Educational Platform for Children with Down Syndrome Manageable by the Educator

Carlos Venegas, Rubén Cevallos, Richard Córdova, Danni De La Cruz, Johanna Tobar, Paúl Mejía

***Abstract*—Nowadays educational mobile apps represent a fundamental tool for the developmental learning of children with Down Syndrome (DS). However, these tools haven't been formally integrated into the learning process due to cognitive growth that hasn't been verified by the educator. In this work the results of the development of a mobile educational platform (m-learning) are presented. These count with many learning modules with technological innovative tendencies throughout the use of recognized tendencies towards the treatment of children with DS that allow the educator to have control over the cognitive development of the students.**

***Index Terms*—Down-Syndrome, Information and Communication Technology, m-learning, Learning, Teaching.**

I. Introduction

THE Information and communication technologies (ICT), nowadays, are an important tool for the cognitive development at different levels. The use of the ICT makes the learning-teaching process effective and interesting [1].

A. Information and Communication Technologies

The ICT is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer, and network-hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning [2]. When such technologies are used for educational purposes, namely to support and improve the learning of students and to develop learning environments, ICT can be considered as a subfield of Educational Technology [3].

B. M-learning

The m-learning comprehends a learning methodology based on the use of mobile devices (mainly smartphones), of significant use on school sectors due to the great interactivity it can provide though these. Also, the increasing use due to the progressive reduction of costs in recent years in the national and international markets. The m-learning can generate a radical change in the educational process. Learning through mobile devices will generate new approaches to the pedagogical conceptions. It is not only about how to teach or making different topics understandable, but it coexists with technology as a tool for daily work, promoting research and student's self-learning. [4]

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C. Down Syndrome

Down Syndrome (DS) is a genetic problem due to alterations in the chromosome 21. This generates complications to the development of the physical and mental aspects that converge to a variable degree of cognitive disability. Also, a percentage of patients require permanent medical assistance while others have a similar life rate as any person. Their deficiencies are characterized by slowness to process and encode information and difficulty to interpret it, produce it and respond to its requirements making appropriate decisions. [5]

D. Educational Guidelines

All children require stimuli for learning and to enhance their motor, cognitive and emotional capacities. Kids with DS are not an exception, but due to their special characteristics they actually need a different training. [6]

The visual capacities of children with DS are, in general, superior to hearing and their understanding capacity is superior to that of expression, for which they have a sparse language which seems to be with certain delay. Although, they compensate their verbal deficiencies with more developed skills like visual contact, a social smile or the use of signs to make themselves be understood. [7]

The first specific programs, called early intervention programs (during the first 6 years) designed specifically for children with DS intend to stimulate the most of their adaptive and learning mechanisms. Therefore, in order to teach a child with DS to read, conventional methods cannot be used, but graphic methods as for instance the case of the British vocabulary scale images (BPVS) does; that takes into account their greater visual capacity and is obtaining excellent results.

The method BPVS is a receptive language evaluation of vocabulary that consists of presenting the kid a group of 4 images. The examiner says one word and the child has to point the image that best describes de word. The scores that go between 85 and 115 are considered to belong to the normal range according to the age. The scores that go between 70 and 84 are a cause for concern. The scores that

ISBN: 978-988-14047-1-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

go between 69 and under indicate a significant difficulty. [8]

Short-term memory is the ability to keep in mind actively a small amount of information, so that it is immediately available for a short period of time.

In various studies it has been proven that people with DS obtain worse scores on short memory term tasks. Overall, a seven year old is able to remember more than six digits. Individuals with DS show to remember the same amount of digits or less than four. Probably, this shows that people with DS have a specific deficit in verbal short-term memory. [9]

II. Development

A. Platform Structure

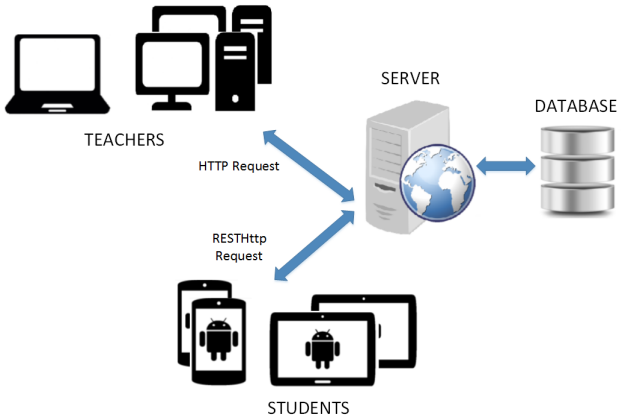

Fig. 1: General platform structure

As shown in Fig 1. The server makes processes that interact with the database, where the information resides, the transactions that are being rewired through various devices are fed by two types of users called:

1) **Educators**
Activities:
- Be trained on the system management
- Pilot test
- Evaluation of the system
- Periodically add information to the to work modules
- Modify or eliminate information
- Submit tasks
- Periodic assessment of each student's progress

Devices that allow access:
- Laptops
- Desktops

The use of the web application for educators works through a web browser so that it works with any operating system.

2) **Learners**
Activities:
- Be trained on the system management
- Pilot test
- Evaluation of the system
- Perform tasks sent by the educator
- Work in each module continuously

Devices for access:
- Smartphones
- Tablets

In the case of mobile devices it is required that they have Android OS 2.3+

B. Modules

For the development of the platform, certain parameters of influence were chosen so that the modules were organized as follows

1) **Development of verbal language**
Severe cognitive deficits are found on people with DS. To influence in a positive way the following activities are performed:
- Play every word syllable by syllable to indicate its pronunciation
- Film and verify that the user pronounces syllables from each word correctly
- Feedback the user about mistakes

For the development of these activities the following libraries are used:
- Synthesizing Text to Speech
- Synthesizing Speech to Text

2) **Development of short-term memory**
In different studies it has been proven that people with DS score worse on short-term memory tasks, so the following activities are proposed:
- Show a sequence to be performed by students
- Students must interpret and attempt the same sequence from the matrix device
- Synchronize results from matrix device with the ones from the indicated sequence
- Feedback the user about mistakes
- Register progress on the server

For the development of these activities the following libraries are used:
- Bluetooth from Android device

C. Mobile Application

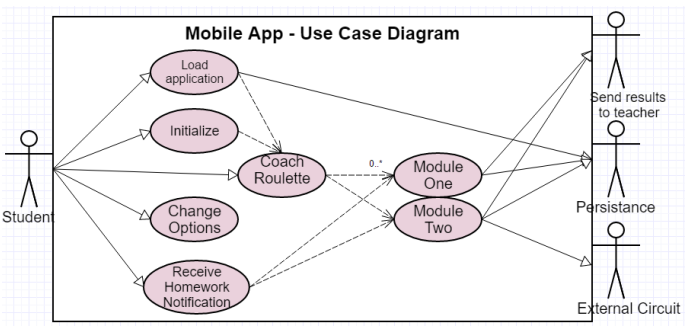

Fig. 2: Diagram of use cases of mobile application

ISBN: 978-988-14047-1-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

According to the diagram indicated Fig. 2:

- In case the application is initiated for the first time synchronization is performed with the server to register the device
- When initializing the application, it displays a graphical interface with a wheel of fortune that will redirect to different modules.
- Asynchronously the user receives notifications of tasks sent by his teacher
- The user can work on the modules even if the teacher has not sent a task; in this case the user's progress is also recorded through a transaction by the database
- In case of receiving a task, the student must complete it; at the end it progress is monitored in the database

1) Module 1: Development of verbal language : By this modulus the development of verbal skills intended in SD patients. The following considerations are made:

- Two-syllable words are used because they are easy driving
- Voice synthesizers' mobile device can be adapted to different languages

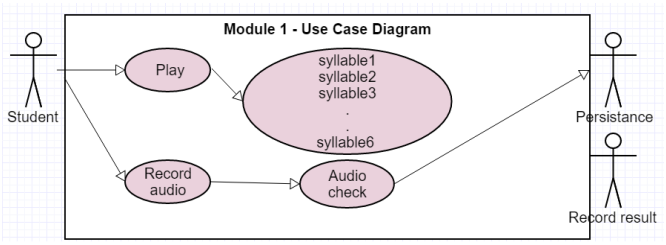

Fig. 3: Diagram of use cases of Module 1.

This module allows the student to receive one combination of 3 two-syllable words, these words have in common the first syllable, the goal is to indicate the user how to pronounce each through the synthesizers' text to speech, and the reproduction of each syllable. Following this the user checks whether the pronunciation is correct, this process is done by synthesizer's speech to text.

An important characteristic to point out is that the information of this module is constantly synchronized with the existing on the server, which is modified periodically by educators.

2) Module 2 : Development of short-term memory : By this module sequences are realized allowing to improve the skills of short-term memory

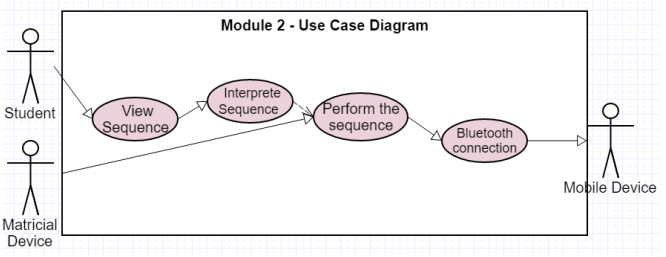

Fig. 4: Diagram of use cases of Module 2.

Fig. 4 shows the diagram of use cases, according to the first, the student of the first visualizes a sequence. After this should interpret the sequence and matrix on the external device when connection fulfills an event that Bluetooth is realizing. A mobile communicates with the correct device and proves the correct realization sequence

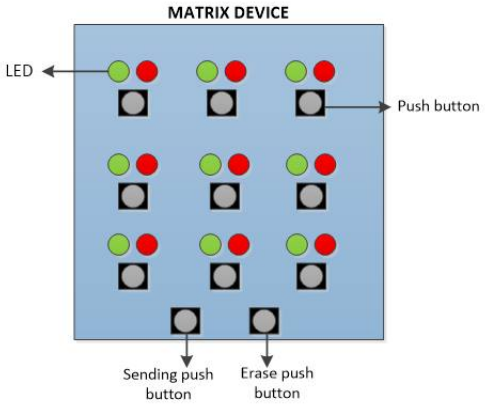

Fig. 5: Matrix device.

Fig. 5. It consists of an array of pushbuttons 4 x 4, accompanying two-color LEDs, when the user presses the button for once the green is activated, if performed twice the color red is activated, so the student can perform the sequence.

An external matrix device is developed for this application. The device shown in Fig. 5 consists of an array of pushbuttons 4 x 4, accompanied by two-color LEDs. When the user presses the button for once the green is activated, if performed twice the color red is activated, so the student can perform the sequence.

D. Web Application

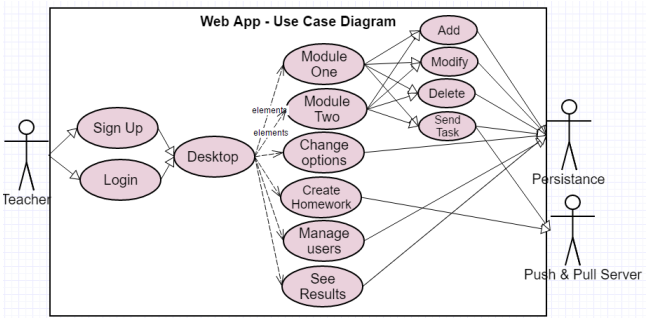

Fig. 6: Diagram of use cases of web application.

The application has the objective to provide administration to the educator, through this, the educator is able to :

- Manage users
- Add information to each modulus
- Remove information from each module
- Edit information to each modulus
- Create tasks and send them to students

The communication style is defined in the following way:

ISBN: 978-988-14047-1-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

- One by one: An educator is able to send a task to a specific user
- One to many: An educator is able to send a task to multiple users registered on the platform
- One to all: An educator can send tasks to all registered users of the platform

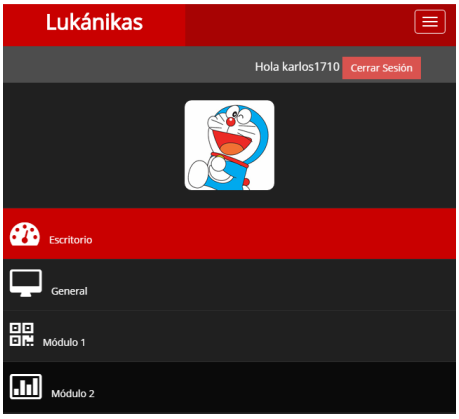

Fig. 7: Web application navigation

III. RESULTS

The educational platform was presented to three different foundations : Foundation "Virgen de la Merced" Foundation "Hermano Miguel" and Foundation "El Triángulo" , located in the canton Rumiñahui, Pichincha Ecuador [10], where they treat children aged 5 to 8 years old with different cognitive disabilities; educators from each foundation proceeded to use it, for which they selected a group of 7 children with DS. Then, cognitive progress of vocalization and short-term memory were assessed.

For testing we have worked with a database of 18 different syllable words for the first module as shown in Fig. 8, also a database of 10 matrices of different colors that corresponded to the second module.

id	word1	word2	word3	syllable1	syllable2	syllable3	syllable4
1	pato	papa	paro	pa	to	pa	ro
2	perro	pera	pedo	pe	rro	ra	do
3	casa	cama	carro	ca	sa	ma	rro
4	silla	silo	sillon	si	lla	lo	llon
5	mama	mano	mapa	ma	ma	no	pa
6	meme	memo	menos	me	me	mo	nos

Fig. 8: Words to use in the development of tests.

The evaluated indicators will be the correct number of words and matrices by children; from the tables presented below, it comprises a universe of 7 users 4 boys and 3 girls ranging in ages from 5 to 6 years, the first 4 users' IDs correspond to female gender users and the remaining to male gender.

In Fig. 9 results of the module of verbal development and short-term memory are shown based on the arithmetic mean of the results obtained, applied in 4 sessions.

TABLE 1: Tabulation of results in the first week

User ID	Age	Gender	Right words	Right matrices
1	5	Male	4	5
2	6	Male	6	4
3	4	Male	4	5
4	5	Male	7	3
5	5	Female	5	4
6	6	Female	4	6
7	6	Female	6	3

TABLE 2: Tabulation of results in the second week

User ID	Age	Gender	Right words	Right matrices
1	5	Male	6	6
2	6	Male	7	5
3	4	Male	6	5
4	5	Male	8	4
5	5	Female	8	6
6	6	Female	7	7
7	6	Female	9	5

TABLE 3: Tabulation of results in the third week

User ID	Age	Gender	Right words	Right matrices
1	5	Male	10	7
2	6	Male	11	6
3	4	Male	12	7
4	5	Male	12	5
5	5	Female	13	7
6	6	Female	11	7
7	6	Female	10	7

TABLE 4: Tabulation of results in the fourth week

User ID	Age	Gender	Right words	Right matrices
1	5	Male	13	8
2	6	Male	14	9
3	4	Male	13	7
4	5	Male	15	8
5	5	Female	15	8
6	6	Female	12	8
7	6	Female	13	9

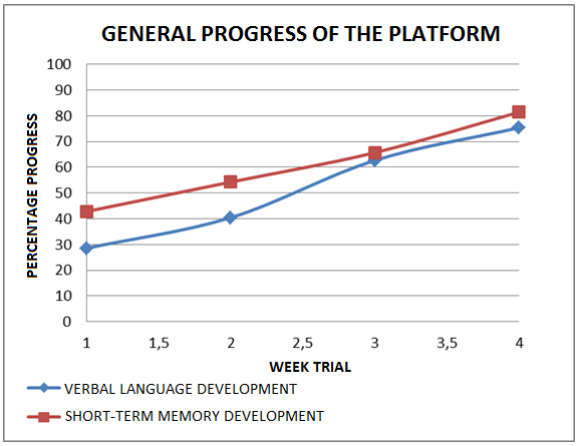

Fig. 9: General Results of the Application

From the total of 18 words applied to users the correct vocalization of 14 words, amounts to 75% of the total, could be achieved, for which the results obtained show progress in the development of learning vocalization.

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ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

From a total of 10 matrices applied to children with DS , after 4 weeks only 8 matrices properly approved, on average.
Two particular cases are analyzed, one of a five-year old male user and another from a seven year-old female user.

5-year old male user with DS:

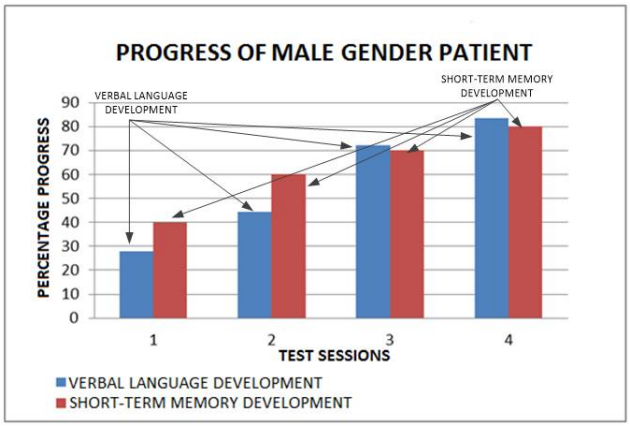

Fig. 10: Application of modules to male user

7-year old female user with DS:

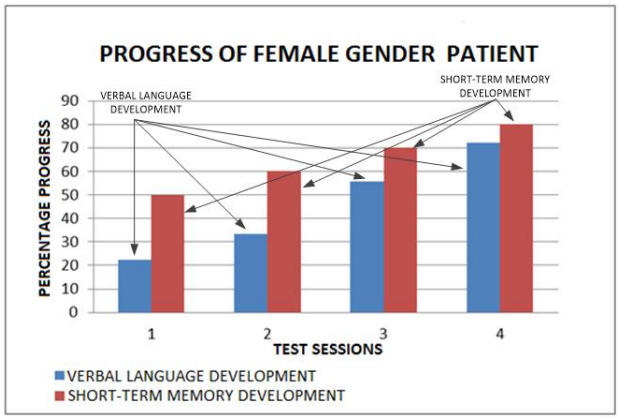

Fig. 11: Application of modules to female user

Figs 10. and 11. indicates progress individually through the educational platform are effective in helping in the development of verbal skills and improvement of short-term memory, so the results are the ones expected and advance linearly so the longer time in therapy will cause a better result in the child's performance with DS.

Educators from these educational institutions mentioned that prior to this platform of development, tools for the application of ICT could hardly get involved in the daily planning of work due to the advance by learners it could not be confirmed.It was also mentioned that the use of such tools fits into a constructivist model of education.

IV. Conclusion

The development of information and communication technologies (ICT) has generated a great impact on the field of teaching and learning process in today's society, with the aim of acquiring new knowledge that will provide in the performance of individuals. The increase of the high level of integration that has been in electronic devices in recent years has allowed to have electronic products that adapt to potentiate the ICT, in addition to its miniaturization, it makes it more educational for using in teaching at all levels. Progress of ICT allows educational platforms development as presented in this work that can be a mainstay in cognitive therapy provided to children with DS, making that even the user can be able to continue the therapy at home.

Mobile devices are highly integrated technology that can develop attractive recreational tools for children. In the case of this platform, using speech synthesizers, as well as communications via Bluetooth technology, the next challenge within the m-learning is to provide administrable features to mobile applications so they can be formally included in the learning process.

Early stimulation in a child with DS, along with the methods implemented in their learning is very important since this will depend on the cognitive development of the child; so the platform is presented as an intuitive, scalable and attractive educational alternative in order to assist in the development of vocalization and short-term memory of children achieving optimal results in the learning time and level of cognitive development, plus it can be submitted to modifications based on the results obtained, and include the development of more modules dedicated to maximize different cognitive disabilities.

In various schools where the platform was evaluated there was a significant acceptance by educators as they could verify the learning process on their students. This platform allows unlimited use of information giving the ability to add, edit and delete information by establishing a dynamic data flow.

In conclusion, the analysis of the results shows that the application of the educational platform holistically helps in the cognitive development of vocalization and short-term memory of children with DS.

Appendix A
Source Code

The source code of the project is attached in a repository GitHub, this includes:

- Source Code Web App
- Source Code Mobile App
- Source Code Rest Api Service

https://github.com/Nemo1710/Lukanikas

References

[1] Kumar, Raju. *Convergence of ICT and Education.* World Academy of Science, Engineering and Technology 40.2008, 2008: 556-559.
[2] Black, Bob, and Amanda Wood. *Utilising information communication technology to assist the education of individuals with Down syndrome.* Down Syndrome Issues and Information ,2003.
[3] M. Elisha, "THE APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY (I.C.T.) IN NIGERIAN ACADEMIC LIBRARIES PROSPECTS AND PROBLEMS," in *The Information Manager Vol.6 (1 & 2) 2006.*

ISBN: 978-988-14047-1-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

[4] ISEA S.Coop, "MOBILE LEARNING, Análisis prospectivo de las potencialidades asociadas al Mobile Learning," in *Ministerio de Industria, Turismo y Comercio, del Programa de Centros del Conocimiento y Contenidos Digitales, en el marco del PLAN AVANZA (2009)*.
[5] Cooley WC, Graham JM. *Down syndrome: an update and review for the primary pediatrician* ClinPediatr. 1991;30:233-253.
[6] Paul Yoder, Tiffany Woynaroski, Marc Fey, and Steven Warren. Effects of Dose Frequency of Early Communication Intervention in Young Children With and Without Down Syndrome.," in *American Journal on intelectual and developmental disabilities. 2014, Vol. 119, No. 1, 17–32*.
[7] Dr Susette T Brynard. Self-Advocacy: Enhancing the Education of Down Syndrome Learners.," in *Mediterranean Journal of Social Sciences, Rome-Italy (2014)*.
[8] K. Naess, A. Lervag, S. Halaas, C. Hulme, "Longitudinal relationships between language and verbal short-term memory skills in children with Down syndrome.," in *Journal of Experimental Child Psychology 135 (2015) 43–55*.
[9] Fundacion Iberoamericana Down21. *La memoria en el síndrome de Down* Aviable: http://www.downciclopedia.org/neurobiologia/la-memoria-en-el-sindrome-de-down
[10] Ministerio de Educación. *Instituciones de Educación Especial* Aviable: http://educacion.gob.ec/instituciones-de-educacion-especial/

ISBN: 978-988-14047-1-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)