SERIOUS GAMES FOR PHYSICAL REHABILITATION: AESTHETIC DISCREPANCIES BETWEEN CUSTOM-MADE SERIOUS GAMES AND COMMERCIAL TITLES USED FOR HEALTHCARE

CATARINA VIEIRA
Universidade Católica Portuguesa,
School of Arts
Research Center for Science
and Technology of the Arts
catarina.vieira.28@hotmail.com

ANDRÉ PERROTTA
Universidade de Coimbra,
Informatics Engineering Department
Research Centre for Informatics and Systems
avperrotta@dei.uc.pt

CARLA PAIS-VIEIRA
Universidade Católica Portuguesa
Centro de Interdisciplinar de Investigação
em Saúde
cvieira@ucp.pt

https://doi.org/10.34632/jsta.2022.11732

Journal of Science and Technology of the Arts, vol. 14, n. 3 (2022): pp. 29-50

ABSTRACT

Serious games are videogames that are used with purposes that go beyond the mere entertainment of the player. Among their many applications, healthcare is one of the most prominent ones, as serious games can have a wide range of uses within this field, namely the physical rehabilitation of patients. For this purpose, both custom-made serious games and commercial entertainment titles, such as those Nintendo Wii, can be used. However, while custom-made serious games appear to be more clinically effective, patients tend to prefer the gaming experience of playing a commercial title. This paper aims to compare the game goals and the aesthetics of *Wii Sports* (a commercial title used in the context of physical rehabilitation) with custom-made serious games that have obtained clinically significant results in upper limb rehabilitation in order to try and understand what can be done to bridge the gap between these two approaches.

Keywords: Serious games; Videogames; Game design; Game aesthetics; Healthcare.

1. INTRODUCTION

It is part of human nature to seek to be entertained. Among the many possibilities available to us, such as cinema, books, and television, there is a form of entertainment that differs from the others as it possesses an inherently interactive nature — videogames.

Videogames have been around and accessible to the general population for two solid decades. Ever since their emergence in the seventies, this new media type has gathered avid fans, curious onlookers and a vast group of people who are seeking the feelings of entertainment, escapism, thrill, relaxation and presence that these videogames can provide, mainly due to their interactivity. As videogames became part of the culture of the 21st century, the exploration of their potential as a media format outgrew their use as a form of entertainment and, to reframe the characteristics that made videogames so enjoyable, videogames acquired new purposes. Serious Games (SG) were born this way. As the name states, an SG is a type of videogame that aims to go beyond mere leisure, tackling "serious" issues through the act of gaming. This concept emerged with Clark C. Abt in 1970. It referred to any kind of game (not necessarily digital) that had an explicit and planned educational purpose, therefore not intended to be played primarily for amusement, denoting that the player is still engaged in the game, experiencing feelings of autonomy and competence, while in contact with a product that tackles topics that are not considered pure entertainment (Abt, 1970). In this sense, SG allow for mundane tasks to be "gamified", making them more engaging and fun to users by imbuing them with elements that are commonly found in videogames. According to Michael Zyda (Zyda, 2005), this approach promotes collateral learning: SG offer the possibility of extended playtime while contributing to an ulterior motive. Thus, this premise was quick to seduce fields beyond education, namely military, business and, the most important one for the context of this paper, healthcare.

Within the field of healthcare, SG target two different types of end-users: patients and healthcare professionals. When SG are used among the latter, they often act as training tools to allow, for example, budding surgeons to practice delicate procedures in safe environments through the use of digital simulations and videogame elements. When patients are the end-users, SG for healthcare can target patient education, where they aim to teach the population about certain medical conditions and/or self-management strategies, they can target wellness and fitness, prompting users to exercise and keep fit, they can be used as distraction therapy tools whenever patients need to undergo painful procedures (e.g.: patients undergoing severe burn treatments), or they can be used as a rehabilitation tool, both physical and/or cognitive (Graafland et al., 2014; Laamarti et al., 2014; Michael & Chen, 2005; Wattanasoontorn et al., 2014).

All this talk about SG raises a question: what makes them different from regular videogames? In fact, regular videogames can be used as SG as long as the purpose behind their use is not the mere entertainment of the player (Lopes et al., 2018). This denotes that SG can be either

https://doi.org/10.34632/jsta.2022.11732

custom-made, meaning that they are games that are designed specifically for a serious end, or they can be commercial off-the-shelf (COTS) titles that are usually available to the general population, either in any local videogame store or, as the digital era roots itself more strongly, at the click of a mouse. Moreover, videogames, whether custom-made serious games or COTS used for serious purposes, can be seen as a key towards motivating patients to better adhere and cooperate with treatments that may bring discomfort to the self (Kato, 2010).

Taking a closer look at how SG can be used, in particular, for physical rehabilitation, it is possible to pinpoint some differences. While both approaches have been successfully used to tackle healthcare issues, acquiring clinically significant results in clinical trials (Avcil et al., 2021; Cuesta-Gómez et al., 2020; Jonsdottir et al., 2019; Norouzi-Gheidari et al., 2020; Popović et al., 2014; Saposnik et al., 2010), there is a problem that seems to persist. Previous studies (Jonsdottir et al., 2018) have shown that while custom-made SG are more clinically effective, COTS titles seem to do a better job at engaging patients and at making these same patients feel like their health is improving. While, as far as our knowledge goes, there are no studies aiming to understand what may be causing this rift, the most plausible explanation that can be raised as a hypothesis is related to the differences in terms of gameplay[1] and game design[2] quality which, in turn, relates to a monetary aspect. While COTS generally benefit from cushiony budgets to cover their production and design expenses, custom-made titles are not so lucky, which means that they have fewer funds to allocate to the various aspects behind the development of a game (such as programming, animation, character design, game design, sound design, UI[3] design, game writing). As such, some aspects must be prioritized over others and, often, game visuals are one of the primary victims of these smaller budgets.

In this sense, this paper has the main goal of understanding these differences by directly comparing SG that have been previously used for upper limb physical rehabilitation and have, in turn, managed to achieve significant clinical results in terms of motor function among their patients, to a commercially-available videogame that has been widely used for the same purpose — *Wii Sports*.

1. Refers to the features of a videogame that determine the way it is played.
2. Refers to the creation of the rules and content of a game, therefore dictating how the game should be played.

3. User Interface.

2. CUSTOM-MADE TITLES VERSUS COMMERCIAL OFF-THE-SHELF GAMES

2.1 OVERVIEW

As it was analysed in the previous chapter, one of the main contributors towards the differences found between these two types of games that can be used for serious purposes has to do with how large their production budgets are. Game design comprises several elements ranging from gameplay features to animation and sound effects. Different budgets will decide how much time (workers * hours) it can spend on each feature. This will lead to differences in game complexity which can potentially

https://doi.org/10.34632/jsta.2022.11732

hinder player motivation and enjoyment. Nevertheless, some elements are present in most games — a game without gameplay elements and, therefore, without interactivity cannot be considered a game (Lebowitz & Klug, 2011). In this sense, gamification elements must be present even if game graphics/visuals are kept simple and even if the game has no music or sound effects. Gamification can be defined as the process of adding game elements (also known as gameplay elements or mechanics) to a certain experience (that usually does not need to be a game) in order to make it more compelling, interesting and/or captivating (Llagostera, 2012). Besides the differences in budget that will culminate in quality differences, COTS and custom-made games are also different when it comes to their availability to the end-consumer (in this case, it would be a patient in need of physical rehabilitation). While COTS are relatively cheap and readily available, this is, anyone can have access to them and can play them for as long as they desire, custom-made titles do not work that way, as most of them are bound to clinics or rehabilitation centres, consequently limiting the possible patient exposure to that form of therapy. Additionally, these interventions are generally supervised by therapists, who monitor the patient's activity and calibrate the game to better match the user's progress and specific needs. On the other hand, COTS, by not demanding a therapist's presence, promotes feelings of independence and self-efficacy that are known to contribute towards patient empowerment, goal-directed training, cognitive behaviour modification and motivational theory (Chiu et al., 2014).

In order to try and go beyond the already plausible explanation that different budgets contribute to the enjoyment discrepancies found in custom-made SG and COTS used for serious purposes, this paper proposes a categorization framework that aims to compare the complexity of game visuals/graphics and the number of gamification elements between custom-made games and COTS, hypothesizing that differences in visual and gameplay complexity can lead to the already proven lower enjoyment, despite not negatively affecting clinical results in terms of upper limb motor function.

2.2 SELECTION PROCESS

For this paper, as its main objective is to present a direct comparison of the previously mentioned aspects found in both COTS and custom-made titles, it is crucial to understand which games are suitable to be included in this comparison. As such, we took into consideration a systematic review that had been previously conducted by the authors in 2020–202: "*Serious Game Design and Clinical Improvement in Physical Rehabilitation: Systematic Review*" (Vieira et al., 2021). However, we chose to refine the results even further. As such, we selected papers where custom-made videogames had been used for the physical rehabilitation of upper limbs, and where significant clinical results were found in the motor function of said limbs (4 papers present in the systematic review mentioned above matched these criteria). For the COTS title, *Wii Sports* (2006)

https://doi.org/10.34632/jsta.2022.11732

was selected as all the COTS studies included in the systematic review that is being reworked featured *Wii Sports* as the most commonly used COTS game. In the case of COTS, however, we did not take clinical result significance into account, as we only wanted to pinpoint which COTS title was the most frequently employed for physical rehabilitation purposes. Nevertheless, we narrowed our selection, only considering papers where *Wii Sports* had been used with the purpose of rehabilitating the upper limbs of disabled patients (three cases that answered these criteria were selected).

Moreover, in order to include games from works published in 2021 and 2022, an additional search was conducted, following the same search methodology used by (Vieira et al., 2021). As such, PubMed, IEEE Xplore and Cochrane were searched using the keywords: “serious games” AND “stroke” OR “cerebral palsy” OR “multiple sclerosis” OR “physical rehabilitation”. Posteriorly, search results from each database were merged and sorted for the removal of duplicates. This search brought to light 81 eligible papers, 12 of which were duplicates and thus were removed. Afterwards, titles, abstracts and full text were screened according to their relevance to the undergoing research. To be eligible to be included in this evaluation, papers must target upper limb rehabilitation through the use of a SG and show clinically significant results, at least, in terms of upper limb motor function. Additionally, the papers must offer factual information about the games that were used and must attach screenshots or pictures of the SG environment. This revised review found one paper that fit the criteria.

Adding both searches, five papers that used custom-made SG were found to be eligible to be part of the undergoing study. Concerning the selected papers that applied custom-made games as a physical rehabilitation therapy approach, two targeted post-stroke rehabilitation (Norouzi-Gheidari et al., 2020; Popović et al., 2014), two targeted multiple sclerosis upper limb rehabilitation (Cuesta-Gómez et al., 2020; Jonsdottir et al., 2018), and one focused on the rehabilitation of children who have cerebral palsy (Avcil et al., 2021). The studies where *Wii Sports* were used targeted post-stroke rehabilitation (Adie et al., 2017; Saposnik et al., 2010, 2016). Following this step, the games presented in this study were consequently analysed in terms of general gameplay, gamification elements and visual complexity.

2.2.1 CUSTOM-MADE GAMES

Jonsdottir et al. (2018) present a study that features a comparison between non-specified Nintendo Wii games and a custom-made SG targeting upper limb physical rehabilitation of multiple sclerosis patients. This SG was split into four scenarios, each requesting the players to either grasp, move or avoid on-screen objects through arm and hand movements. These scenarios aimed to depict a virtual home and its respective garden, therefore proposing activities that fit into this specific simulated environment. As such, the SG offers the player to enter four

https://doi.org/10.34632/jsta.2022.11732

scenarios: in the first one, the player must touch flowers and avoid bees; in the second one, the player is asked to move a basket across the table to capture falling objects; the third one implies that the user moves shapes across the screen from left to right, following a pre-designed trajectory and, in the fourth scenario, the player is asked to move different-coloured cans to the right side of a kitchen shelf. This compilation of SG scenarios is played using Kinect[4]. The main objectives of this kind of intervention were to improve movement coordination among patients, as well as reaction speed and timing, hand-eye coordination and space awareness. The Custom-made title presented by Jonsdottir et al. (2018) can be classified as a simulation[5] offering the kind of gameplay found in casual games 6 (simple and relatively short in length) and simulations. Additionally, the gameplay mode is exclusively single-player[6], the environments it depicts are a mix of simple and realistic, and the player interacts with the game in a first-person perspective[7]. As such, there are no visible player characters/avatars[8] (Vieira et al., 2021).

4. Movement sensor developed by Prime Sense for Xbox 360 and Xbox One.

5. Videogames that attempt to closely simulate aspects of real or fictional reality, providing enjoyment through re-enactment.
6. A game that is played by one player, therefore not featuring any type player/player interactions.
7. Graphical perspective rendered from the viewpoint of the player's character.
8. Refers to the player's representation in the game world.

Popović et al. (2014) presented a study where a group of post-stroke patients engaged in physical therapy using a three-stage SG. The first SG featured an exercise that required the patient to move the cursor across the screen to reach targets, which appeared in pseudorandom positions on the screen. Upon contact, the target would disappear, and the next target the patient had to focus on would appear somewhere else on the screen. The paper also states that the distance between targets would gradually increase during the course of the game. The second stage/exercise also required patients to move a cursor to a particular target, but, for the next target to appear, the player had to move the cursor back to the starting point (which was the centre of the workspace). In the third SG, the exercise consisted in following a target trajectory with the cursor. Upon completion, a new, and more difficult path would appear (Popović et al., 2014). This game can be categorized as belonging to the casual genre. In terms of playstyle, it offers a single-player first-person approach, therefore featuring no playable avatars. The environment where the game's action takes place can be considered realistic in terms of the kind of imagery they depict (Vieira et al., 2021).

Avcil et al. (2021) present a case study where two custom-made SG (part of the *HandROM* section of a SG system called *Fizyosoft™*[9]) were employed as a rehabilitation strategy for children who have cerebral palsy. The first game — CatchAPet — aims to touch rabbits coming out of holes by performing a repetitive wrist flexion-extension movement. In the second game, named *Leapball*, the player was asked to grasp a virtual ball with all fingers of one hand and, through finger extension, throw it. The study presented by the authors also promotes a comparison in terms of clinical efficacy between these custom-made SG, *Wii Fit* (for Nintendo Wii) and therapy as usual. Both digital approaches obtained better clinical results, particularly the custom-made games that, once again, were more effective than COTS in terms of clinical significance (Avcil et al., 2021). In this case, the custom-made SG that are part of the *HandROM Fizyosoft™* can be considered simulations within the casual genre. As for the type

9. http://fizyosoft.com/media/izyosoft_flyer.pdf

https://doi.org/10.34632/jsta.2022.11732

of game environment, the sceneries where the game's action takes place are a mixture of realistic and fantasy/cartoonized. Once again, this custom-made SG offers a single-player approach as well as a first-person gameplay, consequently foregoing the need to let the players use a visible player-character/avatar (Vieira et al., 2021).

In the study by Norouzi-Gheidari et al. (2020), the *Jintronix* system was used as an SG targeting upper limb rehabilitation. The user-system interaction is mediated by the Kinect camera, therefore allowing motion tracking. This system offers five different possibilities of activities to the patients. The first one's goal is to trace a horizontally or vertically oriented path on the screen. The second activity implies that the user has to reach for a target, while the third activity is slightly more complex, asking the player to move hands together to catch, carry and drop objects. The fourth activity's goal is to clap both hands together to catch an object between them, and the fifth and final activity asks the user to select and move kitchen objects. This system does not take finger motion into account; therefore virtual objects are manipulated when the hand is detected to have approached them, meaning that the participants are not required to flex/extend their fingers (Norouzi-Gheidari et al., 2020). Like the other custom-made games described previously, the *Jintronix* system offers single-player, first-person gameplay featuring simple-looking game environments. In terms of genre, the gameplay can be categorized as a casual game (Vieira et al., 2021).

In Cuesta-Gómez et al. (2020), six videogames were developed with the rehabilitation of multiple-sclerosis patients in mind: the *Piano Game, the Reach Game, the Sequence Game, the Grasp Game, the Pinch Game, and the Flip Game*. Motion was tracked through a sensor called Leap Motion[10]. The games targeted upper limb rehabilitation focusing on movements such as palmar prehension, finger flexion and extension, and/or hand pronation-supination. Additionally, the SG developed specifically for this study also aimed to employ strategies targeting cognitive training. As for the games, the *Piano Game* asks the user to play a 10-key piano (each key corresponds to one finger), following the pattern defined by the sequence of illuminated keys. In the *Reach Game*, the player is invited to reach for cubes that are placed in different spatial positions in a tridimensional environment (therefore, placed at different heights and different depths). The cube the player must touch gets illuminated, indicating the order the cubes should be touched (the order is randomized). Upon touch, the cube falls to the floor of the virtual space. To complete the game, the user must reach all cubes. In the *Sequence Game*, the scenario is the same as the one from the reach game, but this time, the user observes a sequence of cubes getting highlighted one at a time. Afterwards, the user is invited to memorize this sequence and reproduce it again by reaching for the cubes in the same order. In the *Grasp Game*, the player must also perform movements of grasping in coordination with reaching movements. This time, the cubes are placed around a red circle representing the virtual environment's centre. The player then has to grab the highlighted cube and then move it

10. https://www.ultraleap.com/product/leap-motion-controller/

https://doi.org/10.34632/jsta.2022.11732

to the red circle, keeping their fist closed. Upon contact, the patient must open their hand, releasing the cube. In the *Pinch Game*, the scenario is the same as in the previous games but, this time, the patient is asked to grasp the virtual cube between their thumb and index fingers, squeezing them together to make the cube smaller, until it disappears. Finally, in the *Flip Game*, the patient is asked to place the palm of their hand over the leap motion device and wait until a tray with a cube appears in the centre of the screen. The patient is then asked to turn the palm of their hand downwards, making the virtual cube fall to the ground (Cuesta-Gómez et al., 2020). In terms of gameplay, all six games are considered casual games that feature simple environments, and are played in a single-player mode, following a first-person perspective (Vieira et al., 2021).

In short, despite their differences in terms of gameplay, all custom-made titles target the rehabilitation of upper limbs, fall somewhere in the spectrum of casual games, and all of them are single-player games that are played in a first-person perspective, therefore not featuring any type of avatar that the player can control. All games, except for the one presented by Popović et al. (2014), position themselves as non-immersive virtual reality games.

2.2.2 *WII SPORTS*

As a game widely used to promote physical activity, *Wii Sports* was quick to reach rehabilitation centres as a novel approach to physical rehabilitation. Over the years, several studies have evaluated the clinical efficacy of *Wii Sports* as a potential physical rehabilitation aiding tool (Adie et al., 2017; Saposnik et al., 2010, 2016). *Wii Sports* is the first game of a franchise that launched with Nintendo Wii back in 2006 when it was considered a novelty within videogames of the genre. The title aimed to merge game mechanics with exercising as if one were actually participating in any of the sports simulated within the game. *Wii Sports* offers the player the possibility to partake in five different sports (that can be selected from the main menu): tennis, baseball, bowling, boxing, and golf. The interaction with the game happens through the motion sensor capabilities of the Wii Remote and of the Nunchuk[11]. As already mentioned, the gameplay of *Wii Sports* expects the player to move, while holding the remote, similarly to how each of the five sports compiled in this videogame would be played in real life. In this sense, the remote could play the role of, for example, a tennis racket if the player happened to be playing tennis, or a bowling ball, had the selected sport been bowling.

In terms of specific gameplay for each of the five sports, Tennis asks the players to try and hit a ball with a racket (in this case, the Wiimote acts as the racket); In Baseball, players have to try and score as many home runs as they can (the Wiimote represents the bat); in Bowling, the objective is to hit as many of the ten pins as possible (in this case, the Wiimote is playing the role of the Bowling ball); Golf expects players to try and get the golf ball into the whole with the least possible number of hits (here, the Wiimote acts as the club); Finally, in boxing, the gameplay

11. Extension controller that plugs into the Wii remote (Wiimote), the main controller for Wii games

https://doi.org/10.34632/jsta.2022.11732

involves more than one player. The match consists of three rounds, and the game will end if one of the players gets knocked out (here, the Wiimote and the Nunchuck are held as if they were boxing gloves). Summarizing, the gameplay of these games highly mirrors how these sports are played in real life.

Nevertheless, not all aspects are controlled by the players. In tennis, the player only controls how they would move the racket, but the computer does the actual player's movement (running across the court). Something identical happens with baseball, as the user is only in charge of batting and pitching. Fielding and base-running are controlled by the game, as it would not be viable to have the player run across the room to mirror the movement in the game world.

Wii Sports allows players to interact with the game in one of three game modes available: standard mode, training mode, or multiplayer[12] mode. In standard mode, the gameplay mimics each game's respective method of play. In training mode, players can practice particular aspects of each available sport and as they progress, they are rewarded with medals to symbolize their achievements. As for the multiplayer mode, it can be either 2-player or, in some games, *Wii Sports* allows up to 4 players. In most cases, if playing in multiplayer mode, players compete against each other, just like they would if they were playing the selected sport in real life. In tennis, however, players are asked to cooperate by playing together in a team.

12. Videogame play mode that allows for different users to play the game at the same time and interact with each other in either Player versus Player (PvP) or Cooperation (Co-Op).

2.3 *LEVEL OF GAMIFICATION*

To follow through with the objective of this paper, a review of the level of gamification found in each game described in the paper was conducted. For this purpose, a list of gamification elements was raised based on a premade list presented by Sienel, Münster, & Zimmermann (2021). The list in question is summarized, along with the definition for each gamification element, in Table 1.

https://doi.org/10.34632/jsta.2022.11732

Table 1

Gamification elements and their definitions (compiled from Sienel et al., 2021).

ELEMENT	DEFINITION
Achievement Symbol	Can also be known as "badges" (although they can come in many forms). They symbolize achievement but are not achievements by themselves. They are given to the user once they accomplish a certain intended task, therefore working towards making the user feel accomplished (Chou, 2016). These refer to virtual or physical items that aim to represent some type of accomplishment/achievement. These are usually obtained by completing varying challenges of equally different difficulty levels (Ferro, 2018).
Assessment	Refers to the act of measuring for a finite period (Swacha & Muszynska, 2016).
Avatar	Avatars are often customizable and contribute towards a sense of ownership which consequently works towards enhancing motivation by providing a representation of the player (Chou, 2016; Ferro, 2018).
Brag Button	A way for the user to "brag" about their accomplishments. A good example of this would be adding the possibility to share a screenshot of the user's high scores in a certain game to social media (Chou, 2016).
Challenge	Can be described as one of the most popular elements of gamification (Arango-López et al., 2017). Works towards making things meaningful: a trophy or badge without challenge is not perceived as something meaningful (Chou, 2016).
Choice	People tend to like something more when they are given a choice than whether they are offered a single option, therefore the importance of the presence of the choice element as part of gamification (Chou, 2016).
Collection Set	If there's something that's part of a set, it will awaken the desire within users to collect the remaining items/badges/ achievements to fully complete the set (Chou, 2016).
Crowning	A gamification technique for development and accomplishment (Swacha & Muszynska, 2016).
Difficulty Selection	A technique that allows the user to select a level of difficulty before they engage with the gaming experience (Ferro, 2018).
Discussion-board	A tool to promote discussion among players (Hallifax et al., 2019).
Feedback	A way of allowing players to know how they are performing and to adjust their performance in turn (Chou, 2016).
Gift	Items or rewards that can only be given to the users by other players (Chou, 2016).
Leaderboard	Game element that works towards ranking users based on a set of criteria that is influenced by the users' behaviours towards the desired actions (Chou, 2016). Generally based on parameters such as points (Ferro, 2018).
Level	The current "status" of the characters/avatar/user in the game that grants them certain stats and abilities (Chou, 2016). It is also a way of providing a sense of progress to a player (Ferro, 2018).
Number Limit	A limit of things a player can do: maximum level, total number of things a player can collect, and so on (Chou, 2016).
Performance Graph	A visual graphic that shows the user how they performed at a certain task (Chou, 2016).

https://doi.org/10.34632/jsta.2022.11732

Journal of Science and Technology of the Arts, vol. 14, n. 3 (2022): pp. 29-50

Permadeath	Permanent experience of the user as a player character. If a user wants to continue, they must start over from the beginning (Ferro, 2018).
Points	Something a user earns over time as they perform the desired tasks, according to their performance. Usually a numerical value (Chou, 2016).
Prize Pacing	A way to encourage users to proceed with the ongoing tasks until full completion (Swacha & Muszynska, 2016).
Progress Bar	Shows the user their progress towards achieving something and influences their behaviour (Chou, 2016). Can be described as a form of feedback that the application shows to the user in real time and allows them to see their advances constantly (Arango-López et al., 2017).
Record	A way to let the player know that they can complete the given task much better or much faster and attribute a reward upon setting a new personal record (Swacha & Muszynska, 2016).
Reward	Something of value within the context of the game/an item users get when they commit the desired actions and arrive at the win state (Chou, 2016).
Schedule	Determines the calendar the player/user must follow to complete the assigned tasks to get a reward (Hallifax et al., 2019).
Social Feedback	A way of providing an evaluation of behaviour (Finkelstein & Fishbach, 2012)
Social Graph	Gamification technique related to social influence and relatedness (Swacha & Muszynska, 2016).
Team	Refers to a group of people that work together to achieve a certain end (Chou, 2016). As a gamification technique, team provides a means of social interaction (Hallifax et al., 2019).
Time Limit	A way of limiting how long it takes a player to complete a certain objective; it usually triggers the sense that if a player does not act immediately, they will fail or lose the opportunity to act (Chou, 2016; Ferro, 2018)
Torture Break	Sudden and often triggered pause to the desired actions. It often comes with a relative timestamp based on when the break is triggered (e.g.: return 5 hours from now) (Chou, 2016).
Unlocking	Works towards opening a new possibility that was not there before a certain milestone is reached (Chou, 2016). This often requires the completion of prerequisite objectives (Ferro, 2018).

Gamification elements are intimately connected to gameplay mechanics which, in turn, affect the aesthetic value of videogames as they interfere with how the player interacts and engages with the game by either delimiting or creating new interaction opportunities. As such, interaction mechanisms implemented through gamification elements are essential to consider whenever a videogame is assessed for its aesthetic quality (Jurgensen, 2018). Additionally, gamification elements can be seen as a means to promote interactivity, heightening one of the underlying ideas behind the concept of "game" — it must be interactive (Lebowitz & Klug, 2011). Moreover, it is possible to affirm that interactivity is linked to unpredictability and, accordingly, the aesthetic experience of playing a videogame will vary according to the degree and source of the unpredictability of the game. In the case of single-player games, unpredictability is game-produced as, in these cases, interactivity is

Journal of Science and Technology of the Arts, vol. 14, n. 3 (2022): pp. 29-50 https://doi.org/10.34632/jsta.2022.11732

exclusively agent to non-agent — this is, the player interacts with the game itself. In the case of multiplayer games, interactivity is player-produced, as unpredictability stems from the interactions between players. Thus, unpredictability ensures that the experience remains interactive and does not turn into mere manipulation (Smuts, 2005).

In this sense, and according to the game descriptions provided in each of the five selected papers featuring custom-made SG approaches, each SG was evaluated according to its gamification elements (present/absent). As this paper aims to compare the discrepancies between custom-made titles and COTS, the same process was done for Wii Sports. It is important to note that, when it comes to custom-made SG, a lot of these are assumptions based on the game description and gameplay screenshots provided by the authors of the papers where the games were applied in a clinical setting, making the sources extremely limited. As such, it might be the case that not all gamification elements that are actually present in the custom-made games analysed for this paper are stated as such, as the authors of the present paper did not have access to these games to confirm their assumptions by playing them. The results are summarized in Table 2.

Table 2

Results of the analysis of gamification elements in custom-made SG for upper limb rehabilitation and in Wii Sports.

	Wii Sports	(Jonsdottir et al., 2018)	(Popović et al., 2014)	(Avcil et al., 2021)	(Norouzi-Gheidari et al., 2020)	(Cuesta-Gómez et al., 2020)
Achievement Symbol	Present	_____	_____	_____	_____	_____
Assessment	_____	_____	_____	_____	_____	_____
Avatar	Present	_____	_____	_____	_____	_____
Brag Button	_____	_____	_____	_____	_____	_____
Challenge	Present	Present	Present	Present	Present	Present
Choice	Present	_____	_____	_____	Present	_____
Collection Set	_____	_____	_____	_____	_____	_____
Crowning	_____	_____	_____	_____	_____	_____
Difficulty Selection	_____	Present	_____	_____	Present	Present
Discussion-boarw	_____	_____	_____	_____	_____	_____
Feedback	_____	Present	Present	Present	Present	Present
Gift	_____	_____	_____	_____	_____	_____
Leaderboard	Present	_____	Present	_____	_____	_____

https://doi.org/10.34632/jsta.2022.11732

Level	_____	_____	_____	Present	Present	_____
Number Limit	_____	_____	_____	_____	_____	_____
Performance Graph	Present	_____	_____	_____	_____	_____
Permadeath	_____	_____	_____	_____	_____	_____
Points	Present	Present	Present	Present	Present	Present
Prize Pacing	_____	_____	_____	_____	_____	_____
Progress Bar	_____	_____	_____	_____	Present	_____
Record	Present	_____	_____	_____	_____	_____
Reward	_____	_____	Present	_____	_____	_____
Schedule	_____	_____	_____	_____	_____	_____
Social Feedback	_____	_____	_____	_____	_____	_____
Social Graph	_____	_____	_____	_____	_____	_____
Team	Present	_____	_____	_____	_____	_____
Time Limit	Present	Present	Present	Present	Present	Present
Torture Break	_____	_____	_____	_____	_____	_____
Unlocking	_____	_____	_____	_____	_____	_____

This allows us to conclude that, as expected, *Wii Sports*, as a COTS title, has a slightly larger number of gamification elements (10 in total) implemented within the game, therefore offering more gameplay possibilities. Additionally, as *Wii Sports* offers the possibility for players to play one of five available sports, being able to skip from sport to sport also contributes towards a sense of novelty in terms of gameplay, even if the underlying premise (in this case, moving the Wiimote around to interact with the game) remains virtually the same. In turn, we hypothesize that both these conclusions may be connected to a higher level of motivation and engagement among players, as they possibly make the game be perceived as fuller, less repetitive and more complex.

2.4 VISUAL COMPLEXITY

Besides gamification elements, visual novelty is also known to be related to higher levels of motivation in videogames (Hocine et al., 2015). Additionally, it is not uncommon for the regular players to pick which games they want to play based on whether or not they like its graphics. Such attitude is particularly prominent in children: there may be lots of videogames available offering identical gameplay, but they will pick the games that appeal to them most, and that usually has to do with a game's visuals or pre-established familiarity with the game's setting

Journal of Science and Technology of the Arts, vol. 14, n. 3 (2022): pp. 29-50 https://doi.org/10.34632/jsta.2022.11732

(Subrahmanyam & Greenfield, 1998). In this paper, we tried to analyse the screenshots of custom-made games provided in the papers where they were used to try and evaluate them from a visual point of view. Some of the parameters we chose to evaluate were whether the game graphics depicted two-dimensional or tridimensional environments, the level of detail of said graphics and, if possible, the quality of animation. Within the two-dimensional virtual environment spectrum, we tried to understand the presence of depth, this is, if the game graphics only resorted flat-colored objects or if they used any sort of shadows and highlights to create an illusion of depth within the two-dimensional imagery. For tridimensional virtual environments, the objects were analysed in terms of the number of polygons used during the 3D modelling process (low poly[13] versus high poly[14]), and regarding whether or not textures were used on the models. We also tried to understand if game backgrounds/sceneries were flat colours, static pictures, static virtual environments, or animated virtual environments.

13. 3D computer asset (polygon mesh) featuring a small number of polygons (which can be defined as 2D shapes, identical to puzzle pieces, that are combined together to create virtual 3D objects).
14. 3D asset in computer graphics that is made of a high number of polygons.

Considering the custom-made games analysed in this study, four featured tridimensional virtual environments (Avcil et al., 2021; Cuesta-Gómez et al., 2020; Jonsdottir et al., 2018; Norouzi-Gheidari et al., 2020), and one opted solely for a two-dimensional virtual environment (Popović et al., 2014).

In the case of two-dimensional virtual environments, only (Popović et al., 2014) used a game that exclusively resorted to this kind of in-game setting. The objects and backgrounds used were shadowed but, even still, the level of visual detail offered by the game is low. The game's background seems to be static. In terms of object movement smoothness, the authors could not discern its quality since they did not have access to the actual game.

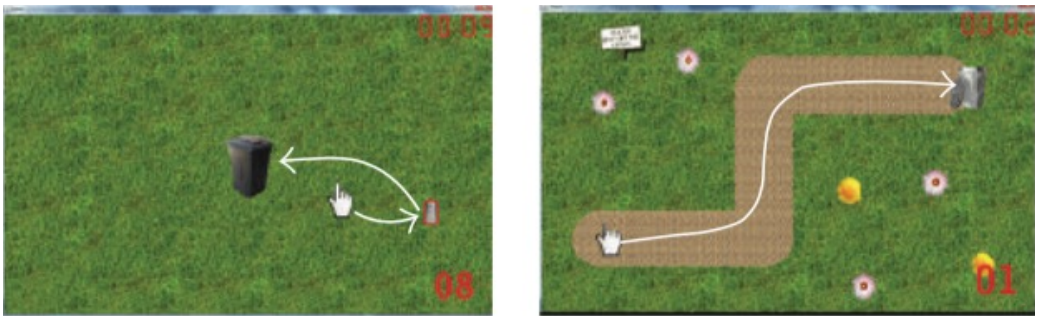

Fig. 1. Screenshots of the games used in the study by Popović et al. (2014)

Additionally, two of the four games presented by Jonsdottir et al. (2018) can also be classified as positioning the user inside a two-dimensional virtual environment. In this case, both games opt for a flat-colour approach and do not really seek to simulate any sense of depth. Once again, the backgrounds seem static and the only moving objects in the game are those directly connected to the gameplay's objective.

https://doi.org/10.34632/jsta.2022.11732

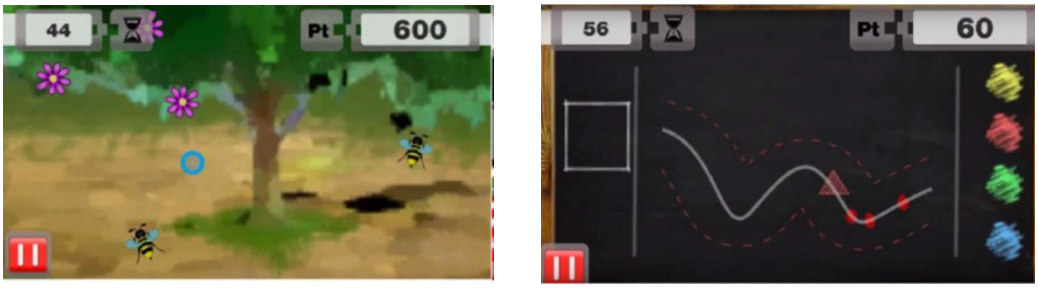

Fig. 2. Two-dimensional Environments in games from the *Rehab@Home* system (Jonsdottir et al., 2018)

Four studies featured games set in tridimensional virtual environments. Tridimensional virtual environments, unlike two-dimensional ones, are often linked to spatial immersion, which can be defined as a type of immersion that is both triggered and maintained by the spatial qualities that a virtual environment is imbued with. This type of immersion can be achieved through the manipulation of spatial compositions of the scene, aiming to trigger the release of adrenaline which, in turn, increases excitement and a sense of presence. This type of immersion appeals to the self's sensory-motor systems instead of aiming to attain immersion through a cognitive-emotional processing of, for example, a game narrative, therefore relying on the spatial qualities of the game's setting (Zhang et al., 2017).

Two of the games featured in the *Rehab@Home* system presented by (Jonsdottir et al., 2018) can be described as tridimensional environments, therefore positioning the player inside tridimensional rooms that aim to depict a kitchen. The entire game is modelled using a low-poly approach, keeping objects simple and details to a minimum. However, the objects in one of the games (Fig 3, on the left) are textured, therefore contributing to a higher sense of realism within the environment. The other game (Fig3, on the right) features basic objects in flat colours, therefore, less detailed.

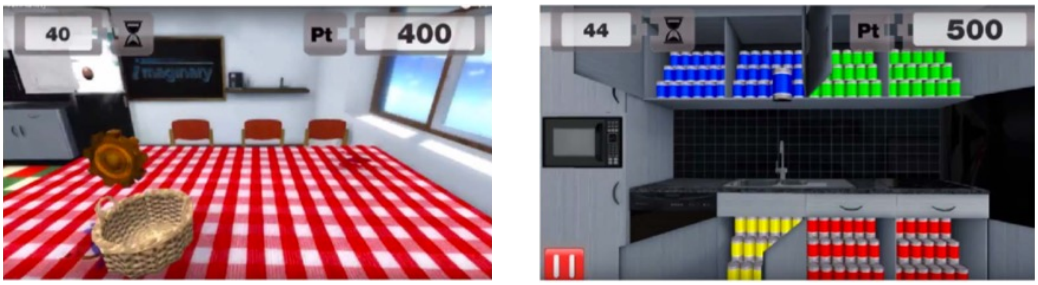

Fig. 3. Two-dimensional Environments in games from the Rehab@Home system (Jonsdottir et al., 2018)

Likewise, the games used in Norouzi-Gheidari et al. (2020) are equally tridimensional environments that rely on flat coloured objects added atop textured ground/walls that aim to simulate the environment where the game takes place (in this case, an empty room, like see on Fig.

https://doi.org/10.34632/jsta.2022.11732

4, bottom left; or a field, as it is seen on Fig. 4, top and bottom right). All objects are low-poly objects, and the level of detail is kept to a minimum. From the available screenshots, it is also possible to infer that the UI complexity is kept simple. Furthermore, the authors believe it is safe to assume that the game's backgrounds/settings are static.

Fig. 4. Jintronix Games (Norouzi-Gheidari et al., 2020)

In the games used in the study by Avcil et al. (2021), visual choices differ between them. In *Leapball* (Fig. 5, a), there is a mixture of non-textured 3D objects and textured 3D objects, all seemingly low-poly. Nevertheless, the level of detail is small, and the objects do not seem to be animated. Therefore, it is hypothesized that the only object movement is provoked by the players as they interact with the game. In *CatchAPet*, all objects are textured, and the level of detail found, mainly in the trees in the background, is much higher than that of *Leapball*. Despite this, all objects are low-poly in terms of 3D modelling complexity. Nevertheless, there is a clear mixture between an overly realistic game scenery and cartoonized rabbit "enemies". In both cases, UI is kept simple, favouring efficacy over the visual appeal, and is poorly designed (the pause button is unnecessarily stretched in *CatchAPet*, for example).

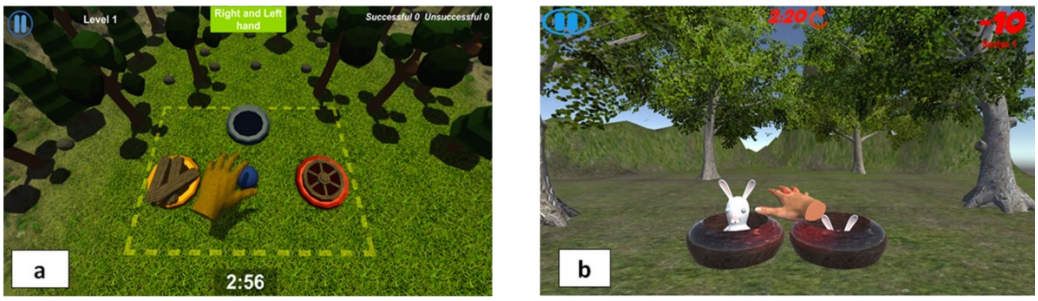

Fig. 5. a) Leapball; b) CatchAPet (Avcil et al., 2021)

Last but not least, and within the tridimensional spectrum, we have the games of the Leap Motion System presented by Cuesta-Gómez et al. (2020). In this case, all the games of this system fit the same visual

https://doi.org/10.34632/jsta.2022.11732

aesthetic and can be categorized as non-textured, low-poly tridimensional environments and objects, respectively. The game's scenery is static and, in the case of the piano game (Fig. 6, on the right), the background is nothing more than a flat colour. In terms of movement smoothness, it is not possible to draw any conclusions since, once again, the authors had no access to the game to evaluate this aspect.

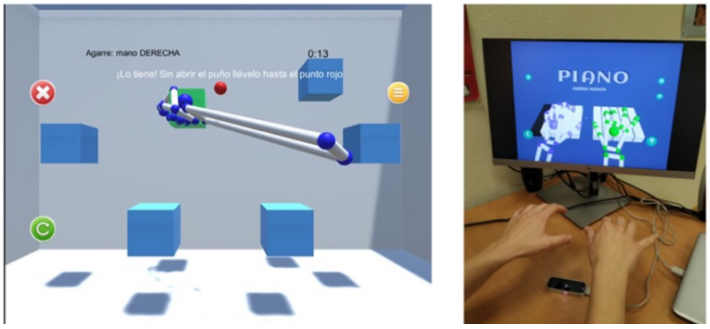

Fig. 6. Left) Grab Game; Right) Piano Game (Cuesta-Gómez et al., 2020)

Moving on to the realm of COTS and to *Wii Sports*, the gameplay moments of this videogame are based on tridimensional virtual environments, featuring animated backgrounds, low-poly characters as avatars (the Miis), and textured objects. The animations featured in the game are smooth to the eye, and movements (such as those performed by the avatars) are not uncoordinated, implying that the character's rigging was carefully achieved.

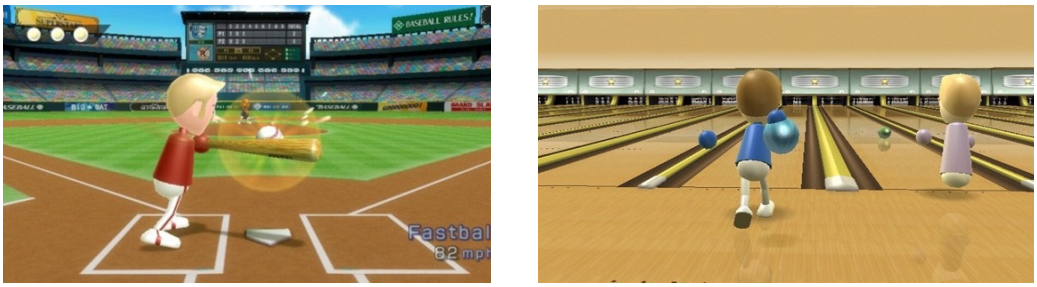

Fig. 7. Screen captures of *Wii Sports*: Baseball on the left, and Bowling on the right (*in https://www.nintendolife.com/games/wii/wii_sports/screenshots/*)

All of these aspects are in line with the idea that *Wii Sports* is primarily a game targeting mass entertainment that, as a Nintendo game, was developed by a large team and with a larger budget than those found among custom-made SG for health. Just like it happened with the gamification elements analysis, *Wii Sports* is visually more complex than any of the custom-made SG used in the studies reviewed in this paper which, possibly, contributes towards player motivation.

3. LIMITATIONS

The main limitation of the present paper has to do with the fact that the only game that the authors of this paper had access to was *Wii Sports*. All the custom-made games that were presented in their respective studies

https://doi.org/10.34632/jsta.2022.11732

were not accessible and, therefore, some of the conclusions drawn on their visual complexity as well as which gamification elements were used by these games might not be entirely accurate, as they were solely based on game descriptions and the screenshots provided by the authors of each study cited and analysed in the present paper.

Additionally, as the scope of analysed custom-made games was small — only 5 SG were considered — it is not fully possible to conclude that all custom-made SG for physical rehabilitation are poorly designed in both visual and gameplay aspects when compared to COTS. Moreover, it is also not possible to infer whether or not visual complexity, as well as the number of gamification elements are linked in any essentially relevant way to clinical success, as we do not know if more complex custom-made games would suffer the same fate concerning clinical significance as COTS. Further research with a higher number of custom-made SG for health that have obtained clinically significant results must be conducted in order to verify this hypothesis.

4. CONCLUSIONS

This paper had the objective of categorizing SG used for physical rehabilitation in terms of their visual complexity and use of gamification elements as a way to potentially compare custom-made SG to COTS and hypothesize on how the differences found in these two aspects can be the main cause of the enjoyment discrepancies found among patients. As was expected, *Wii Sports* is far more complex, both visually and in terms of gameplay, than its custom-made counterparts. The presence of more gamification elements enhances gameplay and game mechanics, giving the player a sense of having more to do than simply completing the same task over and over again (which is the case in the simpler custom-made games that fall into the casual game genre and that present the smallest number of gamification elements). As such, some gamification elements were prioritized over others, and the most common among custom-made SG were challenge, feedback, points and time limit.

This difference in game design reflects a common discussion topic in videogame theory, which tries to counter and entwine story and interactivity (or narrative and game mechanics) (Jenkins, 2004). However, in the context that we analysed (SG for healthcare), the lack of well thought and well-designed elements in custom-made SG is not a result of choice *per se*, but rather due to the lack of choice as a consequence of very limited development budget and development context that is very distant from that of the creative arts and sciences. This hypothesis comes to light when we note that while *Wii Sports* offers players the possibility of creating their own avatar, thus representing themselves, all the custom-made games analysed in this paper featured a first-person perspective, which automatically meant that there was no need to have a player avatar as a gamification element. Consequently, this will lower production costs, as the design and customization options of this gamification element are discarded. In this sense, presence/absence of a customizable avatar does

https://doi.org/10.34632/jsta.2022.11732

not seem to be linked to the clinical significance of results. Nevertheless, patient enjoyment is a crucial factor for better therapy compliance and adherence, and a larger plethora of gamification elements together with more appealing visuals can help bridge this gap by offering the players a prolonged sense of novelty that will work towards maintaining their interest in the game for longer periods of time.

REFERENCES

Abt, C. C. (1970). *Serious games*. Viking Press.

Adie, K., Schofield, C., Berrow, M., Wingham, J., Humfryes, J., Pritchard, C., James, M., & Allison, R. (2017). Does the use of Nintendo Wii SportsTM improve arm function? Trial of WiiTM in Stroke: A randomized controlled trial and economics analysis. *Clinical Rehabilitation*, 31(2), 173–185. https://doi.org/10.1177/0269215516637893

Arango-López, J., Ruiz, S., Taborda, J. P., Guitiérrez, F. L., & Collazos, C. A. (2017). Gamification Patterns : A Catalog to Enhance the Learning Motivation. *V Congreso Internacional de Videojuegos y Educación, December*, 1–7.

Avcil, E., Tarakci, D., Arman, N., & Tarakci, E. (2021). Upper extremity rehabilitation using video games in cerebral palsy: a randomized clinical trial. *Acta Neurologica Belgica*, 121(4), 1053–1060. https://doi.org/10.1007/s13760-020-01400-8

Chiu, H. C., Ada, L., & Lee, H. M. (2014). Upper limb training using Wii Sports Resort™ for children with hemiplegic cerebral palsy: A randomized, single-blind trial. *Clinical Rehabilitation*, 28(10), 1015–1024. https://doi.org/10.1177/0269215514533709

Chou, Y.–K. (2016). Actionable gamification. *Beyond Points, Badges, and Leaderboards*.

Cuesta-Gómez, A., Sánchez-Herrera-Baeza, P., Oña-Simbaña, E. D., Martínez-Medina, A., Ortiz-Comino, C., Balaguer-Bernaldo-De-Quirós, C., Jardón-Huete, A., & Cano-De-La-Cuerda, R. (2020). Effects of virtual reality associated with serious games for upper limb rehabilitation inpatients with multiple sclerosis: Randomized controlled trial. *Journal of NeuroEngineering and Rehabilitation*, 17(1), 1–10. https://doi.org/10.1186/s12984-020-00718-x

Ferro, L. S. (2018). An analysis of players' personality type and preferences for game elements and mechanics. *Entertainment Computing*, 27, 73–81. https://doi.org/10.1016/j.entcom.2018.03.003

https://doi.org/10.34632/jsta.2022.11732

Finkelstein, S. R., & Fishbach, A. (2012). Tell me what I did wrong: Experts seek and respond to negative feedback. *Journal of Consumer Research, 39*(1), 22–38. https://doi.org/10.1086/661934

Graafland, M., Dankbaar, M., Mert, A., Lagro, J., De Wit-Zuurendonk, L., Schuit, S., Schaafstal, A., & Schijven, M. (2014). How to systematically assess serious games applied to health care. *JMIR Serious Games*, *2*(2), e11. https://doi.org/10.2196/games.3825

Hallifax, S., Serna, A., Marty, J. C., Lavoué, G., & Lavoué, E. (2019). Factors to consider for tailored gamification. CHI PLAY 2019 — *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, 559–572. https://doi.org/10.1145/3311350.3347167

Hocine, N., Gouaich, A., Cerri, S. A., Mottet, D., Froger, J., & Laffont, I. (2015). Adaptation in serious games for upper-limb rehabilitation: an approach to improve training outcomes. *User Modeling and User-Adapted Interaction*, *2*5(1), 65–98. https://doi.org/10.1007/s11257-015-9154-6

Jenkins, H. (2004). Game Design as Narrative Architecture. *Computer*, 44(3), 118–130.

Jonsdottir, J., Bertoni, R., Lawo, M., Montesano, A., Bowman, T., & Gabrielli, S. (2018). Serious games for arm rehabilitation of persons with multiple sclerosis. A randomized controlled pilot study. *Multiple Sclerosis and Related Disorders, 1*9(August 2017), 25–29. https://doi.org/10.1016/j.msard.2017.10.010

Jonsdottir, J., Perini, G., Ascolese, A., Bowman, T., Montesano, A., Lawo, M., & Bertoni, R. (2019). Unilateral arm rehabilitation for persons with multiple sclerosis using serious games in a virtual reality approach: Bilateral treatment effect? *Multiple Sclerosis and Related Disorders, 35*(July), 76–82. https://doi.org/10.1016/j.msard.2019.07.010

Jurgensen, Z. (2018). *The Aesthetic Value of Videogames: An Analysis of Interactivity, Gameplay, & Player Performance*. University of Oklahoma.

Kato, P. M. (2010). Video Games in Health Care: Closing the Gap. *Review of General Psychology*, 14(2), 113–121. https://doi.org/10.1037/a0019441

Laamarti, F., Eid, M., & El Saddik, A. (2014). An overview of serious games. *International Journal of Computer Games Technology, 2014.* https://doi.org/10.1155/2014/358152

Lebowitz, J., & Klug, C. (2011). Interactive storytelling for video games: *A player-centered approach to creating memorable characters and stories.* Taylor & Francis.

https://doi.org/10.34632/jsta.2022.11732

Llagostera, E. (2012). On gamification and persuasion. *SB Games, Brasilia, Brazil, November* 2–4, 12–21.

Lopes, S., Magalhães, P., Pereira, A., Martins, J., Magalhães, C., Chaleta, E., & Rosário, P. (2018). Games used with serious purposes: A systematic review of interventions in patients with cerebral palsy. *Frontiers in Psychology, 9*(SEP). https://doi.org/10.3389/fpsyg.2018.01712

Michael, D. R., & Chen, S. L. (2005). *Serious games: Games that educate, train, and inform*. Thomson Course Technology.

Norouzi-Gheidari, N., Hernandez, A., Archambault, P. S., Higgins, J., Poissant, L., & Kairy, D. (2020). Feasibility, safety and efficacy of a virtual reality exergame system to supplement upper extremity rehabilitation post-stroke: A pilot randomized clinical trial and proof of principle. *International Journal of Environmental Research and Public Health, 17*(1), 1–11. https://doi.org/10.3390/ijerph17010113

Popović, M. D., Kostić, M. D., Rodić, S. Z., & Konstantinović, L. M. (2014). Feedback-mediated upper extremities exercise: Increasing patient motivation in poststroke rehabilitation. *BioMed Research International, 2014*. https://doi.org/10.1155/2014/520374

Saposnik, G., Cohen, L. G., Mamdani, M., Pooyania, S., Cheung, D., Shaw, J., Hall, J., Nord, P., Dukelow, S., Nilanont, Y., Rios, F. D. L., Olmos, L., Levin, M., Teasell, R., Cohen, A., Thorpe, K., Laupacis, A., Bayley, M., & Outcomes, S. (2016). *Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): a randomised, multicentre, single-blind, controlled trial. 15*(10), 1019–1027. https://doi.org/10.1016/S1474-4422(16)30121-1.Efficacy

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe, K. E., Cohen, L. G., & Bayley, M. (2010). Effectiveness of virtual reality using wii gaming technology in stroke rehabilitation: A pilot randomized clinical trial and proof of principle. *Stroke, 41*(7), 1477–1484. https://doi.org/10.1161/STROKEAHA.110.584979

Sienel, N., Münster, P., & Zimmermann, G. (2021). Player-type-based personalization of gamification in fitness apps. HEALTHINF 2021 — 14th International Conference on Health Informatics; Part of the 14th International Joint Conference on Biomedical Engineering Systems and Technologies, BIOSTEC 2021, 5(Biostec), 361–368. https://doi.org/10.5220/0010230603610368

Smuts, A. (2005). Are video games art? *Contemporary Aesthetics (Journal Archive), 3*(1), 6.

https://doi.org/10.34632/jsta.2022.11732

Subrahmanyam, K., & Greenfield, P. M. (1998). Computer games for girls: What makes them play? *From Barbie to Mortal Kombat: Gender and Computer Games*, 46–71. MIT Press.

Swacha, J., & Muszynska, K. (2016). Design patterns for gamification of work. *ACM International Conference Proceeding Series, 02–04–November–2016*, 763–769. https://doi.org/10.1145/3012430.3012604

Vieira, C., Ferreira da Silva Pais-Vieira, C., Novais, J., & Perrotta, A. (2021). Serious Game Design and Clinical Improvement in Physical Rehabilitation: Systematic Review. *JMIR Serious Games, 9*(3), e20066. https://doi.org/10.2196/20066

Wattanasoontorn, V., Sbert, M., & Girona, U. De. (2014). S*erious Games for e-Health Care Serious games for e-health care. August 2015*, 0–20. https://doi.org/10.1007/978-981-4560-32-0

Zhang, C., Perkis, A., & Arndt, S. (2017). Spatial immersion versus emotional immersion, which is more immersive? *2017 Ninth International Conference on Quality of Multimedia Experience (QoMEX)*, 1–6. https://doi.org/10.1109/QoMEX.2017.7965655.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer, 38*(9), 25–32. https://doi.org/10.1109/MC.2005.297.

Article received on 10/10/2022 and accepted on 18/01/2023.

https://doi.org/10.34632/jsta.2022.11732