Edufarmy: a multisensory educational software system that improves the learning of children with dyslexia using the Orton Gillingham approach

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EDUFARMY: A MULTISENSORY EDUCATIONAL SOFTWARE SYSTEM THAT IMPROVES THE LEARNING OF CHILDREN WITH DYSLEXIA USING THE ORTON- GILLINGHAM APPROACH

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Abstract. High rates of lack of motivation and lack of interest in learning and carrying out teaching and learning activities are some of the difficulties faced by children with dyslexia during their educational training. However, nowadays the use of technological tools has facilitated the process of reading and writing, providing didactic and interesting teaching for children with special educational difficulties. The objective of this article is to develop an interactive software using virtual reality tools, which implements the Orton Gillingham approach. This approach is mainly designed to work visual, auditory, and kinesthetic skills. By implementing the didactic game, it is possible to evaluate the technological acceptance and improvement of the condition of children with dyslexia in their reading and writing skills. The results of a study carried out in a psychological center prove that children with dyslexia have improved their condition favorably. It was proved that the stimulation of the senses by means of virtual reality allows them to improve their reading and writing skills, improving the areas affected by dyslexia such as background figure, visual-motor coordination, syllabication, laterality, and position in space.

Keywords: technology; e-learning; dyslexia; children.

1 Introduction

One of greatest social challenges facing society today is the integration of children with specific learning disabilities, with an emphasis on dyslexia. In essence, dyslexia are defined as an unexpected difficulty in reading fluency or accuracy that affects an individual's learning, educational level or chronological age. However, studies claim that a child with this disorder can be bright and talented despite a much lower reading level [1].

Deficiencies in word reading, spelling accuracy and fluency in children with dyslexia are accompanied or preceded by incorrect oral expression which tend to constantly cause feelings of stress and failure [2]. The British Dyslexia Association (BDA)

estimates that 10% of the population is dyslexic and 4% are severely affected. The demand for children to be supported in their learning process is growing dramatically, because the traditional educational model is not able to meet the needs of all types of students, with or without disabilities [3].

In Ecuador, one of the main problems is the lack of a specific methodology that adapts to the individual differences of each student. Many parents need to look for specialists to provide methods and techniques to improve the condition of the child with dyslexia. But this requires time and constant perseverance in order to motivate and instill interest in children [4]. In recent years, technological advances have made possible the development of treatments focused on motivating children with dyslexia during their learning process. Among these treatments is the multisensory approach, which allows the practice of reading and writing using visual, auditory, kinesthetic and tactile resources. Using the multisensory approach provides greater interest when performing the activities and shows promising results with Students [5]. However, a characteristic challenge of the country is the lack of technological support tools that use virtual reality. This fact causes the community especially the parents or guardians of those affected to think that there are no treatment alternatives aimed at children with dyslexia [5]. The purpose of this research is to propose an analysis of computer games applied through virtual reality technology to support the psycho-pedagogical treatment of children with dyslexia [6]. The main characteristic of the use of this application is to contribute to the development of reading and writing skills and to reduce the incidence of dyslexia. It provides those affected from an early stage with interest and interaction with multisensory resources [7]. The research was based on the compilation and analysis of the bibliography of scientific publications, psych pedagogy books, and is complemented with a field research work in a psych pedagogical and psychological center where some important results of the development of the multisensory educational play system based on the Orton-Gillingham method were obtained [6].

2 State of the art

Assistive technology drives a methodological change for children with special educational needs. The multisensory educational game system is composed of a web application that focuses on following the child's learning progress, and a virtual reality video game where the child can interact and play at any time. This video game is a perfect combination of Orton-Dillingham's multisensory and technological approach that avoids distractions or lack of interest of the children [8]. Developmental dyslexia (DDD) are a language disorder that primarily affects the ability to read and write. Children with dyslexia have problems in the rate and speed of learning written language, as well as in acquiring an adequate level of performance [9].

According to recent studies, children with dyslexia often use educational playful software to improve their condition. Over time, it was realized that technology can benefit students with special educational needs.

2.1 A multisensory 3D environment as an intervention to help reading in dyslexia

One of these investigations proposes the use of multisensory techniques with teaching methodologies based on phonics and phonemic awareness through the use of 3D environments implemented in interactive games to help improve reading in people with dyslexia [31].

2.2 Multiplatform games for the identification of dyslexia in preschool children

Followed by another study that proposes as a basis the development of serious multiplatform games using a framework called PhoneGap, with the aim of identifying dyslexia in early ages in an interactive and entertaining way [32].

2.3 Multimedia Learning Based on Augmented Reality for Dyslexic Children

The research also points out a software that uses virtual reality technology in the teaching-learning process of people with dyslexia to help develop their cognitive learning and mental development, for which they created identifiers to generate 3D objects through a mobile device generating an interactive learning booklet [33].

2.4 Madrigale application

Finally, we indicate a multimedia application whose objective is to help develop phonological skills and visuospatial attention in children between 7 and 9 years old through interactive educational games in a more attractive way, generating motivation in the learning process. Based on musical and ludic educational approaches [34].

3 Implementation

The development of educational software proposes an iterative approach and includes pedagogical computational aspects, which uses the methodology of Educational Software Engineering (MeISE) [30].

MeISE: Educational Software Engineering Methodology

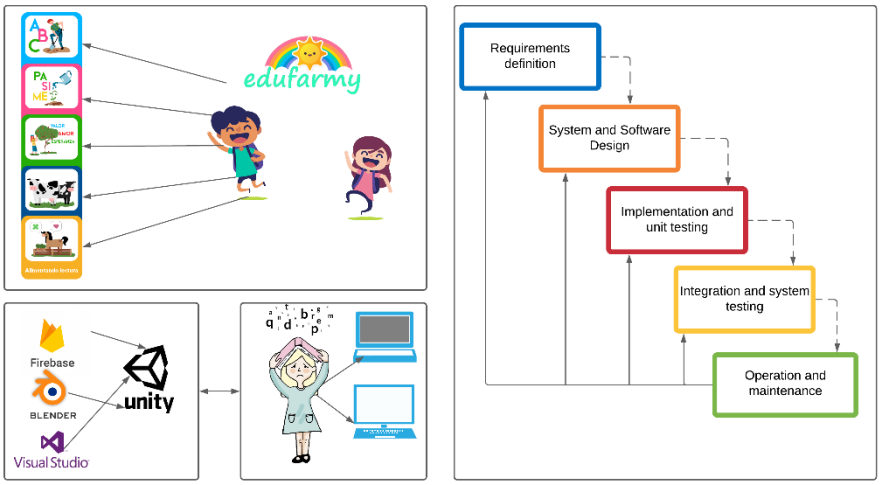

Fig. 1. MeISE Educational Software Engineering Methodology

Figure 1 shows the structure of the application using the MeISE methodology. In the first stage, the definition of requirements, the preliminary analysis and the design of the different educational games are considered. In this process, the characteristics of the product to be made, the teaching, communication requirements and the architecture of the product to be built will serve as the basis for the solution of problems related to reading and writing and the pedagogical characteristics that support the slow development of vocabulary and delay in the development of speech with difficulties in articulating or pronouncing words are established. In the development stage, a detailed computational design for children with dyslexia is made involving motivational element such as music, sounds, animations and images. The software ends with an iteration plan, i.e., it completely covers some of the didactic objectives of the software, facilitating the process of both teaching and learning.

Orton Gillingham's treatment of children with dyslexia emphasizes the individual introduction of each phonogram and all grammatical rules using visual elements, auditory and kinesthetic information where representations of print-sound correspondences are established and, the language units are introduced in a systematic sequence of increasing complexity of simple vowels and consonants through multi-syllable words [11].

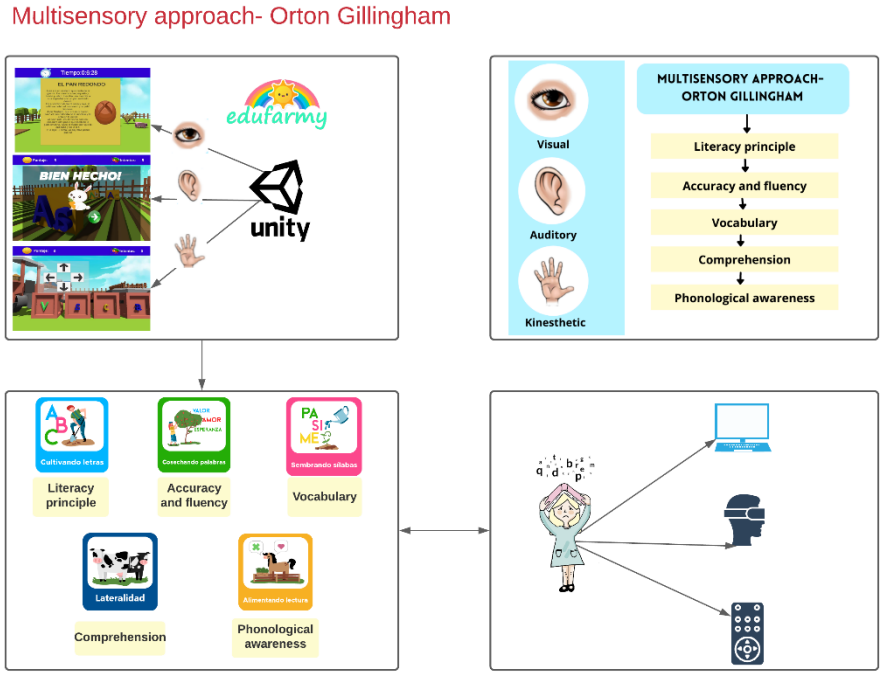

Fig. 2. Multisensory approach- Orton Gillingham

Figure 2 shows the first stage is the visual modality, which teaches the child to master the principles of literacy and to master information accurately and fluently. This is followed by the auditory modality where the child must learn the individual letter sounds by hearing the sounds, saying the sounds, and writing the letters that represent the sounds. The third stage consists of the kinesthetic modality, where the student experiences, relates and pronounces new concepts from his previous knowledge and focuses on writing and spelling. Included in this stage is the memory of the movements made by the muscles. Finally, through this approach, students learn to read, spell and write at their own pace.

In the execution of the project objective and the development of a reliable and robust application, the Unity tool is used. Subsequently, Blender was used mainly to model 3D objects and animation of different elements [12]. Beyond its dynamics, Visual studio was used for the programming control section because it provides a simple, modern and object-oriented language that combines high productivity and speed [14]. Finally, the hosting of real-time data uploaded to the cloud is saved in the in-dependent entity Firebase [15].

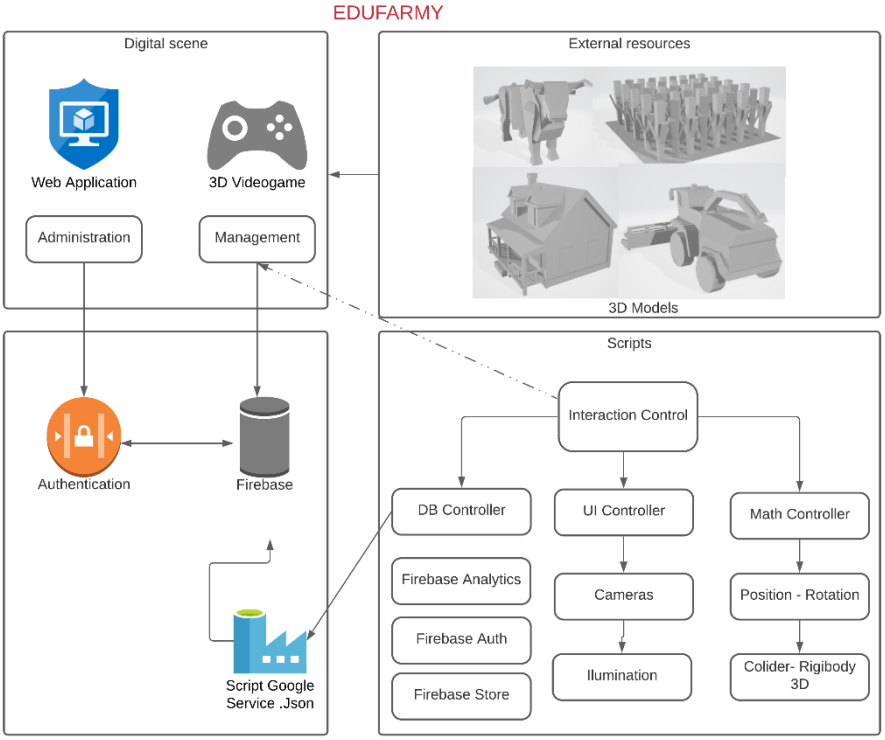

Fig. 3. Educational Software Diagram - Edufarmy

Figure 3 shows the development process of the educational software of a video game in a virtual environment, assisted by a web application that will be managed by a tutor,

this will be a support for the child with dyslexia during his reading comprehension, grammar and reading fluency. The execution of this project will be done through 3D simulation graphic engines and character controller functionalities for a realistic effect within the video game. The project aims to be a virtual support and monitoring tool for children with dyslexia disorder, considering their special needs.

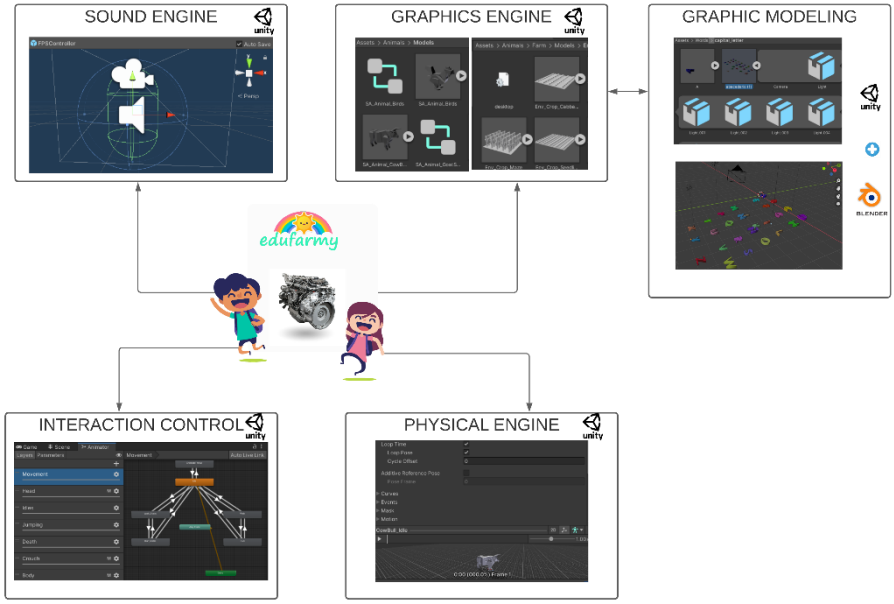

Fig. 4. EduFarmy Game Engine

According to the context defined in Figure 4, the video game engine aims to address the teaching conditions identified in the study of learning disabilities of children with dyslexia, using multisensory tools to apply it within a virtual environment. Therefore, sounds and sound effects were augmented, which give credibility and verisimilitude to a farm environment, along with animal multimedia created by ChiquitinesTV, my Kindergarten, which involve the player emotionally. The graphic engine of the video-game was adapted to the characteristics of the child audience, with artistic and friendly designs. Blender was used to develop the 3D models and animate them. Next, the physics engine integrated in the videogame provides components that handle the physics simulation, such as collisions, forces and gravity. The Interaction Control is in charge of giving functionalities to the player to interact with buttons, cubes and physical elements that belong to the farm. Finally, the precise movement control of characters and their actions was defined to facilitate gameplay.

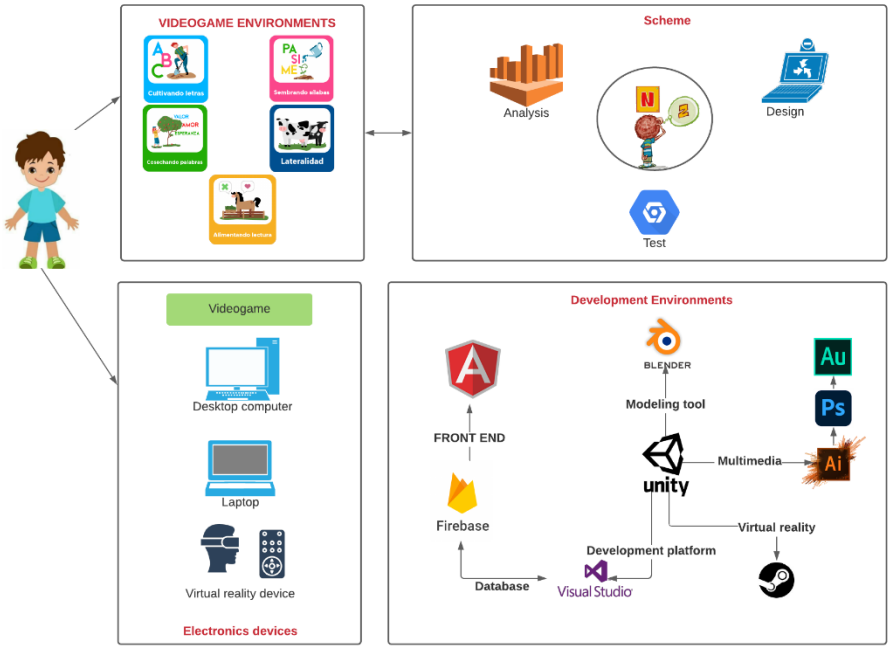

Fig. 5. Implementation scheme

Figure 5 shows the structure of the software, which consists of a desktop application, virtual reality glasses that interact the virtual reality with the user of the application and a web application to manage the child's learning progress.

Requirements Capture

The functional and non-functional requirements identified in the design and gathering stage are presented below. These requirements serve to provide the application with functionalities that contribute to dyslexia in children, and thus, help in their special needs.

Table 1. Requirements of the desktop application.

Functional	Non-functional
• It has a menu, in which the child chooses one of the mini games depending on the state in which their treatment is, and their level of learning. • It shows levels focused on a farm where the child must illustrate their auditory, visual and kinesthetic skills.	• It installs on any operating system since the video game is multiplatform. • It contains motion sensors. • Virtual Reality glasses provide entertainment and safety to the child.

- It has a three-dimensional environment that works with Virtual Reality.

Table 2. Requirements of the web application.

Functional	Non-functional
• Allows the tutor to add the child's information. • Allows the guardian to visualize the child's information. • Allows the guardian to modify the child's information. • Allows the guardian to delete the child's information.	• Child information may only be modified by the guardian. • The children's information will be stored in the Firebase database. • The color of the application is in accordance with a child's environment.

3.1 First stage of the videogame

Fig. 6. Principal's game

Figure 6 proposes a space designed to work on dyslexia through virtual reality, implementing the set of letters of the alphabet, syllables, and words. At the beginning of each game, a multimedia sound is presented with its proper instructions. To keep track of a statistic, the child will be presented with their number of at-tempts and hits. The three main games represent the first stage of the Orton Gillingham Methodology, which helps the child develop classification skills and visual and auditory skills.

3.2 Second stage of the video game

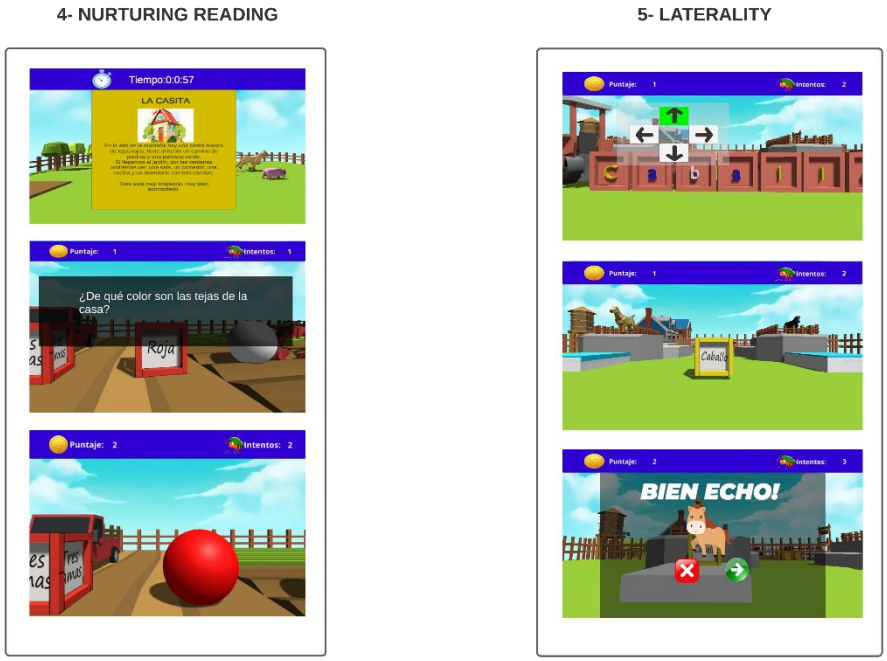

Fig. 7. Secondary game

The second stage of the virtual reality video game is aimed at working on visual, auditory, and kinesthetic skills. Therefore, the child is presented with the reading mini-game, and a laterality mini-game. At the beginning of each game, clear and summarized instructions are provided through multimedia audio.

In the reading game, the child will have a certain time to read a previously selected story, and then answer the questions in the questionnaire.

The game of laterality begins when the child correctly orients the word that is inside the cube. Then you must place the cube with its respective word in one of the two scenarios, to understand its meaning through visual skills.

Both games will count the number of attempts and successes that the child has made to solve the activities.

4 Evaluation of results

To evaluate the results of the treatment progress, a 20-item test was applied, which uses a five-point scale (1=very low, 2=low, 3=medium, 4=high, 5=very high) at the beginning and at the end of the experiment, each of these items evidenced the skills that the child should develop during the treatment. The children were trained on the functioning of the game, indicating the objectives of each one and how to carry them out.

At the end of the evaluation stage, the results obtained at the beginning and the end of the experiment were compared, showing a great difference in the results.

Table 3. Results of the assessment of reading and writing skills

Items	Initial Stage	Intermediate stage 1	Intermediate stage 2	Final Stage
items 1	4,083	3,851	3,538	3,25
items 2	3,917	3,742	3,43	3,333
ítems 3	4,083	3,45	3,313	3,167
ítems 4	4,417	4,03	3,761	3,417
ítems 5	3,917	3,901	3,909	3,911
items 6	4	3,75	3,531	3,333
ítems 7	4	3,81	3,529	3,333
ítems 8	4,25	4,01	3.831	3,5
ítems 9	4,583	4,12	3,881	3,5
items 10	3,833	3,601	3,417	3,333
ítems 11	3,333	3,143	2,993	2,917
ítems 12	3,833	3,734	3,507	3,417
items 13	4,167	3,85	3,709	3,667
ítems 14	4,333	3,142	3,876	3,75
ítems 15	4,667	4,306	4,007	3,833
items 16	4,417	4,315	3,894	3,5
items 17	4,583	4,263	3,926	3,75
items 18	4,25	4,231	4,268	4,252
items 19	4,167	3,806	3,607	3,5
ítems 20	4,417	4,25	3.867	3,5

The table above shows the averages of the scores obtained in the tests at the beginning and end of the treatment carried out on 12 children who were the ones who contributed in the research with the deadlines in the proposed therapy, for research purposes, as it can be observed the results of the application of the game in the treatment of the children during 6 months, there is an evident decrease in most of the child's special difficulties, only in 2 of the 20 items the same score was maintained, the same that are related to the difficulty of laterality, consequently it can be determined that the game

had an effectiveness of 90% in the progress of the child's treatment, the same that can be increased with the use of more training time.

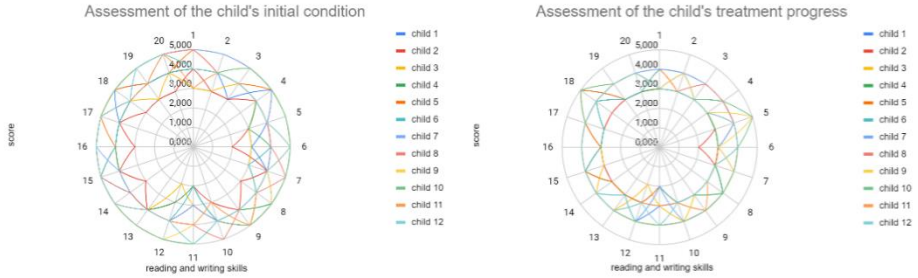

Fig. 8. Graphic representation of the play treatment.

The previous graph represents graphically the results of the progress of each child from the beginning to the end of the proposed treatment, as can be observed at the beginning, the values are within the pessimistic panorama, but as the treatment progresses it can be observed how these tend to be reduced presenting a more optimistic panorama of the progress of the treatment, It should be emphasized that dyslexia, being considered as a condition, cannot be eradicated but rather controlled and diminished, which is the purpose of this software, even though each child has a different way of learning, the playful game has managed to integrate each of these strategies allowing the progress of all of them to the same degree.

5 Discussion

The use of new technologies such as virtual reality in early stages of the teaching and learning process of reading and writing of children with special educational needs such as children with dyslexia, represents a tool for intervention and evaluation of their treatment, which shows substantial improvements in their condition. The proposed software was very well received by the children with dyslexia and the specialists in charge of their treatment. The unique approach of combining a virtual environment with a teaching methodology that fits the unique needs of children with dyslexia has obtained mostly positive results, evidencing progress in the treatment of children. Each one of the games allowed the training of the different literacy skills by the infants who are in the age range between 6 and 9 years old and suffer from dyslexia. The use of virtual reality in an interactive and simple game with friendly environments has allowed to capture to a greater degree their interest and commitment to the treatment, reinforcing their literacy skills, thus improving their confidence in this area of their education.

6 Future works

For future work, it is proposed to improve the game by increasing the number of levels in each of its minigames, where it will be possible to determine precisely which skills

the children need to improve in their treatment and practice them, allowing the specialists in charge of the treatment to better adapt the rehabilitation strategies for each of the children. In addition, the guidance within the game can be improved through artificial intelligence, allowing to simulate the continuous accompaniment of a tutor during the treatment.

7 Conclusions

Through the results of the study carried out with the children, it was possible to observe a remarkable improvement in their reading and writing skills, reducing by 13% the complications of dyslexia during the time determined for the study. In order to make a correct use of the desktop application, it was taken into account that the exposure in simulated environments should be progressive and during the time in which the child is treated, generating a greater interest and commitment in the therapy, which evidences the acceptance of the software by the child.

The play software allows the child to focus on different areas affected by dyslexia such as background figure perception, visual-motor coordination, syllabication, laterality and position in space. All these areas are mostly boosted by virtual reality which helps to involve all the child's senses during the treatment. In relation to the above, we can conclude that virtual reality contributes satisfactorily to the psycho-pedagogical field, specifically in the treatment of children with special educational needs. Technological tools create simulated environments that help to acquire motivation and interest in children at the school stage.

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