Training Socially Responsible Engineers by Developing Accessible Video Games

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Abstract. University has an active social responsibility that is addressed both by acting responsibly as institution and by transferring this ethical duty to the students. Our proposal is achieving the social inclusion of disabled people, as part of the social responsibility of future engineers, through the realization of the final degree project in collaboration with associations of disabled users, in particular through the design and development of adapted video games. This paper presents our experience in developing these projects in collaboration with an association of users with cerebral palsy. The objective is training the students in the social responsibility but also solving some problems of inclusion in the collective of disabled users (such as the access to digital entertainment) and carrying out an in-depth study about the interaction problems for users with cerebral palsy, providing concrete and practical solutions. The methodology for this experience is Action Research, with four research stages (plan, implement, evaluate and reflect) that are iteratively repeated. Following this methodology, three iterations have been carried out and a fourth one is planned. As a result, three adapted video games have been developed and a guide for adapting video games to people with cerebral palsy has been defined. This experience has served to introduce the aspects of social responsibility in the curricula of engineers in a very effective way and to study and design new ways of making video games accessible to disabled people, giving them the chance to exercise their right to entertainment.

Keywords: Social responsibility · Accessibility · Accessible video games

1 Introduction

University has an active social responsibility, that is, it has the obligation to act for the benefit of society at large. This active social responsibility must be addressed from two perspectives: acting responsibly as institution and transferring this ethical duty to the students it educates. The latter is usually tackled by introducing social and ethical aspects in the curricula to prepare the future professionals to be committed to their social environment. One important aspect

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of this social commitment is actively ensuring the social inclusion of any individual, no matter his or her circumstances. A paradigmatic case is the inclusion of disabled people.

The degree of Multimedia Engineering of the University of Alicante, introduced the aspects of inclusion in its curriculum. The main objective of this degree is "to train professionals in the ICT sector who are able to direct new projects in the field of multimedia, both in the sectors of digital leisure and entertainment and of content management for its dissemination in information networks [...] This training is focused on providing students with the skills to build digital systems for the management of multimedia information, provide technical support for multimedia projects in the field of culture, telecommunications, teaching or business, and create and support the technical elements involved in the creation of image and sound related to digital leisure" [23]. It has two specialties: Digital Creation and Entertainment, mainly oriented to the design and development of video games, and Content Management, oriented to the tools for the content management and dissemination, especially through the web. The concepts of accessibility, usability, ergonomics, equality and professional responsibility are present in every subject and area of the curriculum. In this context, the aspects of accessibility for disabled people are fully justified in the curriculum of Multimedia Engineering.

For the development of a mature and fair society, it is essential the citizens to achieve a normalised vision of disabled people in all of the areas, particularly in the field of leisure. The normalized vision and the equal treatment become the key aspects to obtain the true social inclusion. Our proposal is introducing social responsibility for achieving this true social inclusion through the realization of the final degree project in collaboration with entities, institutions or associations of disabled users, in particular through the design and development of adapted video games. This paper presents our experience in developing these projects in collaboration with an association of users with cerebral palsy. The objectives of this experience are:

- Training multimedia professionals in the social responsibility they have as engineers who develop their profession in a social context and in the need to provide solutions to a diverse society.
- Solving some problems of inclusion in the collective of disabled users, including making them participants in digital entertainment, since leisure is an essential human activity and an individual right.
- At the technical level, carrying out an in-depth study of how to solve the interaction for a specific group, that of users with cerebral palsy, providing concrete and practical solutions that allow them to access technology in general and video games in particular.

The methodology that we use for this experience is Action Research [6]. In this methodology the research process is divided in four stages (plan, act, evaluate and reflect) that are iteratively repeated introducing improvements in each iteration. During the plan the activities to develop the project are established (meetings with the association, definition of objectives, requirements and limitations); during the implementation, the adapted video game is designed and developed, using incremental and agile methodologies; during the evaluation, several user tests take place and opinions are collected; during reflection, the collected data are analysed and improvements are proposed for the next iteration. Following this methodology, three iterations have been carried out and a fourth one is being developed right now.

This experience has served, on one hand, to introduce the aspects of social responsibility in the curricula of engineers in a very effective way and, on the other hand, to study and design new ways of making video games accessible to disabled people, giving them the chance to access to the right to entertainment.

The document is organised as follows: Sect. 2 presents the concepts and previous works about social responsibility in higher education, disability and cerebral palsy in particular, and adaptation of video games. Our proposal of methodology is presented in Sect. 3. Section 4 is devoted to explain in detail the iterative and incremental development of the adapted video games. Discussion is presented in Sect. 5, resulting in a list of lessons learned about adapting video games to users with cerebral palsy. Finally, the conclusions and future work are presented in Sect. 6.

2 Background

2.1 Social Responsibility and Higher Education

Within the main functions of the university (teaching, research and transfer), the social dimension is of the utmost importance [1]. The different curricula should incorporate aspects related to professional ethics, the development of key competences and entrepreneurial initiatives, as well as the impact of technologies and processes in terms of social and environmental sustainability, as a driver of change for future professionals. Among the basic principles and values of the university are social participation, through the creation of channels of communication and participation to respond to the demands of its stakeholders.

Particularly, the University of Alicante, in which this proposal is framed, is a public and socially responsible institution, whose mission is Òthe integral training and development of its students. Not only in knowledge and disciplines, but also the promotion of the critical awareness, social responsibility, health and sustainability principles, to contribute effectively to the welfare of the society where it is inserted. It should also be added the guarantee of personal dignity, the free development of persons, without any discrimination, and finally, the right to effective equality between women and men. Research is another basic principle to increase improvement of knowledge. On the one hand, by its transfer through teaching. On the other hand, the direct contribution of the University to the society through its inescapable commitment to the cultural, scientific and technological development. In this way, thanks to the collaboration with other social agents, such research can be realized in innovation for sustainable development and the improvement of the quality of life [24]. The references that guide the values of the University of Alicante are designed in order to foster the quality of a public university. Among these, it can be found solidarity and sustainability.

This initiative is part of the curriculum of Multimedia Engineering, among which the following competences stand out [23]:

- Conceive, organize, plan and develop projects in the field of multimedia engineering and the design, development or operation of multimedia systems, services and applications.
- Design, develop, evaluate and ensure the accessibility, ergonomics, usability and security of multimedia systems, services and applications, as well as the information they manage.
- Analyse and assess the social and environmental impact of technical solutions, including the ethical and professional responsibility of a Multimedia Engineer.
- Know and understand the multimedia concept, the characteristics of the multimedia language, the technologies involved, the organization and management of multimedia systems and the socio-cultural impact in the society of information and knowledge.
- Develop and direct multimedia engineering projects in an efficient and effective manner, taking into account the feasibility, sustainability, legislation, job security, regulation, standardization and accessibility and gender equality related to the information society in the development of projects.
- Create, design and evaluate personal computer interfaces that guarantee accessibility and usability.

The concepts of accessibility, usability, ergonomics, equality and professional responsibility are present in every subject and area of the curriculum. In this context, the aspects of accessibility for disabled people are fully justified in the curriculum of Multimedia Engineering. A good way to complete the training of these future professionals may be the development of final grade dissertations for entities and institutions supporting this group of users.

2.2 Disability and Cerebral Palsy

Disability is defined as the consequence of damage that may be physical, cognitive, mental, sensory, emotional, developmental, or a combination of these. It affects how the individual interacts and participates in the society and it can be present from birth or occurring during a person's life.

According to the World Health Organization [27], more than one billion people live in the world with some form of disability, of whom almost 200 million experience considerable difficulties in functioning. People with disabilities have poorer health outcomes, lower education achievements, less economic participation and higher rates of poverty than people without disabilities. In part, this is a consequence of the obstacles in accessing services that many of us take for granted, in particular health, education, employment, transportation, or information. These difficulties are exacerbated in less favoured communities. In order to achieve development goals, it is necessary to provide means to make people with disabilities independent and to remove the barriers that prevent them from being an active part of the communities, training and finding a job [27].

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour [19]. Although the main characteristic of this disability is movement disorder, of individuals affected by CP, 28% have epilepsy, 58% have communication difficulties, at least 42% have vision problems, and 23% to 56% have learning disabilities [11]. Cerebral palsy is characterized by abnormal muscle tone, reflexes, or motor development and coordination. There may be deformities and contractures of joints and bones or tight muscles and joints. The frequent symptoms are spasticity, spasms, other involuntary movements (e.g., facial gestures), unsteady gait, balance problems, or decreased muscle mass [3]. More specifically, depending on the functional effects, it is possible to distinguish between the following types of CP [17]:

- Spastic: this is the most common group; about 75% of people with CP have spasticity, that is, significant stiffness in the muscles, an inability to relax them, due to an injury to the cerebral cortex that affects motor centres.
- Athetoid: it is characterized by frequent involuntary movements that interfere with normal body movements. There are usually contortion movements of the extremities, the face and the tongue, gestures, grimaces and awkwardness when speaking. Hearing disorders are quite common in this group, which interfere with language development. Injury of the basal ganglia of the brain seems to be the cause of this condition. Less than 10% of people with CP show athetosis.
- Ataxic: the person affected in this case has poor body balance, an awkward gait and difficulties in the coordination and control of hands and eyes. Ataxic cerebral palsy is a relatively rare form of the disorder that stems from damage to the cerebellum.
- Mixed: it is not common to find pure cases of spasticity, athetosis or ataxia. Typically, cerebral palsy sufferers have a combination of the different types.

2.3 Video Games and Disability

Video games have become in the last years a mainstream form of entertainment. Their popularity may be explained, among other reasons, by the immersion produced by the continuous interaction, in contrast to other more classic forms of entertainment, such as books or cinema. Moreover, video games have transcended their role of mere outlets of entertainment, and nowadays many examples of leveraging the potential in other areas can be found. This is the case of teaching [7,9,10,12,20,25] or health [21,26]. However, there are a significant number of potential disabled players that may not be able to access video games if they are not thought of when designing the games. For this group of players, the access to video games can mean a form of leisure that they did not know, and improvements in their education [4] or rehabilitation [13,18].

From the player's perspective, the basic flow of any video game is [28]:

1. Receiving a stimulus.
2. Determining a response to the stimulus.
3. Executing the response.

Creating an accessible video game means giving support and offering options to allow this flow to run correctly to players with any limitation. There are several ways to adapt the interaction so that the flow is maintained. Particularly, in the case of functional diversity in mobility, two main aspects must be considered: the access technologies (the adapted devices that allow the interaction), and the adaptation strategies (the game design decisions that make the game accessible).

The access technologies are the intermediary devices between the player and the game. They manage to translate the functional intentions of the player into the opportune result produced by the game. In the case of motor impaired players, it is often difficult or impossible for them to interact using conventional input devices such as mouses or keyboards. There are some alternative input devices specifically designed to accommodate their abilities, such as [22,28]:

– Mechanical switches: In the simplest case, a mechanical switch consists of two or more contacts and an actuator that connects or disconnects the contacts to close or open the switch, respectively. The mechanism may respond to specific mechanical stimuli, including changes in displacement, inclination, air pressure or force. These switches are controlled with an explicit physical movement. Some examples of mechanical switches are one-button switches, mouth switches or head switches.
– Infrared sensing: these sensors consist of a source of infrared light and a receiver. Receivers detect the radiation and generate a proportional output voltage, identifying the depth of the scene from the point of view of the source. An example of infrared sensor is Kinect sensor, from Microsoft.
– Electromyography (EMG): these devices consist of a set of electromyographic electrodes placed on the skin that record the electrical activity generated by the muscles at rest and during contractions. This allows devices to be controlled by EMG patterns associated with movements of different muscles, such as facial muscles for instance.
– Oculography: gaze-based communication systems can map eye movement or point-of-gaze to cursor position. There are two main technologies: Video-oculography (VOG) and electro-oculography (EOG). VOG is based on an infrared light source and a camera, so that the view direction is calculated from the displacement between the reflection of the cornea and the centre of the pupil. EOG is based on electrodes that are placed around the eyes and measure potential changes between the cornea and the retina that occur when the user changes the direction of the gaze.

– Computer vision: these systems track the location of a facial reference point of the user (e.g. nose or pupil) through a camera and translate the position changes in cursor movements on a screen.
– Brain-Computer Interfaces: these systems directly capture the brain activity through the use of different types of electrodes. Depending on the electrodes placement, the main technologies are electroencephalography (EEG) (superficial electrodes placed on the scalp), electrocorticography (ECoG) (surgically implanted epidural or subdural electrodes) and intracortical recordings (electrodes chronically implanted in the cortex).

Beyond the devices used for the interaction, another aspect to study is how to design video games so that players with motor disabilities can easily access them. In this case, the main strategies for adaptation are [14]:

– Control with one button: it is possible to design games that are controlled only by using a button, or, at least, using the minimum number of buttons.
– Control with one hand: the controller interaction is designed to be used with one hand only.
– Non-simultaneous buttons: avoid that the accomplishment of an action entails to press more than one button at the same time.
– Configurable control sensitivity: provide the possibility of adjusting the sensitivity of controls.
– Configurable game speed: provide a possible decrement of game speed to make the game easier to be controlled.
– Various levels of difficulty: a mode of immunity or the ability to jump directly to the next episode of the game may be used to make the game easier to play.
– Control by microphone: provide the possibility of using the microphone as peripheral to control the game, either by voice recognition or simply by sounds that emulate the pulsations of a single button.

3 Methodology

The final degree projects have been developed in collaboration with APCA (*Asociación de Paralíticos Cerebrales de Alicante*, Association of Cerebral Palsy of Alicante). Its main objective is defending the rights of people affected by Cerebral Palsy, aimed at achieving normality [2]. APCA offers care, advice, education, training and leisure to affected people. The research team made contact with the association in 2013, starting collaboration, initially in an informal and voluntary way, to develop final degree projects for designing and developing accessible video games, adapted for users with cerebral palsy.

The methodology that we chose for this experience is Action Research [6]. In this methodology the research process is divided in four stages (plan, implement, evaluate and reflect) that are iteratively repeated introducing improvements in each iteration. Action research does not have an end point so it always poses new questions. Figure 1 graphically shows the stages of the methodology and the concept of iteration.

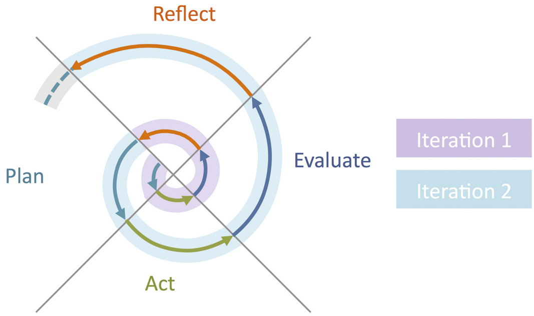

Fig. 1. Action research methodology

During the *Plan* stage, the activities to develop the project are established. In particular, there is an initial meeting with APCA, to know the users and their context; the objectives of the final degree project are defined; there is a process of requirements and restrictions identification (limitations about the users' abilities, technical requirements and limitations, and economic and resource requirements); and the video game design and development planning is set up.

The *Act* stage is devoted to the incremental design and development of the video game. Agile software development methodologies are used, with short iterations, in which different functionalities are incorporated and continuous tests are carried out with users.

The *Evaluate* stage takes place after the development of the project. Tests are carried out with the users (end users and instructors) collecting their opinions, to know their level of acceptance. The results are compared with the initial requirements to know if they have been fulfilled. The implementation plan is also monitored and evaluated.

The *Reflect* stage is based on the results obtained in the previous phases. All data are compiled and analyzed. We collect the recommendations and observations that will help us begin a new iteration with the initial Plan Stage. In short, improvements for the next iteration are proposed.

4 Results

4.1 First Iteration: Footb-all Game

In the first iteration, an adapted video game about football was developed. This first experience allowed us to understand the problem of making video games accessible to users with cerebral palsy, to identify the main strategies to reduce and adapt interaction, to use simple interaction devices such as mechanical switches, and to define the improvements for the next iteration.

Plan Stage. Once the contact with APCA was established, the first step was to meet up with them to know their needs. The participants were: the tutors of the projects, the students, the therapists of the centre and some final users. As a result, a list of general requirements was defined: simple design, configuration options, customizable user profiles, possibility to cancel an action, use of sweeps for element navigation, emphasis when the action succeeds or fails, and graphic support for textual elements. The conceptual design of the video game was the next step: by decision of the final users, the game was about football. It consisted of a series penalty throws. The scenario of the game was a football field. The interaction should be very simple, using a mechanical switch, just to click. The way to select the parameters and characteristics of the throw (direction and speed, mainly) should be through the use of circular or bar meters (sliders), so that just a click is needed to stop the needle. The speed of the needle would also be configurable. The direction of the throw would be complemented with a random variable that represents the nervousness of the player to make the throw more unpredictable. There would also be some extras: choosing different teams, players, and avatars, and including a ranking.

Act Stage. During this stage the application was built following the initial requirements. It needed an iterative refinement of the prototype. After each visit to the association, new or adapted requirements arose or it was necessary to modify some part of the game, generating new versions of the prototype. The final prototype, called *Footb-all* [8], was presented to the members of the association.

The game is played in three main stages: Configuration (the players profile about interaction, the selected team and the avatar are selected, see Fig. 2), game (the direction and speed are setup and the ball is thrown, see Fig. 3), and results (the ranking is presented, see Fig. 4).

Fig. 2. Configuration screen of Footb-all game. The profile is selected just clicking with the switch when the desired picture is highlighted during the sweep.

Fig. 3. Main game screen of Footb-all game. The sliders to select the horizontal and vertical direction and the speed are placed on the right bottom corner of the screen.

Fig. 4. Results screen of Footb-all game. It shows a ranking of the players.

Evaluate Stage. During the previous stages, many data were gathered from the users (CP patients and their therapists) but also from the development of the project. It allowed us to determine the progress and make the necessary adjustments for the project to succeed. The analysis of this information and the comparison against the design and the requirements showed us that there was little deviation during the implementation, so the plan to develop the game was appropriate and complete.

We also sounded out the final users and the therapists to obtain their opinions about the game and how to improve it. The therapists affirmed that the video game enhances the emotional well-being and the motivation for personal improvement. They also considered that playing in a continued way could favour the strategic planning and perceptual abilities, as well as spatio-temporal organization and increased physical response speed. Final users, besides, found to access new technologies very attractive, especially when they are related to leisure. They also pointed out that there had been some competition between them.

Reflect Stage. This first experience allowed us to understand the problem of making video games accessible to users with cerebral palsy, to identify the main strategies to reduce and adapt interaction and to use simple interaction devices such as mechanical switches. All the gathered information and the analysis allowed us to define an improvement plan with two main objectives:

– Explore new ways of interaction: Although the users found very easy the use of adapted switches, the interaction turned out to be too limiting in many cases.
– Introduce characters which the player could identify with: The use of disabled characters could achieve a higher level of empathy of the player.

4.2 Second Iteration: Formula Chair Game

The second iteration was devoted to design and develop a video game about wheelchair races, an adapted sport that many players do. We also introduced the use of a more advanced interaction device, Kinect, using simple movements. The evaluation phase made us detect that Kinect was a good choice.

Plan Stage. In this second iteration we proposed the following objectives, defined in the improvement plan of the previous iteration:

– Maintain the main successful elements of the interface, such as the sweep concept for the selection of profiles, the structure of the profiles and the final screen of ranking.
– Introduce a character and a context in which the users could feel identified.
– Incorporate a new interaction device that would increase the range and variety of movements, but maintaining the requirement of simplicity.

As a result, *Formula Chair* game [5] was designed taking these requirements into account. The game would consist of a character that is infinitely moving in a scenario with three lanes. Some different objects (coins, obstacles or other people) may appear and they must be avoided or collected. The score would be calculated according to the play time without losing all lives, the number of collected coins and the number of dodged obstacles and people.

The user could decide which extremity to use to interact with the game: head, right arm, left arm, right leg or left leg. The capture of the movement of the chosen extremity would be performed using the *Microsoft Kinect* device [16].

Act Stage. This stage was devoted to develop the video game. An agile and incremental methodology was also used. As a result, successive prototypes were obtained, so the work of monitoring the progress and the adaptation to the requirements were facilitated. The main milestones were:

– Start up and configure the interaction using the Kinect device.
– Determine the interaction. Each user had a profile in which he or she selected the extremity for interaction.

– Define the ranges of movement of the extremities. In particular, two configurable ranges were defined: right range (minimum movement range of the extremity to the right to change to the right lane) and left range (minimum movement range of the extremity to the left to change to the left lane).
– Calculate the score in function of collected coins and dodged obstacles and people.

During the realization of the project, we detected some aspects to be redefined: for example, it was necessary to implement a pause function. The game is paused at the beginning, until the user is ready to start, and there is also an automatic pause if the Kinect device loses the user's reference. Figure 5 shows a screenshot of the interaction configuration screen and Fig. 6 the main screen of the game.

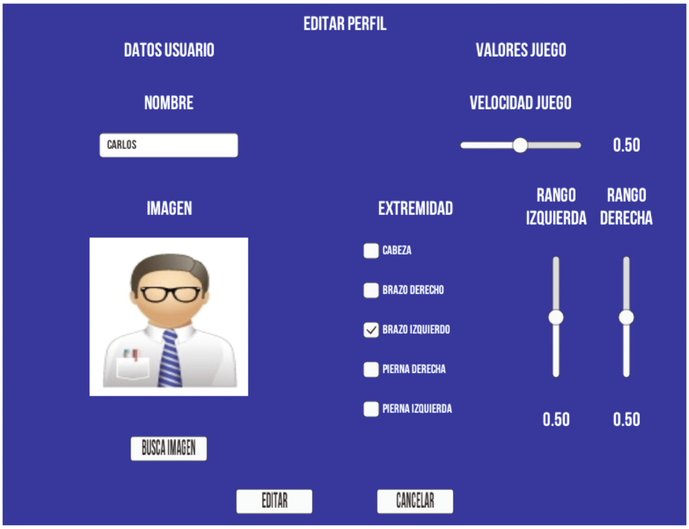

Fig. 5. Interaction configuration screen of Formula Chair game. The profile allows the selection of the extremity and the movement ranges.

Evaluate Stage. Once implemented the video game, several tests were carried out to verify the functionality of the game and to obtain the opinion of the therapists and the users. Therapists responded to three questions on a Likert scale with values between 1 (strongly disagree) and 5 (strongly agree), in addition to providing their personal opinion. An open question was also set out. These questions try to explore the possibility of using video games to complement the work of physiotherapists. Since only two therapists participated, the results are not statistically significative but they allow us to propose improvements for the next iteration. Table 1 shows the questions and answers obtained.

Eight users responded to a more general questionary about their users' experience. All of them liked the game, considered it as a good tool to be incorporated in their physiotherapy sessions and had a high opinion about developing

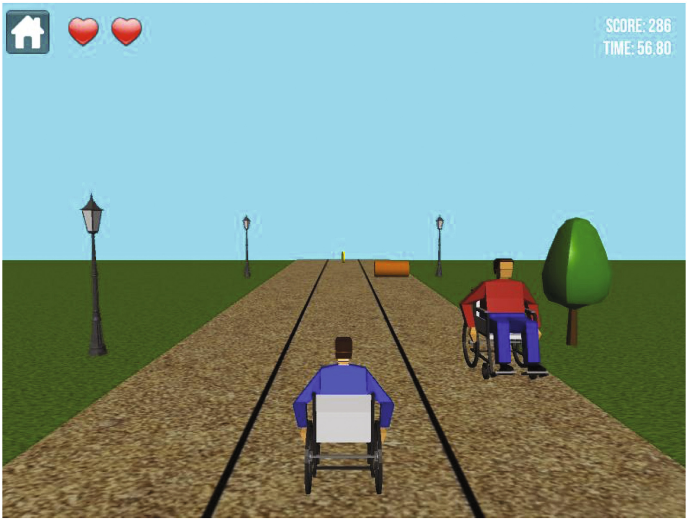

Fig. 6. Main game screen of Formula Chair game. The player must change the lane to avoid obstacles and people and collect coins by moving the selected extremity.

Table 1. Questions and answers of therapists about the use of the video game for physiotherapy

Question	Average value	Opinion
I would use this video game as a possible method of physiotherapy	5	It helps to work with an extremity. The users are motivated to improve their score
The video game can help improve the mobility of people	5	Configuration (speed, extremity and movement range) improves therapy possibilities
The video game is fun and suitable for people with cerebral palsy	4	The game is suitable and fun, but there may be other more interesting topics
What would you improve in the video game?	–	Improve user capture, especially for those who use a wheelchair

this type of collaboration between APCA and the University. Some of them, however, found the game difficult to use because of the limited movements.

Reflect Stage. This second video game allowed us to approach to the access to games from two different points of view: the interaction through new devices and the possible use of games as therapy tools. As a consequence, the new improvement plan has as main objective placing the requirements of the physiotherapists in the centre of the design process. In the previous iterations the aim was providing fun but in the following one this aim should be balanced with the use of the game as a physiotherapy tool.

4.3 Third Iteration: Fisio Run

The third iteration included the team of physiotherapists of the association in the project, developing a new game with two main objectives: serving as entertainment and helping the physiotherapists to achieve their goals with the patient. This game should use several movements to obtain different results, so that it helped the players to distinguish different movements.

Plan Stage. In this iteration the main objective was to develop a video game that, besides being fun, had a therapeutic purpose. The therapists of the centre considered that this type of applications could motivate the users to make more complex movements to achieve their goals, thus it would help in their rehabilitation. Therefore, it was decided that this new video game should include more complex movements than the previous ones.

The video game was decided to be about running while jumping and ducking to avoid the obstacles. The movement should be controlled by different parts of the player's body. The good results obtained in the other iterations led us to maintain the definition of profiles to configure the system (adding the necessary elements to incorporate a more complex interaction) and the sweep scheme for the selections.

Act Stage. The implementation used an agile methodology to carry out the successive prototypes, as in the previous iterations. These prototypes led to a final version of the game, which was called *Fisio Run* [15], which included the following features:

– The scenario was created automatically, from an infinite plane in which two types of obstacles to avoid, by jumping or crouching, were randomly incorporated.
– Two game modes were created for one and two players. This motivates users through competition between them.
– Each player created a profile to configure, among other aspects, the speed, the extremities to interact and their movement. In total, three types of actions must be configured: running, jumping and crouching.
– Each player initially had three lives (the number of lives was configurable though to help the users with higher difficulties), discounting a life each time the avatar crashed an obstacle. The final score was calculated in function of the time the player is able to stay in the game.

Figures 7 and 8 show the configuration and the game screens.

Evaluate Stage. The collection of data during the previous phases and the constant communication with the therapists allowed us to make an adequate evaluation of the development process and the opinion of the users. The main results are:

Fig. 7. Interaction configuration screen of Fisio Run game. The profile allows the selection of the extremities for each movement.

- From the point of view of the interaction, Kinect is a tool of reduced cost and quite acceptable results. However, it leaves out certain users with a very low level of mobility and it still has some problems when detecting users in a wheelchair.
- From the institutional point of view, the need to establish stronger ties between the University and APCA has been detected in order to carry out new joint actions.

Reflect Stage. The collaboration between the University and APCA is close and easy. However, we must go further to develop other projects. Moreover, the Kinect device should be complemented with other interaction devices. Therefore, the next improvement plan has as main objectives:

- Signing a formal agreement between our organization and APCA to deepen our relationship and develop new more ambitious projects.
- Explore the use of other interaction devices to widen the scope of the projects to users with very low level of mobility.

4.4 Fourth Iteration

Now, the fourth iteration is beginning. A first action has been made: signing a formal agreement between the institutions. We have planned two main objectives for this iteration:

Fig. 8. Main game screen of Fisio Run game. The player must jump or crouch to avoid the obstacles by moving the selected extremities.

– Develop new games, exploring the new interaction devices.
– Improve our dissemination actions by letting every development at the disposal of any other institution through the institutional platform of the university.

5 Discussion

Most people who suffer from cerebral palsy have movement limitations. This implies that many of them do not have the physical capacity to respond quickly to certain stimuli, to interact with precise movements or to make combinations of movements that many video games demand. Our experience in these projects tells us that the adaptation of the interaction can be done through several strategies. In the following paragraphs, these strategies, that can be combined in several ways, are compiled to serve as a guide for future developments.

Interaction Reduction. One of the most effective way of making a video game accessible is reducing the interaction so that it can be performed with a single button, by means of just a click, avoiding combinations of buttons, multiple buttons or pointing devices. In general, this is achieved by using mechanical switches that can be pressed with the hand, foot or head, or by other more specific devices.

Sweeping. Reducing the interaction to a single click can be achieved through sweeping strategies. This technique is used to navigate between several options and select one of them. All the options are highlighted, one at a time, at a certain speed, and then changed after a defined time. The user must click on the moment the desired option has the focus. Apart from the option with the focus, the other previous and future options must be displayed on the screen, so that the user can anticipate the next option and prepare to perform the action.

Sliders and Circular Meters. Sliders and circular meters allow the selection of a value within a range. They have a needle that runs the slider automatically, so that the user can stop it at the desired value with a single click. This strategy allows the selection of different values without requiring a pointing device that needs to be handled with greater precision.

Speed. The speed of each user when handling the interaction devices during the game can be very varied. Therefore, it is important to allow the configuration of the speed, both during the selection of the characteristics and the profile, and during the game action.

Interaction Devices. In addition to switches, the inclusion of other more versatile interaction devices can be very interesting. In particular, the use of Kinect in our games has given us very good results. On the one hand, not having to hold any element in the hand facilitates freedom of movement. On the other hand, it is possible to define with which part of the body we want to perform the interaction. It is necessary, therefore, that the games allow different configurations and ranges of movement.

Game Interface and Graphics. The game interface should be simple so as not to divert users' attention from the main focus. The design of the interaction elements should allow easy identification, making use of appropriate colors and sizes. As for the game scenario, we must avoid too many superfluous elements that divert attention from the main character.

6 Conclusions and Further Work

This experience has served, on one hand, to introduce the aspects of social responsibility in the curricula of engineers in a very effective way and, on the other hand, to study and design new ways of making video games accessible to disabled people, giving them the chance to access to the right to entertainment.

The use of the proposed incremental and agile methodology has been proved to be very suitable for this type of projects. It has the advantage of allowing students to gradually introduce themselves in the knowledge of adapting video games to make them accessible. In addition, in this way, the successive reunions and tests with the users of APCA allow the students to know the problems of users affected with cerebral palsy and to strengthen the bonds between students and users. This gives students an important awareness of the need to give all people, regardless of their conditions, access to digital platforms and, why not, to digital leisure.

As a result of the design and implementation of several video games, we have also obtain a guide for designing and developing adapted games. This is a preliminary version that will be completed in the future as next iterations will be performed. This guide can also be extended to other types of digital systems that must be adapted to disabled users.

This work is considered as a seed for the digital transformation of the interaction environments adapted to users with disabilities, and for the involvement of professionals of the future in this transformation. Therefore, the lines of future work are many and widely open. In particular we propose for the future:

– Widen and strengthen the links between our University and APCA and other associations of disabled users.
– Introduce this iterative and incremental methodology of work in other curricula in the context of Information Technology Engineerings.
– Improve the diffusion of the results so that it can be used for any disabled user.

Other future lines are related to other more technological objectives. In this context, our next steps will be:

– Explore other interaction devices. We are particularly interested in Brain-Computer Interfaces.
– Explore new ways of adapting the interaction to complete the guide and lessons learned about adapting video games to disabled users.

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