EAI Endorsed Transactions
on Creative Technologies
Research Article EAI.EU

A Review of Gamification in Virtual Reality (VR) Sport

Nurshamine Nazira Nor[1,2*], Mohd Shahrizal Sunar[1,2] and Azyan Yusra Kapi[1,2,3]

[1]School of Computing, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[2]Media and Game Innovative Centre of Excellence, Institute of Human Centered Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[3]Universiti Teknologi MARA, Pasir Gudang Campus, 81700 Johor, Malaysia

Abstract

PURPOSE: To identify the main findings from research on gamified virtual reality in sport
METHODS: The digital databases for this review were searched and visited on 19 May 2019. Gamification AND ("virtual reality" OR sports fitness) were used as a search string or keyword in the paper selection.
RESULTS: Thirty -three papers were found after the preliminary searches to narrow down the selections that align with the goals of this study. The selected papers were examined to investigate the characteristics of gamification in a broad context of sports. These findings suggest that the use of gamification methods help physical exercise in the immersive VR setting.
CONCLUSION: Through the outcomes of user experience, it can prove that gamification components are boosting the pleasure of the user throughout the physical activity and provide a set of rules to encourage the athlete or user to perform better. Besides, generality of impacts with VR and gamification in sports has been discussed in this paper by listing the advantages and limitations. However, findings need more varied populations, particularly elements, athletes, kids, and older people.

Keywords: Virtual Reality, gamification, sport, User Experience

Received on 30 September 2019, accepted on 14 October 2019, published on 28 October 2019

doi: 10.4108/eai.13-7-2018.163212

1. Introduction

Virtual reality (VR) technology has evolved widely over the previous few years. In the past literature, recent advancements in VR can be seen from desktop displays to virtual reality 360 [1] and Head Mounted Display (HMD). Advanced complexities in HMDs were designed and built for the commercial market and the purpose is far more than just an entertainment game. Education, marketing [2] and a large range of healthcare are now partly covered by VR applications [3]. VR has achieved surprising upgrades and it is also expected to have an enormous influence on daily life. People in everyday life are often attracted by short-term incentives rather than long-term rewards. The attraction to the short-term incentives occasionally drives people to neglect attitude that would be beneficial and subsequently cause an individual to lose focus, skip practice, smoke, and overconsume, for instance [4]. In attempting to break these patterns, powerful self-control alone is not enough, and thus people are actively looking for a new approach of motivation. In previous literature, gamification is one of the approaches to master and practice self-motivation. Hence, this paper will describe gamification and VR terms and the relation between both terms which explicitly focusing on VR's user experience in sports. This paper's primary aim is summarized as follows: to analyze the gamification's element in the general context of sports and secondly, the user experience in VR's sports applications. Then, it aims to identify the aspect of gamified virtual reality experienced by the respondents in VR's sports applications. The outcome of this study will lead to an analysis that identifies the elements of gamification in sports and the component of VR, which is not being implemented. Furthermore, existing factors that contribute to poor VR's user experience will also be discovered. The following section will discuss the theory basis, and these are accompanied by the parts of the

*Corresponding author. Email:shaminenazira95@gmail.com

First version of this paper has been accepted and presented at INTETAIN 2019 and will be published in its proceeding.

literature review and followed by gamification, VR's trends, the advantages and limitations of VR in sport. Conclusion and future work will be presented in the final section.

1.1. Theory Foundation

There has been a growing amount of literature on gamification and VR in recent years. Both terms will be explained further with the definition of sports as the direction of this study.

Virtual Reality (VR)

VR relates to a computer-simulated environment that seeks to cause a feeling of being present in another location mentally or physically [5]. VR technology is primarily presented as an immersive and hierarchical desktop technology that can enhance the perception of reality [6]. VR systems can be categorized into three main categories. There are non-immersive, immersive and semi-immersive dependent on one of the essential aspects of VR [7]. VR was first introduced to sports studies in the 1990s. In sports applications, VR technology can offer a platform for people who may not be able to participate in various sport training courses [8]. One of VR's main advantages is that digital content sharing can result in further representative sampling and complete duplication [9]. Reference in [9] also pointed out that there are numerous opportunities for fans in the sports industry to discover VR technology material that enables fans to get closer than ever before in the field. However, limited researches have been done to study how modern VR technologies could improve the practice of applied sport psychology [10].

Sports

Sports typically involve physical activity that refers to any type of body motion that eventually leads towards a rise in one's energy consumption and is conducted in different situations such as work, daily routines, and recreation time [11]. In sports and fitness, motivation is the basis of all athletic activity and achievement. Contrarily, it appears to be an area in which individuals find it challenging to get motivated. In recent studies, the alternatives to promote involvement in everyday physical activity have received more attention. VR environments are used to improve imaging practice in sport areas as an approach to a real environment [12]. Since motivation is also considered as the basis of gamification, this study proposes to analyze the user experience of gamified VR in the setting of sports training.

User Experience (UX)

Some UX concepts include the user's qualitative experience of engaging with the product [13]. UX is a dynamic process that is taking place in the real world, reshaping the experience and future growth of the user [14]. With such a comprehensive view of UX, researchers are encouraged to understand a global UX viewpoint that incorporates the role of the product in the users' life [14]. The value of UX varies based on the type of product and its intended uses. Several products are produced without the intention of creating a good customer relationship, while others are planned to provide an excellent UX [14]. In brief, UX involves the responses and reactions of the consumer during the engagement with the product, from the moment they are presented with it to the moment they are used in a certain way.

2. Literature Review

The digital databases for this review were searched and visited on 19 May 2019. Gamification AND ("virtual reality" OR sports fitness) were used as a search string or keyword in the paper selection [15]. Thirty-three papers were found after the preliminary searches to narrow down the selections that align with the goals of this study. In the literature review, the selected papers were examined to investigate the characteristics of gamification in a broad context of sports (section 2.1). Moreover, user experience in VR's sport application will be identified (section 2.2), and the combination of gamification and VR in sports applications (section 2.3). Section 4 discusses VR's advantages in sports, while Section 5 examines the limitations of VR in sports. Besides, Section 6 will be discussed about the issues and potentials of gamification in VR sport.

2.1. Gamification in Sport

Yu-kai Chou introduces a complete Gamification Framework called Octalysis [16]. In his perspective, gamification is a model that prioritizes human motivation in the cycle [16]. Essentially, it is a Human-Focused Design. The method is focusing on an octagon design with eight-core drives for each side: epic meaning and calling, development and accomplishment, creativity and feedback, ownership and possession, social influence and relatedness, scarcity and impatience, unpredictability and curiosity as well as loss and avoidance (Figure 1) [16]. The Octalysis Framework is structured so that the Core Drives, which concentrate on creative self-expression and social dynamics, are grouped on the right side of the Octagon or is termed as Right-Brain Core Drives (Intrinsic). The Core Drives that are most commonly associated with logic, analytical thought, and ownership are measured on the left side of the Octagon and are termed as Left-Brain Core Drives (Extrinsic). Extrinsic motivation is a motivation that originates from a goal, purpose, or reward. The goal does not have to be intriguing or attractive, but due to the goal or reward, people are driven and motivated to accomplish the task.

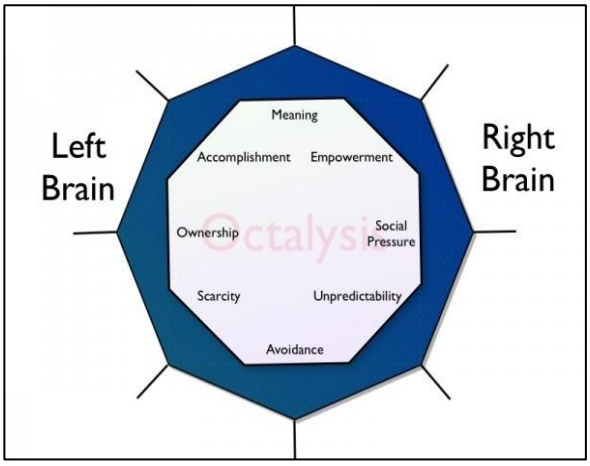

Figure 1. Left Brain vs. Right Brain Core Drives [16].

Based on the Left Core drives (Extrinsic) in the Octalysis framework, gamification elements in the studies have been collected and classified into eight different gamification elements. Figure 2 focused on the frequency of extrinsic gamification elements that are mostly used in the sport context.

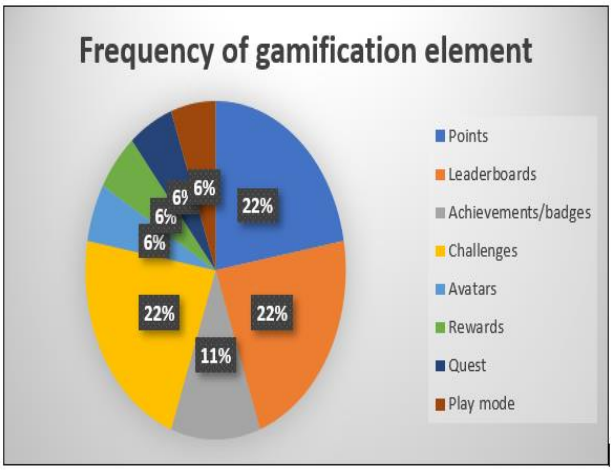

Figure 2. Frequency of gamification element

The overall results indicate that among the game elements tested in the study, points [17], [18], [19], [20], leaderboard [21], [17], [18], [20] and challenges [21], [17], [18], [19] has highest frequency of effects on the study [15]. However, based on the results [15], it can be concluded that different people encounter gamification in different ways and that personal characteristics such as exercise habits and attitudes towards sports technology influence how the gamification affects exercise motivation [21].

2.2. Virtual Reality in Sport

As discussed before, VR systems can be divided into three major groups, which are fully immersive, non-immersive, and semi-immersive [7]. The immersive VR system is the most expensive and offers the highest level of immersion [7] gives the user the impression that they are in real environments. Non-Immersive VR system, or also defined as the Desktop VR system or Window on the World system, is the less immersive and cheapest VR system [7] which enables users to communicate with a 3D environment via a stereo screen monitor and glasses [7]. Semi-immersive VR system, also known as hybrid systems [1], generates a high rate of immersion while maintaining the ease of the VR desktop [7]. It has shown that the results chare influenced by several features of the VR display and the level of the VR system [15]. Based on the selected papers in this study, Figure 3 portrays the review on the presence of immersive user experience in VR display.

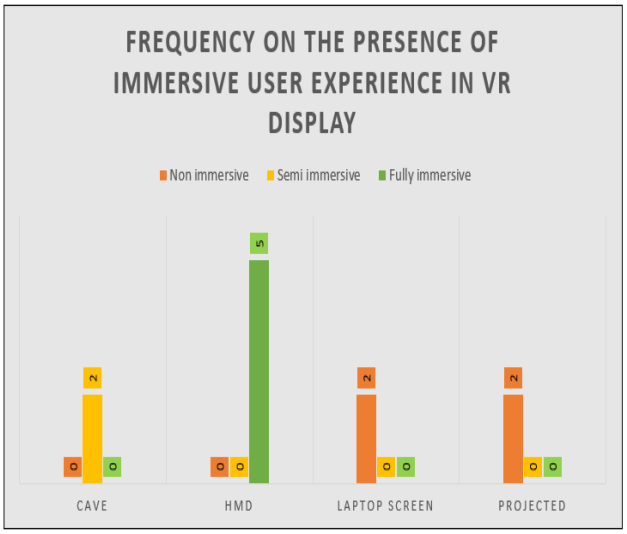

Figure 3. Frequency on the Presence of Immersive User Experience in VR display

As shown, the use of HMD was fully immersive [22], [23], [24], [25], [26] compared to the other VR display. The use of a more immersive virtual environment of sport can improve motivation and participants ' cycling velocity [21]. Based on Figure 3, the user can experience a fully immersive environment when they are using HMD as the VR display. HMDs can create the most immersive experiences that can be achieved through advanced positional tracking, motion controllers, and high frame rates [28]. A more prominent display or the combination of more multimodal environmental components will enhance the feeling of immersion in the virtual globe, and this may affect efficiency [15].

2.3. Gamified Virtual Reality in Sport

Gamification of Virtual Reality in sport has been recognized nowadays. To produce a good user experience (UX), the products must be able to fulfill users' requirements or able to attract the user to engage with the product [14]. Thus, the element of gamification has been used to increase user motivation and to engage the user with the systems [15]. Not to forget, the immersive level of

the environment is also one of the main points for the user to perceive the system as the real environment and to attract them to continue playing or staying with the system [14].

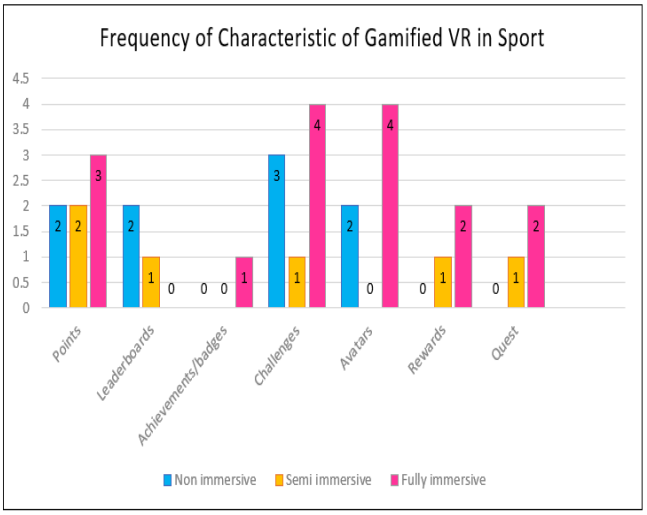

Figure 4. Frequency of Characteristic of Gamified VR in Sport

Figure 4 shows the combination from Figure 2 and Figure 3. Immersion is linked to the feeling of being inside a virtual environment [14]. Based on Figure 4, it can be shown that fully immersive has the highest number [15] of studies compared to the other level of VR system based on UX [27], [28], [29], [30], [31]. Besides that, adding on challenges [27], [31], [30], [28] and avatars [28], [30], [27], [29] as the gamification element has the highest number of studies in fully immersive level of VR system. It is because challenges are essential for the experience, as the user's primary goal is no longer a dull practice, but a challenge within a match that offers greater incentive to complete the activity [27]. Furthermore, the existence of an avatar can be an efficient way of increasing VR exercise concentration [28].

3. Trends

3.1. Improvements of gamification in design practice

One appropriate criticism of the present gamified procedures was the narrow viewpoint on game design, leveraging only a limited amount of design components, mostly aimed at acquiring an instant commitment by conveying extrinsic motivations and behavioral reactions [32]. For instance, Chittaro and Buttussi (2018) begin with the issue of developing a serious game for mobile devices to help in the changing of attitudes in aviation security [33]. They realize that gamification schemes and serious games are always based on real-world scenario simulations that incorporate points, badges and leader boards to benefit the user, while distinct and more complicated design aspects that create enjoyable games are seldom used [33]. The use of components from the arcade game tradition, such as rigid time limits, avoiding barriers and enemies, and a game framework have been organized around levels of difficulty to assist users in conceptual learning on how to act during the evacuation of aircraft [33].

3.2. Visualization of 3D scenarios

Several techniques to visualize a virtual or real situation have been introduced in recent years. Some techniques reflect the real state of recent developments due to being cited among the frequently adopted techniques as the most interesting by customers. There are Immersive (IV), Nomadic (NV), and Head-Mounted Displays (HMD) [34]. A few immersive video techniques that enable navigation in a video have been created [34]. The user can discover the situation in all angles as the video plays. HMDs need to be adapted. Nevertheless, specialists do not suggest the use of HMD at the age of fifteen and below because of the overly stimulating imagery is a hazard to adolescents whose brains are still developing [34].

4. Virtual Reality Advantages in Sport

There are several advantages of using VR in sport. Based on the review, it can be gathered into four core issues, which are availability, reduce cost, realism, and safety.

4.1. Availability

"Practice makes perfect" –this can be a cliché, but this depicts strong motivation for athletes. They need practice sessions if they choose to be good about what they are doing. Some of the best sportsmen gave years of their career practicing to be on the level they are now, as they do not seem to be stopped. Practicing nearly every single day might put a heavy toll on the body. Besides, they need to acknowledge the weather and a variety of laws concerning their training [14]. Due to technological developments, these athletes may exercise their skills at any time to feel confident and comfortable with them. Besides, athletes are able to obtain nearly all locations under designated environmental conditions with VR

4.2. Cost Reduction

VR help to reduce cost and funding [35]. With the innovation of VR technology, users ' opinions have begun to change significantly. It helps to lower training costs in many fields, such as sports, military, and medical. VR gives real training with finite resources. No need for money to be spent on instructors or training equipment. VR uses all the hardware that has been digitally built with such a real feel. Costs involved in development can also be reduced to slash expenses.

4.3. Realism

In VR, the point of view of the user is changed in real-time tends to improve the sense of realism [36] and can be described as one of the present element in a virtual environment [37]. Therefore, the performance of athletes will increase after they have encountered an immersive level of training. While using VR, it has the power to manipulate an athlete's views and control their performance, specifically in sporting environments that are highly structured in their natural setting (i.e., Basketball, Rowing) [38].

4.4. Safety

With virtual environments, athletes can experience the environment and connect with all types of goods safely, even though subjected to controlled crucial situations [14]. This benefit is particularly essential when athletes are expected to engage with dangerous goods or conditions that may include the chance of injury, for themselves or others, and destruction of property. For instance, in order to assess UX with a rowing sport, an athlete can row a boat in all kinds of path environments, under adverse climatic conditions at varying speeds. In contrast, VR removes the implications and social impacts of mistakes made and inaccuracies that are prevalent in training trials [14]. Besides, other circumstances that may affect the quality of athlete and the reliability of UX, such as mental workload or induced pressure, will be handled in a precise manner than might be feasible in actual-world situations.

5. Virtual Reality Limitation in Sport

Despite four core advantages of VR that has been discussed in the previous section, there is also several limitations exist. Several limitations of using VR in sport can be concluded into three core issues, which are visual scene complexity, ages, and haptic devices.

5.1. Visual Scene Complexity

Visual scene complexity (e.g., visual flow rate) is shown to affect either the occurrence or extent of simulator sickness [14]. Therefore, Hettinger (2002) indicated that the width of the visual field and the existence of motion in the environment affect the section. The involvement of scene movements has dramatically increased cybersickness relative to no movements.

5.2. Ages

The previous study has shown that children appear susceptible to motion sickness while using VR. Susceptibility rises until around the age of 12, by which level it decreases again, with some over the age of 25 being half as susceptible as 18-year-old VR in UX Studies 973 individuals [39]. While statistics on this subject are sparse, some authors argue that older people may have an elevated risk of suffering from simulation sickness [40]. However, other studies have shown that the use of VR in older adults is practical [41]. Moreover, during VR experiments, participants need to wear 3D glasses to see with a stereoscopic viewpoint or an HMD with two small screens. The latter device has drawbacks related to the limitation of the field of view, the image resolution produced and the weight of the devices [42].

5.3. Haptic Device

Haptic devices, that are still relatively expensive and bulky, could be used to mimic touch [43] with vibration systems, for instance. However, wires would have been available to simulate the force input required to trust in a collision with a virtual object. Therefore, the use of this technology throughout large and complex movements may seem limited.

6. Issues and Potentials of Gamification in Virtual Reality Sport

The advantages of virtual reality in sport and their limitations have been discussed at the Section 4 and Section 5. However, the issues and potential of the combination element in the gamification and Virtual Reality have not been discovered yet. This section will be discussed the issues and the potential of gamification in Virtual Reality Sport.

6.1. Issues of Gamification in Virtual Reality Sport

Chance to cheat in training

Several of the people who played games appear to cheat in the games [44]. If player performance improvements are based on a game, it can be difficult to avoid the tendency to cheat or reap the benefits of the games. Worse still, attempts to improve competition may lead to players deliberately sabotaging each other or making immoral decisions rather than working together for the benefit of the team as they seek to secure specific aims [44].

High Cost of Implementation

Game development typically leads to a prolonged development time than conventional design. It is because each step of the design stage has specific requirements when gamified [44]. In the business world, time is precious, and it can cause over budget when the development took longer period [45]. Extra functionality

such as music and contents that enhance the game can increase the cost of time and money.

6.2. Potentials of Gamification in Virtual Reality Sport

Improve Performance

Some of the games, particularly serious games, are focused on going from low to high complexity while enhancing skills [28]. Once the preparation is ready in an enjoyable hi-tech game scenario with a script that encourages the player to progress on the next stage or to win a new award, the skills can be learned better [28]. The key is to find the correlation between competence and gameplay complexity so that the player will not feeling bored and give a chance or prevent him from completing unreachable objectives.

Increase Motivation

As an instance of a good combination of gamification and VR is the instruction of the athlete about what to do to improve efficiency [21] throughout the training session. With a virtual reality setting paired with game features such as scores and prizes, the player will be more motivated to participate in the training and give more attention [21].

Simulate the position of the player

Simulation of real-life events helps to develop a realistic perspective on the player's suitability for a position in any situations [44]. It lets the coach allocate a correct position to the player on the basis of the results reported to ensure that the player is aware of their position role [46].

7. Conclusion and Future Work

This review identified studies that explored the use of VR in sport, gamification in sport, and the combination of VR and gamification in sport. A VR based training and involvement scheme has some benefits, such as the ability of athletes to training despite the weather conditions and the ability of individuals to feel the real condition of the environment. Besides, gamification can increase individual motivations where it utilizes a system of goals and accomplishments in boosting the organization's efficiency. Individual satisfaction and performance are increased by implementing gamified elements. In this study, the use of gamification methods to help physical exercise in the immersive VR setting has been studied. Through the outcomes of user experience, it can prove that gamification components are boosting the pleasure of the user throughout the physical activity and provide a set of rules to encourage the athlete or user to perform better. Furthermore, the generality of impacts with VR and gamification in sports has been discussed in this paper by listing the advantages and limitations. However, findings need more varied populations, particularly elements, athletes, kids, and older adults.

Acknowledgments.

Deep appreciation to Universiti Teknologi Malaysia (UTM) for supporting our ongoing research under UTM Transdisciplinary Research Grant (Q.J130000.3509.05G07) that will allow us to identify gamification of VR in sport based on user experience. Based on the analysis of the studies, it will give ideas to boost user motivation and to attract user attention to continuously perform better in sport. Moreover, it able to increase an athlete's quality performance in the sports field as well as experiencing the real environment without having weather limitation for example.

References

[1] Z. S. See, M. S. Sunar, A. Kusnayat, and K. A. Aziz, "Interactive panorama VR360 for corporate communications: An industrial scenario case study," *Int. J. Integr. Eng.*, vol. 10, no. 6, pp. 169–177, 2018.

[2] B. Tomi, M. S. Sunar, F. Mohamed, T. Saitoh, M. K. Bin Mokhtar, and S. M. Luis, "Dynamic Body Circumference Measurement Technique for a More Realistic Virtual Fitting Room Experience," *2018 IEEE Conf. e-Learning, e-Management e-Services, IC3e 2018*, pp. 56–60, 2019.

[3] E. Bastug, M. Bennis, M. Medard, and M. Debbah, "Toward Interconnected Virtual Reality: Opportunities, Challenges, and Enablers," *IEEE Commun. Mag.*, vol. 55, no. 6, pp. 110–117, 2017.

[4] G. Ainslie, "Specious reward: A behavioral theory of impulsiveness and impulse control," *Psychol. Bull.*, vol. 82, no. 4, pp. 463–496, 1975.

[5] R. M. Baños, C. Botella, A. Garcia-Palacios, H. Villa, C. Perpiña, and M. Alcañiz, "Presence and Reality Judgment in Virtual Environments: A Unitary Construct?," *CyberPsychology Behav.*, vol. 3, no. 3, pp. 327–335, 2002.

[6] Y. Zhou and S. Y. Wang, "Study on the application of VR technology in sport reality shows," *Proc. - 2018 1st Int. Cogn. Cities Conf. IC3 2018*, pp. 200–201, 2018.

[7] O. Bamodu and X. M. Ye, *Virtual reality and virtual reality system components*, vol. 765–767. 2013.

[8] J. M. Bird, "The use of virtual reality head-mounted displays within applied sport psychology," *J. Sport Psychol. Action*, vol. 0, no. 0, pp. 1–14, 2019.

[9] B. J. Li, J. N. Bailenson, A. Pines, W. J. Greenleaf, and L. M. Williams, "A public database of immersive VR videos with corresponding ratings of arousal, valence, and correlations between head movements and self report measures," *Front. Psychol.*, vol. 8, no. DEC, 2017.

[10] D. L. Neumann *et al.*, "A systematic review of the application of interactive virtual reality to sport," *Virtual Real.*, vol. 22, no. 3, pp. 183–198, 2018.

[11] R. Tu, P. Hsieh, and W. Feng, "Walking for fun or for 'likes'? The impacts of different gamification orientations of fitness apps on consumers' physical activities," *Sport Management Review*. 2018.

[12] B. Bideau, F. Multon, R. Kulpa, L. Fradet, B. Arnaldi, and P. Delamarche, "Using virtual reality to analyze links between handball thrower kinematics and

goalkeeper's reactions," *Neurosci. Lett.*, vol. 372, no. 1–2, pp. 119–122, 2004.
[13] J. McCarthy and P. Wright, *Technology as experience*, vol. 11, no. 5. 2004.
[14] F. Rebelo, P. Noriega, E. Duarte, and M. Soares, "Using virtual reality to assess user experience," *Hum. Factors*, vol. 54, no. 6, pp. 964–982, 2012.
[15] N. N. Nor, M. S. Sunar, and A. Y. Kapi, "User Experience of Gamified Virtual Reality (VR) in Sport : A Review," 2019, pp. 1–11.
[16] Y.-K. Chou, "Actionable gamification: Beyond points, badges, and leaderboards," *Octalysis Media*, pp. 1–151, 2016.
[17] R. Menéndez-Ferreira, J. Torregrosa, A. Maldonado, R. Ruiz-Barquin, and D. Camacho, "A gamification approach to promote sports values," *CEUR Workshop Proc.*, vol. 2166, 2018.
[18] D. Sevinç and M. Çolak, "The effect of electronic body protector and gamification on the performance of taekwondo athletes," *Int. J. Perform. Anal. Sport*, vol. 19, no. 1, pp. 110–120, 2019.
[19] D. Jurgens, J. McCorriston, and D. Ruths, "An Analysis of Exercising Behavior in Online Populations," *Proc. ICWSM*, pp. 630–633, 2015.
[20] A. Tóth and E. Lógó, "The Effect of Gamification in Sport Applications," *9th IEEE Int. Conf. Cogn. Infocommunications, CogInfoCom 2018 - Proc.*, no. CogInfoCom, pp. 69–74, 2019.
[21] T. Kari, J. Piippo, L. Frank, M. Makkonen, and P. Moilanen, "To Gamify or Not to Gamify? Gamification in Exercise Applications and Its Role in Impacting Exercise Motivation," *BLED 2016 Proc. 29th Bled eConference "Digital Econ.*, pp. 393–405, 2016.
[22] J. Shepherd, L. Carter, G.-J. Pepping, and L.-E. Potter, "Towards an Operational Framework for Designing Training Based Sports Virtual Reality Performance Simulators," *Proceedings*, vol. 2, no. 6, p. 214, 2018.
[23] S. Arndt and A. Perkis, "Using Virtual Reality and Head-Mounted Displays to Increase Performance in Rowing Workouts," pp. 45–50, 2018.
[24] S. Schmidt *et al.*, "Impact of Virtual Environments on Motivation and Engagement during Exergames," *2018 10th Int. Conf. Qual. Multimed. Exp. QoMEX 2018*, 2018.
[25] S. Katsigiannis, R. Willis, and N. Ramzan, "A QoE and Simulator Sickness Evaluation of a Smart-Exercise-Bike Virtual Reality System via User Feedback and Physiological Signals," *IEEE Trans. Consum. Electron.*, vol. 65, no. 1, pp. 119–127, 2019.
[26] K. Petri *et al.*, "Training using virtual reality improves response behavior in karate kumite," *Sport. Eng.*, vol. 22, no. 1, pp. 1–12, 2019.
[27] E. Tuveri, L. Macis, F. Sorrentino, L. D. Spano, and R. Scateni, "Fitmersive Games," *Proc. Int. Work. Conf. Adv. Vis. Interfaces - AVI '16*, no. June, pp. 212–215, 2016.
[28] M. Farrow, C. Lutteroth, P. C. Rouse, and J. L. J. Bilzon, "Virtual-reality exergaming improves performance during high-intensity interval training," *Eur. J. Sport Sci.*, vol. 0, no. 0, pp. 1–9, 2018.
[29] B. J. Parton and D. L. Neumann, "The effects of competitiveness and challenge level on virtual reality rowing performance," *Psychol. Sport Exerc.*, vol. 41, no. August 2017, pp. 191–199, 2019.
[30] J. Bolton, M. Lambert, D. Lirette, and B. Unsworth, "PaperDude: A Virtual Reality Cycling Exergame," in *Proceedings of the extended abstracts of the 32nd annual ACM conference on Human factors in computing systems - CHI EA '14*, 2014, pp. 475–478.
[31] S. Kharbach, S. S. Ahmad, N. M. Haj Ahmed, and N. Fetais, "Virtual Reality Falconry: Simulation of a Traditional Qatari Sport Methodology and Techniques," *2018 Int. Conf. Comput. Appl. ICCA 2018*, pp. 12–17, 2018.
[32] A. Rapp, "Drawing inspiration from world of warcraft: Gamification design elements for behavior change technologies," *Interact. Comput.*, vol. 29, no. 5, pp. 648–678, 2017.
[33] L. Chittaro and F. Buttussi, "Exploring the use of arcade game elements for attitude change: Two studies in the aviation safety domain," *Int. J. Hum. Comput. Stud.*, vol. 127, pp. 112–123, 2019.
[34] "Review of Virtual Reality trends (previous, current, and future directions), and their applications, technologies and technical issues," *ARPN J. Eng. Appl. Sci.*, vol. 12, no. 3, 2017.
[35] S. A. Alhadad, O. Ghazi, and O. G. Abood, "Application of Virtual Reality Technology in Sport Skill Hybrid Compression based Stationary Wavelet Transforms View project LOSSY COMPRESSION USING STATIONARY WAVELET TRANSFORM AND VECTOR QUANTIZATION View project Application of Virtual Reality Technolog," *Int. J. Acad. Manag. Sci. Res.*, vol. 2, no. December, pp. 31–40, 2018.
[36] N. Vignais, R. Kulpa, S. Brault, D. Presse, and B. Bideau, "Which technology to investigate visual perception in sport: Video vs. virtual reality," *Hum. Mov. Sci.*, vol. 39, pp. 12–26, 2015.
[37] F. Article, "Response in an Immersive Virtual," *Virtual Real.*, 2009.
[38] C. P. Hoffmann, A. Filippeschi, E. Ruffaldi, and B. G. Bardy, "Energy management using virtual reality improves 2000-m rowing performance," *J. Sports Sci.*, vol. 32, no. 6, pp. 501–509, 2014.
[39] J. F. Golding, "Predicting individual differences in motion sickness susceptibility by questionnaire," *Pers. Individ. Dif.*, vol. 41, no. 2, pp. 237–248, 2006.
[40] L. L. Arns and M. M. Cerney, "The relationship between age and incidence of cybersickness among immersive environment users," *Proc. - IEEE Virtual Real.*, vol. 2005, pp. 267–268, 2005.
[41] L. Liu, B. Watson, and M. Miyazaki, "VR for the elderly: Quantitative and qualitative differences in performance with a driving simulator," *Cyberpsychology Behav.*, vol. 2, no. 6, pp. 567–576, 1999.
[42] F. Rebelo, E. Duarte, P. Noriega, and M. Soares, "Virtual Reality in Consumer Product Design," no. June, pp. 381–402, 2011.
[43] O. Portillo-Rodriguez, C. Avizzano, O. Sandoval, A. Vilchis-Gonzalez, M. Davila-Vilchis, and M. Bergamasco, "Training Motor Skills Using Haptic Interfaces," *Haptics Render. Appl.*, no. January, 2012.
[44] D. Pierre, "What are the advantages and disadvantages of consumerism?," *Quora*, pp. 1–7, 2012.
[45] R. Tu, P. Hsieh, and W. Feng, "Walking for fun or for 'likes'? The impacts of different gamification orientations of fitness apps on consumers' physical activities," *Sport Manag. Rev.*, 2018.
[46] A. Matallaoui, J. Koivisto, J. Hamari, and R. Zarnekow, "How Effective Is ÐExergamificationÓ? A Systematic

Review on the Effectiveness of Gamification Features in Exergames," *Proc. 50th Hawaii Int. Conf. Syst. Sci.*, no. Hicss, pp. 3316–3325, 2017.