Building Hybrid Interfaces to Increase Interaction with Young Children and Children with Special Needs

Janio Jadán-Guerrero[1(✉)], Cesar Guevara[1], Patricio Lara-Alvarez[1], Sandra Sanchez-Gordon[2], Tania Calle-Jimenez[2], Luis Salvador-Ullauri[3], Patricia Acosta-Vargas[4], and Diego Bonilla-Jurado[5]

[1] Centro de Investigación MIST, Universidad Tecnológica Indoamérica, Quito, Ecuador
{janiojadan, cesarguevara, patolara}@uti.edu.ec
[2] Escuela Politécnica Nacional, Quito, Ecuador
{sandra.sanchez, tania.calle}@epn.edu.ec
[3] Centro de Educación Continua, Escuela Politécnica Nacional, Quito, Ecuador
lsalvador@cec-epn.edu.ec
[4] Intelligent and Interactive Systems Laboratory, Universidad de Las Américas, Quito, Ecuador
patricia.acosta@udla.edu.ec
[5] BH Consultores, Ambato, Ecuador
administracion@bhconsultores.com

Abstract. Young children as well as children with special educational needs learn from their environment with social, emotional and physical stimuli. In this context, educational resources and teaching strategies play a main role for them in order to understand the new information. This paper describes the experience of building hybrid interfaces that combine technology with traditional educational resources. A total of 60 teachers divided in two groups completed some tasks which consisted of generating new educative resources with tecnology. Through Design Thinking methodology, teachers designed three hybrid interfaces: 1. Interactive books, combining traditional fairy tales books with mobile devices, where QR codes and NFC tags give life to the stories; 2. Educational Board Games, where augmented reality markers give an extra information to the players; 3. Tangible educational resources, which integrate Makey-Makey device and Scratch with fruit, clay, aluminum foil or water to build laboratory.

Keywords: Hybrid interfaces · Interaction · Young children · Children with special needs

1 Introduction

The sensory stimulation is fundamental during formative brain development of children. They learn from their environment, from way people treat them and from what they see, hear and touch [1]. These experiences prepare children to better integrate themself to the physical and social environment through the development of executive

I. L. Nunes (Ed.): AHFE 2019, AISC 959, pp. 306–314, 2020.
https://doi.org/10.1007/978-3-030-20040-4_28

functions. Executive function is an umbrella term that encompasses the mental abilities that the human being development in behavioral, emotional and metacognitive functioning regulation. It is in the preschool stage where children present a critical and cerebral plastic opportunity [2]. Any cognitive process that is going to develop within a child, is based on the input of sensory information, so the original information must penetrate the sensory channels and be coded quickly in a way that goes into short-term memory [3]. Considering that the multisensory stimulation contemplates the first element of access of a child with his environment, it is indispensable that this process be developed in an integral way and that being this the initial step on which will depend of perceptions that will provide the foundation for learning [4].

Multisensory stimulation uses the senses of sight, hearing, touch, smell and taste to maximize a child's executive function and understanding of the environment. Multisensory environments improve the development of thought, intelligence and social skills, whilst also offering children with cognitive impairments and other challenging conditions, the opportunity to enjoy and control a variety of sensory experiences [5].

In this context, educational resources and teaching strategies play a main role for young children and children with special needs. Among the educational resources used by teachers are fairy tails, cardboard, colored pencils, glue, scissors and clay. Through them, teachers generate interaction and collaboration through stories, games and recreational activities.

Nowadays as technology advances, new educational resources are being integrated into the classroom, such as the computer, projector, interactive whiteboards, tablets and smart phones, which are giving rise to new pedagogical trend where we can find e-learning, inverted classroom, gamification, serious games, laboratories or remote laboratories, makers spaces or ubiquitous education.

These revolutionary technologies open up space for new ways of learning and are changing the teaching-learning process in classroom. However, in developing countries such as Ecuador, using these new technological and pedagogical tendencies is not common, not even the existing ones are fully exploited due to the fact that teachers ignore how to use them or the lack of adequate teaching strategies for a generation of students with technological skills. This problem releases an opportunity to develop technologies that will close the generational gap and also develop didactic resources for classroom.

This article describes the experience with 60 primary and secondary education teachers, who designed hybrid interfaces that combine traditional educational resources with technological ones, with the purpose of strengthening the interaction in learning of young children and children with special educational needs.

The rest of this article is structured as follows: Sect. 2 details the background and related work, Sect. 3 presents the method used, Sect. 4 presents the results and discussion, and finally, Sect. 5 presents the conclusions and future work of this research.

2 Background

In recent years, a new generation of hybrid interfaces for learning are gaining in popularity within classrooms. These spaces have been digitally augmented by replacing blackboards and tables with computer-augmented surfaces provided with multitouch

interaction [6]. The use of conventional resources with technology has been conducted on new trends in pedagogy and technology. Trends in pedagogy are: Active Learning, Problem-based Learning, Project-based Learning, Collaborative learning, Learning based on challenges, flipped classroom, Space makers and Gamification. Trends in technology are: Adaptive Learning, Learning in Social Networks and Collaborative Environments, Mobile Learning, Ubiquitous Learning, Virtual Assistant, MOOCs, Big Data and Learning Analytics, Remote and Virtual Labs, Internet of Things, Augmented reality and Virtual Reality [7].

In our study we integrated some of these trends in a Moodle Learning Management System, in which we applied the Methodology of Learning Based on Narrative Metaphors and Gamification [8]. Other pedagogies applied were Collaborative learning, and Learning based on challenges through forums and group activities. Augmented Reality through apps, such us Animal 4D+ , Space 4D+ , Humanoid 4D+ and QuiverVision 3D Augmented Reality. Finally, Space Makers using Tangible User Interfaces through RFID tags integrated with physical objects.

3 Method

This research work was based in Design Thinking methodology, defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign. The five stages of Design Thinking are as follows: Empathise, Define (the problem), Ideate, Prototype, and Test [9].

3.1 Participants

The sample of the study was selected from the Master's Degree in Education, Innovation and Educational Leadership of the Universidad Tecnológica Indoamérica, located in the city of Ambato, Ecuador. We worked with n = 60 students. The participants were divided into two groups of 30 each in the Educational Infopedagogy module. The average age of the students was 35.5 years, 44.4% corresponded to the range of 36 to 40 years, followed by 18.5% in the range of 41 to 45 years, 14.8% between 26 to 30 years, 11.1% in the range of 31 to 35 years and the rest in ages under 25 and over 50. In relation to gender 90% corresponded to the female. The training of 75% of teachers was concentrated in basic education, followed by 20% in secondary education and 5% in higher education.

3.2 Materials

The materials used in the research are grouped into three categories: classroom materials, technology and software. In the first category we used paper, cardboard, colors, markers, watercolors, plasticine and aluminum foil. In the second category we used laptops, tablets, smartphone, RFID sensors and Makey Makey circuit board. In the third category we used Scratch, AppInventor, QR Generator, Hi-Q, Animal 4D+, Space 4D+, Humanoid 4D+ and QuiverVision 3D Augmented Reality.

3.3 Procedure

We worked with two groups of 30 students in the module Educational Infopedagogy, which aimed at the introduction of technology in the classroom and how it is integrated with the pedagogy. Five weeks were worked with each group, with an eight-hour session each week.

Following the Design Thinking methodology the teachers worked in groups related by the affinity of each teacher. In the empathise stage, teachers used the platform in six areas: (1) STEAM, (2) language and literature, (3) social problems, (4) learning strategies, (5) Educational Leadership and (6) Innovation and entrepreneurship. In each area, teachers defined the problem and needs of their educational centers through a survey and forums in the framework. Next they ideate the design of the pedagogical strategy according to the technologies used in class. After teachers design a prototype with the materials and technology selected. Finally, teachers test an assessment of learning using interactive and co-evaluation methods with their students.

4 Design of Hybrid Interfaces

In Computer Science an hybrid interface is the interface getting embedded in the objects of the physical world. The latter is perceived as an augmentation of the physical world [9, 10]. This section shows some the hybrid interfaces designed by the groups of teachers. We have divided into three categories: Interactive Books, Educational Board Games and Tangible Educational Resources.

4.1 Interactive Books

Within the category of interactive books, teachers created innovative interfaces for children. The participation and interaction by the reader was made with QR codes. The main idea of this interface was to introduce narrative an questions thought QR codes. First with the Hi-Q app recorded audio in MP3 format. Subsequently teachers generated QR codes of different sizes, which were pasted them in a physical book or they designed a sheet of cardboard with their own story as the Fig. 1 shows. The audio files and pictures were integrated in App Inventor application. In this interface children can use a smartphone to listen a story or answer a question that generates the QR code.

Another interface designed by other group were large sheet drawings that were pasted on the walls of the classroom, each sheet had a Qr code. The objective was the children search with smartphones te QR codes and listen the story or questions.

Finally, a group designed an Educative Twister, a game of physical skill. Children use a smartphone to scan QR codes. Each QR code generates a question and a challenge on the board of twister.

In the stage of testing, teachers evaluated these hybrid interfaces with their students achieving interest and motivation in the learning process. With this technology teachers could design their own educational technology resources to create multimedia reading experience [11].

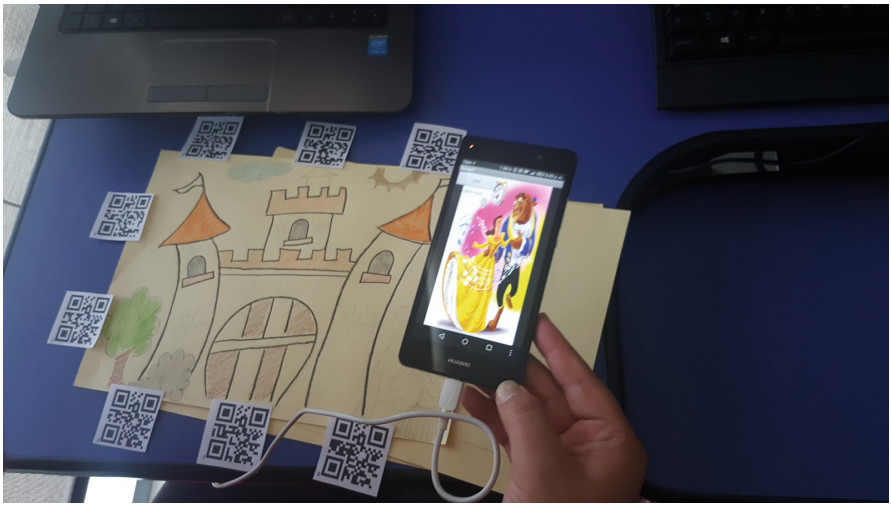

Fig. 1. Story drawn on cardboard with QR codes.

Another idea was based on Leapfrog's book which have enhanced the book surroundings, permitting pen interaction with the book [12]. To simulate this interface, teachers used NFC (Near Field Connection) tags and QR codes, which generate a sound, narrative or question throughout history. Figure 2 shows an example of the interactive book "The Little Prince".

Fig. 2. Interactive book with NFC and QR codes.

The use of NFC tags facilitated the interaction of children with special needs, unlike the QR codes that need more precision with the camera of the smartphone.

4.2 Educational Board Games

In this category teachers designed a new concept of a board game "The inclusive board game" that aims to enable children with especial needs play with other members of their family through activities supported by technology. The board game has traditional elements and in certain cases it is integrated with a tablet to see elements of the game with augmented reality, or smartphones that read NFC tags. For example, a card with Braille codes seen through a tablet can generate an augmented reality with its meaning. Other cards have QR codes that provide additional information or questions on the theme of the game. Teachers designed the hybrid interface "The route of the volcanoes" in which players can see a volcano in augmented reality and information that helps the entertainment and learning. We believe that it is an innovative idea that uses disruptive technology rarely seen in our environment and applicable to a vulnerable and little forgotten population.

The idea to design an inclusive board game was based on The Explorers, a board game of Unicorn Games. Figure 3 shows the idea of this board game.

Fig. 3. Inclusive board game.

The inclusive board game has the classic dynamics of a board game in terms of the distribution of turns, use of dice to advance and interaction between players around the board. The board game joins the logic of the traditional with the world of applications and carries the Tangible User Interface (TUI). The board game utilises traditional board

game play and combines it with mobile and app technology that uses video games and card scanning. The corresponding app includes mini-game challenges, treasure hunts and AR objects.

4.3 Tangible Educational Resources

For tangible educational resources teachers were trained in the use of Makey-Makey and Scratch. Makey-Makey is a circuit board that allows users to connect some objects to computer programs using alligator clips and a USB cable. This board simulates the actions of the arrow of a keyboard or mouse buttons instead of pressing the keys or buttons. For the graphical interface, teachers used the Scratch application, which is an introductory programming language that enables young children to create their own interactive stories, collages, and games [13]. One of the hybrid interface considers the laterality learning with dance-dance revolution music. Figure 4 shows the hybrid interface with cardboard and foil.

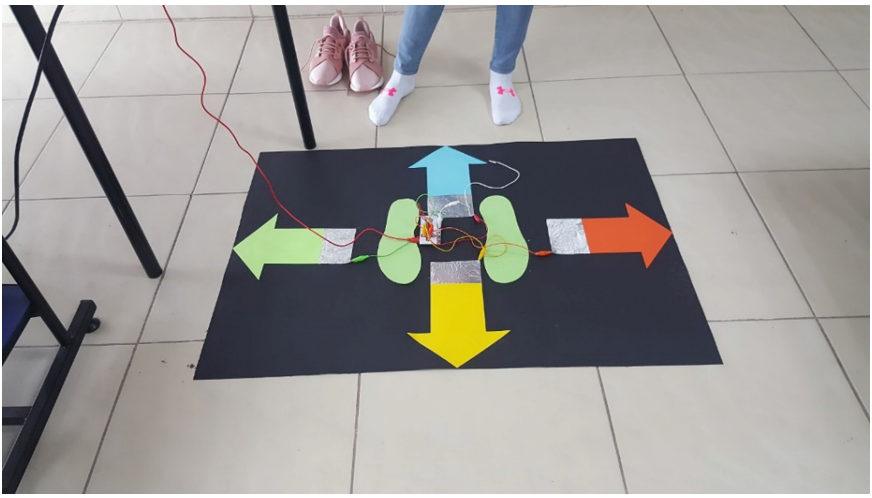

Fig. 4. Dance dance revolution to teach laterality

In language and literature area teachers designed a board built with Scratch and Makey-Makey to teach phonological awareness. The child creates some object with plasticine connected with a computer through Makey-Makey. On the other hand, Scratch shows a pictogram and the sound of the phoneme associated with the clay object. The application of this hybrid interface with children with special needs can improve the reading and spelling [14]. The board is shown in Fig. 5 below:

In the area of natural sciences a group designed a similar board with organs of the human body made with plasticine. When children touch an organ the information is showed on screen with Scratch.

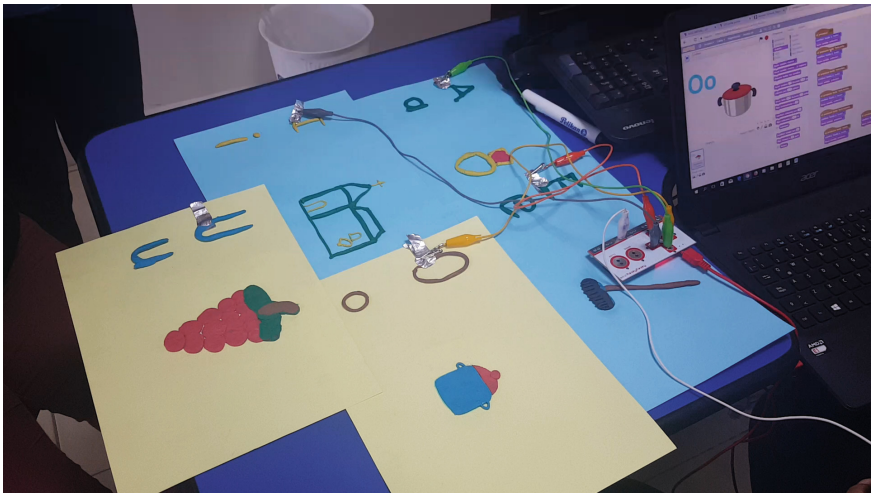

Fig. 5. Language board with Makey-Makey, Scratch and clay

5 Results and Discussion

The inclusion of children with disabilities is still a problem in Ecuador, in the educational, social and even family environment. In this sense, strategies to develop creativity and innovation through design thinking and learning based on challenges allowed to generate prototypes of educational resources supported by technology. This experience was very rewarding, since the participants were highly motivated and developed creative and innovative prototypes.

Another problem in Ecuador is the lack of technological resources in classrooms and the lack of knowledge on the part of the teachers. The introduction of technology to the classrooms is a challenge, but if it is done in an easy way, it allows the teachers create new educational strategies.

6 Conclusions

From the experience gained during the design process and the final evaluation of hybrid interfaces, teachers were motivated to design their own educational resources. The use of the hybrid interfaces allowed that young children and children with special needs were motivated.

With the use of basic apps and traditional resources, teachers can design new educational technologies resources selecting the best digital strategies to allow students enrich learning with activities that incorporate devices. The design of digital content allows the use of interactive tools that keep students' attention more easily and in this way achieve meaningful learning [15].

Technology is an essential factor in motivating users to collaborate with their learning process [16]. For future work, we are planning testing the hybrid interfaces in a real environment, in order to improve and customize the current interfaces to the particular needs. In the future we are planning to design hybrid interfaces for children

with disabilities, such as blind or low vision children, deaf children, children with motor and cognitive disabilities.

Acknowledgments. The authors thank Universidad Tecnológica Indoamérica for funding this study through the project "TIME- ICCHIT" and students of MEILE-3.

References

1. Vosniadou, S.: How children learn. International Academy of Education (2001)
2. Ramos, C., Bolaños, M., Paredes, L., Ramos, D.: Tratamiento Neuropsicológico del TDAH en Preescolares: Entrenamiento de la Función Ejecutiva. Revista Ecuatoriana de Neurología **25**(1–3), 61–69 (2016)
3. Ramos-Galarza, C., Pérez-Salas, C.: Moderator role of monitoring in the inhibitory control of adolescents with ADHD. J. Attention Disord. 1–11 (2018)
4. Price S., Duffy S., Gori, M: Developing a pedagogical framework for designing a multisensory serious gaming environment. In: Proceedings of 1st ACM SIGCHI International Workshop on Multimodal Interaction (MIE'2017), Glasgow, UK, 8 p., November 2017 https://doi.org/10.1145/3139513.3139517
5. Cid, M.J., Camps, M.: Multisensory stimulation in the snoezelen room: concept and fields of application. Revista Española sobre Discapacidad Intelectual **41(4)**(236), 22–32 (2010)
6. Cerezo, E., Marco, J., Baldassarri, S.: Hybrid games: designing tangible interfaces for very young children and children with special needs. In: Nijholt, A. (ed.) More Playful User Interfaces. Gaming Media and Social Effects. Springer, Singapore (2015)
7. EduTrends 2017: Observatorio de Innovación Educativa, Reporte Edu Trends. Monterrey. Tecnológico de Monterrey, México (2017)
8. Jadán-Guerrero, J., Ramos-Galarza, C.: Metodología de Aprendizaje Basada en Metáforas Narrativas y Gamificación Un caso de estudio en un Programa de Posgrado Semipresencial. Hamut´ay **5**(1), 84–104 (2018). https://doi.org/10.21503/hamu.v5i1.1560
9. Razzouk, R., Shute, V.: What is design thinking and why is it important? Rev. Edu. Res. **82** (3), 330–348 (2012). https://doi.org/10.3102/0034654312457429
10. Reimann, D., Herczeg, M., Winkler, T.: Gaining computational literacy by creating hybrid aesthetic learning spaces. In: Proceedings 3rd IEEE International Conference on Advanced Technologies (2003). https://doi.org/10.1109/icalt.2003.1215135
11. Grasset R., Duenser A., Seichter H., Billinghurst M.: The mixed reality book: a new multimedia reading experience. In: CHI 2007 Extended Abstracts on Human Factors in Computing Systems (CHI EA 2007), 1953–1958. ACM, New York (2007). https://doi.org/10.1145/1240866.1240931
12. Leapfrog https://www.leapfrog.com. Accessed Jan 2019
13. Strawhacker, A., Lee, M., Caine, C., Bers, M.U.: ScratchJr demo: a coding language for kindergarten. In: Proceedings of the 14th International Conference on Interaction Design and Children (IDC 2015). ACM, Boston (2015)
14. Fan, M., Antle, A.N., Hoskyn, M., Neustaedter, C., Cramer, E.S.: Why tangibility matters: a design case study of at-risk children learning to read and spell. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, USA, içinde (ss. 1805–1816) (2017). https://doi.org/10.1145/3025453.3026048
15. Kara, N.: Design, development and use of a smart toy for preschool children: a design and development research (Yayımlanmamış doktora tezi). Orta Doğu Teknik Üniversitesi, Ankara (2015)
16. Linke, R., Kothe, T., Alt, F.: TaBooGa: a hybrid learning app to support children's reading motivation. In: Proceedings of the 2017 Conference on Interaction Design and Children, USA, içinde (ss. 278–285) (2017). https://doi.org/10.1145/3078072.3079712