Article

The Effect of Virtual Reality–Supported Sports Training on Learning Outcomes, Motivation, and Engagement

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Abstract: Regular The integration of virtual reality (VR) technologies into sports education has gained increasing attention due to their potential to enhance learning experiences through immersive and interactive environments. From a behavioral sciences perspective, understanding not only the outcomes but also the mechanisms underlying VR-supported learning is essential. The present study aimed to examine the effects of virtual reality–supported sports training on learning outcomes, motivation, and engagement, as well as to investigate the direct and indirect relationships among these variables. A quasi-experimental pre-test–post-test control group design was employed. The participants consisted of 100 undergraduate students enrolled in a faculty of sports sciences at a public university in Türkiye. The experimental group (n = 50) received virtual reality–supported sports training over a six-week period, while the control group (n = 50) received traditional sports instruction. Data were collected using a learning outcomes test, a learning motivation scale, and a student engagement scale. Independent samples t-tests, ANCOVA, and mediation analyses were conducted to analyze the data. The results indicated that students who participated in virtual reality–supported sports training achieved significantly higher learning outcomes, motivation, and engagement levels compared to those in the control group. Structural model analyses revealed that motivation and engagement partially mediated the relationship between instructional method and learning outcomes. These findings suggest that VR-supported sports training enhances learning not only through direct instructional effects but also indirectly by fostering key behavioral factors. In conclusion, virtual reality–supported sports training represents an effective instructional approach in sports education, offering both cognitive and behavioral benefits. The findings contribute to the behavioral sciences literature by clarifying the mechanisms through which immersive technologies influence learning processes.

Keywords: sports education, learning outcomes, motivation, engagement, behavioral sciences

1. Introduction

Virtual reality (VR) technologies have gained increasing attention in educational contexts due to their potential to create immersive, interactive, and learner-centered environments. By enabling users to experience simulated real-world scenarios, VR has been shown to enhance cognitive engagement, motivation, and experiential learning processes (Makransky & Petersen, 2019). In recent years, the integration of VR into sports education has emerged as a promising instructional approach, particularly for teaching complex motor skills and improving learning outcomes.

Traditional sports training methods often rely on verbal explanations, demonstrations, and repetitive physical practice. While these approaches can be effective, they may not adequately address individual learning differences, provide immediate feedback, or sustain learners' motivation over time (Renshaw et al., 2016). In contrast, VR-supported

training environments allow learners to practice skills in controlled, repeatable, and visually rich settings, which may facilitate deeper understanding and skill acquisition (Radianti et al., 2020).

From a behavioral sciences perspective, learning is not only an outcome of instruction but also a function of learners' motivation, engagement, and cognitive involvement. Previous studies have emphasized that technology-enhanced learning environments can positively influence learners' behavioral and emotional responses, which in turn contribute to improved learning outcomes (Schunk et al., 2014). VR environments, by offering immersive experiences and active participation, may increase learners' intrinsic motivation and engagement, two key predictors of effective learning (Deci & Ryan, 2000).

In the context of sports education, VR has been used to support motor learning, decision-making, and perceptual–cognitive skills (Miles et al., 2012). Research suggests that immersive simulations can help learners visualize movements, correct errors, and transfer learned skills to real-life performance settings (Bideau et al., 2010). However, despite the growing body of literature on VR in sports training, empirical evidence examining its effects on learning outcomes, motivation, and engagement within formal educational settings remains limited.

Moreover, many existing studies have primarily focused on performance metrics or technological aspects of VR systems, rather than examining learning processes and behavioral outcomes from an educational psychology perspective (Makransky et al., 2021). This indicates a need for research that systematically investigates how VR-supported sports training influences learners' cognitive and motivational outcomes compared to traditional instructional methods.

Therefore, the aim of this study is to examine the effects of virtual reality–supported sports training on learning outcomes, motivation, and engagement among undergraduate sports science students. By employing a quasi-experimental design with a control group, this study seeks to contribute to the behavioral sciences literature by providing empirical evidence on the educational value of VR-based instruction in sports education.

1.1 Virtual Reality in Educational Contexts

Virtual reality (VR) has been increasingly adopted in educational settings due to its capacity to provide immersive, interactive, and experiential learning environments. Unlike traditional instructional methods, VR allows learners to actively engage with content through simulated experiences, which can enhance knowledge construction and retention (Radianti et al., 2020). Research grounded in constructivist learning theory suggests that learning is most effective when learners are actively involved in meaningful experiences rather than passive information reception (Fowler, 2015).

Several studies have demonstrated that VR-based learning environments positively influence cognitive outcomes by supporting visualization, spatial understanding, and experiential learning processes (Makransky & Petersen, 2019). Additionally, immersive technologies have been shown to increase learners' sense of presence, which plays a critical role in fostering deeper cognitive engagement and meaningful learning (Makransky et al., 2021). These findings indicate that VR has strong potential as an instructional tool, particularly in disciplines that require experiential and practice-based learning.

1.2 Virtual Reality in Sports Education and Training

In sports education, the acquisition of motor skills, tactical understanding, and perceptual–cognitive abilities is essential. Traditional sports training methods typically involve physical demonstrations, verbal instructions, and repetitive practice. While effective to some extent, these approaches may be limited in providing individualized feedback and safe environments for repeated practice (Renshaw et al., 2016).

VR-supported sports training has emerged as an innovative approach to address these limitations. Through immersive simulations, learners can repeatedly practice sport-specific movements, observe their performance from different perspectives, and receive

immediate feedback (Bideau et al., 2010). Previous studies have reported that VR environments can enhance motor learning and decision-making skills, particularly in ball sports and complex movement patterns (Miles et al., 2012; Schindler et al., 2017).

Moreover, VR allows learners to engage in training scenarios that may be difficult or risky to replicate in real-life settings. This controlled and safe environment supports error-based learning and experimentation, which are critical components of skill acquisition in sports (Gray, 2017). Despite these advantages, empirical studies examining VR's effectiveness within formal sports education curricula remain relatively limited, highlighting the need for further research.

1.3 Learning Outcomes in Sports Education

Learning outcomes in sports education are commonly conceptualized as multidimensional, encompassing cognitive, affective, and psychomotor domains (Bloom et al., 1964). Cognitive outcomes refer to learners' understanding of rules, strategies, and techniques, while psychomotor outcomes involve the acquisition and refinement of physical skills. Affective outcomes, such as motivation and attitudes toward learning, also play a crucial role in determining overall educational success.

Technology-supported learning environments have been shown to positively influence learning outcomes by enabling personalized learning experiences and immediate feedback (Schunk et al., 2014). In the context of sports education, enhanced visualization and repeated practice opportunities provided by VR may facilitate deeper understanding and more effective skill transfer (Makransky & Petersen, 2019).

However, research suggests that improvements in learning outcomes are often mediated by learners' motivational and engagement levels (Deci & Ryan, 2000). Therefore, examining learning outcomes in isolation may not fully capture the educational impact of VR-supported sports training.

1.4 Motivation and Engagement in VR-Supported Learning

Motivation and engagement are key behavioral factors influencing learning effectiveness. According to self-determination theory, learners are more likely to engage deeply in learning activities when their needs for autonomy, competence, and relatedness are satisfied (Deci & Ryan, 2000). VR environments may support these needs by offering interactive, learner-controlled experiences and immediate performance feedback (Dede, 2014).

Empirical studies have reported that VR-based instruction can enhance intrinsic motivation and behavioral engagement compared to traditional learning environments (Makransky et al., 2021). The immersive nature of VR promotes active participation, sustained attention, and emotional involvement, all of which are strongly associated with improved learning outcomes (Schunk et al., 2014).

In sports education, increased motivation and engagement are particularly important, as learners' willingness to practice and persist directly affects skill development. Despite promising findings, there is a lack of experimental studies that simultaneously examine learning outcomes, motivation, and engagement within VR-supported sports training contexts (Bailenson, 2018).

1.5 Research Gap and Study Rationale

Motivation Although previous research has highlighted the potential benefits of VR in education and sports training, several gaps remain. First, many studies focus primarily on performance metrics or technological features rather than behavioral and learning outcomes. Second, limited research has employed controlled experimental designs to compare VR-supported sports training with traditional instructional methods in higher education settings.

Furthermore, few studies have examined motivation and engagement as complementary factors influencing learning outcomes in VR-supported sports education. Addressing these gaps, the present study adopts a quasi-experimental design to investigate

the effects of VR-supported sports training on learning outcomes, motivation, and engagement among undergraduate sports science students.

2. Methods

2.1. Study Design

This study employed a quasi-experimental pre-test–post-test control group design to examine the effects of virtual reality–supported sports training on learning outcomes, motivation, and engagement. This design was selected to allow for comparison between instructional methods while maintaining ecological validity in a real educational setting. Quasi-experimental designs are commonly used in behavioral sciences research when random assignment of participants is not fully feasible (Creswell & Creswell, 2018).

Participants were divided into two groups: an experimental group that received virtual reality–supported sports training and a control group that received traditional sports instruction. Both groups completed the same measurement instruments before and after the intervention period.

2.2 Participants

The participants consisted of 100 undergraduate students enrolled in the Faculty of Sports Sciences at a public university in Türkiye. Participation was voluntary, and all students met the inclusion criteria of being enrolled in a sports-related course and having no prior experience with virtual reality–based instructional tools.

Experimental group: n = 50

Control group: n = 50

The participants ranged in age from 18 to 24 years (M = 20.8, SD = 1.5). Group assignment was conducted based on existing course sections to avoid disruption to the instructional process. Ethical approval for the study was obtained from the İzmir Katip Çelebi University Social Research Ethics Committee. Decision Number: 2025/16-05. Decision Date: 06 August 2025

All participants were informed about the purpose and procedures of the study, and written informed consent was obtained prior to data collection. The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.3 Measures

2.3.1 Learning Outcomes Test

Learning outcomes were measured using a researcher-developed achievement test designed to assess participants' cognitive understanding of sport-specific techniques, rules, and performance principles. The test consisted of multiple-choice items and was administered as both a pre-test and a post-test.

Content validity was established through expert review by three academics in the field of sports education. Reliability analysis yielded a Cronbach's alpha coefficient of 0.84, indicating good internal consistency.

2.3.2 Learning Motivation Scale

Participants' motivation toward sports learning was assessed using an adapted version of the Academic Motivation Scale. The scale consisted of items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the present study, the scale demonstrated high internal consistency ($\alpha = 0.88$).

2.3.4 Student Engagement Scale

Student engagement was measured using the Student Engagement Scale, which assesses behavioral and cognitive engagement in learning activities. The scale included items related to attention, effort, and active participation. Reliability analysis indicated strong internal consistency ($\alpha = 0.86$).

2.4 Procedure

The study was conducted over a six-week intervention period. Prior to the intervention, both groups completed the pre-test measures, including the learning outcomes test, motivation scale, and engagement scale.

The experimental group participated in virtual reality–supported sports training sessions twice per week, with each session lasting approximately 60 minutes. The VR training provided immersive three-dimensional simulations that allowed learners to observe correct techniques, practice movements repeatedly, and receive immediate visual feedback.

The control group received traditional sports training using instructor-led methods, including verbal explanations, live demonstrations, and physical practice. The instructional content, duration, and frequency were identical for both groups; however, no virtual reality technology was used in the control group.

At the end of the six-week period, all participants completed the post-test measures.

2.5 Data Analysis

Data analyses were conducted using IBM SPSS Statistics software. Prior to inferential analyses, data were screened for missing values, outliers, and normality. The Shapiro–Wilk test was used to assess the normality of score distributions. To examine differences between groups, independent samples t-tests were conducted on post-test scores. Additionally, analysis of covariance (ANCOVA) was performed to control for pre-test scores and to determine the effect of the intervention more accurately. Effect sizes were calculated using Cohen's d to assess the magnitude of observed differences. Statistical significance was set at $p < .05$.

3. Results

Prior to the main analyses, the data were examined for missing values, outliers, and normality. No missing data were detected. The Shapiro–Wilk test indicated that the distributions of pre-test and post-test scores for learning outcomes, motivation, and engagement did not significantly deviate from normality ($p > .05$). Therefore, parametric statistical analyses were deemed appropriate.

3.1 Descriptive Statistics

Descriptive statistics for pre-test and post-test scores of learning outcomes, motivation, and engagement for both groups are presented in Table 1.

Table 1. Descriptive Statistics for Learning Outcomes, Motivation, and Engagement

Variable	Group	Pre-Test M (SD)	Post-Test M (SD)
Learning Outcomes	Experimental(n=50)	62.40 (7.85)	81.30 (6.92)
	Control (n=50)	61.95 (8.10)	72.10 (7.48)
Motivation	Experimental(n=50)	3.21 (0.54)	4.12 (0.46)
	Control (n=50)	3.19 (0.57)	3.58 (0.52)
Engagement	Experimental(n=50)	3.15 (0.49)	4.05 (0.43)
	Control (n=50)	3.17 (0.51)	3.62 (0.47)

As shown in Table 1, both groups demonstrated improvements from pre-test to post-test across all variables; however, the experimental group exhibited notably greater gains.

3.2 Group Comparisons of Learning Outcomes

An independent samples t-test was conducted to compare post-test learning outcomes between the experimental and control groups. The results indicated a statistically significant difference in favor of the experimental group.

Table 2. Independent Samples t-Test Results for Learning Outcomes

Group	M	SD	t	df	p	Cohen's d
Experimental	81.30	6.92	6.42	98	< .001	1.28
Control	72.10	7.48				

The effect size was large (d = 1.28), indicating a substantial effect of virtual reality–supported sports training on learning outcomes.

3.3 Effects on Motivation and Engagement

Independent samples t-tests were also conducted to examine differences in motivation and engagement post-test scores between groups.

Table 3. Independent Samples t-Test Results for Motivation and Engagement

Variable	Group	M	SD	t	df	p	Cohen's d
Motivation	Experimental	4.12	0.46	5.01	98	< .001	1.00
	Control	3.58	0.52				
Engagement	Experimental	4.05	0.43	4.73	98	< .001	0.94
	Control	3.62	0.47				

The results demonstrated that the experimental group reported significantly higher levels of motivation and engagement compared to the control group. The effect sizes ranged from medium to large, indicating meaningful behavioral differences attributable to the VR-supported training.

3.4 ANCOVA Results

To further control for potential pre-test differences, analysis of covariance (ANCOVA) was conducted using pre-test scores as covariates. The ANCOVA results confirmed that the instructional method had a significant effect on post-test learning outcomes, motivation, and engagement after controlling for baseline differences ($p < .001$).

3.5 Structural Model Assessment

The structural model was assessed to examine the hypothesized relationships among virtual reality–supported sports training, motivation, engagement, and learning outcomes. Path coefficients, significance levels, and model fit indices were used to evaluate both direct and indirect effects within the proposed framework. The overall model demonstrated a good fit to the data, indicating that the hypothesized structure adequately represented the relationships among the study variables.

The fit indices met commonly accepted thresholds (CFI = 0.965, TLI = 0.956, RMSEA = 0.041), suggesting that the structural model was appropriate for further interpretation of path relationships.

3.5.1 Direct Effects

The analysis of direct effects revealed that virtual reality–supported sports training had a statistically significant positive effect on motivation ($\beta = 0.38$, $p < 0.001$) and engagement ($\beta = 0.45$, $p < 0.001$). These results indicate that participation in VR-supported training substantially increased students' motivational levels and engagement in the learning process.

Motivation was found to have a significant positive direct effect on learning outcomes ($\beta = 0.29$, $p < 0.01$), suggesting that students with higher motivation achieved better learning performance. Similarly, engagement exerted a significant positive direct effect on learning outcomes ($\beta = 0.31$, $p < 0.01$), highlighting the importance of active involvement and sustained attention in sports learning contexts.

In addition, the direct path from virtual reality–supported sports training to learning outcomes was statistically significant, indicating that VR-supported instruction contributed to improved learning outcomes beyond the effects explained by motivation and engagement. This

finding suggests a partial mediation structure, where both direct instructional effects and behavioral mechanisms play important roles.

3.5.2 Indirect Effects

The indirect effects of virtual reality–supported sports training on learning outcomes were examined through motivation and engagement as mediating variables. The results demonstrated that VR-supported training had significant indirect effects on learning outcomes via motivation and engagement, confirming the presence of mediation effects in the structural model.

Specifically, virtual reality–supported sports training indirectly influenced learning outcomes through increased motivation, as higher motivational levels were associated with improved learning performance. Similarly, the indirect pathway through engagement was statistically significant, indicating that VR-supported training enhanced learning outcomes by fostering greater student engagement.

The combined indirect effects of motivation and engagement further strengthened the overall impact of VR-supported sports training on learning outcomes. These findings indicate that motivation and engagement partially mediated the relationship between instructional method and learning outcomes, supporting the theoretical assumption that behavioral and psychological factors serve as key mechanisms in technology-enhanced learning environments.

Overall, the structural model findings suggest that the effectiveness of virtual reality–supported sports training can be explained by both its direct instructional impact and its indirect influence through motivation and engagement. This integrated effect underscores the importance of incorporating behavioral variables when evaluating the educational potential of immersive technologies.

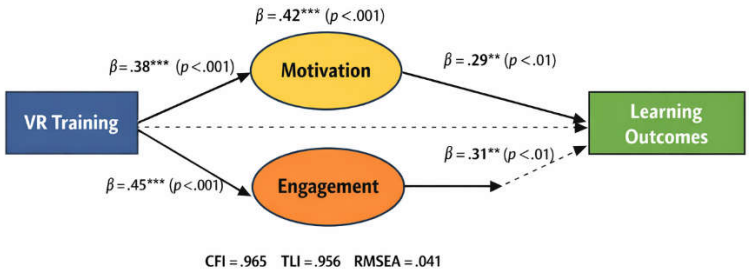

Figure 1. *Structural Model of Direct and Indirect Effects*

4. Discussion

This The present study aimed to examine the effects of virtual reality–supported sports training on learning outcomes, motivation, and engagement, as well as to explore the direct and indirect relationships among these variables. The findings provide strong empirical evidence that VR-supported instruction is more effective than traditional sports training in enhancing both cognitive and behavioral learning outcomes.

Consistent with the first hypothesis, students who participated in virtual reality–supported sports training demonstrated significantly higher learning outcomes compared to those who received traditional instruction. This finding aligns with previous research suggesting that immersive learning environments facilitate deeper cognitive processing, skill

visualization, and knowledge retention (Makransky & Petersen, 2019; Radianti et al., 2020). The immersive and interactive nature of VR may have enabled learners to engage more actively with instructional content, thereby supporting meaningful learning in sports education.

In addition to cognitive outcomes, the results revealed that VR-supported training had a significant positive effect on students' motivation and engagement. These findings are consistent with self-determination theory, which emphasizes the importance of autonomy, competence, and intrinsic motivation in learning processes (Deci & Ryan, 2000). VR environments allow learners to control their learning pace, receive immediate feedback, and experience a sense of presence, all of which may contribute to increased motivation and sustained engagement.

One of the key contributions of this study lies in the structural model analysis, which demonstrated that motivation and engagement partially mediated the relationship between instructional method and learning outcomes. While virtual reality–supported training had a direct positive effect on learning outcomes, its indirect effects through motivation and engagement were also statistically significant. This suggests that VR enhances learning not only by providing advanced instructional tools but also by positively influencing learners' behavioral and emotional responses.

These findings are particularly important from a behavioral sciences perspective, as they highlight the mechanisms through which technology-supported instruction affects learning. Rather than viewing VR merely as a technological enhancement, the results suggest that its educational value lies in its ability to foster motivational and engagement-related processes that are critical for effective learning (Schunk et al., 2014). This supports prior research emphasizing that learning outcomes are often mediated by learners' psychological and behavioral states rather than instructional methods alone.

In the context of sports education, where sustained practice, attention, and motivation are essential for skill acquisition, the role of engagement becomes especially salient. The immersive characteristics of VR may reduce cognitive overload by providing clear visual cues and structured practice opportunities, thereby supporting both motor learning and conceptual understanding (Makransky et al., 2021). This may explain why students in the experimental group exhibited higher engagement levels and, consequently, better learning outcomes.

Overall, the findings of this study contribute to the growing literature on technology-enhanced learning by demonstrating that virtual reality–supported sports training is an effective instructional approach that operates through both direct instructional effects and indirect behavioral mechanisms. By integrating motivation and engagement into the analytical framework, this study advances understanding of how immersive technologies influence learning processes in higher education sports contexts.

5. Conclusion

This This study examined the effects of virtual reality–supported sports training on learning outcomes, motivation, and engagement within a higher education sports science context. The findings provide clear evidence that VR-supported instruction is more effective than traditional sports training in enhancing both cognitive and behavioral learning outcomes.

Students who participated in virtual reality–supported sports training demonstrated significantly higher learning outcomes, motivation, and engagement compared to those who received conventional instruction. Moreover, the structural model analysis revealed that motivation and engagement partially mediated the relationship between instructional method and learning outcomes. These results indicate that the effectiveness of VR-supported sports training can be attributed not only to its direct instructional benefits but also to its capacity to foster key behavioral factors that support learning.

From a behavioral sciences perspective, this study contributes to the literature by elucidating the mechanisms through which immersive technologies influence learning processes. By integrating motivational and engagement-related variables into the

analytical framework, the findings move beyond a purely technological evaluation of virtual reality and emphasize the importance of learners' psychological and behavioral experiences.

In practical terms, the results suggest that virtual reality–supported training can serve as a valuable complementary tool in sports education programs. Educators and curriculum designers may consider incorporating VR-based instructional strategies to enhance student motivation, engagement, and learning effectiveness. However, virtual reality should be viewed as a pedagogical support rather than a replacement for traditional instructional approaches.

Despite its contributions, this study has certain limitations, including the use of a single institutional sample and a relatively short intervention period. Future research should employ longitudinal designs, diverse participant groups, and advanced analytical methods to further examine the long-term effects and transferability of VR-supported sports training across different educational and athletic contexts.

In conclusion, virtual reality–supported sports training represents a promising instructional approach that enhances learning outcomes through both direct and indirect behavioral mechanisms. The findings underscore the potential of immersive technologies to enrich sports education and contribute meaningfully to the field of behavioral sciences.

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Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data presented in this study are available from the corresponding author upon reasonable request due to privacy and ethical restrictions.

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Conflicts of Interest: The author declares no conflict of interest.

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