




Article

An Approach to Accessible Serious Games for People with Dyslexia

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Abstract: Dyslexia is a cognitive disorder that affects the evolutionary ability to read, write, and speak in people, affecting the correct learning of a large percentage of the population worldwide. In fact, incorrect learning is caused because the educational system does not take into consideration the accessibility parameters that people with dyslexia need to maintain a sustainable educational level equal to others. Moreover, the use of mobile devices, such as smartphones and tablets, has been deployed in education programs, offering many benefits; however, the lack of accessibility of those devices creates new barriers to students with dyslexia that hinder their education. With the aim of reducing these barriers, this paper presents an approach to the development of accessible serious games for children with dyslexia. As a case study, a serious game based on a previously proposed serious game development method and a new set of accessibility guidelines for people with dyslexia is presented. The main purpose of the serious video game is to improve the treatment of dyslexia, through the collection of data obtained from two puzzles designed to train certain cognitive areas that affect this disability. This article has a double contribution: on the one hand, the guidelines and the method that can help video game developers and therapists to develop accessible serious games for people with dyslexia and, on the other hand, the two specific serious games that can be used by therapists, family members and people with dyslexia themselves.

Keywords: accessibility; development method; disabilities; educational; impairments; learning; serious games; sustainability



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1. Introduction

The huge growth and popularity that video game industry has had in the last four decades has made them to no longer be used solely for the entertainment of people. Currently, video games have an infinite number of applications in multiples areas of study [1]. Therefore, serious video games facilitate or optimize fields such as: medicine and diagnosis [2,3], special education [4,5], psychology [6,7], university education [8,9], social abilities [10,11], public security [12,13], military training [14,15] and many other areas of knowledge. These video games are known as serious video games [16,17].

Today, mobile video games are becoming the main applications developed for entertainment [18]. Indeed, this is produced because mobile devices have become popular among young people and adults, being acquired by more and more people over time. As a consequence, mobile devices are becoming a necessity to be part of society, both in the academic, labor and social part [19]. Furthermore, mobile devices such as smartphones, tablets, etc., have the potential to improve accessibility. These devices offer users of all ages a way to express themselves in different modalities and customize them with the tools and applications that are more useful for the user. Also, mobile devices give portability to the users, meaning that can be carried and used anywhere, thus strengthening the ties from school to home in the case of students [20]. There are multiple platforms to develop

mobile video games. One of the most popular and used for the development of mobile applications is Unity (<https://unity.com/> (accessed on 1 February 2021)).

Unity is the video game engine manufactured by Unity Technologies. It is currently one of the most popular 2D and 3D game development platform on the market, used by independent developers and large companies or development studios [21]. Unity's philosophy is to provide a tool that makes video game development an easy and intuitive process, so that more developers can implement their ideas and visions about the world of games. The latest version released is Unity 5, which is in constant updates in order to add new features and cover tool patches [22].

On the other hand, people with disabilities have been a traditionally relegated group. Taking this into account, there are several initiatives that seek to generate sustainable attention to diversity in the fields of education, work and more, for people in this condition [23,24].

Dyslexia is a learning disorder that involves difficulty in reading due to problems identifying speech sounds and understanding how these are related to letters and words [25]. Dyslexia, which is also called reading difficulty, affects areas of the brain that process language. People with dyslexia have normal intelligence and usually normal vision as well. Most children with dyslexia can be successful in school with the help of a tutor or a specialized teaching program. Emotional support also plays an important role. Although there is no cure for dyslexia, early evaluation and intervention produce the best results. Sometimes dyslexia goes undiagnosed for years and remains unidentified until adulthood, but it is never too late to seek help [26].

Currently, people with dyslexia have learning difficulties with the conventional methods offered by the educational system. Many times, this happens because it is an essential requirement to be able to read and write to succeed academically. For this reason, it is necessary to seek treatments or experts assistance and qualified professionals to obtain treatment. Usually, this is a process that requires multiple expensive sessions in time intervals that do not meet the requirements of the patients [27]. Serious games can be a great help in these situations, not substituting, but complementing the work done by therapists [28].

Serious video games have received a great increase in interest in education, being used as tools to reinforce the teaching process and provide enriching learning contexts for its users [29]. However, commonly there is a lack of accessibility in these technologies for people with disabilities [30]. As a result, it is necessary to implement a serious video games that can effectively meet the accessibility requirements that people with dyslexia have. Moreover, for an optimal treatment, improving the quality of life of this group of people having a crucial impact on their treatment and learning.

This paper objectives focuses in the compilation of accessibility guidelines and the develop of a serious video game with accessibility features for children with dyslexia that will allow them to learn in a more attractive, fun and entertaining way. This serious game intends to support people with disabilities in abilities such as memory, attention, visual discrimination, sequence, phonological awareness, auditory discrimination, semantic awareness, spatial location, cognitive flexibility, etc. In the same way, the serious game collects information about the performance that children have in the puzzles and stores them in a database. The data collected allow therapists to perform analysis of each user, and thus improve their treatment. In addition, the serious game includes some accessibility features to give a more personalized and better experience to children with this condition.

1.1. Accessibility for Dyslexia

Accessibility is the characteristics implemented to objects, systems or environments to allow their use despite the disability or condition of a person [31]. Accessibility is a problem that the video game industry has only been facing in recent years. Thousands of players with disabilities cannot enjoy the full experience of video games because they have not enough accessibility features. Some of the most common problems experienced by

this group of people are complexity of commands and controls; difficulty understanding texts due to their size, color or font; complicated game-play; non-modifiable controls, among others [32]. In addition, video games have acquired educational value and not just entertainment; therefore, it is important that they are accessible to all audiences [33]. Table 1 shows the most common problems that people with disabilities encounter in current video games.

Table 1. Common problems for the disabled in video games [33].

Problem	Reason
Inability to follow a story	-There is no subtext available, the story advances by scenes. -Complex story and difficult to follow.
Inability to complete a task or puzzle	-Important tracks given in scenes without text. -All clues given in text form. -Precise synchronization with the command is required.
Inability to figure out how the game is played	-The game does not have a tutorial. -Little or no text. -Text very difficult to understand.
Inability to use adaptive hardware	-Video game does not support multiple devices.
The player's character is repeatedly injured/killed in the video game.	-Audio tracks not recognized. -Dangerous situations are not properly shown. -Cannot react quickly with the control/cannot change game speed.

Dyslexia is a disorder that affects the neurodevelopment and interferes with the evolutionary ability of literacy. It usually occurs in children who do not suffer from any physical, intellectual, psychological or sociocultural disability. In addition, children with dyslexia usually show normal and high degrees of intelligence, without taking into account the difficulties they present when performing tasks related to writing and reading. It also happens when they recognize words, analyze or classify sounds, interpret rhymes, etc. [34].

According to studies on reading in multiple languages and different writing systems, it has been considered that dyslexia is only associated with deficiency in auditory processing, speech and writing [35]. Nevertheless, other factors are also involved. Impaired performance was identified in jobs involving cognitive functions such as memory, language, visual-spatial skills, motor skills performance, semantic and phonological awareness, planning, and attention [36,37]. Similarly, dyslexia has a morbidity associated with other disorders such as: dyscalculia, dysgraphia, attention deficit hyperactivity disorder, specific language disability and speech and sound disorder [38,39]. Likewise, it has been identified that the phonological deficit associated with dyslexia has three typical subcomponents in individuals suffering from such disability:

1. The Short-Term and Working Phonological Memory: responsible for correctly recognizing and collecting data such as numbers, letters, words, and punctuation [40].
2. Phonological Awareness: word omissions, word additions, word substitution, and confusion with small words [41,42].
3. Lexical Access: fixation problems [40].

Expanding the accessibility context of the application, the Accessibility Scanner [43] application has been used, which provides advice that developers can incorporate, to improve accessibility for Android applications. Accessibility Scanner provides suggestions related to visual issues such as increasing contrast, or providing content descriptions, among others. These suggestions allow people with disabilities to use the applications more easily. Once the application was executed, when using the video game, certain suggestions related to touch elements and context contrast were appreciated. These changes were incorporated in the final version of the video game, reporting no additional suggestions.

1.2. Sustainability for People with Disabilities

The United Nations (UN) Sustainable Development Goals (SDGs) are a challenge facing humanity in the coming years, until 2030 [44]. Among the 17 proposed SDGs, there are some of them that are related to people with disabilities. In particular, in parts related to education, growth and employment, inequality and accessibility of human settlements, for instance:

- Goal 4. Quality Education. Obtaining a quality education is the basis for improving people's lives as well as for sustainable development. It seeks to provide lifelong learning opportunities for all. Furthermore, it focuses on ensuring equitable access to all levels of vocational education and training for vulnerable groups, including people with disabilities.
- Goal 8. Decent Work and Economic Growth. Achieving full and productive employment and decent work for all people, including people with disabilities, allows people to dramatically improve their lives. It also seeks to generate equal pay for work of equal value.
- Goal 10. Reduce Inequalities. In order to reduce inequality, the application of universal policies that also pay special attention to the needs of disadvantaged and marginalized populations, including people with disabilities, has been recommended.
- Goal 11. Sustainable Cities and Communities. Seeking that cities and human settlements are inclusive, safe and sustainable. This can be achieved by proposing a safe, affordable, accessible transport system, paying special attention to the needs of vulnerable groups, such as people with disabilities. In addition, it proposes universal access to green and safe spaces, inclusive and accessible for people with disabilities.
- Goal 17. Partnerships for the Goals. Highlighting that to strengthen the means of implementation and revitalize the global partnership for sustainable development, data collection and the monitoring and accountability of the SDGs are essential.

There is a close connection between the sustainable development goals taking into account that lack of progress on one goal hinders progress on other goals. Organizations can be successful only if they achieve the 2030 Agenda [45]. In consequence, the development of the proposed serious game is mainly aligned with goal 4 related to quality education. By fulfilling this key objective, the rest of the objectives become much easier to achieve. It means that the most important thing is to provide education to people with disabilities and later the rest of the objectives will show growth.

Before carrying out the design and development process of a serious game, it is highly necessary to have a better understanding of the characteristics and parameters of accessibility required by the disability that the serious game be aimed at. In the next section, the parameters to design an accessible serious game to children with dyslexia are defined.

The rest of this article is organized as follows. In Section 2, we describe the serious games accessibility guidelines for people with dyslexia and the serious game design. Then, in Section 3, we present a case study about a serious game for children with dyslexia. Finally, in Section 4, we conclude the article and we outline our future works.

2. Method and Materials

2.1. Accessibility Guidelines for People with Dyslexia

Accessibility in video games has become a challenge for software developers [46]. Platforms such as Unity allow to include some of the most essential accessibility guidelines in their video games projects supporting the attention of people with disabilities. Next, we present a compilation of accessibility guidelines proposed by some authors for the development of video games for people with cognitive disabilities and specially with dyslexia:

- Use simple language. Using a very specific language may cause the player to not understand the instructions to interact with a video game. For this reason, it is

recommended to use a language that allows to tell a simple and easy-to-follow story and set aside terms that most players cannot understand [47–49].

- Subtitles. Also known as Captions, especially for people with hearing disabilities but also for people with dyslexia [50,51], have become an essential feature. The incorporation of subtitles in video games allows players to have a more pleasant experience in the history of the video game, as well as allowing them to receive instructions in a clearer way [47,48].
- Simple to difficult progression. Commonly used, allow the modification of degrees of difficulty to a greater extent than usual in games. For example, for real time strategy games, add a speed slider or allow the game to change to a turn mode [48].
- Training levels. Another important feature, allow the player to function in an environment free of all the complexities of the video game. There are players with different types of disabilities who may feel frustrated when playing in a real environment. That is why training levels allow the player to strengthen skills within the game [48].
- Objectives reminder during gameplay. Sometimes during the development of a video game it is difficult to remember the objective that must be achieved or what must be done, especially for people with memory problems or who need to take a break between the sessions of the video game. For this reason it is important to include reminders of the objectives of the video game permanently, when the player requests it or from time to time in specific [48].
- Use explicit visual rewards. People with different learning disabilities require receiving explicit visual or auditory rewards, either for animation or video, as motivation to keep their attention in the video game. This feature will allow the player's skills to increase and motivate them to reach new video game challenges [48].
- Possibility for repetition. It is advisable to incorporate the possibility of repeating voice messages or texts within a video game. The repetition feature is used by players when dialogues or texts are difficult to follow [48].
- Pause while text is being read. In a video game, it is helpful to pause, or even repeat, the execution of a text. This feature gives players more time to read the instructions or dialogues of the video game [48].
- Gray-scale at the foreground. It refers to the brightness of the font on a white background. The most recommended source should be as black as possible [27,52].
- Gray-scale in the background. It refers to the brightness of the background when white fonts are used. The darker the background, it is more difficult for the user to read the content [27,52].
- Color pairs. These are the background/font color combinations recommended for dyslexia, these are: white/black, off-white/off-black, yellow/black, white/blue, cream/black, light green/brown dark, dark green/brown, yellow/white and yellow/blue [53]. The combination off-white/off-black is the most recommended for dyslexia in the area of web accessibility [54,55].
- Font size. The recommended font size is 16 or larger [48,56].
- Justified text. It is recommended avoid to use a justify alignment in the text. This can cause rivers of blank space [27].
- Font style. A clear, simple, understandable and more precise font style is necessary, among those recommended are: Arial, Dyslexie, Comic Sans, Helvetica, Verdana, Courier, Tahoma, Computer modern Unicode, Century Gothic, Trebuchet [57,58].
- Space between characters. The recommended space between characters is the standard (0) [27,47,59].
- Space between lines. The recommended space between lines is 1.1 [27,47,59].
- Writing style. Phrases must be maintained with an estimated 15 to 20 words, as simple and concise as possible [27,52].
- Design. Keep information grouped in a single area, it is feasible to include images, photos, tables or graphics to improve interactivity [27,52].

All these features will allow players with dyslexia to enjoy the serious game in an appropriate way and especially reinforce their learning in a fun way.

2.2. Serious Game Design

For the development of the serious game, our method proposed in [60] has been used. This method describes the relevant information to achieve a clear and efficient communication towards the players, developers, publishers, among others, about the serious game through its documentation. In Figure 1, the elements that are proposed in the method are presented. Step 1 collects the general information of the serious game such as the name, target age of the players, characters, among others. Step 2 determines the elements or items with which the player interacts to perform the serious game challenges. Step 3 identifies the type of experience that the serious game will offer the player, such as the number of levels. Step 4 explains everything related to the playability of the serious game. Step 5 describes the accessibility features of the serious game. Finally, step 6 identifies the technological architecture that will allow the interaction of all the elements of the serious game.

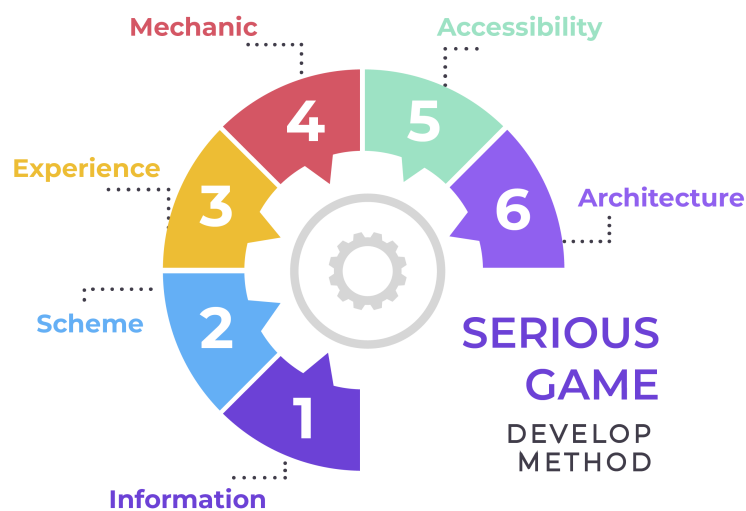


Figure 1. Serious Game Method Scheme [60].

As part of the design process, the Test-Driven Development (TDD) methodology [61] has also been used in order to ensure that there are no gaps between requirements and final product in the serious game development. This strategy made it possible to strengthen the software step by step with new functionalities and features, writing new source code after each test passed through an incremental model.

The following is a brief description of the application of TDD in the requirement of the accessibility guideline *simple to difficult progression*, considering the steps for performance unit testing in [62]:

1. Test Design: Serious game ability to set difficulty.
2. **Execute test suite:** There is only one difficulty mode so the user cannot configure it.
3. Normalization: An option to choose the difficulty of serious games is added in the general settings. This configuration allows you to choose initial, intermediate and expert levels.
4. Test passed?: New functionality has been successfully incorporated.
5. Refactoring: Erasing redundancies and inconsistencies, always checking that the tests continue to validate well.
6. Test Finished?: Yes, to implement the following requirement.

In [63], the elements that a serious game should have are determined. The following describes how the presented video game complies with each of these elements:

- Immersion: The video game allows to maintain a sense of entertainment, as well as that the player is part of the game scene.
- Identity: The player obtains an identity by being part of the video game by recording their progress activity in each game.
- Interactivity: The player interacts every time he performs an action within the video game. In this way, it drags the elements it considers appropriate to solve the challenges.
- Control: As it is a mobile video game, the controls it uses are embedded in the device screen.
- Challenge: The video game maintains different levels of complexity. This feature allows maintaining a challenging environment for the players.
- Narrative: The video game maintains the narrative through the sequence of challenges.
- Feedback: The video game offers visual feedback for each challenge that the player solves. In this way it tells you if the challenge was solved properly or not and how best to solve it.

3. Case Study

Once the method for developing serious games has been selected, its application is presented in a case study oriented to the treatment and learning support of children with dyslexia. The application of the method is detailed below.

3.1. Information

- Game Title: *Puzzle Pieces*. In Figure 2, we can see the serious game logo.



Figure 2. Serious Game Logo.

- Intended game systems: Android OS from version 4.1 “Jelly Bean” to the current one. Keep in mind that Unity also allows compatibility to run applications with the following operating systems:
 - Windows 7 or higher, Ubuntu 16.04 or higher.
 - MAC macOS 10.12 or higher.
 - IOS 9.0 or higher.
 - WebGL any recent version of Firefox, Chrome, Microsoft Edge or Safari.
- Target age of players: 5 to 10 years.
- ESRB classification: eC (early childhood) as it is a video game with educational aspects for young audiences without any inappropriate content.

3.2. Scheme

- Game story summary: The main objective of this serious game is to present two games, one called *Order Cards*, and another one called *Complete Words*. Each game has simple challenges to test the player’s skill. As each challenge is solved, the scores are accumulated and data is generated for later analysis. The purpose is to generate a tool for learning and treatment aimed at children with dyslexia in order to evaluate and improve therapies for various cognitive functions. To achieve this objective, the

information received from the serious game is captured and stored within a database server in real time, to later be visualized and analyzed in graphics by the doctors to carry out the personalized treatment sessions.

- Game Flow: This section describes in detail the performances and requirements that meet the scenes and games that make up *Puzzle Pieces*:
 1. Login: In this scene the user can authenticate. The user will be asked to enter personal data of an account previously created in the game, the username or ID, and the password. In case that the user do not have an account, there will be an option to register and create an account that will be stored on the database server in real time in order to proceed in the game. In the same way, it will be validated that the user enters information in all fields or that they enter the correct information. Otherwise, they will be notified with error messages such as “No username or password has been entered” or “Username or password wrong”. The login section is showed in Figure 3. All the images of the serious game are in Spanish, but they are accompanied by the English translation.
 2. Register: In this scene, the user can create an account to enter the game, in order to track their performance in the puzzles and perform personalized treatments for each user. Personal information of the user is requested such as name, gender, age, username, password, and password verification. It will be validated that the user enters all the requested data, otherwise the account will not be created and an error message will be displayed. The register section is showed in Figure 4.
 3. Main Menu: In the main menu, the user will have four options. The first is the “GAMES” button, which will open a new menu where the user can choose the game they want to play. The second option is the “CONFIGURATION” button, where another menu will open to make some settings in the game that will be discussed later. The third option is the “EXIT” button, which closes the game. The last option is the “CLOSE SESSION” button, which returns the user to the login menu to log in with another or the same account. The main menu section is showed in Figure 5.
 4. Game menu: The game menu simply allows the user to choose between the game *Order Cards* and the game *Complete Words*. It also has a button to return to the main menu in case the user wishes to make any configuration changes. The game menu section is showed in Figure 6.
 5. Order Cards: The logic of the card game is as follows. From a deck of 40 different cards, the user will be presented with a number of cards taken randomly. The indication will be to observe the cards carefully in order to memorize them. After a while, the cards will be turned around and placed in a new random position. Subsequently, the user must place the cards in the empty spaces with the first order presented. The user must place all the cards correctly to win the game as we can see in Figure 7.
The cognitive areas worked on in this game are: memory, visual discrimination, attention and planning.
 6. Complete Words: The mechanics of this game consist of a group of images with objects. Four images are randomly selected, one for each round, and will be presented to the user on the right side as shown in Figure 8. On the left side, there will be 18 random letters, taking into account that the letters required to complete the word in the image that appears. Additionally, at the beginning of each round, an audio will play with the name of the object of the image. In addition, there is a button below the image, which will play an audio with the name of the object as a hint. To win the game, the player must form the word in the image correctly. It is important to emphasize that the selection criteria of the objects for this serious game is based on double syllables or inverse syllables that

are part of common patterns of mistakes and behaviors in reading and spelling that people with dyslexia have [64].

The cognitive areas worked on in this game are: phonological awareness, attention, auditory and visual discrimination, semantic awareness, executive function, spatial location and visual perception.

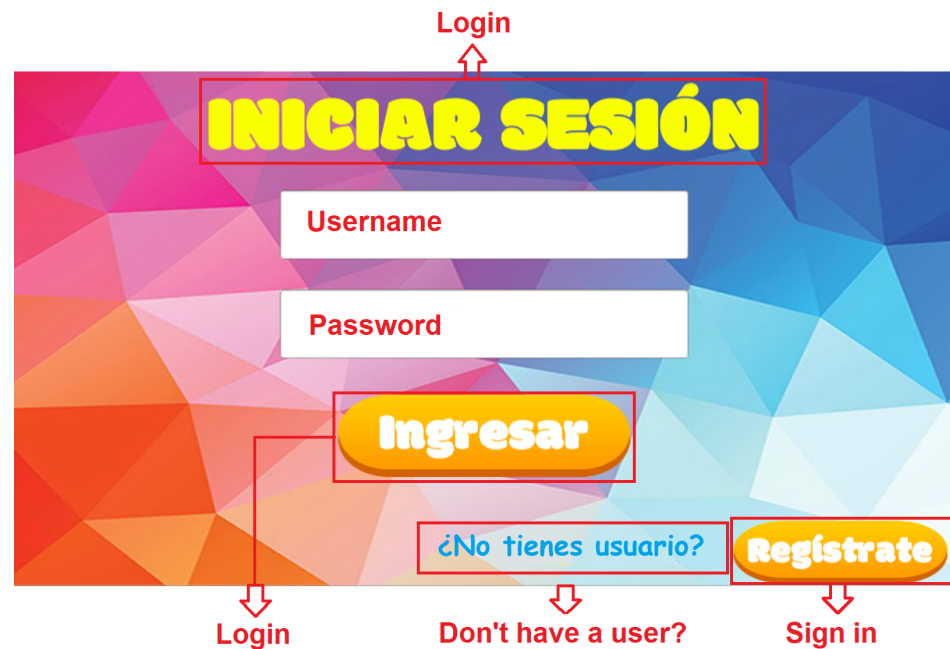


Figure 3. Serious Game Login Screen.



Figure 4. Serious Game Register Screen.

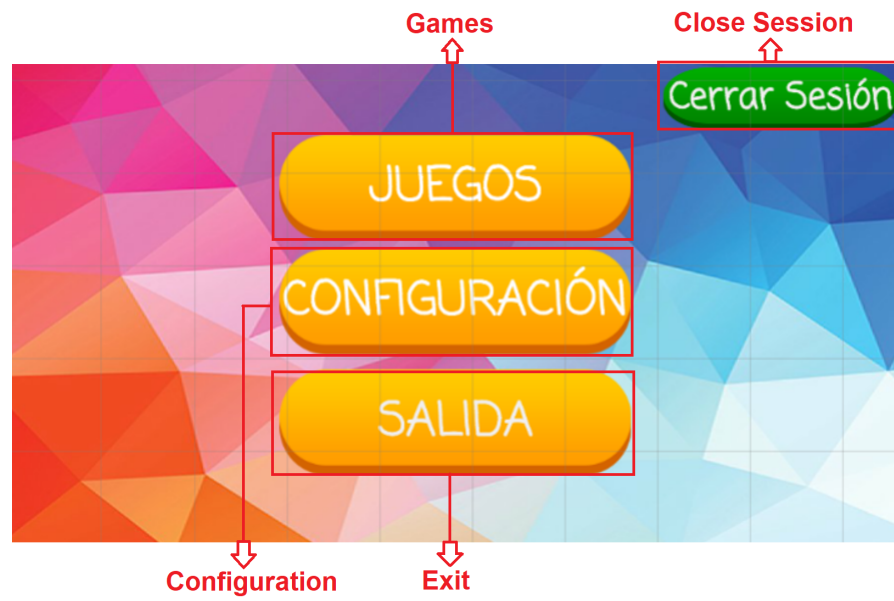


Figure 5. Serious Game Main Menu Screen.

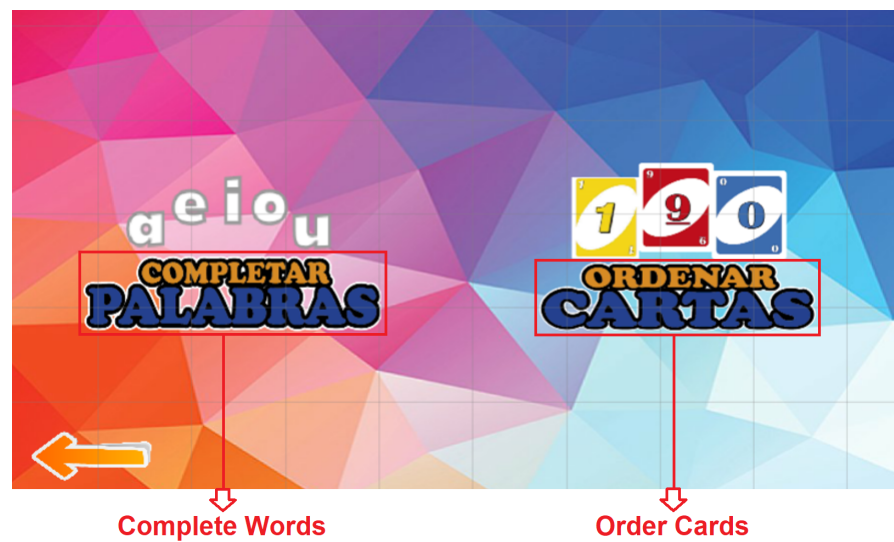


Figure 6. Games Menu Screen.



Figure 7. Game Order Cards from the serious game Puzzle Pieces.



Figure 8. Game *Complete Words* from the serious game *Puzzle Pieces*.

3.3. Experience

The serious game *Puzzle Pieces* was designed so that the experience it offers is friendly and fun aimed at a young audience. Among some features that the game presents are colorful backgrounds to attract attention, large print with a font for children, simple words and instructions, sound effects and children's background music, graphics for a more intuitive interaction, and furthermore. In addition, the difficulty of the games is modifiable, so that the user can work at their own level more efficiently. Depending on the difficulty selected, the following game variables will change:

- Order Letters
 - Initial: 3 cards will be displayed, with 15 s to learn the card order.
 - Medium: 4 cards will be displayed, with 15 s to learn the card order.
 - Advanced: 6 cards will be displayed, with 20 s to learn the card order.
- Complete Words
 - Initial: Objects with 5 letters will be displayed.
 - Medium: Objects with 6 letters will be displayed.
 - Advanced: Objects with 8 letters will be displayed.

In Figure 9, the menu for selecting the difficulty and the volume control are presented.

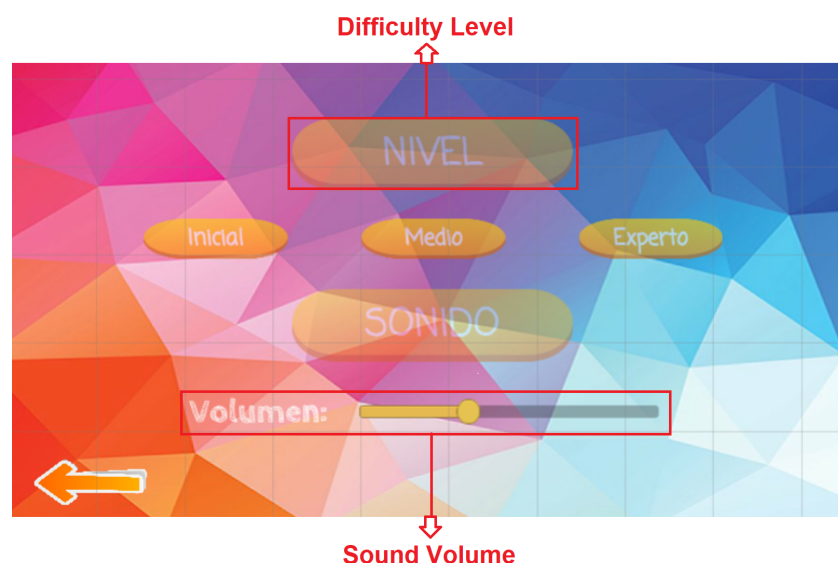


Figure 9. Serious Game Difficulty Level and Volume Control Screen.

3.4. Mechanics

The main mechanics in the game are:

- Each game has four rounds that the user must successfully overcome to finish the game.
- In each game when filling in all blank spaces available, two things happen:
 1. If the spaces are filled in correctly, a message of congratulations with a positive sound is displayed, and the next round begins until the end of the game.
 2. If the spaces are filled incorrectly, an error message with a negative sound will be displayed, and the letters or cards will be returned to their initial positions.
- When completing a game, a window will be shown to the user with a message of congratulations and a victory music will play, in this window the user can choose one of three options:
 1. Go to the next level of difficulty in a new game. If at the end of the game the player is in the highest difficulty, this option will not appear.
 2. The player can restart the game, this means that a new game will start with the same difficulty.
 3. Exit to the main menu.
- When a player completes a game, several data are collected and sent to the server of the serious game database, which will then be analyzed by the therapist. The data collected from the games are necessary statistics such as: time in seconds (that took the player to complete the four rounds), number of hits, number of errors, game difficulty, name of the game, and the ID of the user.
- Each game has the option to pause (when pausing a blur effect is enabled so that the user cannot cheat) and return to the main menu at any time.
- When dragging a card or letter, if it is not released inside or near a blank space, it will return to its initial position. If a card or letter is placed within a blank space, another card or letter cannot be placed on top of it and will return to its initial position.

3.5. Architecture

Puzzle pieces is part of a project that seeks to solve the follow-up of therapies for children with dyslexia. The project architecture is showed in Figure 10. The serious game is installed in a mobile device. Then, the mobile device connects, via Internet, to the Firebase Real-time Database where the information of each user is stored. Firebase is a cloud non-relational database that offers different optimizations and functionalities, such as allowing only fast-running operations [65]. The data are stored as JSON and are synchronized in real time to all users.

The platform on a Windows PC will connect the database server where therapists can observe the graphical data of each user in order to analyze it and optimize the treatments. In Figure 11, the reporting interface of the platform can be seen where the doctor can follow the progress of each user and take decisions about the respective therapy.

Finally, through the report modules doctors can monitor the user's learning progress. Using control charts the doctor or therapist can adjust their therapies or redirect them to achieve a better result in their patients.

At the end of the design process some tests, that were part of TDD, were executed. Some observations and modifications were found in these tests in order to improve the serious game. Table 2 shows these observations and the actions taken to correct them.

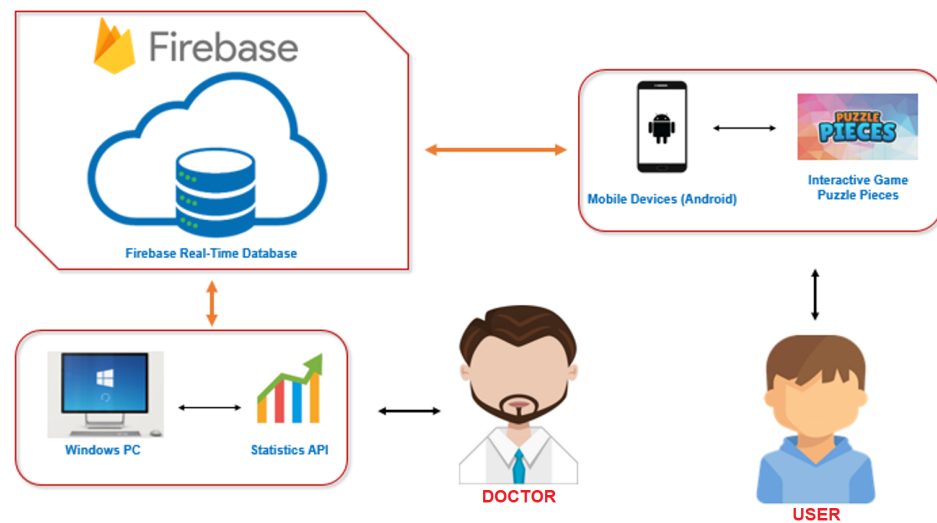


Figure 10. Serious Game Architecture.

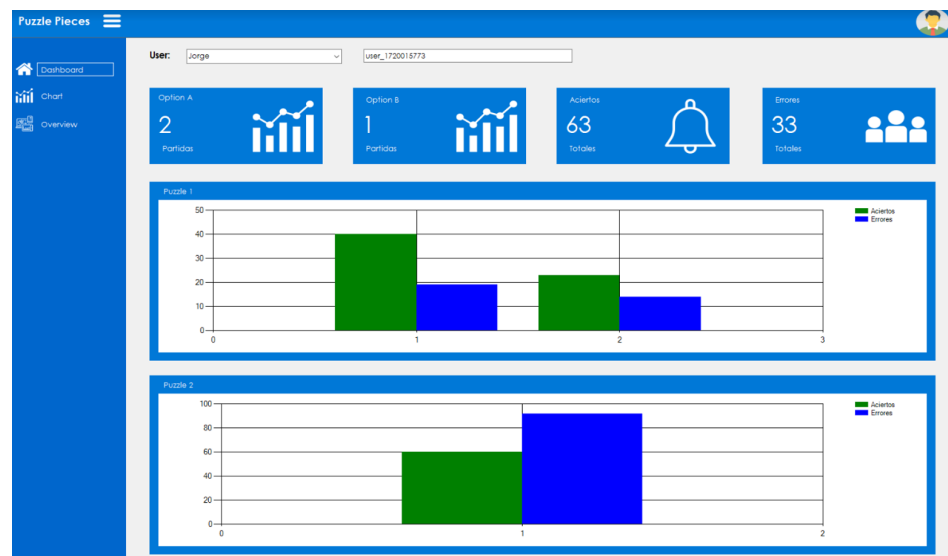


Figure 11. Serious Game Reports.

Table 2. Serious game Observations/Actions.

Observations	Action
In both games, the user does not identify when a new round begins in the game.	Place a “Label” in the user interface in which the current round is shown, and the number of total rounds.
In the game <i>Order Cards</i> , the user cannot re-observe the first order of the cards, causing the user to get stuck if they cannot memorize the order.	Add a mechanic, in which if the user fails two times, the first order of the cards is shown again so that the user has the opportunity to memorize them correctly again.
In the <i>Complete Words</i> In the game <i>Complete Words</i> game, the user finds it difficult to select the desired letter.	Enlarge the touch range to select and drag the letters of the word.
If the user configures the volume of the game sounds, the audio of the words will also be affected to give the user a clue.	Configure the sound controls so that the volume of the audio of the <i>Complete Words</i> puzzle is always at maximum.
In both games, the user cannot read the congratulations or error messages in the rounds of the games.	Make messages show longer time before disappearing.

4. Conclusions

This paper deals with the relation between a serious game and its accessible features for people with dyslexia. This initiative contributes to the improvement in education of people with disabilities. The use of accessible serious games supports the Article 24-Education of the UN Convention on the Rights of Persons with Disabilities [66] and the fourth SDG of the United Nations (UN) - Quality Education [67], considering that it supports people with disabilities to have access to education on equal terms with a people without disabilities.

Serious video games promote the development of people's skills and those with cognitive disabilities are no exception. For this, it is important to consider the implementation of accessibility parameters and the needs of this group of people.

On the other hand, Unity facilitates the development of video games. It reduces the execution times in projects, since the same engine is responsible for performing low-level aspects such as: graphical interface, audio playback, graphics, manager of assets, among others. These features help developers to fully focus on the story and the logic of the game.

Likewise, combining current dyslexia treatment methods with the technology of serious video games, it is an alternative that can improve the neurocognitive abilities that are affected in children with dyslexia. Similarly, children's fundamental learning skills can improve, so they have a better and equal level of education with people without this condition.

Accessibility and effectiveness are the keys to the education of the future, because without these properties the educational gaps will inevitably widen, says Rafael Reif, Massachusetts Institute of Technology president [68]. However, there is a lack of implementation of serious video games with accessibility features. Currently, new studies are emerging every day that are helping to encourage the increase of this type of video games in the market. These studies demonstrate that is not so complicated to apply accessibility features in serious games for people with disabilities. In fact, the video game industry has begun to take into account the need to implement accessibility features [46], so that all players can fully enjoy the experience of video games without any restrictions.

Serious video games are an alternative for learning and treating dyslexia, being a fun and entertaining tool for the target audience. Developing engaging video games that do not require long time intervals to complete is suitable for children with dyslexia, because it prevents loss of attention and interest. In addition, implementing these serious games on mobile devices increases the feasibility of using it in any environment, allowing therapies to be carried out anytime, anywhere.

The case study proposed in this article is one of the first steps in the search for quality education. The proposed serious game development method is general and can be replicated at any level of education, supporting the achievement of goal 4 of the SDGs and, therefore, a sustainable education.

In the future, we intend to test this serious game with a bigger group of players in order to verify and measure its usability and effectiveness. An experimental group of children will be evaluated over a period of time, where the results reflected in the improvement of their cognitive abilities will be evaluated. Likewise, it will be considered a priority to evaluate the level of learning of users with this type of video games to verify its impact on people with disabilities, specifically in this case with dyslexia. In addition, we intend to implement new accessibility features, games for different treatments, and compatibility for more devices or software, such as PC, MAC and iOS, in order to have a multiplatform serious game.

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Abbreviations

The following abbreviations are used in this manuscript:

eC	early Childhood
PC	Personal Computer
JSON	JavaScript Object Notation
API	Application Programming Interface
SDGs	Sustainable Development Goals
UN	United Nations
TDD	Test-Driven Development

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