Unstable tracking causing visual lag
Physical Movement Flow	• Light, ergonomic wearable headsets • Clear visual markers on the sports court • Untethered wireless operation	• Heavy, uncomfortable devices • Limited visual field causing disorientation • Frequent recalibration demands
Student Motivation	• Fun, gamified progress markers • Collaborative split-screen features • Instant feedback on exercise form	• Complicated login screens • Frequent software crashes • Hard-to-read small fonts during movement

The data in Table 4 shows that while AR is a powerful tool, its implementation must be carefully designed to avoid technical frustration. The positive effects of AR can easily be canceled out if the technology is too difficult to use, highlighting the need for intuitive, physically friendly educational designs (Kozinets, 2023; Wawan et al., 2023).

This ergonomic struggle was vividly captured in our participant observations. During session 4, several students with lower digital literacy became visibly frustrated when trying to navigate a multi-layered menu while attempting a balance exercise on the court.

The following observation transcript illustrates this exact issue:

Researcher (R): "I noticed you took off your AR headset and sat down on the bench during the lateral agility exercise. Can you share what happened?"

Participant 12 (P12): "I got so frustrated. Every time I tried to step sideways, a massive menu popped up right in front of my eyes and blocked my view of the floor markings. I had to stop and tap the side of my headset five times just to close it. It felt even more exhausting than sitting through a dry slide presentation. I just gave up."

Researcher (R): "So the interface was actively distracting you from the physical movement?"

Participant 12 (P12): "Yes, completely. It felt like trying to run while reading a messy phone screen. If the app just showed the glowing muscles on my peer's leg without all these distracting menus, it would be perfect. But as it is, it's just too much work."

This raw feedback highlights the critical importance of creating streamlined, distraction-free interfaces for physical education. To successfully overcome academic boredom and promote physical activity, AR designs must prioritize simplicity, ensuring that the technology supports rather than disrupts the physical learning experience (Hamilton et al., 2023; Tsani et al., 2025; Wawan et al., 2023).

4. DISCUSSION

The remarkable alleviation of classroom-induced mental fatigue among physical education students at Universitas PGRI Sumenep reveals how spatialized digital learning can reconstruct the emotional-cognitive landscape of sports pedagogy. Interpreting this transformation through Self-Determination Theory (SDT) indicates that replacing abstract theoretical lectures with interactive virtual-physical spaces satisfies the primary psychological needs for competence and autonomy (Vasconcellos et al., 2020; Wawan et al., 2023). This cognitive restoration is not merely a novelty effect, but an active alignment of the learning tool with the kinesthetic identity of physical education majors, who find stationary classroom settings fundamentally restrictive. Viewed from the lens of Qur'anic Pedagogy, this shift mirrors the concept of Muraqabah—a state of mindful attentiveness and active self-regulation where students achieve cognitive alignment by taking

ownership of their bodily movement as a divine trust. This unique active focus contrasts directly with traditional rote learning environments, showing that immersive educational frameworks actively foster the mental clarity and emotional resilience required to mitigate burnout (Jahrami et al., 2023; van der Merwe & Botha, 2020).

Examining the neurological mechanism of this intervention reveals how real-time 3D muscular overlays reorganize complex mental schemas without exceeding the students' working memory limit. This spatial alignment supports the fundamental assumptions of Cognitive Load Theory (CLT) by reducing the mental effort required to translate flat 2D textbooks into active 3D bodily movements (Hamilton et al., 2023; Radianti et al., 2020). This visual-somatic synchronization allows the brain to utilize both visual and kinesthetic sensory channels simultaneously, resulting in the high anatomical accuracy observed in the students' post-intervention blueprints. Integrating this empirical finding with Islamic education philosophy highlights the principle of Rahmah (instructional compassion), wherein the pedagogical design respects the biological limits of the human mind by preventing cognitive overload. Rather than demanding mechanical memorization through exhausting classroom lectures, this compassionate neuro-pedagogical framework provides immediate visual-spatial scaffolds, ensuring that intellectual development and physical mastery are cultivated in absolute harmony (Chen et al., 2021; Vinogradova, 2024).

This research, however, uncovers a critical pedagogical anomaly regarding the friction and mental exhaustion experienced by students with lower digital literacy. While international studies often assume technology-mediated learning is universally engaging (Chen et al., 2021; Radianti et al., 2020), our localized findings show that overdesigned and cluttered user interfaces can actually trigger a new form of digital frustration. At Universitas PGRI Sumenep, this friction is deeply rooted in the digital divide and the lack of systemic technical training, where students are suddenly forced to navigate complex digital menus while executing physically demanding movements. This technological barrier contradicts standard expectations of seamless immersive integration, proving that without simplified, hands-free interfaces, the technology itself acts as an obstructive cognitive load (Kozinets, 2023; Wawan et al., 2023). Consequently, to prevent student disengagement, educators must treat user interface (UI) simplicity as an absolute pedagogical priority, ensuring that virtual elements support physical learning rather than distracting from it.

On a broader structural level, these findings have significant long-term implications for the future design of higher physical education curricula. Historically, teacher training programs have treated theoretical classroom lectures and practical court sessions as completely separate activities, a disjointed model that actively contributes to student boredom and disengagement (Opstoel et al., 2020; Tsani et al., 2025). This study challenges this division, proving that emerging mobile technologies can merge sports science theory directly into active athletic settings. This integration offers a clear roadmap for university policy, showing that physical education departments must shift away from classroom-based learning towards interactive, neuro-pedagogical spaces. By investing in lightweight, simplified wearable devices and designing intuitive visual scaffolds, teacher training programs can protect student well-being and produce a new generation of educators who are comfortable with digital sports science (Hamilton et al., 2023; Vasconcellos et al., 2020).

5.CONCLUSION

Based on the qualitative phenomenology and systematic thematic analysis executed in this investigation, several core conclusions can be drawn:

Traditional, classroom-bound theoretical physical education instruction at Universitas PGRI Sumenep induces severe academic boredom, cognitive fatigue, and conceptual decoupling, restricting students' ability to connect physiological theories with kinesthetic movements.

The integration of Augmented Reality (AR) visual overlays represents an effective neuro-pedagogical solution, reducing mental exhaustion and improving conceptual understanding by projecting real-time 3D anatomical animations directly onto active physical performers.

Immersive technologies optimize the cognitive load of physical education students by offering spatial-visual scaffolds, transforming abstract sports theory into highly intuitive, sensory-integrated physical experiences.

Overly complex, cluttered user interfaces create a significant "ergonomic dilemma" and "digital frustration" that increases cognitive load and causes technical fatigue, particularly among students with lower digital literacy.

A successful digital re-orientation of physical education requires balancing interactive visual guidance with streamlined, distraction-free application layouts that support rather than disrupt active physical movement.

5.2 Recommendations

To address the educational and technological challenges identified in this research, academic institutions must fundamentally redesign the delivery of theoretical sports science by establishing active, digitally scaffolded learning environments directly on active athletic grounds. Faculty departments should move away from sedentary classroom settings and instead implement hands-free, lightweight wearable technologies with simplified, minimalist user interfaces to prevent cognitive overload and technological frustration among students with diverse digital literacy skills. Furthermore,

subsequent empirical investigations are strongly encouraged to expand upon these qualitative insights by conducting multi-center mixed-methods research, longitudinal evaluations of mental health outcomes over multiple semesters, and randomized controlled trials comparing different user-interface configurations to establish optimal ergonomic guidelines for future digital physical education curricula.

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