Ordering Algorithm as a Support for Children with ADHD Through the Development of Bilingual and Interactive Videogames

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Abstract. Attention Deficit Hyperactivity Disorder (ADHD) involves a pattern of attention deficit, hyperactivity, and impulsivity. There are several works, where videogames are used as a technological support tool in the classroom. However, although the benefits are documented, it is not clear how it was created and especially the purpose of learning for which they were created, so the objective is: to make an application of the software named JaraSmart, in the use of ordering algorithm to support children with ADHD through the development of bilingual videogames. The results are encouraging and allowed us to establish a more formal basis for the use of bilingual videogames with the application of sorting algorithms as support for children with ADHD, aged 10 to 12 years .

Keywords: ADHD · Bilingual videogames · Hyperactivity · Motor skills · Cognitive

1 Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a pathology whose origin and the factors that produce it are unknown. Due to this, the Ministry of Education along with the Specialized and Inclusive Directorate have found 7918 students in the public system of Ecuador with this pathology. [1] Therefore, ADHD has a high psycho-social impact, which is reflected in the deterioration of the child's functioning in family, school, and social life.

For this reason, videogames have great advantages in the educational field, among which stand out the improvement in vision, increase in self-esteem, it favors an interactive learning, while promoting learning through challenge, it also allows improvement in social skills, language, reading rules and messages, and basic mathematics, as well as the articulation of an abstract thinking [2, 3].

Videogames with modern technology have a great applicability in psychology, and they greatly improve the daily lives of many people. New technologies are a perfect ally to treat difficulties, through different applications they can help improve attention, memory, and hyperactivity in children with ADHD in a much more enjoyable and fun way [4].

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There is an application called EndeavorRx which is a video game that was approved by the FDA and aimed at children between 8 and 12 years old with ADHD, where it can be used along with other treatment options, including educational programs, medication and physician-directed therapy [5]. Through this example we can have a starting point for the application that has been created, where 6 different games have been developed that focus on attention and memory. With JaraSmart, the children, besides playing and developing their memory, are also learning mathematics, spelling and Ecuadorian culture. With this, children can have several benefits and at the same time the results obtained can be evaluated, so that experts can use it as an alternative treatment for ADHD.

To contribute to the latter, it focuses on the design-implementation-use-application system, which is called JaraSmart, and its main objective is to help children between 10 and 12 years old with ADHD, to improve memory difficulties, attention or hyperactivity through simple mini videogames adapted to their ages.

2 State of Art

Considering the factors of the advancement of technology and its insertion in everyday life, it is important to think about designing an application that helps 12-year-old children with ADHD, giving them a tool to improve their attention, using ordering algorithm to support them, through the development of bilingual videogames, with a set of tools that will allow the development of applications and software systems. Making it, in this way, an innovative and entertaining application especially for children [6].

2.1 C#

It is a general-purpose language designed by Microsoft for its platform. [7] Along with Java, it is one of the most used programming languages, used for the development of applications, providing the programmer with a level of abstraction that will be useful in the development of complex applications.

2.2 MeISE Methodology

For the development of the application, the methodology of Educational Software Engineering (MeISE) was used. [8] which exposes a life cycle divided into two stages: definition and development, as shown in Fig. 1.

The MeISE methodology bases its operation on the definition of the requirements based on the conceptual phase where the initial design of the application is sketched, the referential framework of the design is established, making sure that the product that is released in each plan is didactically complete [8].

In the second step, the software is developed with the technical team and the interaction with the specialists, making each interaction and designing the application, considering that they have a feedback process, to discover and proactively improve the difficulties presented in the teaching-learning process [9, 10].

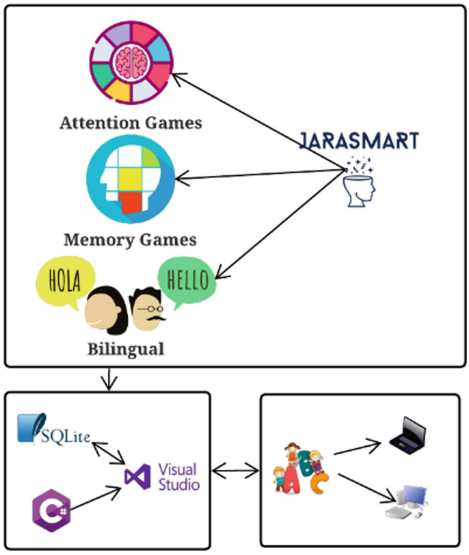

Fig. 1. Outline of the MeISE methodology.

3 Implementation

The educational software has a great impact on children with pathologies such as ADHD, so we used the requirements in order of priority depending on the effort required to develop it, this, through the MeISE methodology, that is in the field of Software Engineering [11], where it has a life cycle for development, consisting of 2 stages of definition that will help the proper implementation of the activities in a structured way.

The interactive videogame is titled "JaraSmart", its purpose is learning through challenge, promoting competition, improving social skills in language in a bilingual way, reading rules and messages, as well as the practice of basic mathematics and the articulation of abstract thinking as stipulated by educational quality [12, 13] (Fig. 2).

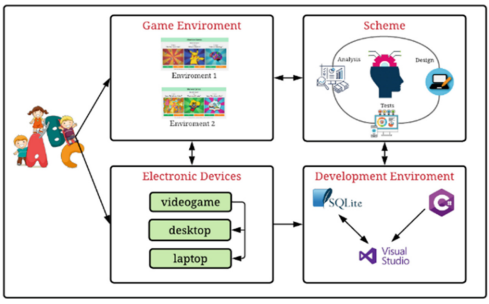

Fig. 2. Implementation schematic.

Based on the proposed context, using the MeISE method, different schemes are designed that provide an interactive approach and include informatics, pedagogical and communication aspects. This methodology proposes a cycle divided into two phases, the main one consisting of a specification and a preliminary drawing addressing the identified educational conditions.

The MeISE methodology for video games makes it possible to obtain a high-quality product, from a technical and pedagogical point of view, which includes instructional design and human-machine interface aspects. Therefore, auditory and visual stimuli are presented when there are encouraging messages such as "You advance in level", "Joker", "Play again", so that the child can see the success or failure, and be encouraged and try again, which is expected to promote healthy competition.

Once the main activities have been identified, the second phase begins, in which the development of different attention and memory video games is proposed, which are the most common areas affected by ADHD [14]. These focus on activities that stimulate the mind and concentration on letters, images, colors, as well as the development of mathematical, cultural and literary thinking according to the objectives established in the application.

The main advantage of MeISE is its focus on the design of video games and peripherals, as these devices contribute to the improvement of reading and writing skills in children with ADHD [15]. The technology provided by C# is used for the functionality of video games and interactive desktop applications. This language complemented with the IDE Visual Studio 2022, allow to define the functions of the video game from object-oriented programming modules and help to organize in folders, methods and functions, in addition to building the application. All the information of the scores of the different attention and memory videogames is stored in a local SQLite database that will be visible to each player, implementing the bubble sort algorithm to sort according to the best score [16] (Fig. 3).

3.1 Main Screens

Fig. 3. Startup screen.

On the home screen there is a field for the child to enter his or her name. This interface is made with the aim of being as simple as possible so that children are not distracted and can access in a quick and easy way. In addition, the language of the application can be changed from this screen (Fig. 4).

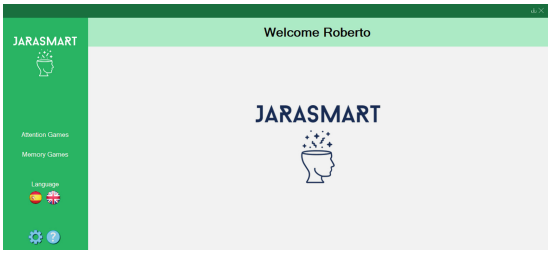

Fig. 4. Main screen.

The main screen consists of two parts, a left sidebar that contains the options menu and a panel that occupies the remaining space where the different screens and videogames will be loaded.

In the left menu you will be able to: enter the attention and memory videogames, change the language of the application, open the settings screen, and access the help screen.

3.2 Configuration Screen

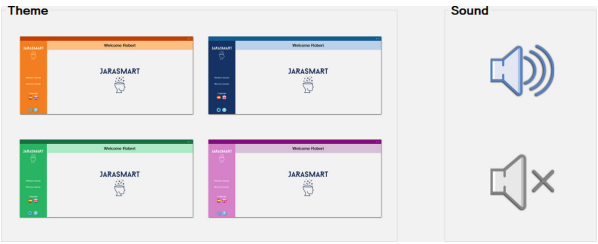

Fig. 5. Configuration screen.

In this interface you can change the main theme of the application, in which the child can choose the colors that he/she likes the most, so that he/she feels comfortable and entertained with the application. Here you can also enable or disable the sound depending on how it is needed (Fig. 5).

3.3 Help Screen

This application is designed to be as intuitive as possible, so there is a help screen where you can find different annotations so that the child or the professional in charge knows how to use this application (Fig. 6).

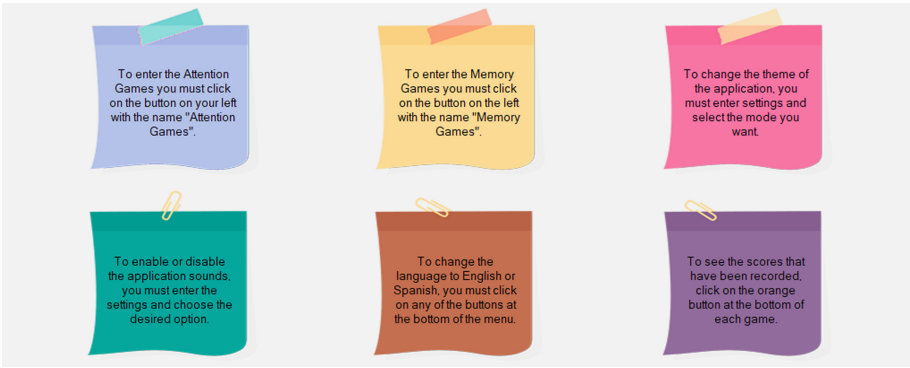

Fig. 6. Help screen.

3.4 Attention Games

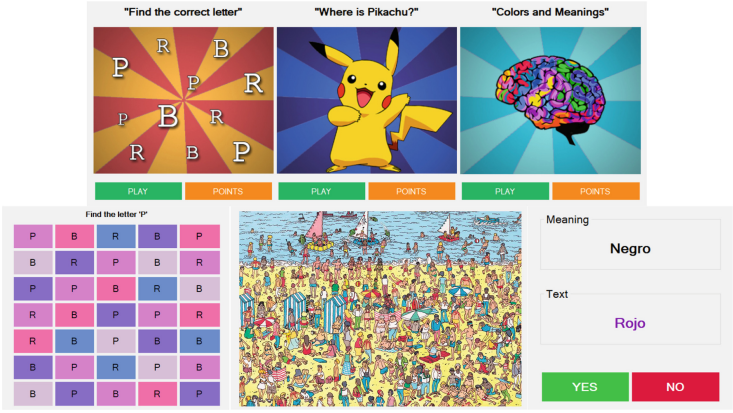

Fig. 7. Attention videogames screen.

In the attention screen (Fig. 7) you can see 3 different videogames that have been selected based on scientific studies and have been shown to develop the child's attention in different ways. Each videogame has different levels of increasing difficulty.

At the beginning of each videogame the objective and instructions will be shown in a clear and summarized way, after this, the time will start to run, to measure the performance of the child based on the successes and mistakes he has had. In addition, in each of the videogames you will have the option to give up if you are not able to finish it or a button that will help you with a hint depending on the videogame.

The first videogame is about the child having to choose the correct letter from a group of letters that are similar. The aim of this videogame is to develop the child's selective attention, which is the ability to focus on relevant information while ignoring irrelevant distractions. There will be shown several squares with a letter and similar colors to

confuse the child, who must click on the letters that are asked in each level, otherwise points will be deducted. Once you have found all the correct letters, you will advance to the next level and at the end of all levels, your score will be calculated according to the mistakes and the time taken.

The second videogame that has been selected is based on the famous videogame "Where's Wally?" but adapted to modern times to arouse the child's curiosity. The objective of this videogame is to find a specific character in the middle of a landscape surrounded by people and objects. Each time the child clicks on the hidden character, he/she will advance to the next level. For each click that is made in another part that is not the character that was indicated, points will be subtracted, and at the end the score will be measured according to the time taken.

Finally, the third videogame that has been chosen is the one in which the child must decide if the color of the word below is the one that is written in the text above. Two words will be shown, one above and one below, if above is written 'Blue' and the word below is blue then the child must choose that it is correct. This videogame has a degree of difficulty in which it forces the child to be completely concentrated to achieve it. The fewer mistakes they make, the higher their score will be and as with the previous videogames, the time taken to complete all the levels will be considered when calculating their points.

3.5 Memory Games

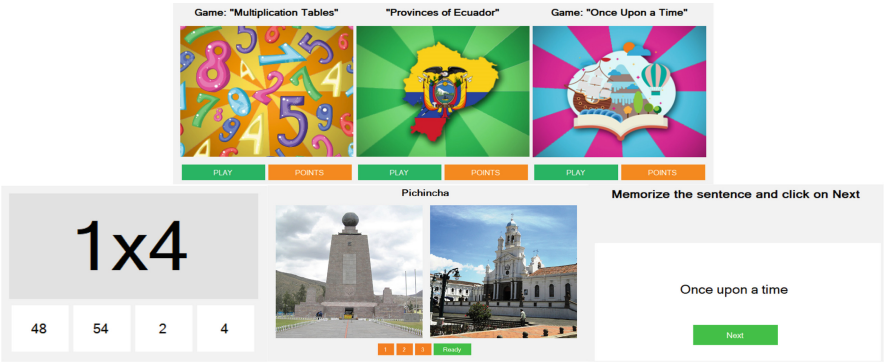

Fig. 8. Memory videogames screen.

In the memory screen (Fig. 8), there are 3 videogames that have been shown to help develop children's memory. Similarly, here, each videogame consists of different levels of increasing difficulty. In these videogames we have sought not only to develop the cognitive part of the child, but also to serve to learn and reinforce their knowledge, in a pleasant and healthy way.

The first videogame is geared towards mathematics, specifically the multiplication tables. The goal of this videogame is to improve quantitative reasoning and problem-solving skills that are necessary to make intelligent decisions, including those related to

procedural memory. Here, multiplications will be randomly displayed and there will be 4 answers, 3 of which are random and 1 of which is correct. Therefore, the child will have to look for the option that is right, to score points. In case he/she gets it wrong, points will be deducted, and he/she will not be able to advance to the next multiplication. Also, the time advances every second to calculate the child's total score at the end of the 3 levels.

The second videogame is based on the provinces of Ecuador. The main objective of this videogame is to develop the child's memory, working with their temporal memories, through representative images. In addition, it is intended to get the child to learn about Ecuadorian culture. The videogame works as follows… In each level the child will be shown several images of 3 different provinces of Ecuador for the child to memorize them in the shortest time possible. After the child is ready, he will be shown a random image of each province and he will have to write down which province each of them belongs to. If the child makes a mistake, points will be deducted, and he/she will not be able to advance to the next level until he/she gets all 3 images right.

The third videogame is one of the most complex and is based on the videogame "once upon a time", where the child must memorize different sentences to from a story. The aim of this videogame is to develop short-term memory, as well as spatial memory, by making the child remember the order of the words that will be shown in different sentences that form a story. Here a sentence will appear, and when the child has memorized it, he will have to write it down, and concatenate it with the sentences he has memorized previously. Each time it becomes more and more complicated until he completes the little story. It is worth mentioning that here the child will also practice his spelling, since he will have to write the words correctly to advance.

3.6 Score Screen

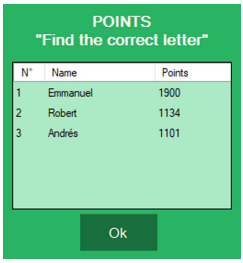

Fig. 9. Scoring screen.

As can be seen in Fig. 7 and Fig. 8 below each videogame, there is an orange button, which will open the scores screen, where a table will be displayed with the results of all the children, sorted in descending order, using the bubble algorithm. This table consists of the position in which the child has been put, his name and the total points he has obtained (Fig. 9).

As you can see, there are two records with the same name, which means that a child can play several times, so that he can see all his scores and develop his healthy instinct for competition to improve.

4 Evaluation of Results

For this study, a quantitative analysis was executed focusing on the treatment of multi-dimensional interventions in ADHD [17], which focuses its attention on healthy competition through cognitive development of attention and memory. In this vein, it can be argued that quantitative analysis can be considered the best for understanding the use of ordering algorithm to support children with ADHD through the development of bilingual videogames. This study will be beneficial as it will critically evaluate both the positive and negative aspects of videogame-based therapy and how it can improve the situation of children affected by ADHD.

This study will be based on the collection of scores depending on the videogame being played and whether it focuses on attention or memory to achieve the outlined objectives. Bilingual videogame-based support can be considered a new phenomenon and therefore the opinion of different researchers was required instead of conducting primary research. Through an average maximum *score* of 1900 points in the attention videogames, where the following intervals will be considered (0–475 = difficult, 476–950 = average, 951–1425 = easy, 1426–1900 = domain) and 1100 in the memory videogames, whereby the following intervals will be considered (0–275 = difficult, 276–550 = average, 551–825 = easy, 826–1 l00 = domain).

Table 1. Results of the average scores obtained in the different videogames.

Videogame	Attention					Memory				
Kid	Find the correct letter	Where is Pikachu?	Colors and meanings	Average score	Average % score	Multiplication tables	Provinces of Ecuador	Once upon a time	Average score	Average % score
1	1300	2600	1000	1633,30	85,96	900	800	700	800,00	72,73
2	1400	2800	1100	1766,70	92,98	800	900	800	833,30	75,75
3	1000	2200	900	1366,70	71,93	800	600	600	666,70	60,61
4	1300	2600	1000	1633,30	85,96	1100	900	800	933,30	84,85
5	1100	2100	900	1366,70	71,93	1000	800	800	866,70	78,79
6	1400	2200	1150	1583,30	83,33	1100	800	800	900,00	81,82
7	1300	1900	1100	1433,30	75,44	1100	700	700	833,30	75,75
8	1500	2700	1100	1766,70	92,98	1000	900	900	933,30	84,85
9	1400	2300	1000	1566,70	82,46	1100	800	800	900,00	81,82
10	1100	2500	900	1500,00	78,95	1000	900	600	833,30	75,75
11	1000	2100	800	1300,00	68,42	900	800	700	800,00	72,73
12	1000	2500	900	1466,70	77,19	1100	900	700	900,00	81,82
% - Total	**Max Average** = 1900				80,63	**Max Average** = 1100				77,27

Table 1 shows the results obtained by the children after having done 2 reviews and these were close to their nearest hundred for the ease of the study, showing an average of 80.63% success rate in the attention videogames and 77.27% success rate in the memory videogames.

Based on the results obtained, this application to support children with ADHD shows a great acceptance in the different types of videogames, as practice and dedication will make them obtain better results.

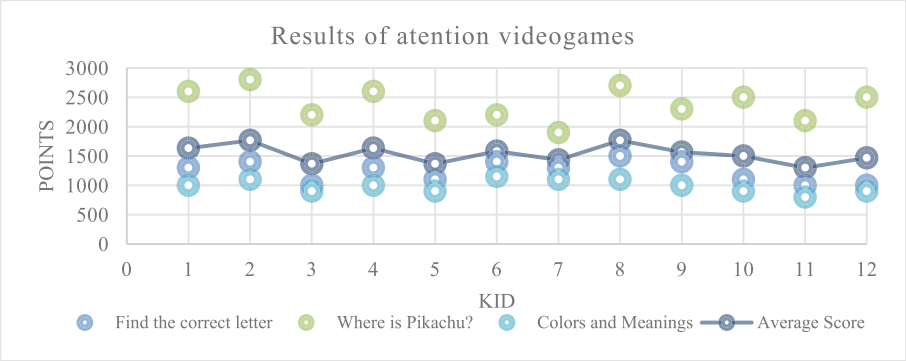

Fig. 10. Graph of the average scores of the attention videogames.

As can be seen in Fig. 10, all children have obtained quite favorable scores, although, child #3 had a lower score than the average. On the other hand, it can also be seen that the videogame "Where is Pikachu" was the most satisfactory, thus demonstrating that children with ADHD can focus their attention on a single thing when they set their minds to it.

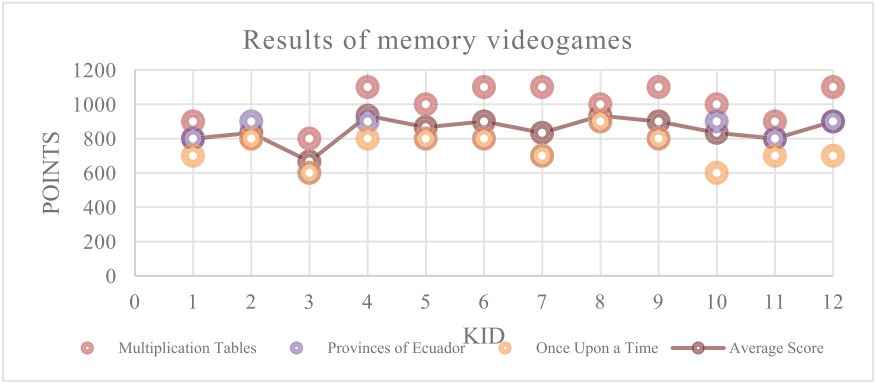

Fig. 11. Graph of the average scores of the memory videogames.

As can be seen in Fig. 11, all the children have obtained favorable scores; however, child 3 has had a little more difficulty with videogame 2, therefore, his percentage of

success has been reduced. Furthermore, it can be deduced that the videogame in which the children have performed best is the multiplication tables, demonstrating that children with ADHD can solve mathematical exercises like the rest of the children.

5 Discussion

Children worldwide who suffer from ADHD require a lot of patience and control by teachers of educational institutions, in turn they do not know how to work with children included in regular education who have ADHD, which causes a negative attitude, making them disobedient, violent, compulsive, distracted, among others [18]. Being victims of discrimination, they lose interest in continuing to attend school activities, which causes the child to fail the grade, and even worse, to drop out of school [19].

Among the attention difficulties detected in Ecuador, they can manifest themselves in social, academic or laboral situations. These difficulties can be translated into:

- Difficulty establishing order in their chores or small responsibilities at home.
- Presents problems in maintaining attention until tasks are completed and must leave one activity for another, shortly after having started it, leaving several unfinished.
- Has trouble selecting what is most important, makes careless mistakes in schoolwork or other activities, not paying enough attention to details.
- They have difficulty paying attention to two alternative or simultaneous stimuli (e.g., listening to the teacher and taking notes at the same time).
- Often avoids or resists tasks that require sustained mental effort and/or a high degree of organization.

Its benefits are sought not only to aid memory and attention but also to have potentially long-lasting effects on other areas of the brain, the brain effects of cognitive development training have been shown to be sustained for five years [20, 21].

6 Future Work

Based on the experience of the research carried out, the urgency of implementation is clear:

- Generation of the mobile application for the interaction of the child with the devices.
- Application of artificial intelligence for human-machine interrelation

7 Conclusion

A software application called JaraSmart has been developed using ordering algorithm to support children with ADHD through the development of bilingual videogames, understanding the arguments of different authors and researchers.

Game-based training was provided to improve memory, attention, and impulsivity. Provided 6 progressive mini games with different difficulty levels and scores.

A results manager is provided that allows families and teachers to observe which exercise obtains better results for control and follow-up.

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