A serious game for cognitive disabilities

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Abstract

Nowadays serious games are starting to be accepted not only as entertainment tools, but also as learning tools, used in a school context and in professional training. Regarding people with cognitive disabilities, the few games dedicated to this population are mostly focused on daily life skills, missing the work-related skills. Training adults with cognitive disabilities is still seen as a big challenge for companies, who face a productivity loss when employing such adults, especially while they are being trained. In the present work was developed a serious game for adults with cognitive disabilities, as a tool to teach work-related skills, mitigating the productivity loss. In the game are approached tasks required to an employee working in a supermarket, as this is the most common situation for adults with cognitive disabilities. The developed game was designed according to recent literature in the area of serious games and validated by psychologists, supermarket managers and a supermarket employee. Finally, we run some player testing sessions and used a model of Playability to evaluate the game. From those sessions we can conclude that most people were able to play the developed game although the Player Experience wasn't maximal. Also, we concluded that for better results regarding serious games for cognitive disabilities there's still a long way to go, being necessary to define standard concepts and evaluation models to guarantee the adequate Player Experience and suitable learning outcomes.

Keywords: Cognitive disabilities, serious games, work-related skills, disabled adults, supermarket

1. Introduction

Serious games primary objective is not pure entertainment, but passing some kind of knowledge to the users. Typically they unfold in an environment that is a simulation of the real world, where the player must solve one or more problems, being able to test several behaviours [1] that could be risked in the real world, either for his/hers physical and psychological well-being or that of others. The player learns which are the best approaches to the problem presented by the game and, as a consequence, when confronted in a similar and real situation, he/she knows how to act accordingly [2]. Several studies indicate that there are many benefits in using serious games for rehabilitation of people with cognitive disabilities.

People with cognitive disabilities have the functions of attention, memory, reasoning, language, perception, problem-solving, conceptualizing [3], self-regulation and social development [4] impaired, not allowing the proper knowledge acquisition. This causes great difficulty in relating and learning concepts and behaviours and expressing themselves through writing or speaking, having implications at social level. As main examples, we have Fragile X syndrome, Down syndrome (also known as Trisomy 21) and autism spectrum disorders (such as Asperger syndrome).

Traditional teaching methods often do not apply because they make learners lose interest, thus increasing the difficulty in learning. Also, we have to take into account that cognitively challenged people do not deal with pressure in the same way as we do, being important to provide them not only the pressure-free environments traditional methods typically don't entail, as well as stimulating and innovative environments that capture their attention and motivate them to activities of learning [4, 5, 6]. One way to achieve this is through the use of serious games, although most part of existing educational games can not be used by this population because take advantage of capabilities that some of them don't have or that are not developed enough. Most of them approach contents like social skills, written language and numeric skills (decimal numeration, addition, subtraction) [6], but let out more complex situations like everyday work life.

The use of serious games is fairly accepted by this population because they do not feel the pressure existing in the real world, feeling comfortable

to explore the virtual world and to repeat tasks until they master it, increasing the confidence of the individuals. Also, games can be adapted to individual person needs, are interactive, can be used individually or in groups [4] and since the computer is recognized as an important tool in our society, impaired people feel proud to be using it as well, having increased confidence and self-esteem [7].

1.1. Main objectives

The employment of disabled people causes a loss of productivity on the employer companies, caused by the time they require to adapt to the new employment circumstances. This situation is specially demanding when the employee is still learning how to fulfil his tasks and thus commits errors and/or forgets what he/she is supposed to do. Even when the training part is over, it's still necessary to check if his tasks were fulfilled correctly and perform the needed corrections.

Hereupon, the main objective of this work is to develop a serious game to help adults with cognitive disabilities to have more success in their jobs and to integrate in society, covering mainly task fulfilling aspects, but also social aspects needed in the everyday job life. By developing such a game, we hope to diminish the company productivity loss caused by the needs of such employees. The game would act as the trainer, easing this task at the responsibility of the hierarchical superior, increasing the company's overall productivity and acting as a stimulating factor towards employing people with disabilities.

1.2. Outline

On Section 2 we analyse briefly what has been made in the area of serious games for cognitive disabilities. With this is mind, on Section 3 we present the Game Architecture for a serious game that teaches work related skills and the developed Proof of Concept derived from it, along with the design decisions we took on the implementation. On Section 4 we evaluate the Proof of Concept under a Playability model and discuss if it fits the population needs and if there is a learning outcome. Finally, on Section 5 we conclude this work by presenting the major achievements and future work.

2. Background

Games developed for people with cognitive disabilities place a great emphasis on adaptability as a way to provide a good experience to players with different needs. They allow adapting elements like: content to be taught, screen position, multimedia assets, difficulty level, help provided [2, 8], number of objects in game [2, 9], number of possible responses, time available to give the answer [10], etc. The way the adaptability is implemented varies in each work. It can be achieved by means of a template, which specifies the adaptations necessary for each user profile [8]; through an hierarchical structure of the game, where "an object can be added to any scenario part, a scenario part can be added to any scenario, a scenario can be added to any story." [9]; and through a system that generates adaptive scenarios taking into account the user's profile and the user's interaction traces [10].

From these works we can obtain valuable informations on how to design serious games for adults with cognitive disabilities. For instance, it was discovered that *point-and-click* adventure games don't present many frequent accessibility barriers and have significant educational potential. Since reflection predominates over action, these games are low-paced and only require simple inputs, specifically mouse clicks [2]. The game genre is an important factor towards a successful learning, since a wrong genre can worsen the users' condition. For example, shooter games may have negative effects on people who have attention disorders and impulsivity [1].

It was also discovered that adult players reject action-based children's games and games where is required to avoid being attacked (they are rapidly eliminated), preferring games like Hangman, Wheel of Fortune and Solitaire, since those are calm and don't require fast thinking and movements [7]. It is very important that the population recognizes the system as a game, and that they feel that they aren't solving exercises, as they typically do, but merely playing. This will generate more attraction towards the content on screen as well as more interest in interacting with the software [7].

Building successful applications or games for the cognitively disabled is not only about the software, but also about the devices used for playing. Studies found that cognitively disabled players prefer to use touch screens to keyboard and, among the touch screens, prefer tablets instead of smartphones, due the screen size [8, 11]. Also, tablets engage more than one user at a time, which enriches the social experience of players [12] and have more room for interface elements, allows showing larger items and it's easier to see and touch [8]. It's important that the devices are socially accepted, like iPods and iPads [13], and have associated an entertainment status, which is crucial to captivate the users. In fact, in some cases, users prefer to use these devices instead of using low-tech options, although some users showed difficulty in operating these devices with sufficient finesse/motor control to activate the

desired function. This suggests that this might not be the most adequate device solution for people with significant motor impairments, unless it can be integrated with other solutions [13].

Another study, pointed out Nintendo DS™ as a device with several advantages: it's resistant, since it is designed to be used by children; has a good autonomy, circa 11 hours; has adequate memory space for games; and it's affordable by a significant number of people. In addition, it has two screens, which offers more interaction possibilities than with just one screen; has wireless connectivity and can be used with other commercial games, which can act as a reward mechanism [5].

As an hypothesis to bypass the accessibility obstacles disabled people often face, there are the multimodal applications, which allow the users to choose one method of input between speech, text or point-and-click [14]. The use of speech in applications has advantages like the development of more natural interfaces, hands free access and increased user satisfaction (because it is a multimodal interface). With this kind of interfaces, even the people who lack manual dexterity (a very common characteristic among cognitively disable people), can play the game.

Figure 1 compares several devices according to their suitability for both motor and cognitive disabilities, summarizing this discussion [15].

Device \ Disability	***Motor***	***Cognit***
Trackball	*	*
Touchpad	*	
Joystick	*	*
Head mouse	*	*
Eye mouse	*	
Touch screen	*	*
Actigraph	*	*
Gesture remote	*	*

Figure 1: Suitability of Interface Devices [15].

Regarding the evaluation of serious games, literature review alarmed us for the lack of consensus in this area. Basilar definitions of games like Player Experience, Playability, Usability and Gameplay are still nebulous [16, 17, 18, 19], since some works use the same words for characterizing different game aspects, while others use the same concepts with different names. This lack of consensus has a consequence: there isn't a standard and universally accepted way to evaluate a serious game. Each investigation often leads to a new proposed model, sometimes with nothing in common with previous ones [18, 20, 21, 22].

A very detailed model on Playability is the one developed by [23], which indicates and defines not only what to evaluate, but also how to do it, departing from Usability and broadening it to include attributes and properties that can describe the Player Experience (PX) adequately. It includes the attributes Effectiveness, Learnability, Immersion, Satisfaction, Motivation, Emotion and Socialization, each one with its properties.

Analysing Playability can be complex because we can use different perspectives to analyse each element of the game. In the work [24], it's proposed to classify Playability based on the six Facets of Playability: Intrinsic Playability, Mechanical Playability, Interactive Playability, Artistic Playability, Intrapersonal Playability and Interpersonal Playability. This means we would apply the model to the game six times (one per facet), evaluating the same properties and attributes from six different point of views. This would produce an enriched way of analysing Playability, that would allow to identify which attributes and properties are affected by the various elements of the game.

To obtain the appropriate data for analysing Playability, exist heuristic evaluation techniques and user tests, complemented with questionnaires and observation techniques based on metrics [23]. Metrics "are numerical data obtained from the user interaction with the game software. They are objective, can be collected form many users, map to specific points in a game and are time-stamped." [25]. They focus on the "what" and how" of player behaviour but can't answer to "why" the users presented that behaviour. To this regard there's the need of using qualitative methods like questionnaires.

3. Implementation

From several studies like the ones discussed previously in Section 2, we designed a Game Architecture (Figure 2) of a serious game to teach work life skills to adults with cognitive disabilities.

There are four main modules in this architecture: (1) Cognitive Capabilities, (2) Game, (3) Assessment System, and (4) Controls:

1. Cognitive Capabilities module - Every cognitive capability needed to play the game represented by the Game module is included in this module. Each Game Level is associated with its own cognitive capabilities, represented by the Sets of Cognitive Capabilities (SCC). The SCCs represent the basic cognitive capabilities required to play a certain Game Level, meaning that if a user doesn't present the cognitive capabilities contained in a certain SCC, it's very

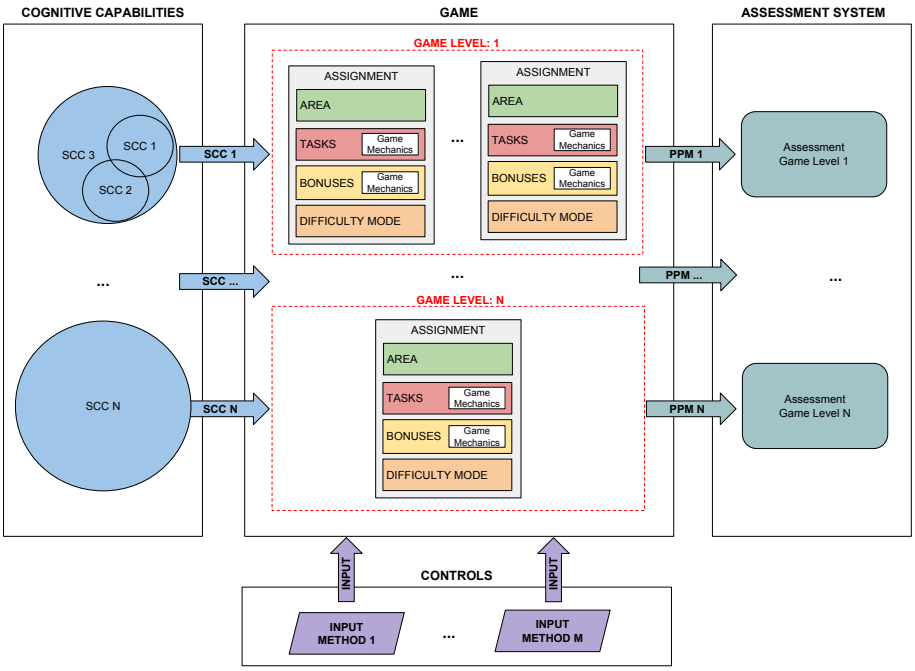

Figure 2: Proposed serious game architecture.

unlikely that he/she is able to play the Game Level associated with that SCC.

2. Game module - Includes one or more Game Levels, each of which has one or more Assignment modules. An Assignment is characterized by: Area - places in the supermarket the user is going to play (sales area, warehouse or loading dock); Tasks - specifies exactly what the user will have to do in the game and the skills to be acquired in a work context and which are mandatory to complete a Game Level; Bonuses - aren't required to complete a Game Level, but are desirable social behaviours valued in the game; and Difficulty Mode - provides adaptability in a certain degree, by allowing players to learn the same work related skills, but taking into account their needs. The game can be played in Easy, Medium or Hard mode.

3. Assessment System module - Receives Player Performance Metrics sent by the Game module and produces detailed reports on player performance, for the player to reflect upon it.

4. Controls module - Defines the several input methods that allow the players to interact with the game, such as mouse, keyboard and trackball.

In order to determine the viability of the Game Architecture just presented, we developed a Proof of Concept, validated it with professionals and tested it with players. In the resulting Proof of Concept, schematized in Figure 3, is possible to play a reduced version of a Game Level 1 Assignment, called "Sales Area Check-up", which involves the most basic tasks an employee can do in a supermarket.

Sales Area Check-up assignment involves walking through the supermarket to locate the displays where there are tasks the players need to carry out. It is composed by four tasks and one bonus:

1. Item Organization task: Given a shopping alley display, organize any items that are in the wrong shelves

2. Fruit Selection task: Given a fruit display, select the rotten fruit, place it in a crate and notify the appropriate colleague

3. Box Discarding task: Discard any empty carton boxes found in the sales area by placing them inside the trash container.

4. Item Counting task: Count the items of each type in the shelves and register that number in a Record Sheet. The counting should take into account the item characteristics, i.e., its type, colour and brand

5. Client Assistance bonus: Help a client that needs to know where an item is located, by guiding him/her to the correct shopping alley

3.1. Game Mechanics

To move in the supermarket, there are two possibilities: using the mouse or using the keyboard keys. Regarding the first alternative, clicking once

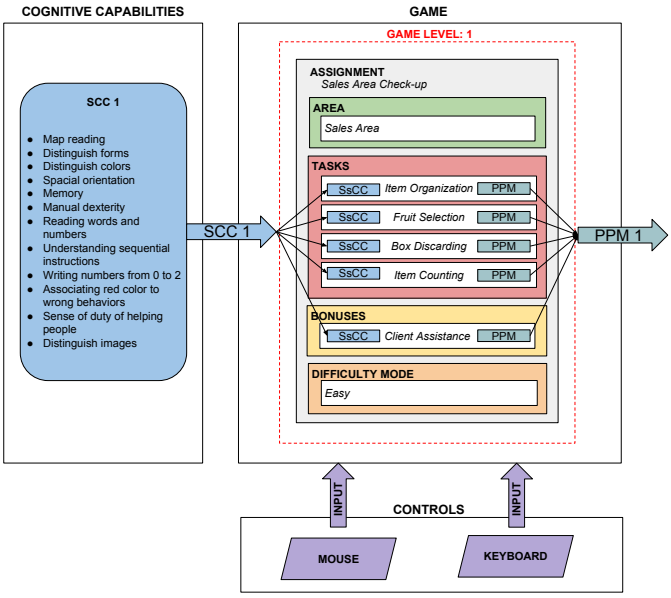

Figure 3: Sales Area Check-up assignment.

with the left mouse button will make the main character move towards that place, stopping the movement when the character reaches it. With the right mouse button the player can rotate the character, allowing him to see what's surrounding the character. To do that, the player clicks and holds the right mouse button down and moves the mouse horizontally or vertically, being executed in a similar way to how panning is done in tablets Regarding the second alternative, there are two options: or they use the direction keys (↑, ←, ↓, →) or they use W, A, S and D keys. Both sets of keys behave exactly in the same way because we just wanted to offer different alternatives to do the same thing, respecting user preferences.

In the Proof of Concept all displays associated to a task are signalized by a flashing white light and by a green arrow on top of the display (see Figure 4). When the player passes the mouse over the display, it turns green to indicate the player to go forward and click on the display to start a task. In a similar way, any character that the player can interact with will present a green contour when the mouse pointer passes over them. Clicking in such a character will make him/her talk, that is, the player will be able to hear the voice of the character and also to read the speech in the bottom bar. When the player clicks on a signalized display, the game enters in a focus mode, which is indicated by the grey background that isolates the displays needed for the task fulfilment from the rest of the supermarket. In the case of the task Box Discarding, we decided to not provide the focus mode and see which option was better for them. Without focus mode they continue to see the whole supermarket, which can generate more immersion, but in the focus mode only certain parts of the supermarket are visible, helping in concentration and freeing players from worrying about the character positioning in the game environment.

Whenever a player finishes a task, he/she gets a large thumbs up symbol and when he/she finishes a bonus, the player gets a large smile symbol. The progress of a player within an assignment can be perceived by looking at the top bar, where there are blue thumbs up symbols for the finished tasks and yellow smile symbols for the finished bonus. Symbols from tasks and bonuses not fulfilled yet stay grey. Due to the lack of abstraction capacity of cognitively disabled people, the interaction with the game was designed to be as simple and similar with reality as possible. So, to complete most tasks we decided to use a drag and drop mechanism, whose sole variation is the axis on which the movement is made: in Item Organization and Fruit Selection tasks, it is done on the y and x axis; in Box Discarding task it is done along the x and z axis.

To guide the client in the Client Assistance bonus, we designed the client to walk on front of the player camera, allowing the player to constantly see the client. So, when the player moved, the client would move in the same direction, only at some distance, instead of being very close to the player camera.

3.2. Technical Challenges

Since realism was an important characteristic of this game, we used very detailed models, composed by a lot of meshes and with high quality textures. As a consequence, the game was so slow that it was hard to interact with the game, like getting the

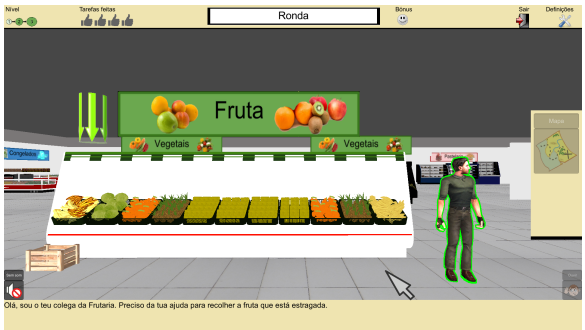

Figure 4: Game Environment.

character to move (it had a "jumpy movement"), implying that that frame rate was too low for providing a good experience, being urgent to increase game performance.

When the frame rate is low, we aim to lower the number of draw calls made in the scene. One or more draw calls are issued to the graphics API each time a model is rendered in a scene, depending on the number of materials composing that model. A model with one material will involve 1 draw call, but a model with three materials will involve 3 draw calls. This means that not only more draw calls are made as the scene gets more complete, but also as models composing the scene get more complex.

In order to keep draw calls number low in the Proof of Concept, we wanted to use as less materials per model as we could and share materials between multiple models, since models sharing the same material can be combined into one draw call only (procedure called batching). To use less materials, we can combine textures of identical materials into a texture atlas. The texture atlas is a big texture that contains smaller textures, allowing that a single material is used across several objects, instead of one material per texture[1].

Another factor can negatively influence game performance: high number of polygon meshes. The geometric complexity can be reduced by attaching the object meshes to each other, process that results in a model with a single mesh and multiple materials.

To improve game performance, we develop a speed up technique used in the Proof of Concept that provided a solution for the presented problems using 3ds Max. It generated models with a single mesh and a single texture atlas, thus providing an acceptable frame rate. This speed up technique was a trade-off between quality and performance, with which we achieved satisfactory results

[1] http://docs.unity3d.com/Manual/DrawCallBatching.html (accessed on 2015-02-28)

4. Results

To evaluate the Proof of Concept Playability, we selected a group of people who constituted a representative sample of the population. This sample was composed by AIPNE's users, which isn't an exact representation of the Portuguese population with cognitive disabilities, but it's similar enough to take conclusions about the game adequacy to the people with cognitive disabilities. The selected participants for the player testing sessions met the following criteria: (1) Identified as having a cognitive disability; (2) No sensory or physical impairments; (3) Able to follow oral and/or written instructions; (4) Having computer experience with mouse; (5) Able to participate in the experiment for at least 30 min. 36 users met the criterion above and participated in the two player testing sessions after parental approval. Each session had the duration of one hour: 5 minutes were reserved for a brief presentation about what the game was about, what was its purpose and to explain why the users were needed for testing; 5 minutes to experiment the game before the session start; and 25 minutes for playing. The last half an hour was reserved for making a survey and discussing their thoughts and suggestions about the game.

In both sessions, users played the Proof of Concept described in Section 3, with only minor changes between them, like placing more displays in the supermarket, as well as audio instructions, complementing the written ones. We also made some adjustments on the Character moment: from using the mouse to using the keyboard.

It's important to emphasize that player testing puts psychological pressure on any person, which has more impact in people with cognitive disabilities. Also, we should not forget that users' answers might not correspond to reality, due to possible comprehension problems, as well as due to the questions being asked by someone external to their usual environment, which can make them uncomfortable or eager to please the interviewer.

4.1. Surface of playability

We evaluated the Proof of Concept according to its value as an entertainment tool,relying on a model of Playability [23]. In this model, Playability characterizes and evaluates Player Experience, being defined by 7 attributes, like described in Section 2. The model can evaluate a game with a variable level of detail, by allowing the evaluation of the game Playability in general and by allowing a more detailed evaluation, according to Facets of Playability. Since Facets of Playability provide a very detailed evaluation of a game, we thought that it would be more adequate to evaluate the Proof of Concept Playability as a whole, since the developed game

isn't very complex.

Each attribute is composed by several properties and, to characterize each property, we used qualitative and quantitative metrics, where the quantitative metrics were derived from observation, while the qualitative metrics were derived from the questionnaires made at the end of each session. Note that since the Proof of Concept wasn't developed to be played in group or with the possibility to be played by several players online, we opted by not evaluating Playability according to the attribute Socialization.

Following the model, each attribute in the Playability model gets a score from 1 to 5 indicating how good is the Player Experience, where 1 is the worst and 5 is the best. The score of an attribute is given by averaging the score of the metrics that characterize its properties. For example, the attribute Effectiveness is defined by the properties Completion and Structuring, characterized by 8 and 4 metrics, respectively. This means that the Effectiveness score is given by averaging the score of those 12 metrics.

Figure 5 shows the contributes of each attribute for the overall game Playability, represented in a surface of Playability per session.

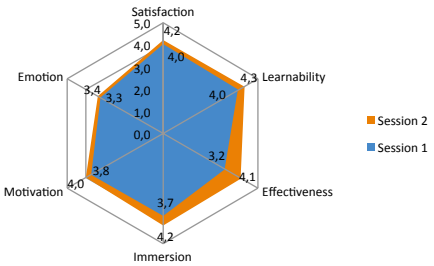

Figure 5: Surfaces of Playability.

As we can see, the adjustments made from one session to the other helped increase the Playability, even if it was just a small increment. In fact, Session 1 achieved a Playability score of 3.48 while Session 2 achieved a score of 3.64. Both sessions were significantly below the target score of 5, meaning that there are some improvements to be done to turn the Proof of Concept to a game offering a good Player Experience. Those improvements should target mainly the Emotion, Effectiveness and Immersion, which are significantly below the score of 4 and thus require a more urgent intervention.

It's important to remember that, given the variability of the characteristics presented by the players, it was hard to determine if some difficulties felt during the tasks/bonus fulfilment were due to flaws in game design or are typical characteristics of the players, like hesitation.

It is also noteworthy that the used model for evaluating Playability was designed for evaluating complete games and not systems like a Poof of Concept. This might have lead us to evaluate it in an incorrect way, due to the lack of information necessary to analyse each property and attribute.

4.2. Learning Outcomes

To assess if the Proof of Concept produced valuable learning outcomes, we evaluated the degree of remembrance of players, the time they took to complete the assignment, the degree of help needed for fulfilling the assignment and compared the results of Player Performance Metrics in each session.

Regarding the degree of remembrance, 73.7% of players from our population sample claimed to remember everything they've done and seen in Session 1, contrasting strongly with 15.8% of people who remembered a lot of things and 10.5% of people who remembered only some things. The degree of remembrance is confirmed by the difference on the time players took to complete the game. In Session 1, players registered in average 15 minutes and 45 seconds to complete the assignment, while in Session 2 they took only 8 minutes and 59 seconds, which constitutes a decrease of 43%. Not only players were faster as they required less or no help to fulfil the assignment, proving that from Session 1 to Session 2 they acquired enough knowledge on the tasks to be able to fulfil by themselves.

Regarding Player Performance Metrics, players registered better performances in Session 2, compared to Session 1. Although those differences weren't drastic, we can conclude that players understood the objectives of tasks and bonuses, only showing more difficulty with the assignment as a whole, meaning that they didn't spent much time exploring every shopping alley of the supermarket.

After the player testing sessions we asked players how confident they were about the knowledge they obtained with the game and we detected that more than 50% of players trust that with two game sessions they have the knowledge needed to fulfil the presented tasks in a real-life supermarket. 27.3% of players think that they would feel more comfortable if they could practise the tasks in the game some more times, but no player considered the game as useless for learning the tasks.

5. Conclusions

The main objective of this work was to develop a serious game to help adult with cognitive disabilities having success in their jobs. In the long run, such game would help to diminish companies productivity loss originated by employing a disabled employee and would ease the training process.

One of the hardest parts of developing serious

games for adults with cognitive disabilities lies on the need to support the game in reality (processes, methods, etc.), when reality is still adjusting to the needs of these adults. Whether we're talking about traditional learning methods, serious games or work training, we see that each area is still trying to define standards for teaching and evaluating users/employees according to their needs, currently mostly driven by common sense. Traditional learning methods constitute the area more developed, having built tools collaborating with psychology, contrasting with the area of serious games, the most recent one. In this area there are many projects exploring different approaches, but most of them fail to obtain a clear evidence of how the developed game was appropriate for a certain population and if it generated knowledge, because it involves comprehending complex concepts like how a player really feels about a video game. This is a problem because there's no stable base from which to start developing a serious game for cognitive disabilities, although many attempts have been done. We based the development of the serious game presented in this work on a set of Design Principles collected from recent literature. Although they helped designing the game, most of them were general, acting like a "hint" about what to look for. Even finding a model for evaluating the game in a systematized way was no easy task.

Only when the academic research agrees upon a standard serious game evaluation model, the serious games will have the possibility to grow and become the learning tool by excellence or, in opposite way, they will be proved as not being good enough tools for learning, situation in which games will be used only as entertainment tools. In the current state of the art, although there are some evidences supporting the effectiveness of serious games as learning tools, it's hard to state in a peremptory fashion that they are in fact more effective than traditional methods for learning. Some research still has to be made to obtain conclusive evidences.

Nevertheless, we made some interesting discoveries on how people with cognitive disabilities think and feel and we developed a Proof of Concept able to transmit knowledge.

6. Future Work

Some aspects of the Proof of Concept still need some work for it to be a game playable by people with cognitive disabilities and providing a good experience. Of course the next step would be correcting these details that weren't so polished in the Proof of Concept and increase its complexity, developing it to be a complete game and making improvements on Player Experience (focusing especially on Effectiveness and Emotion).

Taking into account that we consider a smooth frame rate as at least 15 fps, we got some issues related with texture loading, causing the frame rate to be 6 fps or less at the beginning of the game. As the player walked more deeper in the supermarket, the frame rate would return to a smooth state, being however necessary to improve the performance and Player Experience. To do so, we could use mipmaps technique to pre-calculate multiple textures at different resolutions that can be used in the displays and items, according to their proximity to player [26]. Player Experience would also be improved by the use of hardware specifically designed for this kind of intensive load.

In Section 4 we got evidence that the Proof of Concept generated knowledge on players. However, we should compare the efficiency of the traditional method of training in a supermarket against learning through the presented game. For this, we would select two groups of users with similar cognitive characteristics, in which one of the groups doesn't have any experience in working at supermarkets and the other group has just started his formation in a real supermarket - not an experienced worker. The group with no experience would play the game while the other one would proceed with the normal learning process. Then, when the users are approximately at the same level of knowledge, both would be placed in a real supermarket and asked to do some assignments using the knowledge they acquired. Their performance in those assignments would be an indicative of whether the learning process was more or less efficient with the game.

On the later run, when a complete game is developed, aim for a game extension that focuses in teaching more specific skills like the ones required by sections like butchery, bakery, fishmonger, charcuterie, patisserie, florist, etc. Even more interesting would be simulating a complete work week in a supermarket, where there's a day of the week specific for certain tasks and a specific timetable to fulfil them. For instance: on Tuesdays trucks loaded with meat arrive on the supermarket, being necessary to unload them from 9h to 11h; from 11h to 12h is necessary to restock shopping alleys 1 to 5, from 12h to 13h is lunch break, etc.

Finally, the Game Architecture could be expanded regarding the Assessment System module, to provide a way to players reflect upon their performance and see their improvements.

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References

[1] Dr Mark Griffiths. The educational benefits of videogames. *Education and Health*, 20(3):47–51, 2002.

[2] Javier Torrente, Angel Blanco, Pablo Moreno-Ger, and Baltasar Fernandez-Manjon. Designing serious games for adult students with cognitive disabilities. In Tingwen Huang, Zhigang Zeng, Chuandong Li, and ChiSing Leung, editors, *Neural Information Processing*, volume 7666 of *Lecture Notes in Computer Science*, pages 603–610. Springer Berlin Heidelberg, 2012.

[3] Cecilia Sik Lanyi and David Joseph Brown. Design of serious games for students with intellectual disability. In *Proceedings of the 2010 international conference on Interaction Design & International Development*, pages 44–54. British Computer Society, 2010.

[4] T. Martins, V. Carvalho, F. Soares, and M.F. Moreira. Serious game as a tool to intellectual disabilities therapy: Total challenge. In *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on*, pages 1–7, Nov 2011.

[5] José Luis González, Marcelino J. Cabrera, and Francisco L. Gutiérrez. Using videogames in special education. In Roberto Moreno Díaz, Franz Pichler, and Alexis Quesada Arencibia, editors, *Computer Aided Systems Theory EUROCAST 2007*, volume 4739 of *Lecture Notes in Computer Science*, pages 360–367. Springer Berlin Heidelberg, 2007.

[6] Lucia Vera, Ruben Campos, Gerardo Herrera, and Cristina Romero. Computer graphics applications in the education process of people with learning difficulties. *Comput. Graph.*, 31(4):649–658, August 2007.

[7] Gretchen L. Robertson and Deborah Hix. Making the computer accessible to mentally retarded adults. *Commun. ACM*, 45(4):171–183, April 2002.

[8] Álvaro Fernández-López, María José Rodríguez-Fórtiz, María Luisa Rodríguez-Almendros, and María José Martínez-Segura. Mobile learning technology based on ios devices to support students with special education needs. *Comput. Educ.*, 61:77–90, February 2013.

[9] M. Cagatay, P. Ege, G. Tokdemir, and N.E. Cagiltay. A serious game for speech disorder children therapy. In *Health Informatics and Bioinformatics (HIBIT), 2012 7th International Symposium on*, pages 18–23, April 2012.

[10] A.M. Hussaan, K. Sehaba, and A. Mille. Tailoring serious games with adaptive pedagogical scenarios: A serious game for persons with cognitive disabilities. In *Advanced Learning Technologies (ICALT), 2011 11th IEEE International Conference on*, pages 486–490, July 2011.

[11] Z.S. de Urturi, A.M. Zorrilla, and B.G. Zapirain. Serious game based on first aid education for individuals with autism spectrum disorder (asd) using android mobile devices. In *Computer Games (CGAMES), 2011 16th International Conference on*, pages 223–227, July 2011.

[12] M.S. Saleh, J.M. Aljaam, A. Karime, and A. Elsaddik. Learning games for children with intellectual challenges. In *Information Technology Based Higher Education and Training (ITHET), 2012 International Conference on*, pages 1–5, June 2012.

[13] Debora M. Kagohara, Larah van der Meer, Sathiyaprakash Ramdoss, Mark F. OReilly, Giulio E. Lancioni, Tonya N. Davis, Mandy Rispoli, Russell Lang, Peter B. Marschik, Dean Sutherland, Vanessa A. Green, and Jeff Sigafoos. Using ipods and ipads in teaching programs for individuals with developmental disabilities: A systematic review. *Research in Developmental Disabilities*, 34(1):147 – 156, 2013.

[14] A. Alqahtani, N. Jaafar, and N. Alfadda. Interactive speech based games for autistic children with asperger syndrome. In *Current Trends in Information Technology (CTIT), 2011 International Conference and Workshop on*, pages 126–131, Oct 2011.

[15] Artur Costa-Pazo, Esteban Vazquez-Fernandez, Carlos Rivas, Miguel Gómez, Luis Anido, Manuel Fernández, and Sonia Valladares. Gesture-controlled interfaces for people with disabilities.

[16] JoseLuis González Sánchez, Natalia Padilla Zea, and FranciscoL. Gutiérrez. From usability to playability: Introduction to player-centred video game development process. In Masaaki Kurosu, editor, *Human Centered Design*, volume 5619 of *Lecture Notes in Computer Science*, pages 65–74. Springer Berlin Heidelberg, 2009.

[17] Vinícius Mello and Letícia Perani. Gameplay x playability: defining concepts, tracing differences.

[18] Lennart Nacke, Anders Drachen, and Stefan Goebel. Methods for evaluating gameplay experience in a serious gaming context. 9(2):http://iacss.org/index.php?id=96, 2010.

[19] Wong Seng Yue and Nor Azan Mat Zin. Usability evaluation for history educational games. In *Proceedings of the 2Nd International Conference on Interaction Sciences: Information Technology, Culture and Human*, ICIS '09, pages 1019–1025, New York, NY, USA, 2009. ACM.

[20] Francesco Bellotti, Riccardo Berta, Alessandro De Gloria, and Ludovica Primavera. Player experience evaluation: An approach based on the personal construct theory. In Stéphane Natkin and Jérôme Dupire, editors, *Entertainment Computing ICEC 2009*, volume 5709 of *Lecture Notes in Computer Science*, pages 120–131. Springer Berlin Heidelberg, 2009.

[21] Wijnand Ijsselsteijn, Yvonne De Kort, Karolien Poels, Audrius Jurgelionis, and Francesco Bellotti. Characterising and measuring user experiences in digital games. *ACE Conference*, 2007.

[22] C. Lindley and L. Nacke. Boredom, immersion, flow - a pilot study investigating player experience. In *IADIS Gaming 2008: Design for Engaging Experience and Social Interaction,*. IADIS, 2008.

[23] José Luis González Sánchez, Francisco Luis Gutiérrez Vela, Francisco Montero Simarro, and Natalia Padilla-Zea. Playability: Analysing user experience in video games. *Behav. Inf. Technol.*, 31(10):1033–1054, October 2012.

[24] J.L.González Sánchez, N.Padilla Zea, and F.L. Gutiérrez. Playability: How to identify the player experience in a video game. In Tom Gross, Jan Gulliksen, Paula Kotzé, Lars Oestreicher, Philippe Palanque, RaquelOliveira Prates, and Marco Winckler, editors, *Human-Computer Interaction INTERACT 2009*, volume 5726 of *Lecture Notes in Computer Science*, pages 356–359. Springer Berlin Heidelberg, 2009.

[25] Lennart E. Nacke, Anders Drachen, Kai Kuikkaniemi, Joerg Niesenhaus, Hannu J. Korhonen, Wouter M. van den Hoogen, Karolien Poels, and Wijnand A. IJsselsteijn. Playability and player experience research [panel abstracts]. In *DiGRA &#3909 - Proceedings of the 2009 DiGRA International Conference: Breaking New Ground: Innovation in Games, Play, Practice and Theory*. Brunel University, September 2009.

[26] Tomas Akenine-Moller, Tomas Moller, and Eric Haines. *Real-Time Rendering*. A. K. Peters, Ltd., Natick, MA, USA, 2nd edition, 2002.