Using Games for the Phonetics Awareness of Children with Down Syndrome

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Abstract. Computers and technology can play a key role in supporting learning, namely for students with special educational needs. Nevertheless, despite the emphasis the society puts on the use of technology and its fast proliferation in the area of education, few initiatives focus on the specific needs of children with disabilities. Motivated by this gap, this research work proposes a computer assisted education application that targets to teach talking and reading through games. The work described herein was carried out in close cooperation with *Centro Diferenças - Centro de Desenvolvimento Infantil*, a child-care institution that works with children with distinct growth disorders, namely the Down syndrome.

Keywords: Down syndrome · Multi-platform · PhaserJS · Educational games · Neuro-development · E-learning

1 Introduction

The availability and accessibility to technology is rapidly growing. In Portugal, during the year 2014 it was registered that 70% of Portuguese households had internet access within the home and 66% were able to access the internet outside the home and workplace with the use of mobile devices [1]. Taking into account the large amounts of existing devices, the opportunity arises to make use of technology to solve day-to-day problems.

Technological advances as related to educational tools is one key area that has received increased attention. With this, several applications and tools have been devised to assist in both the accessibility to information as well as in the education element itself [8–10].

Learning to read is a complex and challenging task which requires explicit teaching and considerable practice to acquire. It involves two interacting, but separate,

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components which are key to effectively reading: word recognition and language comprehension. Work with typically-developing children has identified phonological awareness and letter knowledge to be essential for the development of alphabetic reading. Phonological awareness being defined as the ability to reflect on the sound structure of speech and is assessed by tasks which require children to separate words into syllables, identify and produce rhymes, match words that begin with the same sound, and to manipulate individual sounds (or 'phonemes') in words, for example by blending, segmenting and deleting them. As evidenced, there is clearly a need for further research to evaluate those methods which appear promising for supporting reading in children with Down syndrome, using well-designed and controlled research methods. In addition, despite recent advances in knowledge, it remains significant areas in which our understanding is lacking, and this is particularly true for comprehension. More research is needed to explore the comprehension skills of children with Down syndrome, and to evaluate methods of instruction which may support the development of this skill [2]. The number and quality of existing electronic tools to assist these children in their learning process have proved to be limited.

To help address this problem, specialized associations have begun to partner with universities. One example of this type of initiative is the partnership formed between the "Centro Diferenças" and the "Faculdade de Ciências Tecnologias da Universidade Nova de Lisboa". Through such partnerships, commitments to create and continue the development of several tools to help in the education and integration of these children have been initiated, some of them within the area of neuro-development. In Portugal, 1 in 800 children are born with Down syndrome [3]. These children face day-to-day learning challenges, such as attention deficit disorders, difficulties in associating objects with words, etc. Despite these statistics and facts, as dispelled within the "Down Syndrome Fact Sheet" of the National Down Syndrome Society (www.NDSS.org), although all people with Down syndrome experience cognitive delays, the effect is usually mild to moderate and is not indicative of the many strengths and talents that each individual possesses. People with Down syndrome attend school, work, participate in decisions that affect them, have meaningful relationships, vote and contribute to society in many wonderful ways. Inclusively life expectancy for people with Down syndrome has increased dramatically in recent decades – from 25 in 1983 to 60 today [4].

Perhaps the most important lesson learned through the course of this project, is one also shared within another study on online learning tools for individuals with Down syndrome, whereas in spite of the many unknowns and challenges in embarking on such endeavor if time is taken to value and understand design from the user's perspective, one can chart unknown territory and yield transformational results. This view embodying and setting forth the overarching goal of this work [2].

2 Proposal

As part of this project, a set of functional and non-functional requirements were devised. According to Makesys, the functional ones define a software function or a part thereof. The non-functional ones are related to the performance of the application while it is being used, as well as restrictions on the functional requirements [5].

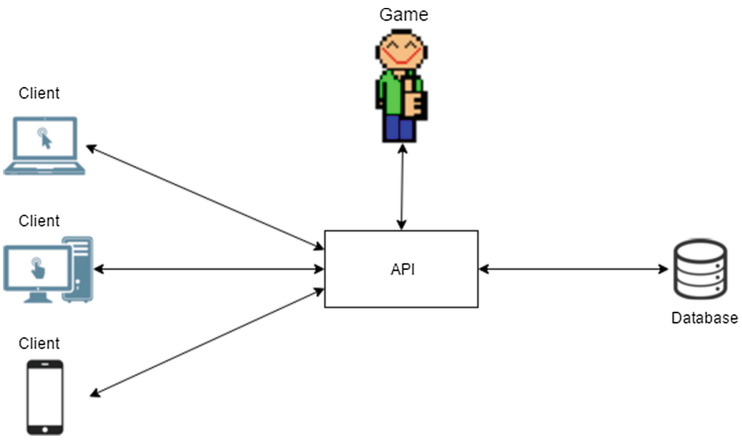

Fig. 1. Architecture description, where it can be observed how the clients will access the application as well as how their communication will work.

Considering all specified requirements, an architecture was created with the following components: one database, one Application Program Interface (API) and one game (Fig. 1). The use of the API was essential to establish the connection between all the components as previously described, as well as allowing for changes to each one of these without affecting the behavior of the other components.

Game The game consists of several mini-games that are designed to address a specific issue in order to most effectively teach the individual player. There are 7 mini-games:

- 2 designed to teach the association of images with words or phrases.
- 2 intend to teach the child how to separate components present in the sounds of the images and to force them to count the number of previously-separated components.
- 2 intend to teach the child how to associate words and objects - in this particular case, associating words and similar objects based on their sound.
- Finally, the last mini-game aims to teach the child how to make associations between a grapheme (smallest meaningful contrastive unit in the writing system [7]) and a phoneme (any of the perceptually distinct units of sound in the specified language that distinguishes one word from another [7]).

The application should be equipped with a data recording process which provides for the recording of data at the end of each level, so as to avoid excessive use of memory. This process should be fluid and must never interrupt the natural flow of the game.

2.1 Mini-Games: “Palavra-a-Palavra” and “Fraseando”

The model presented by the “Centro Diferenças” for the mini game “Palavra-a-Palavra and Fraseando“is based on the repetition of a word or phrase, while the child is being shown a picture (Fig. 2). The image display will be chosen at random and displayed in

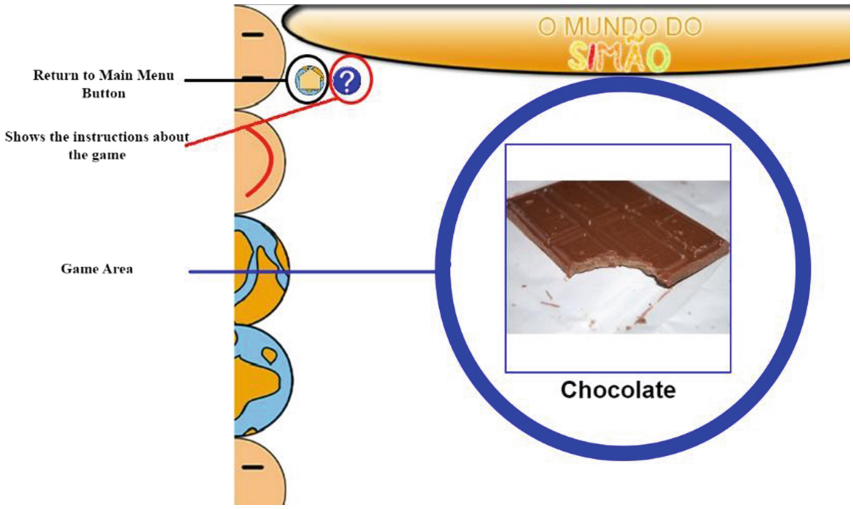

Fig. 2. Screenshot from the mini-game "Palavra-a-Palavra" with layout explained

the center of the screen. The goal of this exercise is to teach the child to speak using images as corresponding to the text in order to provide a visual support. This method was previously tested and is proven to increase the child's understanding and information recall [6].

2.2 Mini-Games: "Palavras a Rimar" and "Sons Iniciais"

The main objective of these mini-games is to prompt the user to find a relationship between the referenced image and options provided. In both games, several images are displayed to the user. One will be the reference and the remaining will be the options that may be selected. In the mini-game "Palavras a Rimar", the user must identify the images that have rhyming sounds. For the "Sons Inicias" mini-game, the user must identify the images that have words that begin with the same sound (Fig. 3).

In this mini-game two buttons, one in green and another in yellow is utilized to record the responses. The yellow is used to lock the answer and the green button is used to confirm the answer as entered.

2.3 Mini-Games: "Contar as Palavras" and "Contar Os Bocadinhos"

The mini-games "Contar as Palavras" and "Contar os Bocadinhos" aims to divide a word and force the student to count the number of words which can be divided into phonemes or syllables. The game "Contar as Palavras" will divide words into phonemes and will force the student to count the number of phonemes (Fig. 4). In the case of the game "Contar os Bocadinhos", the word is divided into syllables. Students may proceed to the next image once you have chosen the right amount of syllables or phonemes.

Fig. 3. Screenshot from the mini-game "Sons Iniciais" (Color figure online)

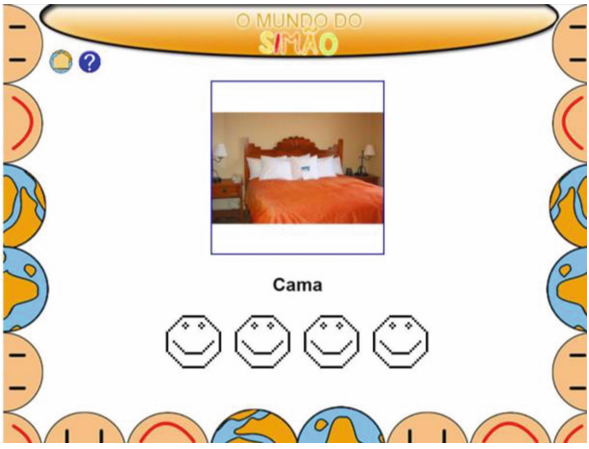

Fig. 4. Screenshot from the mini-game "Contar as Palavras"

2.4 Mini-Game: "Guardar os Sons"

"Guardar os Sons" is a mini-game to teach the user to make associations between a grapheme and a phoneme (Fig. 5). After the start of this mini-game, two random figures together with an associated sound are presented. The child will then have the opportunity to drag the image to one of the chests that represents the corresponding grapheme. If the child drags the image to an incorrect chest, the image will return to its original position.

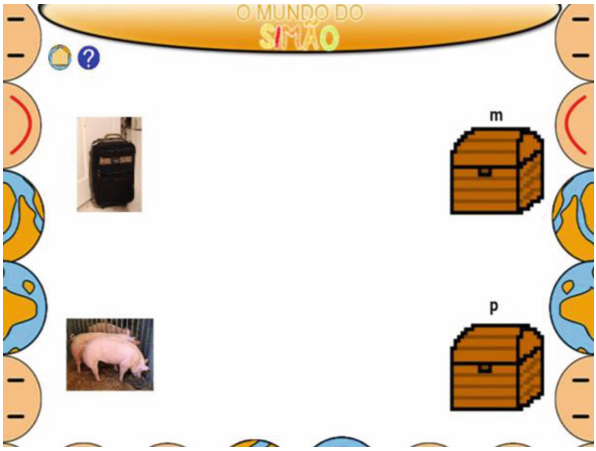

Fig. 5. Screenshot from the mini-game "Guardar os Sons"

3 Validation

This research initiative took place within the Social Tech Booster (http://stb.uninova.pt) branch from the Robotics and Industrial Complex Systems (RICS) research group, trying to solve a concrete problem and pursuing the real deployment of the result, as illustrated in [11].

The validation of this research work was divided into two phases: 1 - the development of a prototype system with the above-mentioned seven mini-games; and 2 – the testing of these games with learning impaired children, i.e., with Down syndrome.

Implementation - Different methods and tools were considered as part of this project. The tools as selected included PhaserJS. This was primarily due to being an open-source system coupled with the level of support provided to the users either by tutorials, or examples as included in its official website. The need to create an API using RESTful Web Services was identified during the project development. It was responsible for the communication between different components. The API also served as a possible interface for the user, in a manner that s/he could access their information along with its restricted modifications within its security parameters.

Validation of the Experimental Data - Between the period of the 5th of October and the 2nd of December, data for three children with Down syndrome from the "*Centro Diferenças*" was gathered as part of this project. The data as collected, represented a total of 3 sessions for each child with varying spacing between the individual sessions. The sessions contained information from the various mini-games.

Every correct answer from the player received a score of 10 points, and every wrong answer received 0 points. The evaluation of the improvement is based on comparing scores between individual sessions. If the score is higher, the child improved and learned something, if the score is lower, the child did worse and did not demonstrate any improvement. The statistics of three children are shown in Tables 1, 2 and 3.

Table 1. Sample results for child number 1

Mini games\Days	Day 1	Day 2	Day 3	Analysis
Palavra a Palavra	50	50	50	Maintained
Fraseando	0	0	10	Improved
Guardar os Sons	40	40	**x**	Maintained
Contar os Sons	50	10	**x**	Diminish
Palavras a Rimar	10	20	**x**	Improved
Contar os Bocadinhos	50	50	50	Maintained

Table 2. Sample results for child number 2

Mini games\Days	Day 1	Day 2	Day 3	Analysis
Palavra a Palavra	10	10	50	Improved
Fraseando	0	10	10	Improved
Guardar os Sons	0	10	**x**	Improved
Contar os Sons	**x**	**x**	**x**	No Data
Palavras a Rimar	0	10	0	Diminish
Contar os Bocadinhos	0	40	30	Improved

Table 3. Sample results for child number 3

Mini games\Days	Day 1	Day 2	Day 3	Analysis
Palavra a Palavra	0	50	x	Improved
Fraseando	0	10	x	Improved
Guardar os Sons	40	x	**x**	Not enough Data
Contar os Sons	x	x	**x**	No Data
Palavras a Rimar	0	10	**x**	Improved
Contar os Bocadinhos	0	50	x	Improved

4 Conclusions and Future Work

The conclusions drawn were that:

- In a universe consisting of 6 distinct mini-games, 83.3% of the mini-game universe showed an improvement in the children's scores between individual sessions. The total universe of the mini-games should have been 7, however, one mini-game was excluded as data was not available.
- Two mini-games were subject of negative results, but only one had 100% negative results, the other game had 2 children showing improvement and one negative performance.
- In 5 of the 6 mini-games (83.3%), 2 of the 3 children (66.67%) showed improvement in their overall results.

- The activities that demonstrated the most improvement were those as specific to the image association with the object and the separation of the image into sounds along with its count.

For final consideration, it should be noted that based on results obtained, great success was highlighted and continued initiatives should be undertaken to improve the mini-game that was subject of negative results.

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