

Towards Game Design Elements on the Perception of a Fun Game: an Exergame Case Study

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Abstract. Exergames, which combine physical activity and video games, present an innovative approach to promoting health and well-being. This paper aims to identify key game design elements contributing to the successful integration of physical activity and a fun gaming experience. The objective is to propose more effective and engaging game elements applicable to therapeutic activities. The paper discusses the development and results of an experiment exploring how design elements can alter the player's perception of fun. In a previously conducted systematic literature mapping (SLM), a diverse range of elements that impact the perception of fun was revealed. These findings served as the foundation for modifying an exergame, SIRTET, by incorporating selected elements. Thirty one responses were received from experts, with the majority holding a Ph.D. These responses indicated a consensus on the importance of the Feedback element, which was identified as the primary contributor to fun. However, there was uncertainty regarding the contribution of the Control Device to fun, which was recognized as a minor contributor.

Keywords: Game Design · Fun · Exergame · Serious Games.

1 Introduction

Serious games (SG) [10] have the potential to enhance player motivation by fostering interest and curiosity, thus engaging the user's emotions and promoting active engagement [2]. Furthermore, SG can amplify interest and effort during gameplay through providing immediate feedback and adaptability. This approach not only mitigates patient stress but also offers well-balanced challenges that cater to cognitive, emotional, or physical needs [2]. Some advantages of SG include motivation to carry out and continue treatment, being a fun activity, gaining results, and the possibility of measuring progress in rehabilitation [1].

According to Soares [12], SG minimizes negative factors in the rehabilitation process, generates greater attention, motivation and pleasure in treatment, and is considered positively associated with rehabilitation.

There are gaps in understanding about fun in SG, and, due to the serious nature of SG, they can enhance or hinder the benefits of SG. Serious elements in games can take the fun out of the game [9], just as fun can take the focus off the serious goal [3]. On the other hand, there are those who argue that fun can increase effort and motivation during use [6] and thus improve the results of the serious objective for which the game was developed. In a comparison made by Marsh et al. [9], it was found that the greater the fun, the greater the excitement and attention of the player; on the contrary, the less fun, the more frustrating and easy to get distracted the game will be. Furthermore, lack of fun in an SG can turn it into a “boring” tool, not achieving the objective of the game, damaging the experience and results [5].

Several elements lead to fun in games [8, 15, 7], and the results of the fun generated by these elements vary according to the genre of the game and, above all, how the player absorbs this experience. Fun is a recurring theme among researchers and designers in the field and is considered one of the great challenges of game design [14]. In addition, there is a list of constructs and outcomes that are related to fun and can change the experience in a SG [13].

The combination of motion capture technology and physical activity creates a new type of video game called exergames. These interactive experiences combine the classic gaming elements with physical exercise, offering a unique way to promote health and well-being.

Despite the increasing popularity of exergames, there is a gap in understanding how to optimize the design of these games for both increased physical activity and increased player engagement. The efficacy of exergames in promoting sustained physical activity depends not only on the integration of exercise, but also on the ability to make the gaming experience fun and motivating. This poses a multifaceted challenge that requires a nuanced understanding of the principles of game design that contribute to creating a fun game. This paper investigates the synergy between serious exergames and fun game design elements, with the primary goal of identifying key elements for the successful integration of physical activity and a fun gaming experience.

For the experiment, the serious exergame SIRTET [11] was used because it was specifically designed to help the elderly maintain balance. SIRTET has undergone testing and study, demonstrating its utility and effectiveness as an SG [12]. Within this experiment, certain elements of the game, acknowledged for their potential to enhance fun in an previously conducted systematic literature mapping (SLM)[13], undergo alterations. The anticipation of fun resulting from these modifications is then assessed through a questionnaire administered to developers and physiotherapists.

This research will assess the gaps in understanding about fun in digital games, seeking to reduce them and improve understanding on the topic. Through an

exploration of game design elements that generate fun, the objective is to provide insights guiding the development of more effective and appealing exergames.

The central question guiding this research is: How do game design elements influence the potential of an exergame to promote fun for the elderly, as perceived by experts?

The article is structured in 7 sections divided into 3 groups. First, the topic and related works are introduced. Then, the changes made to the evaluated game and how this evaluation was carried out are presented. Finally, the results are presented, discussed and a conclusion is drawn.

2 Related Work

SIRTET is an SG that uses a gesture-based interface to stimulate balance and reduce the risk of falls in the elderly [11]. This game was created using Unity engine, and is played on the computer using the Kinect as a control device.

SIRTET's basic mechanics is to issue a challenge composed of a set of objects to be touched (targets) or to be avoided (obstacles). These objects come from a distance in a tunnel where the avatar of the player is placed. Challenges were created and ranked according to its balance requirement considering a frail elderly as a player. These challenges were specified by a neurophysiotherapist.

The game was tested and studied [12], and the tests showed that the game can be a significant and facilitating tool in the treatment of balance in the elderly, improving not only balance but also mood and cognition of the players.

In a previous study, we analyzed various constructs and outcomes associated with fun on a SG [13] throughout a Systematic Literature Mapping (SLM), where the findings revealed a spectrum of factors that can change the perception of fun, including elements such as control device, level of balance, control mechanisms, rewards, competitiveness, difficulty, immersion, game mechanics, multi-user interactions, narrative, unpredictability, and the utilization of the virtual world. Through separate research efforts, each factor has been independently studied, revealing its unique contribution to the perception and varying levels of fun.

2.1 Methodology

This paper extends the review of these elements[13] by modifying the SIRTET game to evaluate their impact on fun. To pursue this objective, our approach is divided by 3 steps: redesigning the game SIRTET was performed based on the elements found by the SLM; then a questionnaire applied to game developers and physiotherapists was used to evaluate the new version in comparison to the previous one; and then, an analysis of the results.

The methodology involved analyzing and comparing different versions of each design element to determine which one generates more fun. Rather than directly assessing how these changes altered the perception of fun, the aim was to confirm that elements identified as fun-altering could positively influence a game's fun. Prior to implementation, each change was thoroughly discussed and analyzed to

ensure it would effectively enhance fun. The participant list was derived from articles discussing fun in digital games, ensuring that the selected individuals possessed relevant experience in the subject.

3 Redesigning SIRTET

Of the 13 elements listed in the SLM, 6 were selected according to the need and possibility of change within the chosen game. The 7 that were not changed were either already part of the game design, such as physical effort, or did not fit into the game's main design, such as competitiveness. Figure 1 shows a comparison between both versions.

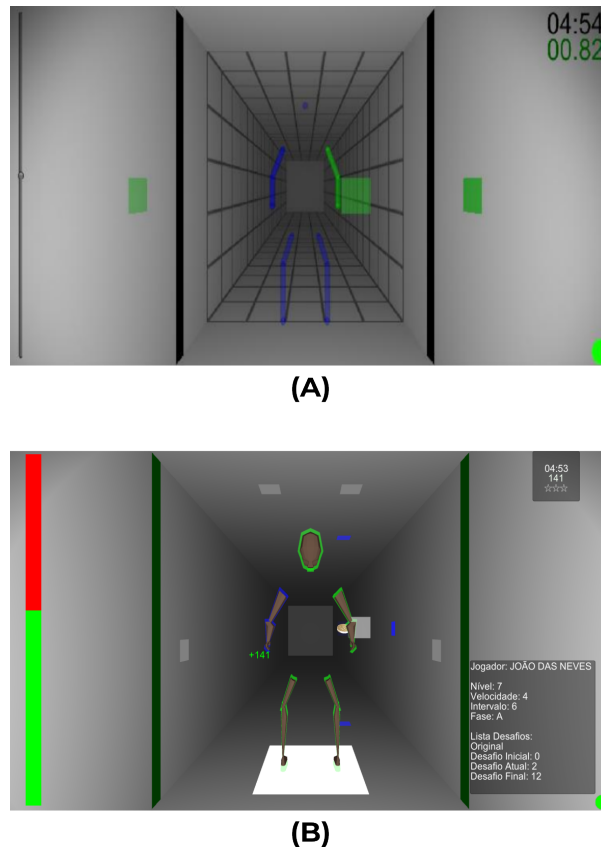


Fig. 1. SIRTET old (A) and new (B) versions

Control device Initially, the game used Kinect as a control device, which requires not only specific hardware but also a series of drivers and installers that are

currently difficult to access, as Kinect has been discontinued. To solve these problems, a motion tracker capture was created using MediaPipe [4], which uses a webcam as an input device to control the character. MediaPipe is an open source framework with several solutions for computer vision.

Control movement Control is related to the player’s mastery of the game mechanics. As the game is in second person (the player sees himself inside the game), the controls must be responsive and fast. To achieve this objective, tests were conducted involving different people. Some errors were identified and later corrected. After subsequent tests, no further errors were observed in the reading or behavior of the character of the game. The control was shown to be agile and responsive, allowing for a smooth gaming experience.

The original project did not see the need to promote jumping, since the game was created to help balance of frail elderly people and jumping was not in the scope as one of the actions carried out for this process. However, in tests carried out, and considering the possibility of expanding the project to new audiences, it was seen (based on comments from those who tested the game) the possibility of requiring the player to jump. In order to achieve this it was necessary to implement a solution for an the fact that MediaPipe did not recognize jumps.

Immersion Although the game is already immersive, some elements were included to increase this immersion. Initially, the character of the player was an green stick figure, to enhance the immersion, 3 human model avatars was added (see Figure 2), one female, one male and one neutral. The original avatar’s stick-figure remains and the player can change it at will.

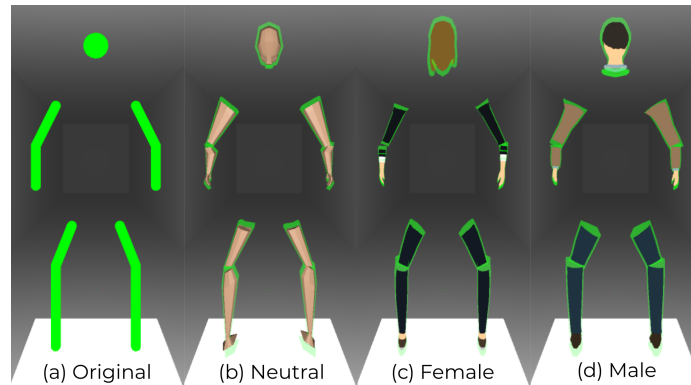


Fig. 2. New SIRTET characters

Unpredictability Initially, the game featured predetermined challenges. To introduce an element of surprise, a new mechanic has been developed with the

primary goal of surprising the player. This mechanic does not interfere with the existing object mechanics, but instead introduces an unpredictable element for the player.

From the beginning of the game, a surprise in the form of three stars will appear. These stars move towards the player at the same speed as the other challenges in the game. However, what makes them a surprise is the constant variation in their positions on the screen, since they move both vertically and horizontally. Collecting the stars does not change the game's score (a score used by the professionals), but is represented on the game screen for analysis and appears as a result in the reports.

Narrative and Aesthetics SIRTET does not have a complex narrative, consisting of blocks that move in a digital environment, requiring good spatial vision from the player. Due to the simplicity of the game, the possibility of changing blocks was studied in order to improve the aesthetics and, in a subtle way, incorporate a narrative. This change involved replacing game elements, transforming not only the appearance of the blocks but also modifying the player character from a green skeleton (previous version) to elements that help the narrative in wanting to touch (target) and evade (obstacle) from the objects, a factor in conjunction with immersion.

Targets (desirable objects) have been changed to look like coins, signalling to the player that these are the objects to collect. Obstacles (unwanted objects) have been redesigned in the shape of fireballs, indicating to the player that they must be avoided. The new and old objects can be seen in Figure 3, where the old target is shown in (a), the old obstacle in (b), the new target in (c) and the new obstacle in (d).

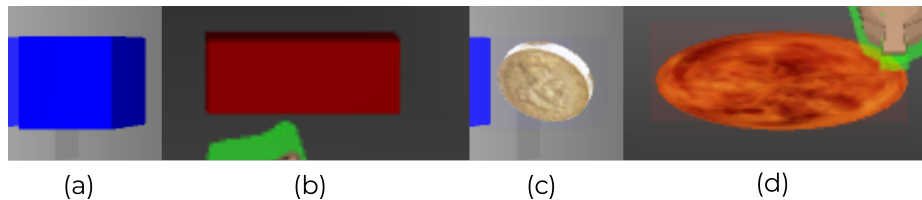


Fig. 3. SIRTET Objects

Feedback Other changes made to the game were related to feedback for the player, these changes were:

- The game screen shakes when the player collides with an object, a factor that also contributes to immersion;
- There is a border on the character to make it easier to differentiate the character from the background;

- The border changes color when colliding, going red if it collides with an obstacle and blue if it collides with a target;
- When colliding or missing the challenge, in place of the related object, the value in points that the player won or lost will appear;
- Point values are rounded to the player.

4 Design Evaluation

This evaluation seeks to analyze the design elements that can change the experience of fun in a digital game. The aim is to improve the therapeutic potential of serious digital games that provide more effective and pleasant experiences. To evaluate fun from a technical point of view, a questionnaire was created based on the changes made to the game. This was created using Google Forms to ask:

- (a) Which game design element most contribute to promote fun;
- (b) What are other elements that can increase the perception of fun from the perspective of the professional;

Most of the ways of analyzing fun in games found on the SLM were questionnaires, and were normally used to evaluate the fun of the game as a whole and not a part of it compared to the version without that part. The following questionnaire was developed.

- In section 1, the game and the objective of the research are mentioned, and a free and informed consent is requested from the subject. The research, the game and the following questionnaire are presented;
- In section 2, the demographic data of the subject is collected ('A' questions).
- In section 3, the SIRTET game is presented, taking care not to explain the current version of SIRTET, limiting the presentation of the game to the minimum as possible. If it is of interest to the subject, there is a link to the website in section 1 with all the data, images, videos and even the game itself to download, for free.
- Section 4 presents the game design elements that were changed from SIRTET. Questions B1 to B6 ask about: Control Device, Control Movement; Immersion; Unpredictability; Narrative and Aesthetics, and; Feedback). An image of each version is presented and the subject is asked which one contributes more to the perception of fun. Options include the following: Version A; Version B; None and; Both. The versions presented in questions B1 to B6 were randomly mixed, that is, not all Versions A are the old version of SIRTET and not all Versions B are the current version of SIRTET.
- Section 5 ends the questionnaire. In addition, the researchers' e-mails are presented again if the subject has any interest in getting in contact.

None of the questions were compulsory, and so some were not answered, in which case the value was not taken into account in the calculations.

5 Results

An email was sent to contacts inviting them to participate in the investigation. The contact list included 187 e-mails, extracted from the papers resulting from the SLM. These subjects have previously explored the concept of fun in games in their research, making them experienced in this area.

A total of 31 subjects answered the questionnaire, 19 were male and 12 female; their ages ranged from 22 to 71, with an average of 36.7 and a standard deviation of 11.4. Regarding to complete schooling, 2 had secondary education, 5 had higher education, 11 had a Master’s degree, and 13 had a PhD. The professional experience ranged from 0 to 55 years, with an average of 14.1 and a standard deviation of 11.94; regarding the level of knowledge on digital games, the average was 3.83 (on a scale of 1 to 5) and the standard deviation was 1.21. As for their area of work, 21 of them answered Technical, 5 Health, 1 Education and 4 Other (“Graphic Design, Illustration and Development of Pedagogical Games”, “Music Education”, “Project Management” and “UX Designer”).

Table 1 presents the subjects’ votes on which systems’ version they believe would better promote fun to players. The results are shown as Current and Previous version, but (we stress again) for the subjects each version was randomized between version A and B. Column Ag calculates the agreement by subtracting votes against from votes for the current version. Column Un calculates the uncertainty by adding votes from Both and None version and line \sum shows the sum of n (the number of votes) in each column. The color illustrates the highest (green) and lowest (red) results. The question used in the questionnaire is shown as a legend.

Table 1. Fun design questionnaire results

Question* ¹	Previous		Current		Both		None		Ag	Un
	n	%	n	%	n	%	n	%	* ²	* ³
B1. Control Device	5	16.1%	15	48.4%	9	29.0%	2	6.5%	10	11
B2. Control Movement	3	9.7%	28	90.3%	0	0.0%	0	0.0%	25	0
B3. Immersion	2	6.5%	25	80.6%	4	12.9%	0	0.0%	23	4
B4. Unpredictability	4	12.9%	23	74.2%	4	12.9%	0	0.0%	19	4
B5. Narrative and Aesthetics	1	3.2%	27	87.1%	3	9.7%	0	0.0%	26	3
B6. Feedback	0	0.0%	31	100.0%	0	0.0%	0	0.0%	31	0
\sum	15		149		20		2			

*²Ag = Current - Previous;

*³Un = Both + None

*¹ Regarding “DESIGN ELEMENT”, which version(s) below do you consider can contribute most to the perception of fun?

B1 displayed the highest uncertainty (Un = 11) among the subjects and had the lowest agreement value (Ag=10) among the questions, suggesting that altering control devices (i. e. using Kinect or a Webcam) may not significantly

impact the perception of fun. This result could also imply that the specific example presented in the redesign was not sufficient to generate a consensus among subjects.

The design element with highest agreement to the current version was Feedback (Ag = 31). This emphasizes the important role of feedback in enhancing the perception of fun in digital games.

All 31 subjects provided responses to questions B1 to B6, and consensus emerged on the perception that the current version incorporates game design elements that significantly enhance the game’s fun aspect. The total count of 149 votes for the current version signifies a clear inclination toward the modified aspects, implying their significant impact on the overall fun of the game. This substantial support underscores the effectiveness of the modifications and offers insights for further analysis of the specific modifications made to the game.

The three most voted questions to the current version were: B6 (Feedback, n=31), followed by B2 (Control Movement, n=28) and, in third place, B7 (Narrative and Aesthetics, n=27), highlighting the influence of these elements in changing the expectation of fun in the game, especially feedback due to its unanimous votes. Except for the least voted question in the current version (B1 - Control Device), all others questions obtained votes and an Ag value above 60% (majority). Only B1 (Control Device) received less than 50% of the votes in favor of the current version, indicating a relatively smaller but still positive contribution to perceiving the game as fun.

6 Discussion

Most of the subjects that answered the questionnaire had a doctorate or master’s degree. The vast majority of subjects were from the technical area such as game design experts which is the focus of this research.

In terms of the game design elements that can contribute more to fun (B1 to B6, Table 1), the subjects perceived the current version to be more fun in all six elements studied, even without knowing which version is the current one. Feedback is the most chosen design element in the current version, selected by all 31 participants (100%). In contrast, Control Device was chosen by the lowest number of subjects, with only 15 participants (48.4%), making it the only element below 74% of responses. Feedback plays a crucial role in gaming, with the potential to completely transform the player experience. In contrast, the Control Device has not received the same emphasis, although it is fundamental to gameplay. Based on the participants’ opinions, quality of technology has a relatively limited impact on fun, since, when it is efficient, it tends to become seamless. These results highlight the importance for the gaming experience of incorporating elements into the design that can attract and engage the player.

Although the “Both” and “None” options were included, they were selected less frequently, which points to a clear preference and distinction between the versions presented. In the evaluation, only ‘Control Device’ got responses in the ‘None’ option, with two participants voting for it. Meanwhile, the ‘Both’

option had a total of 20 votes, spread among 4 game design elements. This varied distribution highlights the diverse perspectives and uncertainties among participants, especially regarding the role of ‘Control Device’ in enhancing the expectation of fun in a game.

The Un value was employed to illustrate uncertainty in the results, calculated as the sum of n values from Both and None votes. The findings indicate that ‘Control Device’ generated greater uncertainty among the subjects with an Un value of 11. In contrast, ‘Feedback’ and ‘Control Movement’ exhibited 0 in the uncertainty value, signifying a clear understanding among subjects regarding the contribution of these elements to the perception of fun in an exergame.

The Ag value serves to visualize the agreement among the results, representing the difference between the votes to the current version and to the previous version. The findings indicated a substantial agreement for the ‘Feedback’ and ‘Narrative and Aesthetics’ elements. Conversely, ‘Control Device’ had the lowest Ag value. Thus, the conducted experiment suggests a consensus that ‘Feedback’ is more likely to promote the perception of fun, while ‘Control Device’ raises uncertainties regarding its contribution to the anticipation of fun. Another noteworthy element is ‘Control Movement’, which obtained 28 votes, stressing its importance in shaping the expectation of fun.

The study is primarily geared towards evaluating the overall gaming experience. This focus poses a potential threat to the validity of the study, as it constrains the scope of analysis. Additionally, the study encounters validity concerns due to the restricted selection of elements considered significant for the game. The limitation stems from not assessing all resulting elements in game design, potentially impacting the generalizability and completeness of the findings. It is worth noting that the choice of each game element was made based on suitability and project requirements.

7 Conclusion

Exergames stand out as innovative tools that integrate fun, learning, and health. This research investigated the expectations of fun related to game design elements applied in an exergame aimed at improving balance in the elderly. The objective was to understand the dynamics that contribute to fun in exergames to optimize the potential of these tools providing more effective and pleasurable experiences. A questionnaire was sent to experts asking about the contribution of some design elements to the perception of fun in an SG in an updated version it. The current version was considered the one that most aroused expectations of fun in the experts’ assessment.

We explored the synergy between six elements of game design for fun and their impact on exergames. The results indicate that all the implemented changes generated heightened expectations of fun, as observed by experts. Notably, Feedback emerged as the primary element in seamlessly integrating fun with physical activity. Feedback was identified as the primary contributor to fun, while Control Device was recognized as the minor contributor to fun. “Feedback” and “Control

Movement” exhibited zero uncertainty, contrasting with the higher uncertainty observed in the case of “Control Device”.

In response to the research question guiding this study, we conclude that game design elements have varied influence on the game. While all elements play a role in shaping the player’s experience, their impact varies, with some exerting a stronger influence than others. Certain elements possess a higher potential for negative outcomes than positive ones, and when executed seamlessly, they might go unnoticed by the player. It is essential to take into account the intended audience when creating a game to guarantee that the components are in harmony and lead to a pleasant experience for the player. Therefore, crafting a fun game requires a focus on elements that can detract from the fun, rather than solely emphasizing those that contribute to it.

Based on the case study conducted, we recommend prioritizing the emphasis on specific elements to enhance the fun factor in the game. Key elements include **Feedback** and **Control Movement**, which, when executed **effectively**, contribute **positively** to the perception of fun. In contrast, **poor** execution Feedback and Control Device elements may **decrease** the fun, making the game a less engaging and potentially boring experience. Therefore, **taking care not to take away the fun is easier than creating it**.

Future investigations should expand beyond the current scope, encompassing various game genres like fighting, puzzles, FPS, and racing. This broader approach aims to generate diverse observations about the fun experienced through the modification of these elements. Additionally, there is a need to explore the integration of other game design elements. The SLM[13] outlines several elements contributing to fun, including the seven proven elements overlooked in the SIRTET redesign. This exploration should not only encompass initially considered elements but also those that might influence the perception of fun. Furthermore, the exploration and identification of additional design elements capable of altering the perception of fun deserves attention in future studies.

This research corroborates what was previously found in the literature where all game design elements added to an exergame were found to contribute to promoting fun. The comments provided by the experts not only contributed to improving the game, but also enriched the research, deepening the overall understanding of the concept of fun their point of view.

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