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Research Article

Development of a Gesture-Based Game Applying Participatory Design to Reflect Values of Manual Wheelchair Users

Alexandre Greluk Szykman, André Luiz Brandão, and João Paulo Gois

Federal University of ABC–UFABC, Avenida dos Estados 5001, Santo André, Brazil

Correspondence should be addressed to André Luiz Brandão; brandao@daad-alumni.de

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Wheelchair users have been benefited from Natural User Interface (NUI) games because gesture-based applications can help motor disabled people. Previous work showed that considering values and the social context of these users improve game enjoyment. However, the literature lacks on studies that address games as a tool to approach personal values of people with physical disabilities. Participatory design encompasses techniques that allow absorbing and reflecting values of users into technologies. We developed a gesture-based game using participatory design addressing values of wheelchair users. To manage the development of our game, we permitted creativity and flexibility to the designers. Our design is aligned to the Game SCRUM and make use of concepts from the Creative Process. The products of each stage of the design that we applied are both a gesture-based game and its evaluation. We tested the *enjoyment* (immersion, difficult while playing, etc.) of users for the game that we developed thought game-based quantitative and qualitative analyses. Our results indicate that the game was able to provide a satisfactory entertaining experience to the users.

1. Introduction

Practicing exercises has been proven to develop physical, social, and cognitive capabilities of wheelchair users [1, 2]. Further, researchers showed that exercises lead wheelchair users to have a better life quality than able-bodied people who do not practice [3]. Nevertheless, in the current social context, wheelchair users have reduced opportunities to participate in group physical activities [1, 2]. Researchers have been tackling this issue with the development of exergames, where users perform physical exercises while interacting with the mechanics of digital games [1, 4]. User interaction with exergames often employs Natural User Interface (NUI) through motion capture [5]. There is evidence that people with disabilities, including wheelchair users, become motivated while practicing solo or group exercises through interaction with NUI-based games [6].

Szykman et al. [6] described the panorama of the research involving people with physical disabilities and NUI-based games developed until the year of 2015. The authors sought answers to the question "How are researchers conducting studies with NUI games and people with physical disabilities?". Szykman et al. [6] evidenced the importance of the development of NUI games for people with disabilities through two main observations: (1) 35% of the users who went through a treatment involving NUI games declared some form of improvement in life quality and (2) 95% of the researchers that measured the users' enjoyment for the developed games pointed out that the users had a positive experience.

Most of the gesture-based games have their main focus on the development of the rehabilitation of the users [6]. Examples for rehabilitation are games whose users' interface is structured upon the necessary movements for physiotherapy after a stroke or cerebral palsy. Szykman et al. also observed that there is a small number of games that focus on the inclusion of people with physical disabilities into society. An example of inclusion is a game that allows people with an amputated arm to play together with able-bodied people.

From the designing side, Gerling et al. [7] analyzed the importance of cooperation between experts and wheelchair users in the development of games with participatory design (PD). The authors concluded that expert designers who are not wheelchair users had more positive expectations about

the representation of disabilities in a game content than wheelchair users. We understood that the process as a whole has benefited from the balance between insights of those two roles. They also mentioned that the manner in which the disability is represented in the games influences the positive experience of the game. In general, the enjoyment was higher when the act of overcoming the handicap was represented in a manner that empowered users [7]. That insight converges to the conclusions of Hutzler et al. [8] and Szykman et al. [6] about representing tools for overcoming disabilities as personal values of users in the game.

In 2016, Gerling et al. [9] represented the values of young powered wheelchair users in the design of gesture-based games through the application of PD techniques. The authors elicited the participants' values for self-perception, gaming preferences, and gesture-based play. The results, based on testimonials from the users, showed that the positive player experience of the game was substantially satisfying with the representation of their values in content [9].

We describe the design that we conducted to the creation of a gesture-based game with manual wheelchair users. We based the design aligning it to Game SCRUM and on concepts of participatory design. Besides, the design activities that occurred during our design also took into account aspects of Creative Process to aid the emerging of users' values. We measured the enjoyment, e.g., immersion and difficult while playing, of users towards the developed game with quantitative and qualitative analysis. The evaluation of the game indicates that the design that we applied lead to a productive game. The contribution of this paper is the description of the design of a gesture-based game that reflects values of wheelchair users employing participatory design. Specifically, this work aims to develop a game focused on entertainment that reflects the values of the wheelchair users with the purpose of entertainment.

We organize this paper as follows. In Section 2 we present value-guided approaches, from seminal studies to those closer to our approach. In Section 3 we present our design, detailing the set of sessions that composed it as well as aspects of the game we developed. After that, in Section 4 we evaluate the gesture-based game that we developed, in which wheelchair users and their relatives played together. In Section 5 we discuss how the concepts we employed influenced the design. We also compare our design sessions with those ones in previous studies and discuss the values emerged along the PD sessions. In Section 6 we detail limitations of our study. In Section 7 we conclude the present work.

2. Value-Guided Approaches to Design

The interest for and the distinct conceptualizations of human values have been continuously present in several areas, e.g., computer ethics, social informatics, and participatory design [11]. Nonetheless, a significant challenge when taking into account values in the design process arises. Precisely, values, which are naturally controversial or conflicting, not always are natural to be detected and incorporated into the technology. Such a challenge, as well as the different views of values, has led the HCI community and correlated research areas to produce fruitful studies, reflections, and methodologies to elucidate values into the development of technologies. One common aspect of the main studies is that values must be dominant and central in the design process [12–15].

Friedman and colleagues presented seminal studies about the *value-sensitive design* (VSD) [11, 16, 17]. The starting point of VSD is the values that center the human well-being, dignity, rights, and justice and welfare. The VSD methodology relies on an iterative process that combines a tripod of studies: conceptual, empirical, and technical [11]. Such studies provide a rich set of questions, from philosophical to technical aspects, to be answered and refined along the design process.

Cockton [13] addressed the importance of redefining, focusing, and, consequently, recreating Human-Computer Interaction (HCI) as a design discipline. From a historical reflection of HCI, beginning at the System-Centered 70s to the Context-Centered 90s, Cockton converged to the Value-Centered HCI. For value-centered design, the author argues that the framework must be tailored around three processes [18]: opportunity identification, design, and evaluation and iteration.

These previous works provided comprehensive value-centered frameworks, as well as taxonomies and lists of general values. However, recently, authors have made significant questions about such studies [12, 14, 15, 19]. They are concerned about proposing more dynamical and flexible approaches for identifying and applying values in the design process. Iversen et al. [12] firstly paid attention to how PD has deviated from its original principles, i.e., from the Scandinavian traditions. The authors highlighted that the use of PD methods, e.g., the most common, having stakeholders during the design process, does not qualify a work as PD. They emphasize that PD is "about negotiating values". According to them, values are dynamic and emerge by a dialogical process, distinctly from previous studies [20]. The values interact recursively with the design process while permeating the whole process. In that sense, Iversen et al. approached techniques to mediate the emergence of values in the design process [21]. Halloran et al. [19] grasp values as a spontaneously emerging and dynamic resource for codesigners. They found that values are susceptible to changes; more specifically, the main question is not about identifying values, but a process for rethinking the values. They observed the need for a codesign approach that, as well as making use of preselected values, also integrates values that emerge during the process.

The theme of values has also permeated game design [22–25]. Flanagan et al. [23] emphasize the difficulty of designers in balancing their values with those from other sources. In their work, the authors proposed a framework, based on a working list of important values related to the project. Such values arise from designers, stakeholders, users, and previous work, project goals, and further hypotheses. Kultima and Sandovar [24] also proposed a set of categories of game design values, among them, the value of artistic expression, social impact, and commercial values.

For wheelchair users' games, Gerling et al. [9] presented the closest work to our approach. The authors employed

PD for developing a gesture-based game centered on players with mobility impairment. The authors focused on players' preferences and perspectives on the value of gesture-based play. It is worth mentioning that the studies from Gerling and colleagues [9, 10] are very expressive in addressing the development of gesture-based games for wheelchair users with participatory design. They observed that previous work [4, 26, 27] about wheelchair users with gesture-based games did not employ participatory design during their development. In counterpart, their resulting studies [7, 9, 28] led to relevant insights in including wheelchair users as designers in the game development as well as considering values in the design process.

Based on previous studies [6, 9], we noticed the importance of exploring the value of a gesture-based game for wheelchair users. As Iversen et al. [12], in our work, values emerged from a dialogical process, however, the tight schedule imposed by SCRUM leads to not having several sessions for refinement of the values. As observed by Friedman [16], the identification of codesigners is one of the most relevant steps while conducting a value-sensitive design. We also believe this observation is significantly relevant. In this sense, we seek codesigners that are both wheelchair users and sports practitioners. Particularly, they are tennis practitioners. We also considered as our codesigners the coaches of the wheelchair players.

3. Designing a Gesture-Based Game with Wheelchair Users

The design team consisted of eight members: the five codesigners (three wheelchair users and two able-bodied, who are their tennis coach and physiologist.), henceforth named *participants,* and three authors of this study, henceforth called *researchers*.

The coach and physiologist have a degree in physical education and are the oldest participants. Among the wheelchair users, people are from elementary school to undergraduate in health sciences. All of them are tennis practitioners. Also, the wheelchair users enjoy playing digital games. Notably, the men like to play fighting and soccer games while the girl enjoys dancing games.

The researchers not only acted as facilitators and developers but also have participated in design activities. We invited the codesigners among members of the tennis organization *CR Tennis Academy*, in the city of São Caetano do Sul, Brazil. We identified the participants by labels, summarized in Table 1. Fiorilli et al. [2] suggest the functional classification criteria of the *International Wheelchair Basketball Federation* (IWBF Table) to classify the functional abilities of users in a range from 1.0 (little or no controlled trunk movement) to 4.5 (normal trunk movement in all directions). Two of the wheelchair users have paraplegia, one classified as 3.0 and one as 4.5. The other wheelchair user has quadriplegia, scoring 2.0, respectively.

We conducted five sessions of participatory design. According to previous studies, we time-marked our sessions to 60 minutes [30]. This time limit aims to avoid fatigue and the pressure under the participants and keep their focus. Before the beginning of each session, we announced the time limit to all participants.

Every PD session occurred after a wheelchair tennis practice by the participants. Since our participants always wanted to make productive contributions, an effect of an agreed-upon time limit was that participants tried to resolve future discussions timely instead of getting lost in endless arguing.

All sessions were video-recorded to capture the information of the design as a narrative [9, 31]. The application resulted in a reviewed prototype of a gesture-based game. For the artistic assets, we had the support of the Jecripe Project (https://jecripe.wordpress.com/english/).

The role of the participants during the sessions, as "experts of their own lives", included providing information based on their values to nourish the participant's Creative Process. Furthermore, they participated in identifying and prioritizing requirements, evaluating prototypes, and interpreting and discussing collected data. The tasks of our role as researchers are listed below [31]:

(i) Explain the objectives of the design activities in each PD session

(ii) Facilitate discussions among participants

(iii) Document data coming from participants

(iv) Abstract the resulting information in the game elements considering the technical feasibility of their implementation

(v) Discuss the results with the participants taking into account the findings in our previous studies and good practice in participatory design in the literature

3.1. Session 1: Introducing the Framed Problem. Our design initially required researchers to pursue an analysis of the population and social impact and used technology for the game to be developed. Our research is detailed in a previous work [6] and resulted in a problem framing: *How to develop a gesture-based game for wheelchair users focusing on their values and social context?* In this session, we introduced the *framed problem* and conducted a conversation to settle the participants. Our objective was to capture relevant elements from values of the participants. The discussion flowed freely, and the participants did not seem to worry about the final goal (the game). The main topics of the conversation were objects or events of interest of the participants, such as the sports that they used to practice and obstacles of their daily life. We defined and conducted a design lasting 60 minutes and with a theme focused on *elements of interest of the participants*. Figure 1 shows a photo of the first session; the meeting format of the other sessions was similar to that one shown in the figure.

As supporting materials for the creative stimulus of the participants, we provided paper, pencils, colored pens, scissors, and glue, following the observations from Pommeranz et al. [30], who investigated how the use of such materials can influence the creativity stimulus during design sessions. Thus, we made such materials available to participants to help them express their ideas. Nevertheless, we did not set specific rules for the use of materials. We noticed that all participants

Table 1: Characteristics of the codesigners (participants).

Label	Role in PD	Age	Sex	IWBF Classification
A	Wheelchair User	26	Female	2.0
B	Wheelchair User	40	Male	3.0
C	Wheelchair User	34	Male	4.5
D	Tennis Coach	58	Female	4.5
E	Physiologist	53	Female	4.5

Figure 1: Participants A, B, and C during the first PD session: they used paper and pencil to annotate their insights.

adopted the practice of writing their elements of interest as topics on the paper voluntarily. They ignored scissors and glue. We believe that, as the designers were very excited because the session occurred just after their tennis practices and there was a time restriction of 30 minutes, they opted to a strong conversation interaction instead of using manual materials where they would not interact with each other.

The influence of time constraints in the process was evident. The predetermined time span for the session induced the participants to write more elements on paper and faster. The feeling of participating in a game with time constraints made participants worry about optimizing the process. Sometimes, when the conversation involved only a part of the participants, the others used the time to write down more elements. We used the written elements to restore the pace of the conversation when it decreased. During long gaps between interactions, we (the researchers) intervened asking the quietest participant to read aloud the elements that he or she had written and about which we had not yet talked. As a result, the entire session generated data to be analyzed. Therefore, we obtained a satisfactory outcome from this session. However, we noticed that extending the session's time could have led to more information being collected.

To not influence the flow of the conversation, we interacted with participants in rare opportunities. The main interaction took place at the beginning of the session when we explained the framed problem. There were also interactions to keep the pace of the conversation. In that case, we interacted when we perceived a lack of balance in the discussion, i.e., when one of the participants spoke much more than others. In those situations, we asked the opinion of the quieter participants on the subject at hand. We opted to keep the discussion among wheelchairs A, B, and C and not between able-bodied (and their tennis coaches) D and E [31]. Thus, we took into account but did not voluntarily encourage interactions between participants D and E.

Finally, we realized that the fact that users are aware of our intention to develop a game with the *Kinect* sensor contributed to this topic being often mentioned during the conversation, as observed by Smith et al. [32, 33]. The final goal of the session was to compile valuable information from participants. We outlined the information in the form of a recorded discussion. Afterward, we could work with that information to represent it in a cloud map. We detail that step of the process in the next session. Table 2 summarizes the characteristics of Session 1.

3.2. Session 2: Cloud Map Building. Watching the recording of the first session, we analyzed it, transcribing all the main elements that were verbalized during the conversation. We considered as main elements the substantives or verbs that represented relevant aspects to the theme of the conversation. Supported by the visualization software *VOSViwer* [34], we output those elements into a cloud map, highlighting and evidencing the most relevant words from texts. The maps can also represent words that have a close relationship to each other.

During the second PD session, participants B, C, and E (Table 1) attended. We conducted the meeting with those participants and updated the others afterward. In this session, only two from the three researchers participated. We managed to keep the number of participants higher than the number of researchers to allow the participants to feel more comfortable during the sessions [8]. In the session, the participants recommended performing manual changes in the cloud map so that it reflected more accurately the elements that they tried to express. Figure 2 displays the resulting cloud map from this PD session. That map contained information about values and social context of the participants. We used that information in the future sessions to structure relevant *user stories*, commonly employed in Game SCRUM [35] that guided the development of the game. Table 3 summarizes the characteristics of Session 2.

As the codesigners asked to modify the cloud map, we noticed that some values started to arise. For instance, the words in the cloud map (Figure 2) *adrenaline, speed, race,* and *height* were mentioned in the context where the codesigners

Table 2: Summary of the characteristics of Session 1.

Objective	Collect information from the participants to solve the framed problem
Format	Design Activity played with the participants and facilitated by researchers
Duration	60 minutes
Output	A recorded video with information about the participants

Table 3: Summary of the characteristics of Session 2.

Objective	Generate and check a document compiling the information (cloud map)
Format	Meetings among researchers and participants
Duration	Non pre-defined duration
Output	A cloud map with the main information recorded in the video of Session 1

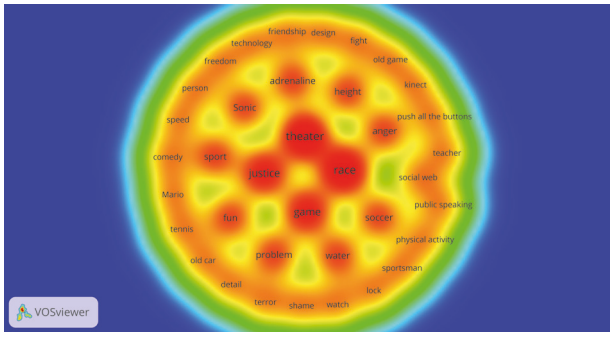

Figure 2: Cloud Map generated from information collected in Session 1. The most relevant words are highlighted and located closer to words related to them.

were looking for *empowerment*. While the codesigners were discussing *theater, friendship,* and *justice*, they focused on *noncompetitive* sports. Finally, when talking about *fun, sports, game,* and *physical activity*, they are talking about their *motivation* to engage in diverse activities in their lives. We discuss in detail each of these aspects in Section 5.

3.3. Session 3: Generating User Stories. The goal of Session 3 was to combine into user stories the possible aspects of the cloud maps within the given time. The participants randomly read some items in the maps and tried to create sentences with those elements. We suggested that, while forming the sentences, participants kept in mind the essential game elements: mechanics, technology, story, and aesthetics [29]. The stories did not necessarily use the exact words that are in the cloud map. Instead, we noticed that the participants were inspired by the words in the maps to create stories with similar words [36]. For instance, the fact that the words *car* and *adrenaline* were present in the maps led to a discussion about including a *race* in the game. As the codesigners connected the elements, the values emerging in the previous session started to be more evident.

The use of cloud maps showed to be effective for the session. To perform the combinations, participants tended to focus on elements highlighted in the cloud map. Cloud maps evidence elements that were frequently mentioned, which are the most relevant to the users. Therefore, participants prioritized combinations among the most relevant elements. In this session, we had to intervene as researchers more often than in previous sessions. We realized that, at first, the participants had some difficulties to understand the purpose of the Design Activity. Thus, we provided some examples of combinations to clarify the purpose. We noticed that the participation of at least two researchers in the session was important. While one researcher intervened with examples of combinations, the other mediated the session to guarantee that participants created their combinations.

We observed divergence of views between participant A and the subgroup formed by B and C. B and C proposed user stories directing to a more realistic and serious game, whereas A produced user stories leading to a more recreational and playful game. Regarding the gesture-based aspect of the game, participant A proposed controls by extravagant gestures inspired by dance moves. Participant B demonstrated to be slightly disconcerted in imagining himself executing those kinds of movements. However, participant B discoursed on the importance of the game has an educational aspect for people who need to gain experience in conducting wheelchairs. Participant C agreed with B by nodding his head, while A demonstrated signs of frustration.

Concerning participant values, the conflict appears at least on two levels: first, the question whether the game and its educational dimension should be something serious or something playful or even artistic and, second, the question whether game mechanics should allow or also require a more extrovert expressibility. To include more participants in the discussion and thus give everybody a chance to be heard, we solved this conflict in the next session.

As a result from Session 3, we obtained a database of 42 user stories for the development of the game. We saved the user stories in tables classified into the four basic game elements proposed by Schell [29]: Aesthetics, mechanics, story, and technology. In this study, the stories are sorted in the tables according to their prioritization level, defined in Session 4. We observed that even though user stories related to technology (Table 5) influence other elements of the game [7], the participants produced a lower number of those stories compared to different categories. Keith [35] recommended around 100 user stories for simple games. Nevertheless, as the session got close to its end, the frequency of creating

Table 4: Summary of the characteristics of Session 3.

Objective	Connect the information the cloud map into user stories
Format	Design Activity played with the participants and facilitated by researchers
Duration	60 minutes
Output	A set of user stories

Table 5: User stories about technology collected from participants during Session 3.

1	As a player, I want to control the character mostly with arm movements.
2	As a wheelchair user, I do not want to have to move around with the wheelchair to control the game because I want to be able to play the game also in relatively small rooms.
3	As a player, I do not necessarily want the character of the game to copy my movements, because I want to be able to control it with representations of movements.

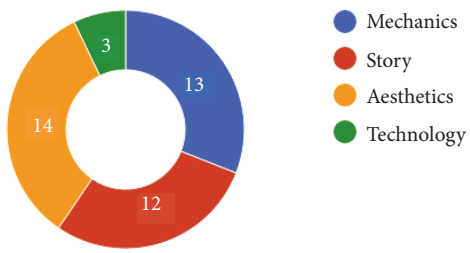

Figure 3: Number of suggested user stories by basic elements of games [29].

combinations for the game decreased considerably, and the participants appeared to be tired [32, 33]. Figure 3 relates the number of suggested user stories and the basic game elements. Table 4 displays the summary of the characteristics of Session 3.

3.4. Session 4: Prioritizing User Stories. The goal of the fourth PD session was to converge the user stories retrieved in Session 3 into the basic elements for structuring a Concept Prototype of the game. Between the third and fourth sessions, we did not interact with the participants to allow subconscious idea generation, also referenced as the period of *incubation of ideas* of the Creative Process, to improve the quality of the creative outputs [36, 37]. We understood that the session successfully reached its goal because the information received in it was enough to develop the Concept Prototype. The convergence of the collected information in the other sessions marked the illumination event [36] and the transition from the concept to the preproduction phase.

We started the session asking the participants to try visualizing the structure of a game based on the user stories generated in Session 3. The participants remained at the consensus on the game elements that should build in the game. After 15 minutes of discussion, there were some disagreements. The main impasse of the session was the balance between the playful and educational aspects of the game. This question had already appeared in the previous session, during a discussion between the participant A and participants B and C. We intervened by providing printed versions of the tables with the user stories. We suggested to the participants to decide which stories would be prioritized to minimize the conflict [38]. With the tables at hand, it was easier for the participants to converge their opinions. We understood that such a fact happened because the stories that represented contradictory elements were not eliminated, but attributed with a lower level of prioritization [35]. This prioritization is how we tackled the conflict of the previous session. Table 6 displays a summary of the characteristics of Session 4.

3.5. The Concept Prototype. The result of Session 4 was the definition of the Concept Prototype to be developed. Considering the deadline needed for the project, we agreed with the participants which user stories would be implemented for this first functional version of the game. We implemented seven user stories out of 13 about the game mechanics, three of the three about technology, 9 of the 12 about story, and 9 of the 14 about aesthetics. We developed the first version of the game following the directions in the prioritized user stories. We structured the aspects of the game not covered by the user stories based on insights from previous work [6]. In the next subsections, we detail the prototype. Because this is a Concept Prototype, we implemented the main character as male because he reflects a high-performance athlete who is a friend of the codesigners. However, in future versions of the game, we can develop a customizable character to the users.

3.5.1. Design and Gameplay. Differently, from the study of Gerling et al. [9], all the participants of our work requested that the main character of the game should be a wheelchair user. Having the main character as a wheelchair user evidenced the motivational value of the game because the players felt more engaged to participate in outdoor activities by watching the character of the game. We managed to create the context and scenarios of the game in a way to involve the character in diverse activities as a wheelchair user. Thus, we divided the game into four stages named *House, Street, Sea*, and *Sky*. The first playable stage is the *House* of the main character. Figure 4 illustrates the possible flow between stages. Starting from the *House*, the player can choose from carrying out activities inside the home or moving to another

Table 6: Summary of the characteristics of Session 4.

Objective	Prioritize the generated user stories
Format	Design Activity played with the participants and facilitated by researchers
Duration	60 minutes
Output	User stories prioritized in a way that allows the development of the game

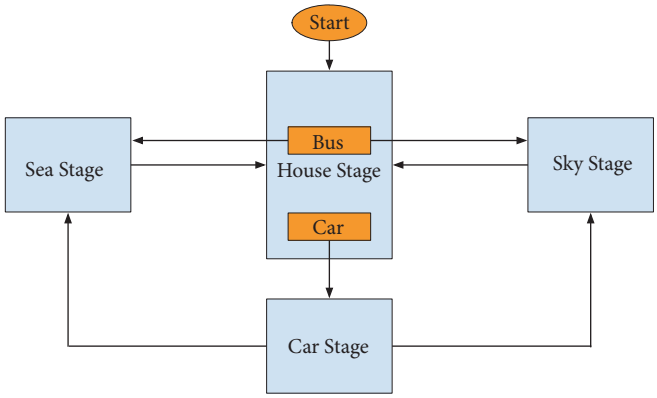

Figure 4: Possible flow between stages: the player can choose to go directly to stages *Sea* or *Sky* by taking the bus or drive to them by passing through the *Street* stage.

Figure 5: A screen from the developed game with one person playing. The depicted stage is the *House*, where the character of the game explores the scenario to enter the other stages.

stage. Figure 5 displays the scenario of the *House* stage. For selecting the stages, the character can drive a car or take a bus. Thus, the stage *House* works as a *selection menu*. Opting for driving the vehicle, the player enters the *Street* stage. Opting to take the bus, he or she comes directly into the chosen stage.

Except for the *House* stage, the game is essentially multiplayer. This aspect encourages interactions of the main player, whom we are assuming is a wheelchair user, with other people around him or her. The game mechanics are similar in the stages *Street* and *Sea*. The player must dodge obstacles while piloting a car and a jet-ski, respectively. The goal of all stages is to travel onto a route and cross a finish line at the end of the stage. At the end of each stage, the game records the players' time-stamp in a ranking that is reproduced on a panel in the *House* stage. The player starts the route with an initial speed. This speed increases as the player go around obstacles without colliding or go through items in *turbo* mode. Hitting obstacles causes the speed to decrease. Having the speed varying according to how well players move around the stage causes the difficulty of the game to vary according to the skills of the players. Especially in the *Sky* stage, the player rides a paraglider from a starting point until the finish line, but not through a predefined route. The speed does not vary in that stage.

The game aims to produce an encouraging atmosphere to the player. This aspect was a result of our balance between the playful and educational aspects suggested by the participants during the PD process. Players can try the stages various times to improve their scores (playful). As a consequence, players perform more exercises (educational). The game is multiplayer, but noncompetitive. The stage is only finished when both players cross the finish line. The speed is equal for both players during the whole gameplay. For instance, if one player hits an obstacle, the speed for both players decreases. The purpose of this feature is to allow friendly and equal interaction between players. In all stages, when one player is close to the finish line, applause sounds and supporting voices are played. At the end of each stage, the game shows fireworks and celebrating audiences to reward the players. Figure 6 displays the celebration screen after players completing the *Street* stage. In general, the game aims to encourage wheelchair users to practice activities considered obstacles by the community, such as driving a car or riding a jet-ski or a paraglider.

3.5.2. User Interface. There were few user stories concerning the technology of the game, so we had few features to define the user interface. Nevertheless, we designed the controls of the Concept Prototype as simple as possible to facilitate

Figure 6: Celebration screen after a stage completion.

the engagement and understanding of the participants. The gesture-based interaction for this version of the game prioritized the movement of the arms, including wheelchair users with high or low mobility in the column. We developed the controls equally for all stages as a simulation of handling a steering wheel.

In particular, in the *House* stage, the character speed in the forward plane was controlled by small head movements. In the *Sky* stage, the head movements controlled the height of the character. A forward bend causes that character to move forward, and vice versa. Figure 7 represents the logic for controlling the character.

3.6. Session 5: Enhancing the Game's Interface Based on Users' Values. Session 5 was based on the methodology of Sprint Reviewing of the Game SCRUM [35]. Along with the participants, we decided which features of the game could be enhanced with the experience that we acquired. We enhanced game features to increase the playing experience in general. Moreover, we detected with the participants the necessity of including features to evidence their values in the game. At this point, we could represent the game values that emerged during the sessions (*empowerment, noncompetition, and motivation*).

The *empowerment* of the players in the game was mainly symbolized by the explicit representation of the main character as a wheelchair user. In the game, the character handles his wheelchair without any help and is capable of moving to any location. He performs activities that, according to the participants, are considered obstacles to that group of people: taking a bus, driving a car, riding a jet-ski, and a paraglider. For starting the performance of any of the activities, the character steers the wheelchair to the location where the action starts. In that context, we represent the wheelchair as a mean to transition from the game character's home to a more attractive place, rather than a tool to supply a disabled person.

The *noncompetition* value is represented by the fact that succeeding in the levels does not depend on beating the other player. Instead, both players have to cross the finish line to store a record for the level. The participants mutually agreed with this feature. Their objective was to develop a friendly atmosphere for friends and relatives that had suffered a lesion and were still recovering from a potential trauma of learning how to handle a wheelchair.

The *motivation* value was mentioned by the participants as a necessity of the game working also as an encouragement for players to try to perform the same or similar activities in real life. All the participants agreed that the gesture-based aspects of the game could increase the potential for this value if the required gestures in the game are more similar to the ones used in the real-life activities. It is because, according to our discussion, by repetitively performing similar gestures during the game, there is a better probability of players to feel more confident to perform those gestures in real life.

From the Sprint Review, we concluded that values empowerment and noncompetition were well represented in the game. However, motivation could be better represented with a revision in the gesture inputs. Thus, we decided to modify the user interface so that the required gestures were more similar to the ones in real life. Table 7 summarizes the characteristics of Session 5.

3.7. The Preproduction Prototype. We developed the reviewed game during the *preproduction* phase, according to the Game SCRUM's principle [35]. Therefore, we considered it a preproduction prototype. The developed game was named "Wheelchair Jecripe", as a continuity of the works of the Jecripe Project studies [39].

In Sessions 3 and 4, we structured the user stories to guide the game development. Most of the user stories were related to the mechanics, aesthetics, and story of the game. Only three user stories defined the game technology about the gesture inputs (Figure 3). As a consequence of not having focused on the game technology, the features that had to be modified the most in Session 5 were the gesture inputs. According to the participants, the revision of the movements reinforced the motivational aspect of the game. With the new inputs, players performed movements not precisely identical to those that they would do in real life in the activities depicted in the game. Nevertheless, the revised movements are more similar to the real movements than the initial ones. This aspect potentially increases their confidence to enroll in those activities in real life.

As a recommendation from the participants, we switched from hand movements to body movements in the *Street*, *Sea*, and *Sky* stages: reclining the body to the left (right) makes the character move to the left (right). Specially for the *Sky* stage, players control the character with open arms, imitating the movement of flying. We modified the input movements in the *House* stage so that players could control the character by representing movements of controlling a wheelchair: representing turning the left (right) wheel of the wheelchair makes the character turn to the right (left). Representing turning both wheels to the front while reclining the body to the front moves the character forward. Representing the movement of pulling back with the arms makes the character move back. Figure 8 displays the revised inputs for the game.

The gesture inputs for the *House* sage required a specific mounting setup of the Kinect sensor and a more complex approach for motion capture. Contrary to the other stages,

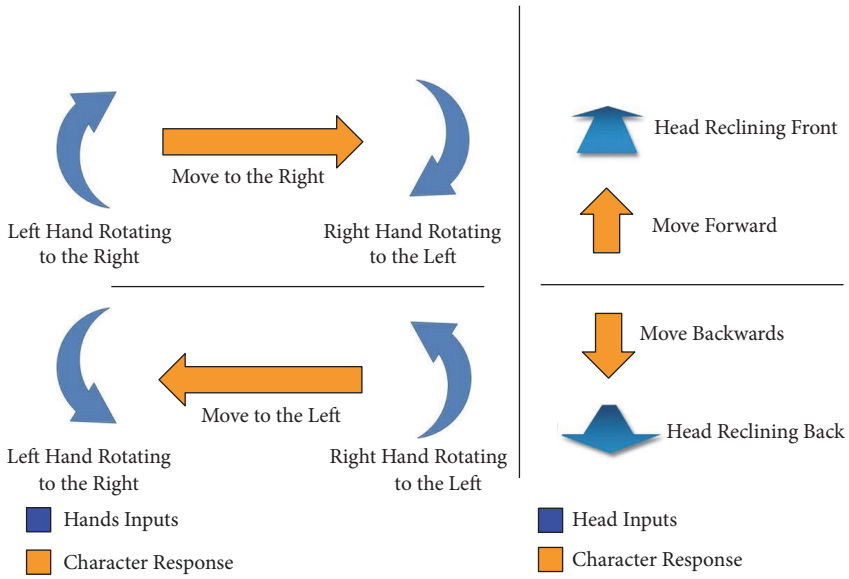

Figure 7: Relationship between body movements and the inputs in the game for controlling the character by gestures in the first version of the game.

Table 7: Summary of the characteristics of Session 5.

Objective	Review the developed game with the participants
Format	Sprint Review with the participants
Duration	Non pre-determined duration
Output	A set of refinements to be done into the game

the gestures in the *House* stage required tracking of body parts in the z-axis (Figure 8). For optimized motion capture, the Kinect was placed at a total height from the floor of 2 meters. The distance between the players was 1.5 meters. The defined distances provide better motion captures of the spatial coordinates because it avoided occlusions of the players' body parts in the z-axis. Figure 9 illustrates the mounting setup for the revised inputs.

In addition to the revision of the user interface, the participants asked for alternative inputs to control the game's flow. We implemented a pause menu with options to quit the game and return to the *House* stage. At any time in the game, players can lift the left arm and access that menu, in the same way as in other Kinect-based games. As a consequence, the flow among the stages of the game was modified. Figure 10 demonstrates the revised flow of the game.

4. Evaluating the Enjoyment of the Game

We analyzed the enjoyment of the game. Thus, we asked some of the participants and other wheelchair users as well as their relatives to play the developed game. To estimate the enjoyment of testers for the game, we evaluated metrics such as learnability, immersion, enjoyment, or fatigue. Then, we compared the player experience of those groups (participants and other wheelchair users and their relatives) for the game. This section presents the experiment and its results. All testimonials presented in this section were freely translated from Brazilian Portuguese by the authors.

4.1. Experimental Setup. We experimented the preproduction prototype of our game with a population of 19 people ($N = 19$), divided into two groups. The first group consisted of four members of the codesigners: two wheelchair users and two able-bodied users, three female and one male, aged 58, 53, 26, and 34.

The second group was the noncodesigners group, with 15 testers. This group contained seven wheelchair users and eight able-bodied users. All the able-bodied users were relatives or colleagues of the wheelchair users. Seven were female, and eight were male. The average age of this group was 32 years old, ranging from 10 to 60 years. Figures 11 and 12 represent the sex and age distributions of the groups.

Figure 13 displays the favorite game genres among the testers. It is possible to see in Figure 13 that, for all the groups, most of the testers prefer games related to sports. We noticed that having the common practice of playing sports increased the expectation among participants for the game. A testimonial of one of the participants before the testing session reflects this fact:

(i) "I like to practice sports, I am really enjoying this project. I am sure it will be of great value to all involved people. Perhaps this game will make me

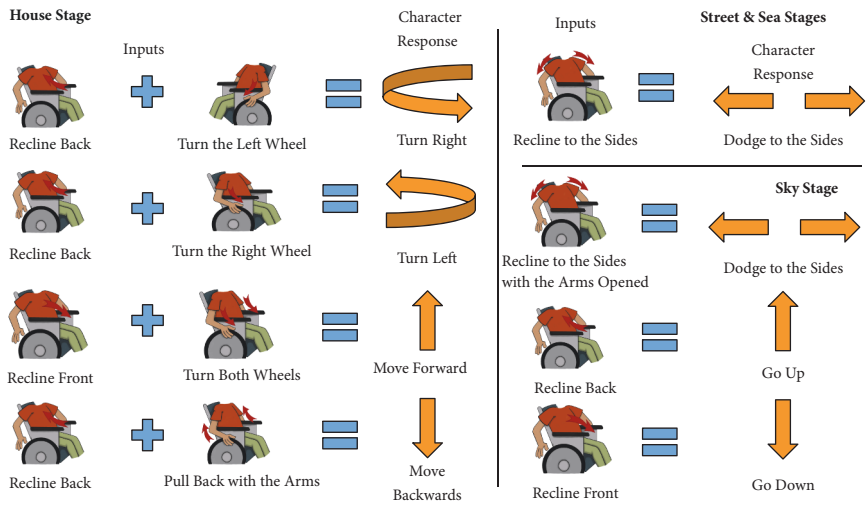

Figure 8: Relationship between body movements and the inputs in the game for controlling the character by NUI in the revised version of the game.

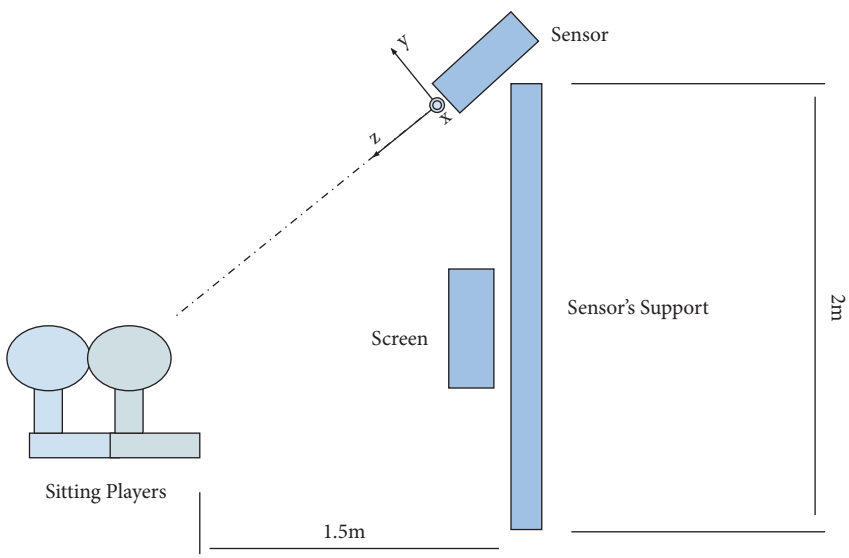

Figure 9: The Kinect mounting setup for the revised inputs. The *xyz* coordinates for the game follow the sensor's direction. This configuration reduces occlusions of body parts.

play more video games." (Translated from Brazilian Portuguese)

The testers filled a pretest questionnaire, played the game from 15 to 20 minutes, and filled a posttest questionnaire. We have also registered testimonials and observations from the testers. We only interrupted the test to provide the first explanation on how to play the game and in the case of software or hardware problems. The experiment had the approval of the *Federal University of ABC's Ethics Committee*. For the testers that did not have physical or cognitive conditions to fill in the questionnaires, we asked their parents to answer the questions. A testimonial from the father of one of the testers reflected that situation:

(i) "I am the father of the child playing the game. The answers of the questionnaires are based on the playing session of my son. He is a ten-year-old wheelchair user with coordination and cognitive limitations. His cerebral palsy is due to a problem during birth. He is a kid of easy comprehension. He communicates trough gestures or communication tablets. He is very interested in electronic games." (Translated from Brazilian Portuguese)

We summarized the user experience questionnaires in Tables 8 and 9. Table 8 shows the pretest questionnaire, which was based on insights from our previous studies [6]. We have formulated the topics in the pretest questionnaire to inquire the player profile of testers. Table 9 displays the posttest questionnaire, also based on related the work of

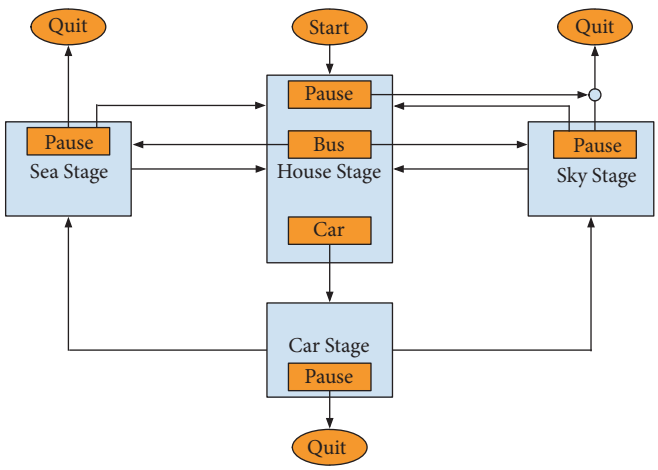

Figure 10: Revised flow of the game stages: with the new configuration, players can quit the game or return to the *House* stage at any time during gameplay.

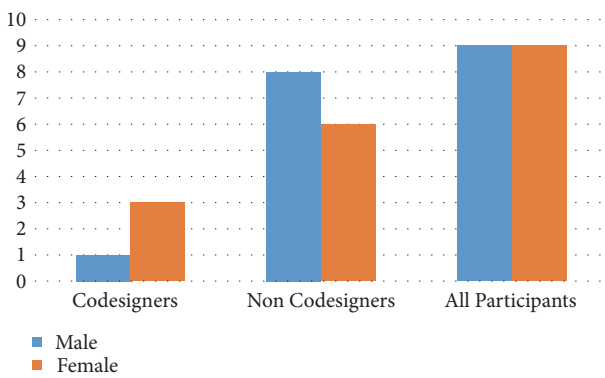

Figure 11: Genre distribution among the testers.

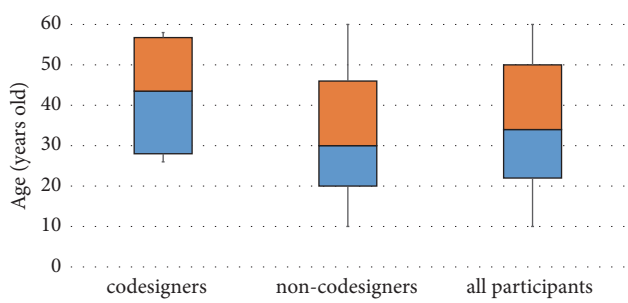

Figure 12: Age distribution among the testers.

van der Spek [40]. We have formulated the topics in the posttest questionnaire to inquire the enjoyment of testers on the game. Testers were graded from each topic from the questionnaires from 1 to 10 according to how much they agreed with the information presented on that topic, except for topic 1 from Table 8, where testers informed their classification in the *IWBF Functional Classification* [2].

To generate topics 1 to 11 from Table 9, we employed part of the standardized *ITC Sense of Presence Inventory* [41] that measures the immersion level of testers when experiencing digital media. We formulated our questionnaire following the study of van der Spek [40], who employed the ITC Sense of Presence Inventory to measure the immersion of several testers in different versions of a serious game. Spek's study was able to provide clear conclusions by using the ITC Sense of Presence Inventory since part of the ITC Sense of Presence Inventory is related to engagement and other factors, for instance, physical spaces and negative effects. Thus, the average of topics 1 to 11 from Table 9 formed an index for the immersion caused by the game to players.

In addition, as our game is gesture-based for wheelchair users, we had the necessity of including specific questions related to the movements of the users to infer the tiredness of the users as well as the facility of getting used to the Microsoft Kinect Sensor in our game.

4.2. Results. For our analysis of the results, we created boxplots from the questionnaires (Tables 8 and 9) and also considered the testimonials of the testers. Figure 14, for instance, displays the boxplots of the players' immersion level (average of grades resulting from the answers of topics 1 to 11 in Table 9). Each boxplot depicts the results of the codesigners and noncodesigners, individually, and then the results for all testers.

Figure 14 reveals that, even though the developed game was in a prototype stage during the test, most of the testers experienced a satisfying immersion level, close to 9. The outliers in Figure 14 occurred due to the presence of a boy who has cerebral palsy. The boy had a hard time understanding how the game works. This result conforms to the results shown in Figures 15–17. These boxplots show facility of learning how to play, getting used to the sensor, and scoring in the game. Those topics received median grades equal to or higher than 5 for both groups. Testers' testimonials that reflect their player experience are listed below.

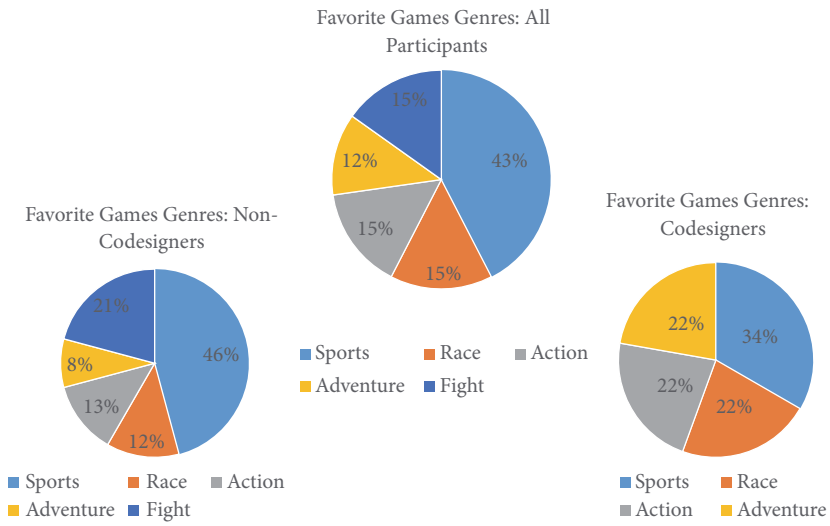

Figure 13: Favorite game genres among testers.

Table 8: Pretest questionnaire for characterizing the player profiles, translated from Portuguese.

1	What is my score in the *IWBF Functional Criteria*
2	I have experience in playing video games
3	I enjoy playing video games
4	I have experience in playing video games with NUI
5	I enjoy playing video games with NUI

Table 9: Posttest questionnaire, translated from Portuguese.

1	I had the sensation of coming from a journey
2	I wish my playing experience continued
3	I remember very well parts of the experience
4	I felt thrown inside the game
5	I felt involved with the universe of the game
6	I lost the notion of time
7	I enjoyed myself
8	My experience was intense
9	I paid more attention to the game than to my thoughts
10	I felt emotionally involved with the game
11	The game content was made for me
12	I felt physically tired after playing
13	I felt mentally exhausted after playing
14	I wish movements in the game were more intense
15	I wish movements in the game were less intense
16	It was easy to learn how to play
17	It was easy to get used to the sensor
18	It was easy to get a good score in the game
19	The game was fun

(i) "The game is an important encouragement for inclusion and physical and emotional rehabilitation for people with physical disabilities. It is the great training of balance and coordination." (Translated from Brazilian Portuguese)

(ii) "It was very good to see the excitement of my son when he perceived that he could control and interact with a video game with a simple body movement." (Translated from Brazilian Portuguese)

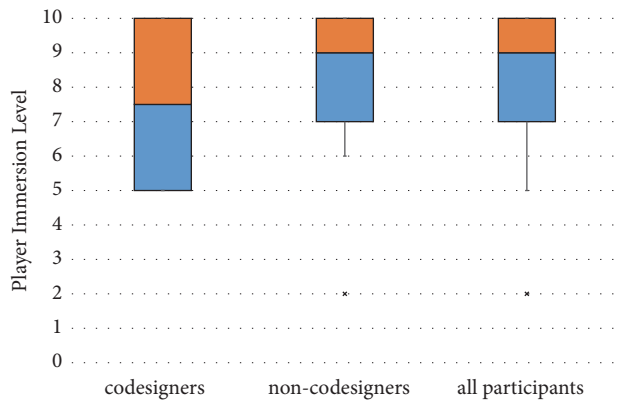

Figure 14: ITC score boxplot graphics: the graphs compare the dispersion of results from the immersion level for the codesigners and noncodesigners in the game. The ITC score was formed by the average of grades from topics 1 to 10 of Table 9.

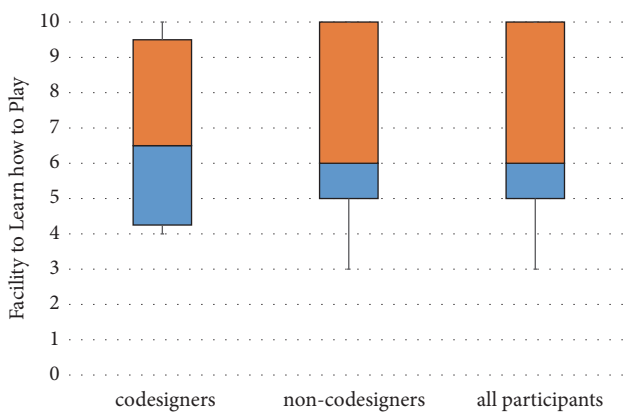

Figure 15: Answers from topic 16 of Table 9: this topic measures the facility of users on learning how to play the tested game.

The boxplot in Figure 18 displays the level of enjoyment during the game. This topic received median grades greater than or equal to 8.5. Testers' testimonials that reflect their enjoyment are listed below.

(i) "Playing was very enjoyable and likable. I enjoyed it very much. I had lots of fun and guess that the game will be a success. Congratulations to the dedication and commitment of the involved people." (Translated from Brazilian Portuguese)

(ii) "I enjoyed the game very much!" (Translated from Brazilian Portuguese)

(iii) "The game is amazing for people with disabilities." (Translated from Brazilian Portuguese)

(iv) "The game was delightful! I loved it!" (Translated from Brazilian Portuguese)

Moreover, we noticed that the lower scores to immersion and enjoyment levels (Figures 14 and 18) were frequently related to difficulties in playing the game due to more severe cognitive or physical disabilities of some testers. We display below a testimonial reflecting that scenario.

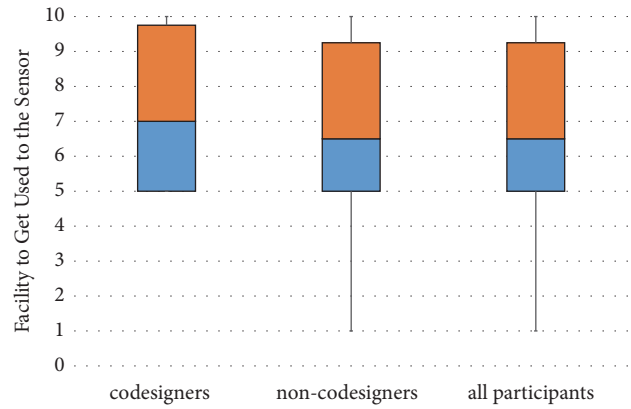

Figure 16: Answers from topic 17 of Table 9: this topic measures the facility of users on getting used to the gestures requested in the game.

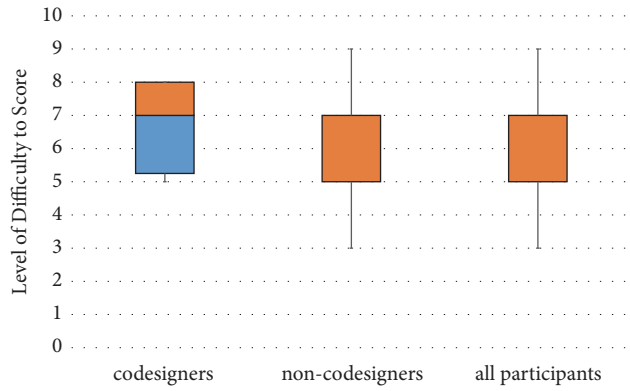

Figure 17: Answers from topic 18 of Table 9: this topic measures the facility of users to score in game.

(i) "It was pleasant. However, in the case of my son, we need something more playful and interactive to capture his attention better. As he does not have body control, he has difficulty to interact with the game. The experience was valuable, though." (Translated from Brazilian Portuguese)

It is possible to see in Figures 19 and 20 that the medians of the answers from topics 12 and 13, which concern physical and mental fatigue levels after playing the game, are higher for the noncodesigners group than for the codesigners group. This result is potentially due to the adjustments of game inputs implemented in Session 5. In that session, codesigners suggested more intense controls, which provided better movements in the game. On the other hand, the noncodesigners with less body control were harmed with the new inputs. In general, Figures 21 and 22 imply that most of the testers from both groups would prefer a game with even more intense movements.

We noticed that, even though the immersion (Figure 14) and enjoyment (Figure 18) evaluations indicated satisfying results, noncodesigners evaluated these dimensions more positively than the codesigners. We believe this is probably due to the expectation that the codesigners group had for

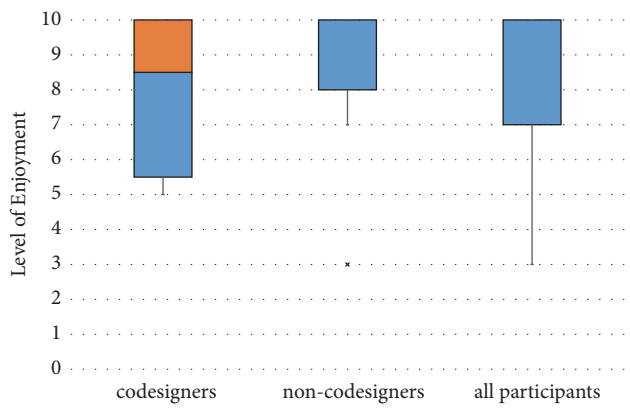

Figure 18: Answers from topic 19 of Table 9: this topic measures the enjoyment proportioning the game.

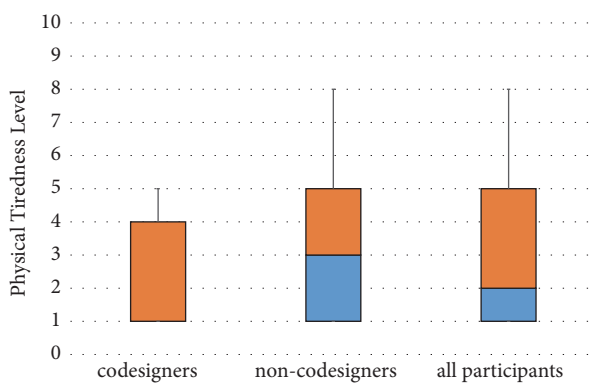

Figure 19: Answers from topic 12 of Table 9: this topic measures physical fatigue after playing the game.

Figure 20: Answers from topic 13 of Table 9: this topic measures mental fatigue after playing the game.

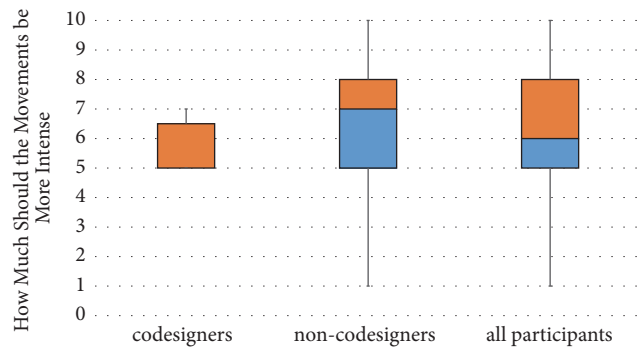

Figure 21: Answers from topic 14 of Table 9: this topic measures how much testers would prefer the movements in the game to be more intense.

the game since they participated in its development. Another hypothesis relies on the fact that codesigners had contact with the game along with its design process. Therefore, it was expected that the game would cause less impact on them. We collected testimonials from all testers referring to technical improvements in the game. Those improvements can be implemented in possible future Sprint Reviews. We list the testimonials below.

(i) "I loved participating in the test. I think that the characters could have more intense colors. Congratulations for the initiative. I loved the project." (Translated from Brazilian Portuguese)

(ii) "I liked it. However, some things did not work well in my opinion. The movements in the House scenario, for example, were not easy or practical. Maybe you guys should change the movements in that scenario. In the flying scenario, I did not find the correct route. Maybe it would be easier if I had more lights to follow, like a path. Lights in the arriving lane would be good too. In the Street scenario, the initial velocity was low. Maybe it could start faster." (Translated from Brazilian Portuguese)

(iii) "My son is losing his vision, and the screen was too high; he did not see the game adequately. In our home, where the television is in his eyes' height, he makes better progress. All in all, the game was great, I loved it. It gives players a sensation of freedom. This is very good and interesting. Congratulations for the initiative." (Translated from Brazilian Portuguese)

(iv) "I have an Xbox 360 with a Kinect. This new Kinect is more sensitive than mine; then, I messed up a little bit with the controls." (Translated from Brazilian Portuguese)

(v) "Suggestion of Improvement: Improve the velocity of the vehicles. Improve the Pause Menu that is called up every time we raise the left arm." (Translated from Brazilian Portuguese)

As a final observation, it is relevant to mention that the atmosphere during the tests was pleasant. We often noticed testers laughing and performing game gestures even when not playing the game. The atmosphere allowed even the shyest testers to interact and cooperate with their colleagues. We believe that the fact that we developed a game focused on the values of the users provided a friendly environment. The users seemed to feel comfortable with their representation in the game.

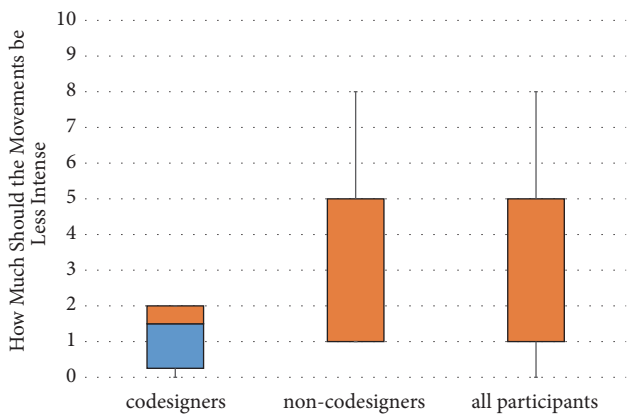

Figure 22: Answers from topic 15 of Table 9: this topic measures how much testers would prefer the movements in the game to be less intense.

5. Discussion

The participants actively contributed to the data analysis and interpretation, e.g., during the discussion and adaptation of the cloud maps. The researchers participated mainly as facilitators during the sessions. As a consequence, the participants generated a few user stories concerning technology. If the researchers had opted to be more active in the discussions with the participants, perhaps some issues could have been avoided, for instance, the refactoring of the input gestures. However, this could have also led to less freedom of the participants regarding expressing their values.

The design that we applied enabled the participants to influence the design process, e.g., by defining and prioritizing the user stories or by redefining the input gestures. One goal of the design process was to create a game that could improve the quality of life of players by increasing their self-confidence and by encouraging them to conduct the activities portrayed in the game or other sports activities in the physical world. Although it is too early to make assertive claims, testers' testimonials indicate the potential of the game to reach this goal. Regarding the context or user situation, we recruited participants that are already active sports practitioners, in this case, tennis. For future iterations of the design, practitioners of other sports could be included, as well as people who are less active and even practice no sports at all.

The participants contributed to defining, designing, and evaluating aspects of the game mechanics, content, aesthetics, and the base technology. Thus, all participants performed crucial roles during the design process. The base technology was defined by the researchers since the other participants had no expertise in this area. In the remaining areas, they were seen as equal partners and conflicts of different opinions during the design were resolved by open-ended discussions; i.e., the researchers did not try to push through preestablished decisions. Adjustments to the design were made on a smaller scale, i.e., regarding the content of scheduled sessions, e.g., the evaluation and redesigning the gestures. Since the applied design is aligned to the Game SCRUM, major adjustments are also possible, resulting in additional iterations or sprints.

As described in Section 3.2, words in the cloud map originated the user stories, which turned into game features. For each of those user stories, we reflected the values features of the codesigners nonresearchers into the game. Figure 23 describes a summary of how the insights for the game originated from the participatory design meetings, fed the game values, and transformed into the game features that we evaluate in our qualitative analysis. In the qualitative analysis, we were interested in how testers reacted to the game concerning the values it proportioned. In Figure 23, we also linked the testimonials and our observations about the environment's atmosphere during the user tests.

As an example of flow in Figure 23, it is possible to see that words, such as speed and height, originated the *empowerment* value of the game. It happened because, in the context that those words were mentioned during the meetings, the codesigners expressed a need for empowerment. That empowerment was translated into the excitement of testers while playing the game. The testimonial to which we linked the empowerment value exemplifies this fact. Afterward, in other meetings (Section 3.5), we concluded that representing the main character as a wheelchair user could also bring an empowerment value to the wheelchair in the game. Therefore, the empowerment value linked the words speed and height. Furthermore, we also realized the speed could be an essential feature of the game. Together with the codesigners nonresearchers, we decided that controlling the speed was an efficient way to develop the mechanics of the Street and Sea stages. Figure 23 presents the word *speed* is also linked to those stages, as it influenced their design.

We believe that the Creative Process elements aided our work to support the elicitation and discussion of values of the users. We employed the Creative Process concepts into a PD consisting of five segments: (1) a free, recorded conversation, (2) representation of the conversation topics into cloud maps, (3) connection of the elements in the cloud maps into user stories with high significance to user experience, (4) prioritizing of those stories by participants after a period of no workload, and (5) revising the outputs of the stories. Based on such segments, the activities were structured to promote creative and effective participation of the participants. As a consequence, we developed a game that had a satisfying and near homogeneous positive player experience of wheelchair users with different characteristics. Therefore, we believe that the used tools and techniques successfully led us to represent those people's values into the game.

The Game SCRUM concepts were important to manage the design with flexibility for participants to express themselves. We realized that user stories were a simple technique that allowed the participants to express user experience related aspects in a way that could be understood and used by the developers. Moreover, structuring the process on Game SCRUM avoided workload being applied to elements with low value to the game. As a result, we could develop a simple, but effective game. We display a graphical scheme of our design process in Figure 24.

The closest study to ours is the one from Gerling et al. [9] that also addressed the development of gesture-based games for wheelchair users with participatory design. The

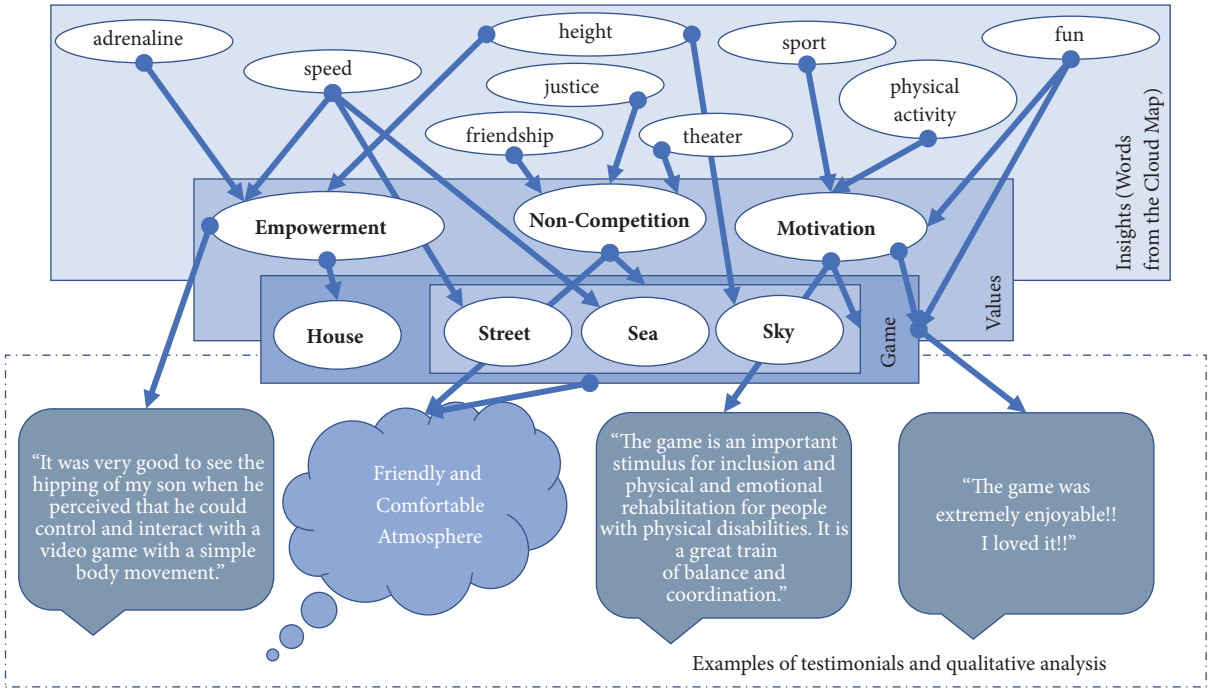

Figure 23: Visual analysis from the flow of insights that generated the game and its implication to the qualitative analysis of the game.

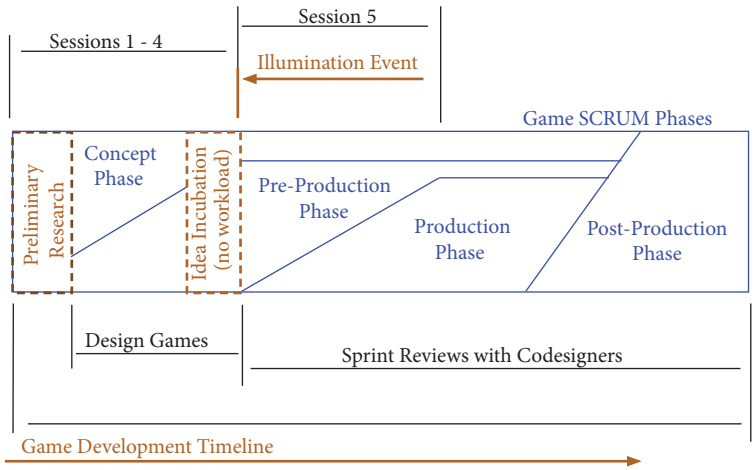

Figure 24: Flow of the process stages during game development: the framework stages overlap with Game SCRUM phases and Creative Process' events.

main focus of the work of Gerling et al. [9] was to explore with a qualitative analysis the value of gesture-based games for young powered wheelchair users. Different from Gerling et al. [9], we defined the gesture-based interactions during the process of PD. We aimed to provide more flexibility to participants to express their values through the definition of the interaction. Nevertheless, some of the defined movements were not compatible with wheelchair users with more limited body abilities. We also noticed that Gerling et al. [9] and our works represented disabilities of participants in a way that empowered them in the game. However, our representation was explicit, displaying a wheelchair user as the main character. Gerling et al. [9] empowered their characteristics with implicit features in the game. For both cases, we confirmed that the players had a positive experience with the game. We summarized the main differences concerning the PD process and experimentation that we observed from the present work and the work of Gerling et al. [9] in Table 10.

We detected three main values that emerged during the process and that were "designed into" the preproduction prototype: (1) empowerment of wheelchair users by representing the wheelchair in the game as an apparatus to enroll in interesting activities instead of a tool to supply a particular need, (2) noncompetition in the game to amplify the friendly atmosphere of the game, and (3) motivation in terms of

Table 10: Main differences between the present work and its most similar study.

Characteristic	Gerling *et al.* [9]	Present Work
Input device	Kinect V1	Kinect V2
User Interface	Gestures to control game features defined in previous research [10] and utilized during PD	Gestures to control game features defined during PD
Users in PD	Young powered- wheelchair users	Manual wheelchair users with diverse age
Representation of disabilities in the game	Implicit	Explicit
Main focus of the Experimentation	Explore value of the developed games for a users similar to the participants	Apply and evaluate a process that includes values of wheelchair users in NUI games
Main form of Experiments Evaluation	Testimonials from users	Questionnaires and testimonials
Number of users in the Experiment	4	19

encouraging players to enroll in similar activities in real life. In particular, the (3) motivational value influenced technical aspects of the game. We evidenced this value after a review meeting among participants and performed the necessary changes. The modifications of the game were mainly regarding the user interface. We modified the motion capture inputs so that the required gestures in the depicted activities in the game were more similar to the ones performed in those activities in real life. The new inputs increased the confidence of players to enroll in those activities in real life. That situation reinforced the importance of developing the game through iterations in conformance with an agile process. We learned with the critiques of the first prototype to enhance the prototype in the second iteration.

6. Limitations

We applied a method with a determined social niche: manual wheelchair users that practice sports as a hobby. Also, we tested the outcome of the participatory design process, a digital game with NUI, in a testing group formed by wheelchair users and their relatives. It is worth mentioning that we evaluate the outcome, indicating a positive player experience by the testing group. It leads us to observe the effectiveness of the participatory design. However, we are aware of the importance of evaluating another audience.

We acknowledge that the circumstances in which we developed the game and applied the tests influenced the results. Due to schedule restrictions of participants, all the PD sessions took place after their training. As a consequence of the physical exercises, the mood of those codesigners was frequently high. Even though the relaxed atmosphere supported us in conducting meetings with a good flow, we suggest performing potential next sessions in varying situations to get a more diverse input from the participants. Similarly, due to resource constraints, we (the researchers and developers of the game) were responsible for applying the playing tests during the experiments in this study. Even though we focused on being as impartial as possible, potential sympathy created between the participants and us could have influenced the results. In future work, we suggest conducting additional tests and evaluations with evaluators and test subjects unrelated to the design and development team.

We understand that the participatory design process is expansible and flexible. We fundamentally based the process on Game SCRUM. However, we believe that it is possible to adapt the process to be used with different development processes. Examples of variables liable of being explored with different configurations in the current process are the period of each session, time-spacing between sessions, and the frequency and degree of participation of researchers or design experts during sessions in opining about the design of the game. As a next step, researchers can adapt the process to Agile Software Development in general. We also believe that the process has the potential to assist in the development of games for a mixed social audience.

As a final observation, we evidence that we apply the process under an academic approach. We recognize that the process is liable of being applied in any commercial game development. Therefore, we believe that some modifications have to be performed to reach the often tight deadlines of commercial game development projects [35, 42, 43]. As a suggestion of modification, instead of performing five weekly participatory design meetings, researchers can conduct two more extended meetings applying design games. In the first meeting, researchers introduce the framed problem, build the cloud map, and generate the user stories. The second meeting is spaced from the first by one day, so participants have enough time to incubate the idea. In the second meeting, participants prioritize the user stories, build a concept for the prototype, and submit it to critiques. We reinforce that the mentioned time periods are liable of being optimized by experimentation. In particular, the time before the illumination event and the periods of stimulating participants with design objective related content can be critical factors to evaluate.

7. Conclusions

In this work, we described a design process for the development of a gesture-based game, where manual wheelchair users (and their stakeholders) acted as participants in the sessions. Values from the participants emerged during the design sessions and were explored for the development of the game. Sessions were aligned to Game SCRUM, employing concepts such as user stories, prioritization, and sprints.

Creative Process elements were also employed to stimulate the emerging of values.

Our study aims to develop a game focused on entertainment that reflects the values of the wheelchair users with the sole purpose of entertainment. With the possibility of reflection of values in an entertainment game, we will be able, in future works, to carry out studies with physical and educational challenges, as continuity of the research described in the current study.

We believe that the game can further be improved based on the results and testimonials retrieved during the experimentation. Even though we understood that the pre-production prototype of the game reached its objective in representing values of the users, it can be adapted to encompass a broader public. Possibly, the next group of people to be involved in the game content are wheelchair users with more limited functional abilities than the users that participated in the development of this study.

Data Availability

Our study is the description of the development of a gesture-based game based on participatory design that reflects values of wheelchair users. The data were collected through experiments made by testers.

Conflicts of Interest

The financial support that we mention did not lead to any conflicts of interest regarding the publication of this manuscript.

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Supplementary Materials

To better illustrate the design of the Wheelchair Jecripe game, we provide supplementary material. The supplementary material is constituted by a video that illustrates the participatory design sessions with the wheelchair users and the researchers described in this study. The wheelchair users in the video have given consent for the video to be published. *(Supplementary Materials)*

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