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Downtown, A Subway Adventure: Using Learning Analytics to Improve the Development of a Learning Game for People with Intellectual Disabilities

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***Abstract*— In this paper we analyze the process of designing and developing a Serious Game intended to train people with intellectual disabilities in moving around a city using the public transportation system. The first step in our investigation is to understand the cognitive, psychological and motor abilities of our users and their specific needs. Secondly, we translated the characteristics of the players into user requirements, with adapted mechanics to improve the understanding and to increase the probability for the user to be able to carry out the tasks to perform in the video game. Finally, due to the specific characteristics of our final users a Learning Analytics module has been included in the game to collect relevant information about how users are actually playing and to infer how the learning process of every user is occurring. We also discuss the next steps in our research and the future work related with it: design a range of experimental tests to verify the adequacy of the video game as a learning tool for this type of users.**

Keywords- serious games; learning games; intellectual disabilities; videogame design; learning analytics

I. INTRODUCTION

People with intellectual disabilities, like ASD (Autism Spectrum Disorders) or Down Syndrome, have to face more barriers than other people in order to have an autonomous life. According to the American Association on Intellectual and Developmental Disabilities [1] more than two hundred million people in the world have an intellectual or developmental disorder (3%). This figure reveals the need of adapting, not only our environment, but also the methods and technologies used for teaching skills to this population.

Video games are one of these emerging tools. In the last decade, researchers have explored the effectiveness of the Serious Games as learning mechanisms for users with certain intellectual disabilities, obtaining positive results in their investigations [2] [3] [4] [5] [6].

Following this trend, we have designed and developed a Serious Game that aims to teach people with intellectual disabilities to move around the city using the subway. For that purpose, we simulated a virtual and realistic 3D environment of the subway of Madrid (Spain) and we designed a range of challenging situations that this type of users face when they are using the public transportation system, such as: choosing the right route to get their destination, what to do if a strange talks to them, how to act in an emergency or what to do if they get lost during their itinerary.

In this paper we discuss the references and the steps that we followed to build the design and the mechanics of the game, starting from the characteristics of the users and the accessibility requirements to its implementation in the videogame. The final goal of the game is to improve the learning process of the intellectual impaired population in the process of being self-sufficient. In the discussion, we describe lessons learnt during the designing phase and future work identified from our research.

II. DESIGNING AND DEVELOPING A LEARNING GAME FOR PEOPLE WITH INTELLECTUAL DISABILITIES

Creating a video game with educational purposes for people with intellectual disabilities is a complex task because of two reasons: First, not all Serious Games are suitable as learning tools for all disabled game players. This happens because there is a wide range of mental conditions that can

be considered an intellectual disability, depending on its causes, signs and symptoms [7]. Secondly, the cost of developing a video game is higher compared with other traditional learning tools such as books, blackboards or in-situ training [8]. As a result, the design and use of learning video games for these users is still a relatively unexplored field.

With this scenario in mind, we want to evaluate if a videogame can be a suitable choice for training this population in day-to-day tasks, like moving around the city using the public transportation system.

The main goal of our videogame, *Downtown: A Subway Adventure*, is teaching young users with intellectual disabilities (between 15 and 30 years old, depending on their cognitive skills and their level of independence) how to use the subway by themselves. Nowadays, users learn to travel in the subway accompanied by an instructor. This method has an issue: there is a wide range of problems that can happen while the users are travelling alone that may not had happened when they were with the instructor.

Downtown is designed to fill this gap, including all the potential problems that the experts identify as tricky for this population. Each problem is translated as an event to solve in the game.

We want to evaluate if the users that are trained with the videogame before the in-situ training are able to learn faster how to use the subway system versus those that only receive in-situ training. We are also studying which group is better trained to face stressing situations like getting lost or taking the train in the opposite direction.

A. *Game Mechanics*

The mechanic of the game is designed as follows: *Downtown* is a spy game where the user has to discover where, when and how the enemies are going to hold a meeting. For that purpose, he must travel around the subway map and find three different objects that provide a clue about the meeting. Different events related with the problematic situations that we want to train will appear during the journey. The user cannot continue his journey without finding a solution for them.

Each player will have his own user account to collect important data in each session with relevant information about the progress and the improvement of his learning process. We included a Learning Analytics [9] module inside our game to acquire data in real time such as: time spent without achieving a goal, total time played, number of attempts before completing a task or users' progression between the first sessions played and the subsequents. All the collected parameters are described in detail in this article.

The user can also customize the main character to help him identifies with it, changing the gender, facial features (including down features) and clothing. Previous research [10] shows that the more similarities between the user and its character, the easier he can transfer the knowledge achieved in the game to reality "Fig. 1".

B. *User Characteristics*

Designing a video game ad-hoc for players with intellectual disabilities requires bearing in mind all the cognitive/intellectual, psychological and motor characteristics of the user that can impact in his learning abilities.

Despite the fact that the skills of every individual can vary, there are common characteristics that we can use as a base to create the video game design [11] [12] [13]. We divided those that we found relevant for our design into psychological areas:

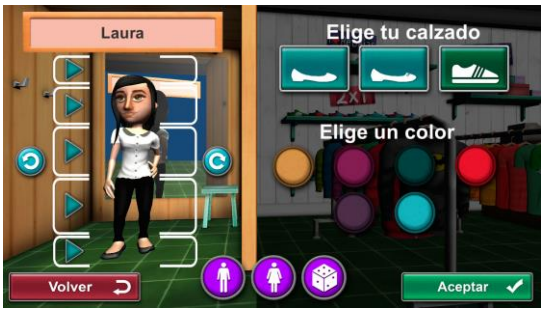

Figure 1. Character Selector

1) Intelligence, Memory and Perception

- Better visual perception and visual retention than hearing
- Good procedural memory
- Limitation in the number of instructions/numbers that they can handle at the same time (3 sequential instructions and 3-6 digits)
- Difficulty sustaining attention during long periods of time
- Mild intellectual deficiency
- Problems of understanding the information
- Difficulty in the process of abstraction, conceptualization, generalization and learning transfer

2) Personality

- Limited initiative
- Persistence of behavior and resistance to change
- Less response capacity and reaction to the environment
- Good at collaboration and sociability

3) Biological and motor skills

- Listening and eye problems
- Heart disease
- Clumsiness in motor skills (gross and fine)
- Poor coordination

C. *User Requirements*

Once we know what is distinctive in our user, the second step is to translate these features into formal user requirements. We also included cognitive accessibility guidelines [14] [15] to avoid usability barriers for the players.

Here we describe a list of the technical requirements that can impact in the learning process of the user. The

requirements are divided by the structure of the game in: start menu and game session, texts and dialogs, interface, mechanics and others.

1) Start Menu and Game Sessions

a) Sessions: Each user will have a unique user name to record his learning progress. The game will save the settings for each user and every session that the user plays. The user will be able to save his progress anytime during the game to avoid repeating processes that are already completed. The game will also auto-save the game periodically, when the user achieves a goal or completes a level. If the game shuts off unexpectedly, the player won't lose his goals and progress "Fig. 2".

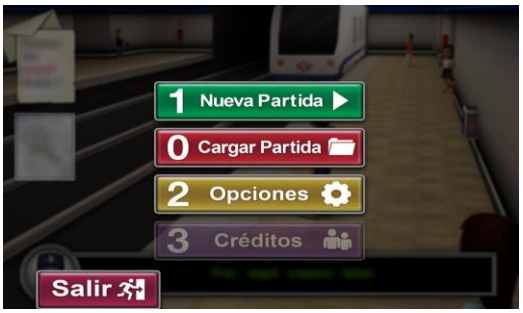

Figure 2. Start Menu

b) Accesibility: The game will allow the user to change the accessibility parameters like the speed of the dialogs, the size of the texts, the colors of the texts and the color of the background in the text box to assure a good understanding of the tasks to complete. "Fig. 3".

c) Consistency: The titles of the menu and buttons will be self-descriptive and will have consistency with the link that they are pointing to. There won't be different buttons with the same text pointing to different links.

2) Levels

a) Difficulty level: The user can choose the difficulty level between "easy", "medium" or "hard" depending on his skills. Each level will have the explanation about the challenges that are included in it. The user would be able to change the level in the middle of a game session if he finds it is too difficult/easy for him. This way, we adapt the level of then tasks to complete to every single user.

b) Sandbox mode: There will be a sandbox mode where the user can practice the mechanics and the controls of the game without any possible failure or reward.

3) Texts and Dialogs

a) Text speed: The user will move forward the conversations at his own pace and will be able to repeat every narration, conversation or instruction as many times as he needs to assure a good understanding of the tasks.

b) Language and structure: All the texts will be written and spoken at the same time. The language used will be direct, clear and simple without double meaning. The narrative structure will be easy to understand for every user despite of the level of cognitive disability. "Fig. 4".

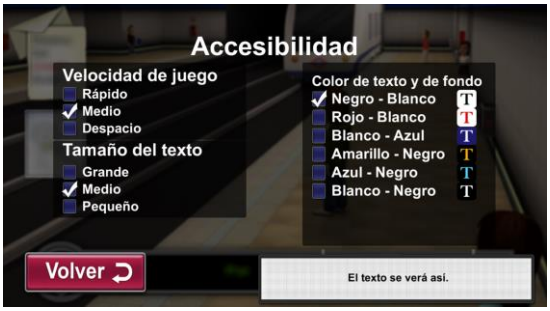

Figure 3. Accessibility Menu

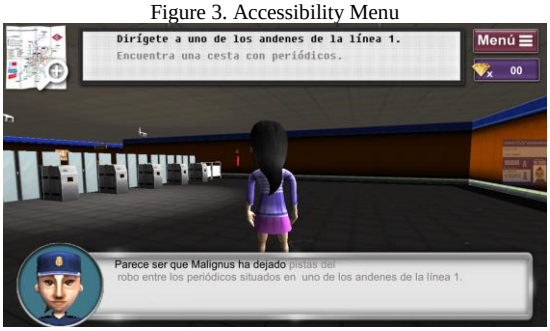

Figure 4. Example of the text box appearance during the game

4) Interface

a) Help: There will be a "help" button permanently in the screen. If the user doesn't perform any action for a long period of time, a pop-up aid will appear providing guides, tips and advices.

b) Tasks: The list of the tasks to perform will be permanently in the screen to help the user focus on what he is doing and take decisions accordingly. "Fig. 5"

5) Mechanics

a) Time: The user can switch off or adjust the time available for the tasks that are time-limited. There won't be a limited time to perform the general mechanics (like traveling from one station to another or finding an object in a station).

b) Tutorials: The description about how to achieve the goals in the game will be performed as a video explanation for every task. Previous research prove that visual explanations help to understand the assignments better than hearing or reading [16]. "Fig. 6"

6) Others

a) Sounds: There are several types of sounds in the game: sound effects, conversations, music and event tunes. The user can stop, pause or adjust the volume of them at any time during the game session. There won't be the same sound assigned to two different objects or actions.

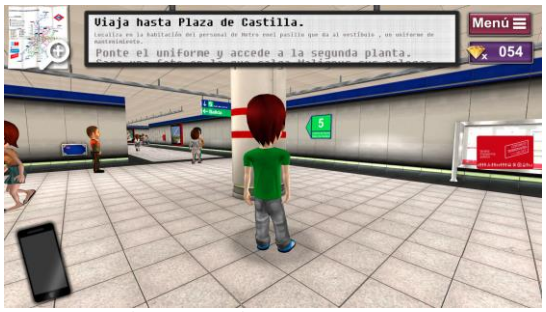

Figure 5. Example of tasks to perform in screen (ongoing task in bold text)

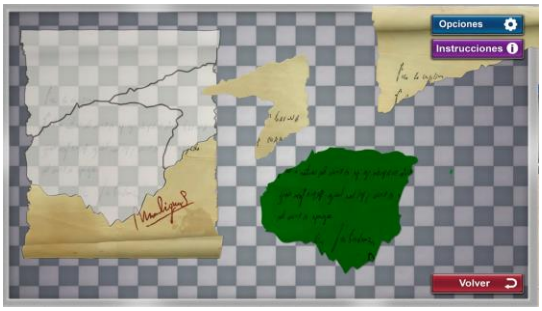

Figure 6. Video explanation about a minigame

b) Camera: We should avoid any unexpected movement of the camera to help the player focus on what he is doing. The automatic movements, flickers or displacements longer than three seconds could be shut off by the user if needed.

III. Collecting Learning Information Using Learning Analytics

Once we have the game designed and developed following the requirements that we described, the third step is to collect relevant learning information of the users during the game sessions.

Tracking players' interactions is critical for analyzing their learning progress while they are playing the game, especially if the users have an intellectual disability. This population has problems articulating their opinions and expressing the situations that they found problematic. For that purpose, we integrated a Learning Analytics (LA from now on) module in the game.

LA has become popular in the past years thanks to the spread of data mining science in companies and institutions. LA is defined as the *collection and analysis of the "digital breadcrumbs" that students leave as they interact with various computer systems to look for correlations between those activities and learning outcomes* [17].

The information that we want to collect from the game gives us an overview of a) the learning process of the user and his engagement and b) the effectiveness of the game design and the validity of the user requirements described.

The set of traces that we included in *Downtown* is listed below:

A. *Main menu*

Parameter	Objective
Unique user id	Match every game session with a unique user to collect related data.
Number of login attempts	Check if the user is able to remember his user name and password without assistance.
Number of attempts creating a user	Check if the interface of the Main Menu is understandable and easy to use.
Number of clicks in the accessibility menu	Observe if the user is able to adapt the parameters of the game in an autonomus way without assitance.
Parameters changed in the accessibility menu	Understand which are the parameters that the users find problematic while they are playing.
Total time spent in the main menu	Check if the login process is understandable and clear to the user.
Mouse heatmap	Monitor the sections of the screen that the user tends to interact with.

Table 1. Parameters collected in the Main Menu

B. *Character Selector*

Parameter	Objective
Character parameters	Match the game character with the user image and verify if the hypothesis of the learning transfer to reality commented above is accurate .
Time spent in the character selector screen	Verify if the user understands that the game is not started yet (some players tend to get stuck in the character selector screen as they think this is the game).
Time between clicks	Check if the user is clicking nonsense or really choosing the features of the character.
Mouse heatmap	Monitor the sections of the screen that the user tends to interact with.

Table 2. Parameters collected in the Character Selector

C. *Game Sessions*

Parameter	Objective
Game session total time	Evaluate the improvement of the learning process through sessions.
Time consumed completing a task	Check the evolution of the user while training a certain skill. We also want to check if the level of difficulty chosen by the user is appropriate accordingly to his cognitive skills
Number of attempts before completing a task	Evaluate the improvement of the learning process through sessions while training a certain skill.
Number of clicks in the "help" button	Check if the mechanics of the tasks are designed accurately and the user is playing whithin the appropriate level for him.
Number of clicks in the "map" button	Test if the user is able to learn the paths and routes after playing several sessions.
Number of times that the "automatic help" appears	Check the engagement of the user with the game and the evolution of the learning process.
Mouse heatmap	Monitor the sections of the screen that the user tends to interact with.

Table 3. Parameters collected in the Game Sessions

IV. Summary and Discussion

The process of designing and developing a video game with educational purposes for people with intellectual disabilities requires an effort of understanding the capacities, abilities and skills of this type of users.

We designed *Downtwon, A Subway Adventure* focusing on the cognitive, psychological and motor characteristics that impact in their learning process. The translation of these features into game mechanics suitable for this population is reflected in a list of user requirements (both technical and non-technical) presented in this paper. As long as there is a wide range of cognitive conditions it is not possible to fully standardize the process that we followed in this development. We describe an example of good practices to minimize the number of backward changes in an agile Serious Game development taking into account features of the user that can impact in the design of the game.

We also included a LA module to capture relevant information about the learning performance of the player during the game sessions. The main issue we have to face is to analyze the large amount of data that a videogame can generate due to its highly interactive nature. The application of GLA (Game Learning Analytics) models and LA techniques, such as clustering or predictive techniques, are required in future analysis to understand the collected observables and obtain useful results.

Next steps in our research will be to design a range of experimental tests to check the adequacy of the video game as a learning tool for this type of users. The purpose of the tests will be the validation of the hypothesis described during the development phase.

Another line of investigation is the assessment of the information collected to predict the success of the learning experience using Serious Games, comparing the performance and evolution of the players who played *Downtown* with those who received the traditional training.

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References

[1] Shalock et al., Intellectual Disability: Definition, Classification and Systems of Supports. 11th Edition, AAIDD (American Association on Intellectual and Development Disabilities), 2010.

[2] S. Bernardini and K. a. S. T. Porayska-Pomsta, "ECHOES: An intelligent serious game for fostering social communication in children with autism," *Information Sciences*, vol. 264, pp. 41-60, 2014.

[3] Y. Chang and Y. a. L. F. Kang, "A computer-based interactive game to train persons with cognitive impairments to perform recycling tasks independently," *Research in Development Disabilities*, vol. 35, no. 12, pp. 3672-3677, 2014.

[4] F. e. a. Fernández-Aranda, "Video games as a complementary therapy tool in mental disorders: PlayMancer, a European multicentre study," *Journal of Mental Health*, vol. 21, no. 4, pp. 364-374, 2012.

[5] H. Karal and M. a. A. U. Kokoç, "Educational computer games for developing psychomotor ability in children with mild mental impairment," *Procedia - Social and Behavioral Sciences*, vol. 9, pp. 996-1000, 2010.

[6] C. Lee, M. Park, K. Park and M. a. J. J. Choi, "Clinical applications for the Ntelligent geriatric serious games for mild cognitive impairment," *Alzheimer's & Dementia*, vol. 8, no. 4, Supplement, 2012.

[7] A. R. Cano, Á. García-Tejedor and B. Fernández-Manjón, "Highlights in the Lliterature Available in Serious Games for Intellectual DIsabilities," in *ICWL 2015*, Guangzhou, China.

[8] J. Torrente, A. del Blanco, P. Moreno-Ger and B. Fernández-Manjón, "Designing Serious Games for Adult Students with Cognitive Disabilities," in *19th International Conference on Neural Information Processing (ICONIP2012)*, Doha, 2012.

[9] Á. Serrano-Laguna, J. Torrente, P. Moreno-Ger and B. Fernández-Manjón, "Application of Learning Analytics in educational videogames," in *Entertainment Computing*, Elsevier, 2014, pp. Volume 5, Issue 4, December 2014, Pages 313–322.

[10] C. Klimmt, D. Hefner and P. Vorderer, "The Video Game Experience as “True” Identification: A Theory of Enjoyable Alterations of Players' Self-Perception," *Communication Theory*, vol. 19, no. 4, pp. 351-373, 2009.

[11] P. Arranz, Niños y Jóvenes con Síndrome de Down, Egido Editorial. ISBN: 8495879093, 9788495879097, 2002.

[12] R. S. Chapman and L. J. Hesketh, "Behavioral phenotype of individuals with Down syndrome," *Mental Retardation and Developmental Disabilities Research Reviews*, vol. 6(2), pp. 84 - 95, 1999.

[13] M. V. Troncoso and F. Jesús, Síndrome de Down: Avances en Acción Familiar, Santander: Fundación Síndrome de Down de Cantabria. ISBN: 84-404-3312-3, 1988.

[14] W3C World Wide Web Consortium, "WCAG 2.0," 2008. [Online]. Available: http://www.w3.org/TR/WCAG20/. [Accessed 14 octubre 2015].

[15] Ablegamers Foundation, "Game Accessibility Guidelines," 2012-2015. [Online]. Available: http://gameaccessibilityguidelines.com. [Accessed 10 January 2015].

[16] A. Savidis, D. Grammenos and C. Stephanidis, "Developing inclusive e-learning and e-entertainment," *Universal Access in the Information Society*, vol. 5, no. 4, pp. 401-419, 2007.

[17] D. M. Norris, "7 Thing you should know about first-generation Learning Analytics," December 2011. [Online]. Available: http://www.educause.edu/library/resources/7-

things-you-should-know-about-first-generation-learning-analytics. [Accessed February 2016].