EDUCATIONAL GAMES FOR CHILDREN WITH DOWN SYNDROME

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ABSTRACT

In the last 10 years, the incidence of Down syndrome increased worldwide. In order to improve the quality of life of these children, and to increase their life expectancy, many systematic measures have been undertaken. Inclusive education, which embraces educational, social and emotional practises, based on well-structured instruction, interventions and support in the classroom is definitely one of them. In parallel with the in-class activities, educational software stimulates the inclusion. This paper presents the recommendations how to create such educational applications together with the pilot study intended to develop literacy skills, basic mathematical competencies and memory. A small Android application was created and presented to children attending the recently open Day Care Centre for Down syndrome (DCCDS) in Skopje. The enthusiasm and interest to use the application is the greatest motivation to carry on with the study, to create more ambitious applications and after an approval by the experts and parents to offer them to the all the children in the country. The application can be easily adapted to all languages, making it available to much wider community.

KEYWORDS: Basic learning skills, Down syndrome, Educational games, Inclusive education, Mobile and tablet applications for children with disabilities, Preparation for independent life.

1. INTRODUCTION

Regardless of the considerably improved prenatal detection, and the good prenatal diagnostics of fetal DNA, including the highly sensitive Down syndrome specific non-invasive screening, the incidence of this congenital anomaly increased worldwide. Down syndrome is a chromosomal disorder, which causes: phenotypic characteristics; physical growth and nonverbal cognitive delays; mild to moderate intellectual disability; adaptive behaviour problems; and evidence of adult dementia (Chapman & Hesketh, 2000).

People with Down syndrome deserve the same opportunities and care as others, which results in increased life expectancy and better quality of life. This can be achieved by constant parental care and support, monitoring of the mental and physical conditions, medical therapies, and consistent community support (Reid, 2018).

Inclusive education proved to be the best way to provide educational, social and emotional benefits starting from very early childhood (Felix, 2017). The pilot study of the use of emerging computer technologies proved the improvement of the effectiveness of reading and writing therapies in children with Down syndrome (Gilmore et al., 2003). Moreover, it changed the attitudes towards this disability and improved the interaction with children with Down syndrome (Campbell et al., 2003). If well designed and implemented, specially created educational applications can significantly facilitate the process of inclusive education, enhancing the cognitive and learning skills of these vulnerable children.

The paper continues with a brief overview of the cognitive and neuropsychological profile of these children, which determine the features of the dedicated educational software for them. The cognitive and neuropsychological profiles of the children with Down syndrome, and the recommended features are briefly presented in Section 2. The creation of the pilot project implementing the recommended features is presented in Section 3. Each part of the application is introduced and illustrated in more details, preceded by an explanation of the virtual tutor. Section 4 is dedicated to children feedback. The paper concludes with the suggestions how to increase inclusive education for children with Down syndrome and with the intended future work within the project.

2. FEATURES OF EDUATIONAL SOFTWARE INTENDED FOR DOWN SYNDROME

Similarly to most children from Generation Z, children with Down syndrome have become familiar with the computer technology since their early childhood, particularly to tablets and mobile phones (Feng, 2010). Therefore, the potential of various applications, including educational software can be very important for their development and education, enabling them to stretch the skills and abilities. Children with Down syndrome are usually gifted for one-type skills: language, math, strategic thought or physical coordination. They typically manifest a deficit of attention, thus they are not capable of comprehending longer or more complex rules (Mason, 2015). Children with Down syndrome are not patient to wait for the application to download or to process the following steps (Skotko, 2005). They also need instant rewards for each successful outcome. Furthermore, it was noticed that children with Down syndrome have significant vision deficit and anomalies in colour discrimination (Krinsky-McHale, 2014), and a lack of control of muscles stiffness affecting their motor skills (Vicari, 2006).

These cognitive and neuropsychological profiles, amplified with the guidelines for supporting children with disabilities (Encarnação, 2018) and the recommendations of the specialists from DCCDS resulted in the following conceptual design criteria:

1. Intuitive gameplay with easy navigation and few, simple functionalities accessible by clicking over a perceptive icon, which is active throughout the whole image;
2. Clear interface with bright colours, clear contours, realistic and simple images, and without anthropomorphic features or facial expressions (Lee, 2018);
3. Adjustable progression pace, based on the performance of the Down syndrome child;
4. Virtual tutor who announces the game, and responds with an appropriate facial and voice expression (Herring, 2017);
5. Simple and unambiguous instructions, which are repeated whenever an image is touched;
6. Substituted single and double finger gestures by two touches: from the source place to the target (Landowska, 2018);

7. Learners are not capable of reading, so the instructions should be spoken or presented with the sign language;
8. Quick download and very short waiting time to advance from beginning to end;
9. Free of charge.

All the eight conceptual design criteria were carefully followed while creating the whole application. It is currently installed on 10 tablets, which are a donation to Day Care Centre supplied by a successful fundraising event. The stable version, which will include the modification initiated after observing the children's feedback, reactions provided by their parents, and particularly the specialists from the Day Care Centre will be offered free of charge for all the children interested to use it.

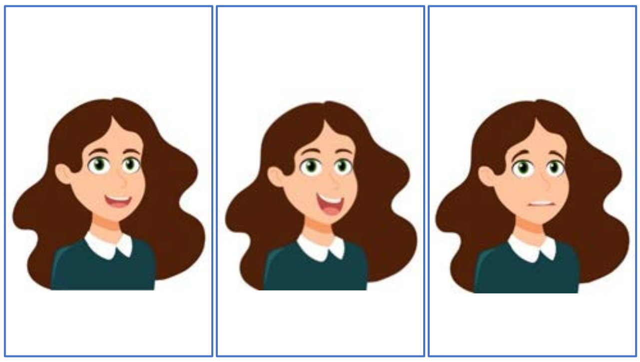
3. CREATED APPLICATION

The application consists of three integral parts: developing literacy skills, developing basic mathematical competencies and practising memory. The screens have a white background, few images and intuitive navigation, thus they fulfil the first two design criteria from the previous section. To give learners an opportunity to set their own pace, and to enable progress, all three parts have several levels, starting from the simplest and ending with the most advanced. They are compatible with the third design criteria.

The application was created using App Inventor 2 (App Inventor, 2020), a very nice and user-friendly development environment, which supports several operating systems. App Inventor 2 is a cutting age educational tool initiated by Google and maintained by the Massachusetts Institute of Technology. It was created in accordance to modern constructivist learning theories (Giordano & Maiorana, 2014). The decision to select the Android operating system was made due to its predominant share on the local smartphone market.

Each part of the application has its own virtual teacher, two young female teachers responsible for basic literacy skills and memory practice, and a young male teacher for mathematical skills (Fig. 1). Tutors have a full and deep voice and a perfect pronunciation. They introduce the task, the levels, speak out the names of the touched objects or pronounces the two navigation icons (the arrows in the upper left corner on Fig 2, and on the lower left corner on Fig 4.).

Figure 1. Three tutor's moods: instructional, happy and sad.



Source: Designs created by Ana Zdravkova

Most of the prospective learners are not capable of reading the instructions, the corresponding virtual teacher slowly speaks them, first by announcing the goal of the level, and then by introducing the task. If the learner accurately performs the task, tutor's face smiles and says a randomly picked congratulation with a happy voice. If the learner has failed, tutor's face becomes sad. After three wrong attempts, sad faced tutor suggests to repeat the task with a calm voice. After five consecutive mistakes, the advice is to go back to the previous level or to ask for help.

Whenever the learner successfully performs the task, one of the congratulations is loudly spoken. They are randomly picked out from the following list: amazing, bravo, compliments, great job, excellent, and well done. After finishing a whole task, the congratulations become stronger and personalized: you are a genius, you are gorgeous, and you are remarkable. At the end of the level, the learner is awarded with a badge (Fig 3.). If the learner has not been successful, the virtual teacher politely suggests to repeat the task. Whenever the learner persistently gives wrong answers, the suggestion is to ask the parents, guardians, or learning assistants for help.

The presence of a virtual tutor, which reacts after each successful or unproductive activity fulfils the fourth and the fifth conceptual design recommendation. Bearing in mind that the majority of the children with Down syndrome are not capable of reading, all the messages are spoken, which is in accordance with the seventh design criterion. In the near future, it is intended to combine the application with the avatars from the (Joksimoski, Chorbev, Zdravkova, Mihajlov, 2015).

During first testing of the pilot application, it was noticed that almost all of the children were not capable of implementing the drag and drop gestures. To avoid this obstacle, they were replaced by two separate activities, touching over the source place, and then touching of the target place. Implementing this approach, the sixth design criterion is also achieved.

Finally, all the images are extremely simple, and they are presented using the vector graphics. In total, the size of the whole application doesn't exceed 1MB. This constraint is much lower that the App Inventor 2 maximum size limit, enabling very quick download, as recommended by the eight design criterion. The following three subsections describe the three integral parts of the application in more details.

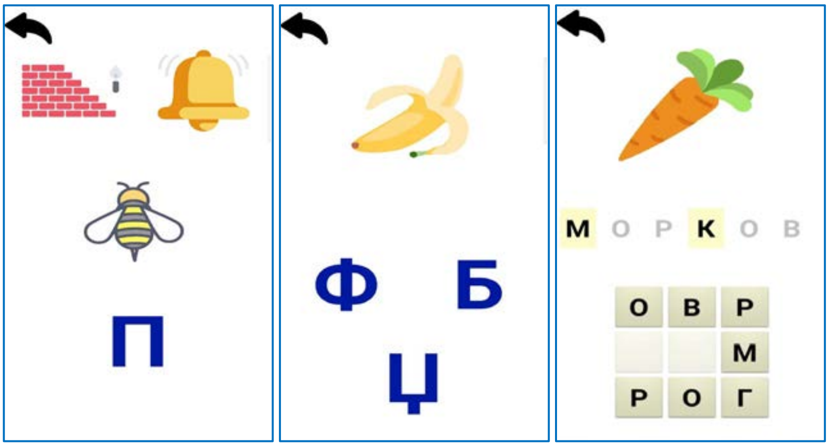
3.1. Developing literacy skills

The part intended for developing basic literacy starts with the introduction of the upper case and lower case letters, which are presented below the image that starts with that character. For each letter, at least three different images exist in the pool. For example, under the letter A a, the images of a plane (авион = avion), a car (автомобил = avtomobil), and a pineapple (ананас = ananas) are presented one by one. For the letter Ж ж, the corresponding images are a frog (жаба = zhaba), a turtle (желка = zhelka), and a giraffe (жирафа = zhirafa). After the presentation of the images for one letter, children are given an option to draw the uppercase letter. It can't be checked by App Inventor 2, so the success can't be verified.

The successful recognition of the letters is the task of the three games (Figure 2):

- Finding the corresponding image that starts with a presented letter,
- Finding the corresponding initial letter of the presented image
- Spelling a word presented as an image from distributed letters

Figure 2. Intermediate level of finding the correct word starting with an initial letter, the correct initial letter of the presented image and spelling a word with two syllabi.



Source: Mobile application for learning the alphabet for children with Down syndrome, developed by Iva Mihajlovska, B.Sc.

In the simplest level of the first game, two images are presented under the letter, the image that starts with it, and an image with a different initial letter. The intermediate level has three images, one of which is the correct one, and the most advanced level has four images.

The reverse game starts with two uppercase letters offered for one image, continues with three letters, and ends with four. Similarly to previous game, only one letter corresponds to that image.

In the third game, the letters of a simple word are randomly presented on the bottom of the screen. By clicking and positioning them at the right place in the middle of the screen, they make the word which is presented as an image, and after the successful spelling, it is spoken by the virtual teacher. The simple level consists of words with one syllable, the intermediate has two syllabi, while the most advanced level has more than three syllabi. In order to stimulate the recognition of the letters, the set of prospective letters contains characters that don't exist in the word.

3.2. Developing basic math competencies

The order of the traditional concepts for developing basic mathematical competencies is the following: forms, relations, numbers, and measures. The first goal is to teach the learner to determine the exact form among these 3D forms: sphere, box, cylinder, and the 2D forms: square, triangle, circle and rectangle. The relations usually include: up – down; over – below; in front of – beside – between; inside – outside – over; left – right; identical – different – similar; big – bigger – the biggest; bigger – smaller; wide - narrow; high – low, fat – thin; deep – shallow; and same quantity – less – more. The introduction of numbers is accompanied by the relations less – more – the same. The measures start with the length, the weight, the time and currencies.

Each of these concepts is usually performed as an in-class activity, where learners use toys or special tools that enable them to practically resolve a task. The use of the tangible objects enable them to implement problem solving method based on trials and errors (Newell et al., 1958), which is more convincing and effective than a computer game. Therefore, the games intended for developing the basic mathematical skills in our application covered the amounts of objects and forms (Figure 3). The simplest level comprises the values up to 3, the intermediate up to 5, and the most advanced, up to 10. After the training session, where children see how to count the objects and the forms, they are invited to perform the same task. Depending on the level, the list with the squares containing the numbers up to 3, 5 or 10 is presented in the lower part of the screen. To improve the clarity of the interface, the orientation of the screen in this game is landscape.

This game introduced the rewarding with badges, and the demonstration of the correct answer (Figure 3, middle screen). A badge is obtained after 5 consecutive correct answers. After next 5 correct answers, a new badge is awarded, and the screen with all collected badges so far appears on the screen, together with a spoken personalized congratulation. However, not all attempts will be successful. If the child is not capable of getting the correct answer within two attempts, the application turns into a training mode, showing steadily the answer. Then, the child has an opportunity to repeat the same task individually. If even after the demonstration the success is not achieved, virtual teachers suggest to ask for help from someone.

These two concepts: rewarding with badges, and demonstration of the task solutions will be soon added to the games responsible for developing literacy skills, and practicing memory.

Figure 3. Introductory screen, the badge, collected and explanation of the correct answer.

Source: Mobile application for developing math skills for children with Down syndrome, developed by Marija Krsteska, B.Sc.

3.3. Memory game

The memory game reinforces the skills gained in the previous two games, uniting the letters, the objects, the forms, and the numbers. For that purpose, four smaller units are created: coupling pairs of equal images; coupling the initial letter with the image; coupling the written word corresponding to the image; and coupling the numbers with the corresponding written word. Similarly to previous two games, three levels are established. The simplest level couples two pairs, the intermediate three, and the most advanced four pairs. In a near future, it is intended to extend the game with units responsible for coupling pairs of equal numbers and words, including the words representing the numbers, as well as coupling several identical objects with the value expressed with numbers.

Figure 4. Memory game, intermediate level: coupling equal images, the initial letter with an image, the written name with an image, and numbers with a word.

Source: Mobile application for practicing memory of children with Down syndrome, developed by Davor Trifunov, B.Sc.

This game was presented and tested in the Day Care Centre for Down syndrome in Skopje during September 2019. The feedback of the game is presented in the next section.

In February 2020, Davor Trifunov, one of the collaborators in the project, organized a very successful fundraising event, and with the support of ANHOCH (https://www.anhoch.com/), 10 tablets were provided for the Day Care Centre. The pilot application was downloaded on each of the tablets as currently the only content. At that time, the amount of children attending the Centre tripled, and the range of the children increased. It was a great opportunity to make a more methodical assessment and collect crucial information for its evolution. Unfortunately, due to the Covid-19 pandemic restrictions, the Centre was closed in the beginning of March. Ii will remain inactive until the end of this academic year. Therefore, the next version of the application will be presented next September, and the new feedback will be available later on.

4. FEEDBACK

Seven young boys and two girls aging from 15 to 19 and their parents were the first evaluators of the application. The game was installed on one tablet and demonstrated to every child individually. The age and the basic reading skills enabled them to successfully play the memory game. The whole event was touching for everyone. The kids were noticeably amused and attracted, except one girl, who was too shy. She listened the tutor with great attention and observed how the others played.

The most experienced boy comprehended the game immediately and asked to play the first. After trying all the options several times, he generously let others play. He manifested his frustration from the absence of an immediate congratulation after each successful coupling by lifting the speaker to hear the greeting.

Other five kids explored him, tried the game and managed to play it independently. The most extrovert boy succeeded after several trials and errors, and then tried to download the game from Google Play. Two kids, a boy and a girl created a strategy to first open all the tiles, and then couple them.

Two boys were not competent with the written words, one couldn't even discover the initial characters. They turned to the easier level of the game of own accord and were not enthusiastic to play it again.

During the second visit, all the kids, except the shy girl, activated the game and played it more competently, including the boys with lower literacy skills.

5. CONCLUSIONS

The ultimate goal of Day Care Centre for Down syndrome in Skopje is to prepare the kids for an independent life. They started making own meals under a full supervision of DCCDS staff and organized a cocktail with self-made bread and snacks. The next stage is to purchase the ingredients and start cooking according to a written recipe. To achieve this goal, their literacy and understanding of quantities should increase significantly. According to DCCDS staff and their parents, the educational game will be of a great use.

The major challenge is the indifference and the anxiety of some kids. Hopefully, they are very confident in using the smart phones. Before launching it on Google Play, the application will be polished and upgraded with new contents suggested by the specialists from DCCDS. As a consequence, those kids who were shy to show their incompetence or who were not interested to use it will be able to experience it with the support by their family members.

The educational game is in Macedonian only. It can easily be adapted to other languages, making it available to wider community.

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