



Shahid Bahonar
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A Model for Improving the Interaction between Spectators of Sports Events Using Virtual Reality and Augmented Reality Technologies: Based on Gioia's Approach

Vajiheh Javani¹ | Masoud Ansari² | Fateme Abdavi³

1. Corresponding Author, Associate Professor of Sport Management, Faculty of Physical Education & Sport Sciences, University of Tabriz, Tabriz, Iran.
Email: V.javani@Tabrizu.ac.ir
2. Ph.D. Candidate, Faculty of Physical Education & Sport Sciences, University of Tabriz, Tabriz, Iran.
Email: ansarimasod@gmail.com
3. Associate Professor of Sport Management, Faculty of Physical Education & Sport Sciences, University of Tabriz, Tabriz, Iran. Email: fatemeabdavi@gmail.com

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ABSTRACT

This research aimed to provide a model for improving the interactions of spectators of sports events using virtual and augmented reality technologies. The study population included technology experts, management experts, and sports specialists. Purposeful sampling and snowball sampling techniques were used to conduct 15 in-depth interviews, and data were analyzed using the Geo-analysis method. The analysis revealed 97 initial codes, 21 themes, and three dimensions of conditions, solutions, and consequences for improving spectators' experience. The conditions included hardware and software advances, popularity of games and entertainment programs, strong broadband networks, investment from federations and organizations, durability and battery limitations, and resistance from traditional spectators. To address these conditions, experts proposed developing and improving virtual and augmented reality hardware, encouraging spectators, using novel modeling and simulation techniques, producing quality content, and educating spectators. The consequences of utilizing these technologies were increasing spectator engagement and interaction, improving the quality of experience, generating more revenue for organizers, attracting more spectators, enhancing satisfaction, and fostering a sense of presence among fans and athletes. The study demonstrates that purposeful implementation of virtual and augmented reality technologies can enhance the spectating experience, increasing enjoyment and satisfaction.

Introduction

In today's society, modern technology has gradually attained a special status. Every field that has progressed and achieved growth and advancement attributes this success to its science and technology (Naikoo et al., 2018; Singh, 2018). In the field of sports, two fundamental concepts, virtual reality and augmented reality, have gained a prominent position (Bedir & Erhan, 2021). The

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term "augmented reality" was first used in 1968, when Sutherland developed the first augmented reality system at that time. This term has been defined by several researchers in different fields, and one of the well-known definitions was provided by Azuma et al. (1997). They introduced augmented reality as a classification system that operates by combining and aligning real and virtual environments. The term "virtual reality" has also been widely used since the 1970s. Virtual reality has become a popular tool for product design, shopping, training, and entertainment in various industries (Soltani & Morice, 2020).

Virtual reality technology has revolutionized the way fans interact with sports. By simulating sports environments and providing unmediated experiences, this technology enables fans to have a virtual presence at sports events and training sessions (Abbas & Jasim, 2018). Using virtual reality headsets, fans can envision themselves in various positions, such as virtual seats next to the field or the competition ring. This experience brings a sense of real presence at the event and allows for close observation of details and different angles of the competition. Virtual reality technology also enables virtual interaction with athletes. Fans can have a virtual presence in the training sessions of their favorite athletes and witness their movements and techniques up close (Pickman, 2023). This experience increases fans' motivation and enthusiasm for sports and provides a unique opportunity to learn from and emulate their favorite athletes (Sapkaroski et al., 2018). Augmented reality is a computer-based technology that presents an image of the real world with the help of techniques such as graphics, video, and audio (Okado et al., 2021). By combining digital information and the real world, augmented reality technology creates a novel and dynamic experience for sports fans. This technology enables the display of interactive information and content in the real environment, leading to enhanced interaction and immersion of fans in sports events. Through augmented reality, fans can use their smartphones to view information and content related to the sports event in the real world. This information can include live statistics and figures, slow-motion replays, exclusive images and videos, as well as information about players and teams (Liu et al., 2018).

Integrating Virtual Reality (VR) and Augmented Reality (AR) technologies in sports and entertainment has gained significant attention in recent years, offering transformative potential for spectator experiences and athlete performance. Mainstream adoption of VR and AR technologies requires extensive consumer education to raise awareness about their capabilities (Ross & Harrison, 2016). This aligns with the observation that technology acceptance issues have become increasingly important in recent years, given the rapid pace of innovation across various domains. The potential of these technologies to enhance spectator engagement is well-documented. VR and AR enable spectators to interact more deeply with the game environment, access real-time statistics, and view replays from multiple angles, leading to increased engagement and enjoyment (Suh & Prophet, 2018). Similarly, AR can provide interactive and shared viewing experiences, fostering a sense of community among fans and enhancing the overall spectator experience (Hertzog et al., 2020). These technologies offer immersive, interactive, and personalized viewing options, enhancing fan engagement and emotional connection to the game (Pickman, 2023). This aligns with the assertion that new technologies enhance sports consumption and improve fan experiences (Chan-Olmsted & Xiao, 2019). VR sports viewing enhances the flow experience through vividness, interactivity, and virtual presence more than traditional 2D screens, leading to increased viewer satisfaction (Kim & Ko, 2019). The potential applications of VR in sports extend beyond spectator experiences. A systematic review of interactive VR applications in sports documented their impact on a wide range of performance, physiological, and psychological outcomes (Neumann et al., 2018). A growing interest in VR technology among athletes across various sports disciplines suggests its potential for training and performance enhancement (Gradl et al., 2016). In the realm of AR, key features in sports event videos have been identified, including informativeness, innovation, liveness, and sense of presence (Wang et al., 2023). These elements contribute to the overall enhancement of the spectator experience. AR's potential to improve both athlete preparation and spectator engagement highlights the dual benefits of this technology in the sports industry (Sawan et al., 2020). From a business perspective, the implementation of VR and AR technologies can drive revenue growth for sports event organizers through targeted advertising, enhanced ticket and experience packages, and increased sponsor attraction (Vailati Facchini, 2016). This economic potential is likely to drive further investment and innovation in the field. Recent technological advancements have

significantly enhanced the capabilities of VR and AR. Improvements in communication and interaction hardware have enabled more immersive and realistic virtual experiences (Li et al., 2021). However, the availability of robust and stable broadband networks is crucial for supporting these technologies effectively (Hamari et al., 2019). Despite the promising potential, several challenges remain. Issues such as battery and processor limitations, hardware durability concerns, and resistance from traditional spectators are potential barriers to full adoption (Khor et al., 2016). Addressing these challenges will be crucial for the widespread implementation of VR and AR in sports settings. Looking to the future, sports federations and teams are increasingly interested in investing in VR and AR technologies, recognizing their potential to enhance both regular supporter experiences and global engagement (Sohail et al., 2022). Ongoing advancements in VR hardware devices will continue to drive the development and application of these technologies in sports contexts (Xie et al., 2021). In the rapidly evolving landscape of sports entertainment, spectators expectations and experiences are undergoing a significant transformation. While traditional in-person attendance offers a unique depth of experience, modern audiences increasingly seek immersive and informative viewing options that rival or surpass live attendance (Glebova, Desbordes, & Geczi, 2020). Virtual Reality (VR) and Augmented Reality (AR) technologies present a promising solution to this challenge, offering an immersive experience that conveys a sense of presence at the game. These technologies not only enhance the visual aspect of sports broadcasting but also cater to the growing demand for real-time, comprehensive information during sports events (Kim & Ko, 2019).

Innovative sports organizations are exploring ways to leverage new technologies to create compelling and engaging experiences for spectators. In the contemporary sports landscape, audience engagement and information access have become critical factors. Sports fans now expect a continuous stream of information and a high level of connectivity during events (Rogers et al., 2017). This shift in spectator behavior has redefined the way sports are watched and experienced, both in stadiums and through remote viewing (Uhrich, 2022). The application of VR and AR in sports spectating has the potential to meet the dual needs of immersive experience and information-seeking behavior among sports fans (Esposito, 2015). Understanding these technologies can guide sports organizations and broadcasters in developing more engaging, informative, and technologically advanced viewing experiences. The integration of VR and AR could bridge the gap between traditional sports viewing and the digital expectations of modern audiences, potentially revolutionizing the sports spectating experience (Miah, Fenton, & Chadwick, 2020).

In today's digital era, sports spectatorship is evolving rapidly, particularly in developed countries where emerging technologies like virtual reality (VR) and augmented reality (AR) are reshaping the viewer experience. These technologies offer interactive access to data and statistics, novel viewing angles, increased emotional involvement, and a heightened sense of presence at sports events (Uhm, Lee, & Han, 2020). Globally, VR and AR have demonstrated significant potential in enhancing spectator engagement, creating a stronger sense of presence, and increasing overall enjoyment of sports events (Dan et al., 2015; Hertzog et al., 2020; Rogers et al., 2017). However, a significant disparity exists in the Iranian sport industry. Despite the global trend, Iran has yet to leverage the full potential of VR and AR technologies in its sports sector. This lag is characterized by a notable research gap, limited implementation of VR and AR in Iranian sports contexts, and the absence of a comprehensive model for integrating these technologies into sports events. Consequently, Iranian sports organizations have not fully capitalized on the potential of VR and AR to enhance spectator experiences and interactions. This situation presents a pressing need for a systematic approach to bridge the technological gap in Iranian sports spectatorship. The lack of a comprehensive framework for implementing VR and AR technologies in Iranian sports events hinders the industry's ability to meet evolving spectator expectations and compete on a global scale. Addressing this problem is crucial not only for enhancing the attractiveness and enjoyment of sports events for Iranian spectators but also for contributing to the global body of knowledge on VR and AR applications in sports.

Methodology

This research employed the interpretive qualitative (Gioia, Corley, & Hamilton, 2012) approach. This flexible qualitative approach is suitable for research areas that are new and have been less studied in the past (Corley & Gioia, 2004). Due to limited studies in the field of spectator experience and virtual reality and augmented reality technologies, we deemed this method appropriate for this research.

The study population consisted of technology experts and sports management professionals. For selecting participants for in-depth interviews, purposive sampling and the snowball technique were employed. The inclusion criteria for participants were carefully determined to ensure the selection of individuals with relevant expertise and insights. Eligible participants were required to have a minimum of five years of experience in either sports management or technology fields relevant to VR/AR applications. Additionally, they needed to demonstrate a comprehensive understanding of current trends in sports spectatorship and possess in-depth knowledge of VR/AR technologies and their potential applications in the sports industry. Preference was given to individuals who had been involved in projects or research related to VR/AR. Furthermore, participants were required to have a track record of publications, presentations, or practical implementations in the field of sports technology or management. To ensure a diverse perspective, efforts were made to include experts from various backgrounds, including academia, industry, and sports organizations. Sampling continued until theoretical saturation was achieved, which occurred after 12 interviews. However, to ensure comprehensive data collection, a total of 15 interviews were conducted. The demographic characteristics of the interviewees are presented in Table 1.

Table 1. Demographic Characteristics of Interviewees

| Participant Code | Gender | Occupation | Education | Age | Work Experience (Years) |
|------------------|--------|--|---------------------------------|-----|-------------------------|
| S1 | Male | VR and AR Technology Specialist | Computer Software | 40 | 8 |
| S2 | Male | IT Specialist | Bachelor's in Electronics | 40 | 11 |
| S3 | Male | VR and AR Technology Specialist | Software Engineering | 35 | 7 |
| S4 | Male | Computer Specialist | Computer Software | 32 | 8 |
| S5 | Male | Faculty Member | Ph.D. in Sports Management | 41 | 8 |
| S6 | Male | IT Specialist | Bachelor's in Electronics | 36 | 6 |
| S7 | Male | Intelligent Systems, AR, and VR Specialist | Software Engineering | 38 | 8 |
| S8 | Female | Faculty Member | Ph.D. in Sports Management | 38 | 6 |
| S9 | Male | Software Specialist | Bachelor's in Software | 27 | 5 |
| S10 | Male | Software Specialist | Bachelor's in Software | 31 | 7 |
| S11 | Male | Faculty Member | Ph.D. in Sports Management | 38 | 9 |
| S12 | Female | Faculty Member | Ph.D. in Sports Management | 42 | 9 |
| S13 | Male | Computer Specialist | Bachelor's in Electronics | 29 | 6 |
| S14 | Male | Faculty Member | Ph.D. in Sports Management | 39 | 7 |
| S15 | Male | IT Engineer | Computer Technology Engineering | 41 | 12 |

Due to the geographically diverse locations of the experts, the need for flexibility in scheduling, and the interviewees' work commitments, the interviews were conducted online. The Telegram app was chosen as the platform for these interviews. This online approach allowed for the inclusion of a wider range of experts from various locations, ensuring a more diverse and representative sample while accommodating the busy schedules of the participants. The interviews were conducted online

through the Telegram app. The interviews lasted approximately 50 minutes. Similar to other qualitative methods, in the Gioia approach, data collection and analysis occur simultaneously. In this approach, the data analysis process involves an iterative process between the obtained data and the emerging theory. Data analysis in the Gioia approach has three stages, resulting in the identification of first-order codes, second-order themes, and dimensions. In the first-order analysis, the goal is to use the terms employed by the interviewees to create initial codes. In the next stage, the initial codes are reduced to a fewer number of categories called second-order themes. After obtaining the second-order themes, the researchers will attempt to classify these themes into dimensions. None of these stages are linear but rather an iterative process, continuing until the researcher gains a clear understanding of the emerging relationships (Corley & Gioia, 2004). After identifying a complete set of first-order codes, second-order themes, and dimensions, the researchers shape the data structure of the research (Gioia et al., 2012). To ensure the validity and reliability of the research findings, a comprehensive approach combining strategies from (Skinner, Edwards, & Smith, 2020) and the Gioia methodology was employed. The constant comparative method was used throughout all three stages of data analysis, enhancing the rigor and trustworthiness of the findings. This method involved continuously comparing data within and across interviews, leading to a more accurate and nuanced analysis (Corley & Gioia, 2004). Validity was further strengthened through prolonged engagement with the data, persistent observation, member checking, and triangulation of data from multiple sources. To ensure reliability, the "percentage of agreement" index among coders was utilized. A research colleague was invited to participate in coding, and three interviews were coded by both the researchers and this colleague. The level of agreement among coders was calculated to be 88.60%, well above the 60% threshold, confirming the reliability of the coding process. The reliability of interviews is presented in Table 2.

Table 2. Reliability of interviews

| Interview | Total Number of Codes | Number of Agreements | Number of Disagreements | Reliability Percentage |
|--------------|-----------------------|----------------------|-------------------------|------------------------|
| 1 | 41 | 17 | 9 | 82% |
| 2 | 65 | 29 | 14 | 89% |
| 3 | 52 | 27 | 12 | 92% |
| Total | 158 | 73 | 35 | 88% |

In this research, a total of 97 first-order codes were identified. Subsequently, second-order analysis was employed to detect a deeper pattern of meaning, leading to the emergence of themes. At this stage, 21 themes were identified, and ultimately, in the third-order analysis, the identified themes were integrated into broader dimensions. This stage resulted in the identification of three overarching dimensions. A sample of the data analysis process is presented in Table 3.

Table 3. Examples of data analysis process

| Sample Interview Text | First-Order Codes | Second-Order Themes | Dimensions |
|--|---|---|---|
| Improving display quality allows viewers to more easily experience greater detail in virtual environments and gain a stronger sense of actual presence. | Improved Display Quality | Hardware Advancements | Advancement of Virtual Reality and Augmented Reality Technologies |
| Applications and systems related to virtual reality (VR) and augmented reality (AR) can enable viewers to conveniently and quickly access and utilize various information, | Rapid and Convenient Access to Information via VR and AR Applications and Systems | Ease of Access via Related Applications and Systems | Accessible Technology |

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| content, and functionalities. | | | |
| By investing in VR and AR technologies, sports federations and organizations can provide new avenues for spectator engagement and enhance the viewing experience. | Providing New Avenues for Spectator Engagement by Sports Federations through Investment in VR and AR Technologies | Investment by Sports Federations and Organizations in AR and VR | Support from Sports Federations and Organizations for Emerging Technologies |
| When using VR devices, the size and weight of these devices can impose limitations on viewers. | Challenges Posed by Weight and Size of VR Devices | Challenges Such as Weight and Size of VR Devices | Technical Hardware Limitations |
| Developing software and platforms to deliver customized sports VR and AR content requires substantial investment and the capabilities of skilled developers. | Substantial Investment Required for Developing Software and Platforms to Deliver Customized Sports Content | High Cost of Producing Customized Sports Content | High Cost of Producing Customized Sports Content |
| With the enhanced accuracy of AR cameras and sensors, viewers can have a highly precise experience of events and players in VR or AR environments. | Highly Precise Experience of Events Enabled by AR Cameras and Sensors | Improved Accuracy and Performance of AR Cameras and Sensors | Development and Improvement of Virtual Reality and Augmented Reality Hardware |
| When new sports viewers have a positive initial experience using VR and AR technologies, it increases the likelihood of developing loyalty to these technologies. They may continue as recurring customers with greater interaction and more extensive use. | Fostering Loyalty through Incentives | Offering Incentives to New Spectators | Incentivizing Spectators |
| Sports spectators can distinctly position themselves amongst teams and players, enjoying close observation of techniques, movements, and capabilities. | Close Observation of Techniques, Movements, and Player Capabilities | Viewing From Compelling and Impossible In-Reality Vantage Points | Enhancing the Quality of Sports Event Viewing Experience |
| Increasing prices for virtual tickets could effectively attract high-income sports viewers and lead to increased revenue generation for virtual ticket providers. | Revenue Generation by Increasing Prices for Virtual Tickets | Sales of Higher-Priced Virtual Tickets | Increasing Revenue Generation for Sports Event Organizers |

Results

The analysis of data obtained from in-depth interviews with technology experts and sports management experts revealed 97 first-order codes, 21 second-order themes, and three dimensions, as shown in Table 4.

Table 4. Codes Extracted from the Data Analysis Process

| First-Order Codes | Second-Order Themes | Dimensions |
|--|---|--|
| Improved Display Quality | Hardware Advancements | Conditions for Enhancing the Sports Spectator Experience |
| Powerful Processors | | |
| Lighter and Smaller VR Headsets | | |
| High Accuracy of AR Cameras and Sensors | Software Advancements | |
| Advanced Algorithms | | |
| Engaging Applications | | |
| Improved Network and Cloud Connectivity | | |
| Increasing Popularity of VR and AR | Popularity of Games and Entertaining Applications Based on Virtual Reality and Augmented Reality Technologies | |
| Growing Familiarity Due to Technology Popularity | | |
| Providing an Innovative Experience for Sports Spectators | | |
| Creating Greater Appeal for Sports Spectators | | |
| Experiencing More Sports-Related Activities | Robust and Reliable High-Bandwidth Networks | |
| Need for High-Speed Connectivity and Big Data Usage | | |
| Low-Latency Connectivity via Robust Networks | | |
| Accessing Latest Stats, Information, and Critical Details through High-Speed and Reliable Networks | | |
| Leveraging Full VR and AR Capabilities with Access to Robust, High-Bandwidth Networks | Ease of Access via Related Applications and Systems | |
| Rapid and Convenient Access to Information via VR and AR Applications and Systems | | |
| Facilitating Direct Connection and Interaction Between Sports Spectators and the VR World Through VR and AR Applications and Systems | | |
| Enhancing the Experience of Sports Spectators via VR and AR Applications and Systems | | |
| Rapid and Convenient Access to Information Through VR and AR Applications and Systems | Investment by Sports Federations and Organizations in Augmented and Virtual Reality | |
| Investment by Sports Federations and Organizations in VR and AR Technologies | | |
| Providing New Avenues for Sports Spectator Engagement by Federations Through Investment in VR and AR Technologies | | |
| Improving Sports Spectator Interactions Through Investment by Federations and Sports Organizations in VR and AR | | |
| Facing Some Issues Regarding Durability and Robustness of Devices | Durability and Robustness Challenges of Hardware in Open Stadium Environments | |
| Hardware Device Failure Due to Weather Conditions | | |
| Reduced Hardware Performance | | |
| Importance of Regular Hardware Maintenance and Repairs | Battery Life and Processor Limitations | |
| Battery Limitation as a Challenge | | |
| Battery Requirement for VR Devices | | |
| Time Constraint on Sports Spectator Experience | | |
| Necessity for Powerful, High-Performance Processors | Poor Network and Internet Coverage in Some Sports Facilities | |
| Spectator Experience Impacted by Devices With Weak Processors | | |
| Need for Strong and Stable Internet Connectivity at Sports Venues for AR and VR Technologies | | |
| Diminished Seamless and Convenient Experiences for Spectators with Disconnected and Poor Network Coverage | | |
| Facilitating the Use of AR and VR Applications and Platforms with Reliable Internet Connectivity at Sports | | |

| | |
|---|---|
| Facilities | |
| Reduced Quality of Sports Spectator Experience Due to Lack of Network Coverage and Poor Internet at Sports Facilities | |
| Preference of Sports Spectators for Traditional Viewing and Lack of Perceived Need for New Technologies | |
| Creation of Excitement and Emotions in the Stadium Atmosphere | Resistance from Some Traditional Spectators to Adopting New Technologies |
| Inclination for Personal Connection and Proximity to the Sports Environment and Culture | |
| Design of VR Headsets | Development and Improvement of Virtual and Augmented Reality Hardware |
| Reduction in Weight and Size of VR Headsets | |
| Comfortable Fit of Compact VR Headsets | |
| Increased Portability of VR Headsets | |
| Enhancing the Sports Spectator Experience in Using VR and AR | |
| Improving Resolution and Image Clarity | |
| Rendering the Viewing Experience More Realistic and Engaging Through Improved Image Clarity | |
| Increased Field of View | |
| Attracting New Sports Spectators Through Incentives | Encouraging Adoption by Sports Spectators |
| Creating a Positive Initial Experience by Offering Discounts to New Users | |
| Fostering Sports Spectator Loyalty Through Incentives | |
| Importance of Novel Modeling, Animation, and Sports Simulation Techniques | Utilization of Advanced Modeling, Animation, and Sports Simulation Techniques |
| Experiencing All Player Movements and Decisions by Sports Spectators | |
| Creating a Realistic Experience Through Sports Simulations | |
| Enhancing Engagement and Time Spent in the VR or AR Environment by Providing a Realistic Experience | |
| Delivering Customized Sports Content to Spectators for Sports Events | |
| Offering Customized Content Utilizing VR and AR | |
| Immersion of Sports Spectators in the Virtual World and Experiencing Details via VR Devices | |
| Providing Additional Information by Offering Customized Sports Content | Production of High-Quality and Tailored Content |
| Enhancing Engagement and Viewing Experience Through the Production of Customized Sports Content | |
| Familiarization with New Technologies via Educational Courses | Education of Sports Spectators |
| Improving Interaction with the Event Through Educational Courses | |
| Increasing Knowledge and Awareness via Educational Courses | |
| Selecting Different Viewing Angles and Perspectives of the Live Sports Event | Increasing Engagement and Interaction of Sports Spectators |
| Sense of Presence in the Game Environment Due to Multiple Viewpoints | |
| Receiving Visually Displayed Game-Related Images and Statistics on Smart Devices Using AR | |
| Interacting with Other Sports Spectators | |
| Sharing Experiences with Other Sports Spectators | |
| Connecting with Sports Players | |
| Access to Information About Favorite Players for Sports Spectators | |
| Live Transmission of Images, Sounds, and Sports Events Using Sensors, Cameras, and Network Technology | Enhancing the Quality of Experience in Watching Sports Events |
| Direct Viewing of Matches and Games by Sports | |

Strategies for Improving the Sports Spectator Experience

| | | |
|--|--|---|
| Spectators Using Sensors, Cameras, and Network Technology | | |
| Access to Information About Games, Teams, Players, and Sports Events | | |
| Active Participation in Games by Receiving Comprehensive Information | | |
| Analysis and Decision-Making About Games by Sports Spectators | | |
| Access to Desired Viewing Angles and Vantage Points | | |
| Close Observation of Techniques, Movements, and Player Capabilities by Sports Spectators | | |
| Sports Spectators as Players | | |
| Creating an Unforgettable Experience of Sports Competitions by Being Part of the Game | | |
| Offering Virtual Tickets | Increasing Revenue | Applied Ramifications for Enhancing the Sports Spectator Experience |
| Increasing Prices for Virtual Tickets Due to Higher Demand | Generation for Sports Event Organizers | |
| Substitution of Virtual Tickets for In-Person Tickets | | |
| Appeal of Premium-Priced Tickets to Certain Sports Spectators | | |
| Revenue Generation by Increasing Prices for Virtual Tickets | | |
| The interest of Sports Spectators in Innovative and Realistic Experiences | Attracting More Spectators by Offering an Improved Experience | |
| Attracting a Larger Number of Spectators by Offering Diverse and Engaging Experiences | | |
| Providing New Opportunities for Sports Spectators | Elevating the Satisfaction Level of Sports Spectators | |
| More Enjoyable Sports Viewing Experience for Spectators | | |
| Unique Experiences for Sports Spectators | | |
| Strengthening the Emotional Connection of Spectators with the Sport and Their Favorite Team by Providing Useful and Exciting Information | | |
| More Informed Perspective on Matches with Easy Access to Useful Information | | |
| Gaining Analytical Insights into the Game Process by Sports Spectators | Fostering a Sense of Presence Alongside Fellow Fans and Athletes | |
| Sharing Opinions, Emotions, and Thoughts in Real-Time | | |
| Forming Virtual Sports-Related Groups and Communities | | |
| Connecting with Other Fans in the Virtual Space | | |
| Experiencing a Sense of Presence in the Stadium or Sports Arena | | |
| Enhancing Interactions Among Sports Spectators | | |

The First Dimension: Conditions for Enhancing the Sports Spectator Experience: the Conditions for Enhancing the Sports Spectator Experience was one of the dimensions that technology experts and sports management experts referred to regarding enhancing the sports spectator experience using virtual reality and augmented reality technologies. These conditions comprised ten themes.

The first theme states that recent advancements in technologies such as displays, sensors, cameras, and processors have led to the development of more efficient hardware for virtual and augmented reality. One of the experts commented on hardware advancements as follows:

"Improvements in display quality allow spectators to easily experience more details in the virtual environment and gain a greater sense of real presence. Powerful processors also bring higher capabilities in processing virtual and augmented reality scenes. This means a smoother and more seamless experience of virtual or augmented reality for spectators."

The second theme pertains to software advancements, stating that software improvements have enabled the expansion and enrichment of user experiences with virtual and augmented reality. One interviewee stated:

"Advanced algorithms for image and audio processing enable sports spectators to have a more realistic experience in the virtual world, and the spectator experience is enhanced through more engaging virtual reality and augmented reality applications."

The third theme is the popularity of games and entertaining programs based on virtual and augmented reality technologies. The growing popularity of virtual and augmented reality-based games and entertainment has created more incentive for the development of this field. One expert stated:

Virtual reality games and augmented reality applications have become extremely popular in recent years, and this has familiarized more people with these technologies.

Another expert, emphasizing the creation of an innovative experience through applications, stated:

"Virtual reality games and augmented reality applications provide an innovative experience for sports spectators and other users."

The fourth theme related to improving the sports spectator experience is strong and stable broadband networks. Participants emphasized the need for fast and stable internet access to run virtual and augmented reality applications, stating:

"With the development of virtual reality and augmented reality technologies, the need for high-speed connectivity and the use of big data for transmitting images and information in real-time has increased significantly."

The next theme was easy and simple access to related applications and systems. One crucial factor in the widespread adoption of virtual and augmented reality technologies is the easy and simple access for users to related applications and systems. Most of these applications are readily available to the public through app stores and digital distribution channels. Additionally, simple user interfaces and step-by-step tutorials have made using these technologies very easy for everyone. Interviewees stated that spectators could easily access virtual reality and augmented reality-related applications and systems, allowing them to quickly and easily receive and use various information, content, and features.

Investment by sports federations and organizations in augmented and virtual reality was another condition for improving the spectator experience. One sports management expert stated:

"Investment by sports federations and organizations in virtual reality and augmented reality technologies as modern tools and development activities in the field of sports can have a significant impact on improving the spectator experience. Through the investments made by these organizations, they can provide new opportunities for spectator interactions and enhance the viewing experience."

The seventh theme involves the durability and robustness issues of hardware in the open-air environment of sports stadiums. Interviewees stated that hardware device failure due to weather conditions can lead to reduced hardware performance. One technology expert said:

"Utilizing virtual reality and augmented reality in the open-air environment of stadiums requires specific hardware devices. These hardware devices may face durability and robustness issues, leading to limitations and problems for the spectator experience. Hardware device failure due to weather conditions is likely."

The next theme is battery and processor limitations. Processing and battery limitations of devices remain challenging. The high battery demand of virtual reality devices causes time constraints in the spectator experience. One interviewee explained that these devices require a significant amount of battery power for operation, and if the usage duration is excessively long, they need to be recharged. Additionally, another participant commented on processors, stating that running complex and high-quality programs on devices with weak processors could lead to sluggishness and errors, affecting the spectator experience. Therefore, powerful and high-performance processors are essential for using virtual reality and augmented reality.

The ninth theme highlights the weak network and internet coverage in some sports facilities. Augmented reality and virtual reality technologies require a strong and stable internet connection to deliver conceptual and live experiences to spectators. With intermittent connections and poor network coverage, the ability to provide seamless and effortless experiences for spectators is diminished. One expert's opinion on this issue is as follows;

"Lack of network coverage and weak internet in sports facilities can lead to problems such as connection interruptions, delays in data transmission and reception, and decreased quality of the spectator experience."

Finally, the experts pointed to the resistance of some traditional spectators to accepting new technologies. One individual stated:

"Some spectators may be unwilling to learn and use new technologies like augmented reality and virtual reality for personal reasons. They may prefer traditional sports viewing and feel no need for significant challenges or innovations brought about by new technologies."

The Second Dimension: Strategies for Improving the Sports Spectator Experience: Experts provided various strategies to address the conditions hindering the improvement of the spectator experience at sports events through virtual reality and augmented reality technologies, comprising five themes.

The first theme involved developing and improving virtual reality and augmented reality hardware. Continuous hardware improvement is a primary prerequisite for the expansion of virtual and augmented reality applications. One participant stated:

"With improved accuracy of augmented reality cameras and sensors, spectators can have a high-precision experience of events and players in virtual or augmented reality. When moving towards a virtual experience, we expect to observe finer details of the event and players."

The second theme related to utilizing advanced techniques in sports modeling, animation, and simulation. Advanced sports modeling, animation, and simulation techniques enable spectators to experience games and sports in virtual or augmented reality. A technology expert stated:

"Creating a realistic experience through sports simulation will make interacting and spending time in the virtual reality or augmented reality environment more engaging for spectators."

The third theme involves encouraging sports spectators. Interviewees stated that by offering discounts to new users, they can experience virtual reality and augmented reality technologies economically and without high risk. This initial positive experience can motivate them to use these technologies more in the future and have a better experience of sports events. One sports management expert said:

"Through virtual reality and augmented reality, spectators will be able to enter sports environments in a virtual world and feel the live experience. They can experience being present in stadiums or other sports-related locations, and interact with sports players, teams, and popular sports personalities."

The next theme that emerged from the data analysis was the production of high-quality and exclusive sports content. Producing exclusive sports content means creating and delivering content to spectators for specific sports events and different locations. This content can include videos, images, charts, statistics, and supplementary information related to events and venues. One interviewee stated:

"Producing exclusive sports content enhances interactions and the viewing experience. Unlike traditional viewing, spectators can delve into more details about events, access supplementary information, and access analyses. This allows spectators to be present as an active participant in the event and have a more personalized experience."

Finally, the interviewees mentioned educating spectators. Educational courses may be held to familiarize spectators with virtual reality and augmented reality technologies and how to use them for a better experience at sports events. One expert stated:

The third dimension: Applied Ramifications of Enhancing the Sports Spectator Experience: The sports spectator experience refers to the set of practical results and achievements obtained from employing new technologies to enhance the quality of watching sports competitions and events from the spectators' perspective. Experts highlight the applied outcomes of improving the sports spectator experience. This dimension comprises six themes.

The first theme involves increasing the engagement and interaction of sports spectators. Greater spectator involvement in sports events through technology, such as virtual reality and augmented reality, can significantly improve the spectator experience in the sports sector. By using these technologies, spectators will be able to have a more realistic presence in the stadium environment and enjoy the real event atmosphere. One sports management expert stated:

"The next theme is improving the quality of the sports event viewing experience. By employing virtual reality and augmented reality technologies, virtual spectators can access the game from desired angles and vantage points by creating an augmented or virtual reality environment.

One expert said:

"Spectators can realistically place themselves on the field by looking through a virtual reality device, observing the game from different angles, such as from behind the goal or up close."

The third theme involves increasing revenue generation for sports event organizers. By offering virtual tickets, spectators can participate in sports events online and in a virtual environment. As demand for virtual tickets increases, their prices are likely to improve. Due to the provision of a realistic experience and the ability to offer more details in the virtual space, virtual tickets can be considered a valuable alternative to in-person tickets. This may lead to an increase in the price of virtual tickets. One interviewee stated:

"Increasing the price of virtual tickets can be effective in attracting higher-income spectators and lead to increased revenue generation for the providers of these tickets."

The fourth theme discusses attracting more spectators by providing a better experience. The use of virtual reality (VR) and augmented reality (AR) in sports can be an effective way to attract more spectators. By offering a better and more engaging experience, spectators can directly and vividly engage with sporting events and experience novel adventures. Through VR and AR, spectators can be exposed to a more immersive game experience and feel a sense of presence at the event venue. As one interviewee stated:

"Spectators are interested in innovative and realistic experiences that motivate them to attend games and stadiums. This interactive and near-real experience with sports content provides spectators with a unique and engaging experience that can be shared through social media and other communication channels."

The fifth theme relates to enhancing spectator satisfaction in sports. With AR and VR, spectators can participate in sporting events more actively and dynamically. Spectator interactions with virtual products and services during sporting events can create new opportunities. For example, one interviewee stated:

"AR and VR can transform the spectator experience more enjoyably. They can be more realistically immersed in the game environment, experience 3D visuals and realistic visualizations, and feel a greater sense of excitement about watching sports events."

The final theme refers to being present alongside other fans and athletes. Through VR and AR technologies, spectators can have a live and immersive viewer experience of sporting events by being virtually present in these environments. They can interact with other fans and athletes in virtual spaces, experience the atmosphere of being in a stadium or arena, and not miss out on the excitement of the event. As one expert noted:

"By forming virtual groups and communities related to sports, the ability to connect with other enthusiasts and share experiences and interests is also created. Spectators can share their opinions, feelings, and thoughts with other spectators."

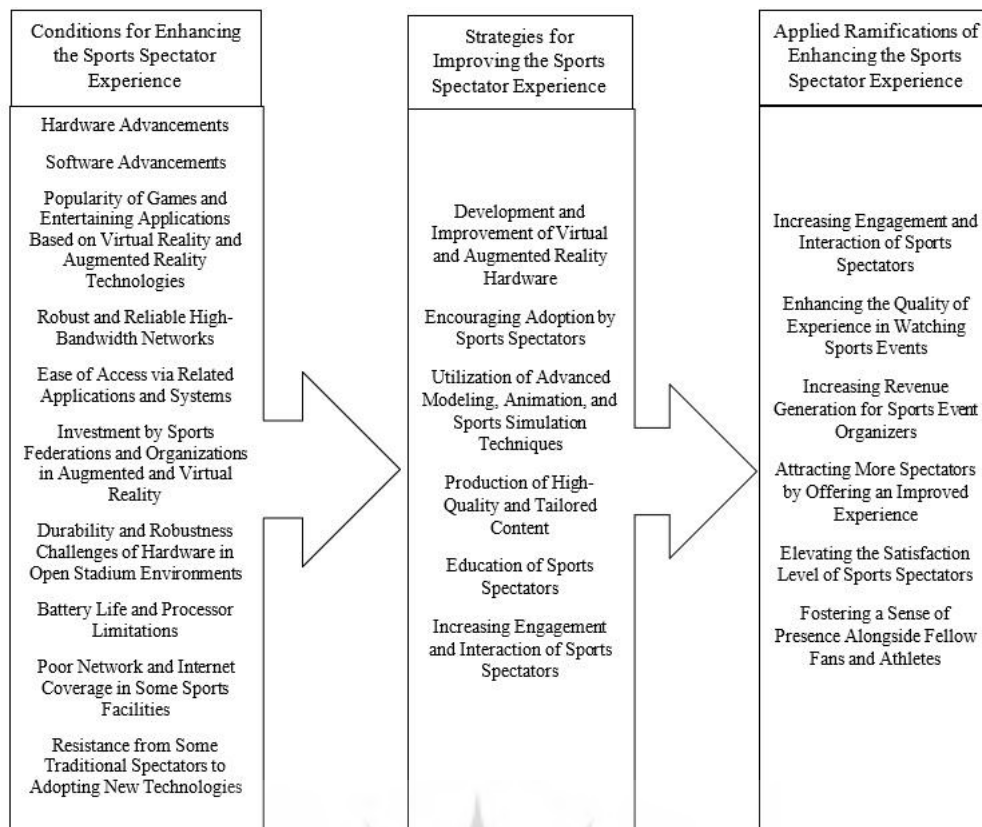


Figure 1. Data-Grounded Model Resulting from Research Analyses

Discussion and Conclusion

This research aimed to understand the improvement of spectators' experience at sporting events through the use of virtual reality (VR) and augmented reality (AR) technologies by comprehending the conditions, strategies, and implications of these technologies.

The research findings indicate that hardware and software advancements in VR and AR technologies are among the key conditions for enhancing the spectator experience at sporting events. The development of more powerful hardware and advanced software offers new possibilities for providing rich and immersive experiences to spectators. According to the interviewees, hardware advancements were among the conditions for improving the spectator experience at sporting events using VR and AR technologies. Recent improvements in communication and interaction hardware have significantly enhanced the capabilities of VR and AR technologies (Li et al., 2021). These advancements enable users to experience immersive environments that go beyond traditional three-dimensional representations, providing more engaging and realistic virtual experiences. The growing popularity of VR and AR-based games and entertainment applications is another important condition that can contribute to improving the spectator experience. These types of applications significantly increase the ability to engage spectators by creating captivating and immersive experiences (Hamari et al., 2019).

Simultaneously, the availability of strong and stable broadband networks is a necessary condition for supporting these technologies. On the other hand, challenges such as battery and processor limitations, hardware durability issues, and resistance from some traditional spectators to new technologies can hinder the full utilization of these technologies (Khor et al., 2016). With the rapid strides taken in technological innovations in every conceivable domain, issues related to technology acceptance have gained increasing importance in recent times (Sharma & Mishra, 2014). Enormous investments are made by organizations and governments to introduce new technologies that have the potential to change users' lifestyles. However, if the innovations are not adopted by the intended users, these investments may not yield results. Technology acceptance does not only relate to technological aspects but is a much more complex process involving the user's attitude, personality

dimensions, and multiple facilitating conditions. Sports federations and teams believe that VR and AR technologies can enhance the experience of regular supporters and enable financial backers to feel like they are on the sidelines worldwide (Sohail et al., 2022). They are looking to invest more in these technologies. In response to these conditions, technology experts and sports management professionals have adopted various strategies. One of the key strategies proposed by experts is the development and improvement of hardware related to VR and AR technologies. Technological advancements in this field can provide new opportunities for delivering richer and more realistic experiences to spectators. With increased processing power, improved graphics quality, and enhanced interactive features, these devices can lead to greater immersion of spectators in virtual environments. Technological advancements in VR hardware devices may enable the development of this technology (Xie et al., 2021). Other proposed strategies include educating and encouraging spectators to use these technologies. Familiarizing spectators with how to use VR and AR devices, interacting with virtual content, and understanding the applications of these technologies can enhance their experience and satisfaction. Offering incentives and motivations, such as discounted ticket prices for spectators who use AR and VR technologies, hosting contests and raffles for this audience segment, and providing opportunities for increased interaction and feedback can create greater motivation and desire for spectators to experience these technologies. The move towards the mainstream of VR and AR requires more consumer education to make the potential market aware of the capabilities offered by the technologies (Ross & Harrison, 2016). Additionally, producing high-quality, customized content for spectators can enhance their experience with VR and AR technologies. The use of realistic graphics and visual effects, as well as content design that encourages greater interaction with the spectator, can increase immersion and engagement. Employing techniques such as volumetric animation, high-quality rendering, the use of advanced 3D textures and models, and the creation of more realistic visual environments can influence the spectator's immersion and enjoyment (Jung et al., 2016).

Considering the strategies and conditions, increasing the engagement and interaction of sports spectators is one of the most significant positive consequences of utilizing emerging technologies such as virtual and augmented reality. The ability for spectators to interact more with the game environment, access real-time game statistics and information, observe replays of game events from different angles, and other capabilities of these technologies have led to increased engagement and interaction of spectators, which enhances their positive and enjoyable experience (Suh & Prophet, 2018). The use of virtual and augmented reality technologies, by providing supplementary information in real-time, displaying event replays, enabling viewing from various angles, and facilitating greater interaction with the environment, leads to an improvement in the quality of the spectator experience. Users derive greater satisfaction from the augmented reality experience in sporting events. Moreover, the utilization of emerging technologies such as augmented and virtual reality can lead to increased revenue generation for organizers of sporting events. The use of new technologies can facilitate increased revenue for organizers of sporting events by offering more engaging and immersive experiences to spectators, through avenues such as more targeted advertising, ticket and experience package sales, and attracting sponsors (Vailati Facchini, 2016).

The application of augmented and virtual reality technologies, by providing a more captivating and enriched experience for spectators, enhances their level of satisfaction. Access to statistics and information, greater interaction with the environment, and experiencing exciting moments from different angles enrich the spectator experience. The ability to interact with other spectators and fans in the virtual environment, facilitated by augmented and virtual reality features, strengthens the sense of presence alongside fellow fans. This reinforces the collective experience and group excitement of watching sports. Augmented reality can provide interactive and shared viewing experiences for sports spectators, allowing them to connect with a community of fans and enhance their overall viewing experience (Hertzog et al., 2020). The sense of being present in a larger crowd and sharing the viewing experience with other fans in the stadium is facilitated by the features of augmented reality. Additionally, augmented reality can facilitate a sense of connection with other fans by enabling remote spectator interaction and reaction sharing.

The results of this research indicate that the advancement of virtual and augmented reality technologies has the potential to improve the experience of spectators at sporting events. Factors

such as hardware and software development, increasing popularity of virtual reality games and applications, expansion of high-speed networks, and investment by sports organizations can be effective in this regard. However, some challenges should not be overlooked, including technical hardware issues, battery and processor limitations, and resistance from some traditional spectators to embracing these emerging technologies. This study suggests that by adopting strategies such as developing and improving hardware, encouraging and educating spectators, and producing high-quality content, positive outcomes such as increased spectator engagement and interaction, enhanced quality of viewing experience for sporting events, increased revenue generation for organizers, attracting more spectators, improving fan satisfaction levels, and strengthening the sense of presence alongside other fans and athletes can be achieved. Therefore, the findings of this research indicate that through the purposeful and appropriate utilization of emerging virtual and augmented reality technologies, the experience of watching sporting events for fans can be enhanced, and their enjoyment and satisfaction can be increased.

From a theoretical perspective, this research can open new avenues for theoretical studies in various fields. On one hand, examining the level of familiarity and readiness of people to accept virtual and augmented reality technologies can serve as a basis for future research in the field of technology acceptance among different segments and groups of Iranian society. Additionally, identifying cultural and social barriers paves the way for further research on the cultural and social impacts of emerging technologies in Iran. Furthermore, analyzing the existing infrastructure and capabilities in the country can facilitate further studies in the area of policy-making and technology development planning in Iran. From a practical application standpoint, the results of this research can be beneficial for companies, organizations, and stakeholders in this field. Based on the findings of this research, companies operating in the virtual and augmented reality field can adopt more appropriate marketing and promotional strategies to introduce and institutionalize these technologies among Iranian audiences. Additionally, the results of this research can assist policymakers and legislators in formulating the necessary laws and regulations to facilitate and regulate the development and application of these technologies in Iran. On the other hand, by identifying the economic and investment aspects required, private investors can have more accurate assessments of the risks and opportunities for investment in this field.

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Author Contributions

All authors have contributed in conducting this study.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Abbas, B. K., & Jasim, I. A. (2018). The models of used virtual reality technology in sports. *International Journal of Computer Science and Mobile Computing*, 7(9), 76-85.
- Abbas, B. K., & Jasim, I. A. (2018). The models of used virtual reality technology in sports. *International Journal of Computer Science and Mobile Computing*, 7(9), 76-85.
- Chan-Olmsted, S., & Xiao, M. (2019). Smart sports fans: Factors influencing sport consumption on smartphones. *Sport Marketing Quarterly*, 28(4), 181-194.
- Corley, K. G., & Gioia, D. A. (2004). Identity ambiguity and change in the wake of a corporate spin-off. *Administrative science quarterly*, 49(2), 173-208.
- Dan, M., Yutaka, K., Yutaka, K., Shinya, S., Kenta, N., & Keisuke, K. (2015). Audio-visual Technology for Enhancing Sense of Presence in Watching Sports Events. *NTT Technical Review*, 13(4), 52-57.

- Esposito, R. (2015). How smart, digital stadiums are changing the way we watch sports. In.
- Gioia, A., Corley, G., & Hamilton, L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organisational Research Method*, 16 (1), 15-31. In.
- Glebova, E., Desbordes, M., & Geczi, G. (2020). Relocations of sports spectators' customer experiences= A sporteseményt nézők vásárlói élményeinek áthelyeződése. *Testnevelés, Sport, Tudomány*, 5(1-2), 44-49.
- Gradl, S., Eskofier, B. M., Eskofier, D., Mutschler, C., & Otto, S. (2016). *Virtual and augmented reality in sports: an overview and acceptance study*. Paper presented at the Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct.
- Hamari, J., Malik, A., Koski, J., & Johri, A. (2019). Uses and gratifications of pokémon go: Why do people play mobile location-based augmented reality games? *International Journal of Human-Computer Interaction*, 35(9), 804-819.
- Hertzog, C., Sakurai, S., Hirota, K., & Nojima, T. (2020). *Toward augmented reality displays for sports spectators: A preliminary study*. Paper presented at the Proceedings.
- Jung, T., tom Dieck, M. C., Lee, H., & Chung, N. (2016). *Effects of virtual reality and augmented reality on visitor experiences in museum*. Paper presented at the Information and communication technologies in tourism 2016: Proceedings of the international conference in Bilbao, Spain, February 2-5, 2016.
- Khor, W. S., Baker, B., Amin, K., Chan, A., Patel, K., & Wong, J. (2016). Augmented and virtual reality in surgery—the digital surgical environment: applications, limitations and legal pitfalls. *Annals of translational medicine*, 4(23).
- Kim, D., & Ko, Y. J. (2019). The impact of virtual reality (VR) technology on sport spectators' flow experience and satisfaction. *Computers in Human behavior*, 93, 346-356.
- Li, Z.-N., Drew, M. S., Liu, J., Li, Z.-N., Drew, M. S., & Liu, J. (2021). Augmented reality and virtual reality. *Fundamentals of Multimedia*, 737-761.
- Liu, Q., Huang, S., Opadere, J., & Han, T. (2018). *An edge network orchestrator for mobile augmented reality*. Paper presented at the IEEE INFOCOM 2018-IEEE conference on computer communications.
- Miah, A., Fenton, A., & Chadwick, S. (2020). Virtual reality and sports: The rise of mixed, augmented, immersive, and esports experiences. *21st century sports: How technologies will change sports in the digital age*, 249-262.
- Naikoo, A. A., Thakur, S. S., Guroo, T. A., & Lone, A. A. (2018). Development of society under the modern technology-a review. *Scholedge International Journal of Business Policy & Governance*, 5(1), 1-8.
- Neumann, D. L., Moffitt, R. L., Thomas, P. R., Loveday, K., Watling, D. P., Lombard, C. L., . . . Tremeer, M. A. (2018). A systematic review of the application of interactive virtual reality to sport. *Virtual Reality*, 22, 183-198.
- Okado, I., Floyd, F. J., Goebert, D., Sugimoto-Matsuda, J., & Hayashi, K. (2021). Applying ideation-to-action theories to predict suicidal behavior among adolescents. *Journal of affective disorders*, 295, 1292-1300.
- Pickman, D. (2023). The Use of Virtual Reality and Augmented Reality in Enhancing the Sports Viewing Experience. *International Journal of Arts, Recreation and Sports*, 1(2), 39-49.
- Rogers, R., Strudler, K., Decker, A., & Grazulis, A. (2017). Can augmented-reality technology augment the fan experience?: A model of enjoyment for sports spectators. *Journal of Sports Media*, 12(2), 25-44.
- Ross, H. F., & Harrison, T. (2016). *Augmented reality apparel: An appraisal of consumer knowledge, attitude and behavioral intentions*. Paper presented at the 2016 49th Hawaii international conference on system sciences (HICSS).
- Sapkaroski, D., Baird, M., McInerney, J., & Dimmock, M. R. (2018). The implementation of a haptic feedback virtual reality simulation clinic with dynamic patient interaction and communication for medical imaging students. *Journal of medical radiation sciences*, 65(3), 218-225.

- Sawan, N., Eltwari, A., De Lucia, C., Pio Leonardo Cavaliere, L., Faccia, A., & Roxana Moşteanu, N. (2020). *Mixed and augmented reality applications in the sport industry*. Paper presented at the Proceedings of the 2020 2nd International Conference on E-Business and E-commerce Engineering.
- Sharma, R., & Mishra, R. (2014). A review of evolution of theories and models of technology adoption. *Indore Management Journal*, 6(2), 17-29.
- Singh, K. (2018). Impact of Science and Technology on Law and Society with Dimensions of New Challenges of Cyber Security. *OIDA International Journal of Sustainable Development*, 11(10), 43-48.
- Skinner, J., Edwards, A., & Smith, A. C. (2020). *Qualitative research in sport management*: Routledge.
- Sohail, Z., Firdos, A., Ikram, S., & Talha, M. (2022). The impact of virtual reality and augmented reality on sport psychology. *Revista de Psicología del Deporte (Journal of Sport Psychology)*, 31(1), 217-226.
- Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human behavior*, 86, 77-90.
- Uhm, J.-P., Lee, H.-W., & Han, J.-W. (2020). Creating sense of presence in a virtual reality experience: Impact on neurophysiological arousal and attitude towards a winter sport. *Sport Management Review*, 23(4), 588-600.
- Uhrich, S. (2022). Sport spectator adoption of technological innovations: A behavioral reasoning analysis of fan experience apps. *Sport Management Review*, 25(2), 275-299.
- VAILATI FACCHINI, L. (2016). Digital strategy in a sport club: a model to support the analysis.
- Wang, T., Du, Z., Wang, F., & Wang, S. (2023). Augmented Reality in Sports Event Videos: A Qualitative Study on Viewer Experience.
- Xie, B., Liu, H., Alghofaili, R., Zhang, Y., Jiang, Y., Lobo, F. D., . . . Akdere, M. (2021). A review on virtual reality skill training applications. *Frontiers in Virtual Reality*, 2, 645153.