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Development of The AR School App for Children with Hearing Impairment Who Begin Learning Ecuadorian Sign Language using Augmented Reality

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Abstract*: Augmented reality AR has been used for many years in different fields of education. It has provided advantages in learning, However, no applications focused on the initial learning of Ecuadorian sign language for children with hearing impairments in their primary school years have been found. In this paper we present the development of a mobile application based on augmented reality, the Unity tool was used as a platform for mobile devices and the Vuforia SDK complement for augmented reality. With this application, the child can see the gesticulation of words in sign language through the use of printed templates. It also has an option to perform a quiz that will allow it to evaluate the knowledge the children acquired from the learning module. The mobile application called ARSchool based on augmented reality which is designed and adapted for people with hearing impairment, mainly for school-age children, as support for the initial learning of sign language in Ecuador. Once the application was developed, it was tested both at school and at home, in which teachers and parents made children with hearing impairments interact.

Keywords*: Augmented reality, Deaf, Hearing disabilities, Sign Language.

I. INTRODUCTION

Sign language is the main language of communication for people with hearing impairment [1], therefore, it is fundamental for children with hearing impairment to learn it from an early age. In Ecuador, it is prepared by the National Federation of the Deaf (FENASEC) [2].

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New emerging technologies such as Augmented Reality should be used for children's education, especially for those with some type of disability [3].

Due to the different factors that can be tapped into, such as its simple use, interactive learning [4], [5], creativity and skill development [6], it provides a better level of attention and positive acceptance, resulting in a greater motivation in learning [7].

AR School is an application based on Augmented Reality that focuses on the learning of sign language for children with hearing impairment. It is divided into two modules, the learning module, in which through the use of templates printed with an image, the child can see the gesticulation of the word in an augmented video, and the quiz module with an interactive game, where the child chooses the correct word between two options according to a projected video. In essence this is one of the best ways for children to have fun while learning.

II. LITERATURE REVIEW

A. Existing System

Out of the existing applications that use Augmented Reality for sign language learning, we find [8], [9] and [10], which are based on the use of markers to display 3D objects, or videos with the gesticulation of words or sentences associated to these markers. All of these are aimed at people with some knowledge of sign language.

In Ecuador, the use of existing technological tools for teaching children with hearing impairment is very scarce, in fact, augmented reality applications for sign language learning were not found. One of the few technological tools is the "Gabriel Román" Ecuadorian Dictionary [11], in web format, which teaches the correct way of articulating words through graphics and videos.

B. Proposed System

Our work focuses on providing a tool for sign language learning using augmented reality, for children with hearing impairment who are just beginning school. We seek to arouse the interest, participation and curiosity of people with hearing impairment with the use of this tool, so that they can have many more learning opportunities from early stages.

III. TECHNICAL REQUIREMENTS

For an application to work correctly, it is necessary to present a set of specifications that must be taken into account. The requirements that must be considered for AR School to function optimally and efficiently are detailed below.

AR School displays augmented reality generated videos associated with printed cards, for this reason, the application must be installed on a smartphone with the Android operating system (OS) version 2.5 or higher.

In addition, it is necessary to have a 1.3 GHz processor, 2GB of RAM and a recommended resolution of 720 x 1280, so that the application can be used without any inconvenience.

IV. SYSTEM ARCHITECTURE

The mobile application was designed in Unity with the Vuforia SDK add-on, for the generation of videos with augmented reality from a real-world image. The user focuses the image with the mobile device, and the application takes care of processing the image to search the database for the associated video. Consequently, once the video is processed the application projects the video on the mobile device. The interaction diagram of the described application is shown on Fig. 1, with the processing of the captured image and the generation of the Augmented Reality video.

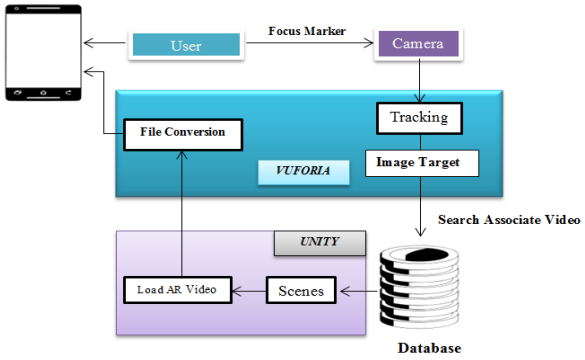

Fig. 1.AR School Application Interaction diagram.

A. Learning module

The learning module of the application was developed in offline mode, with the topics' contents pre-installed, so that no type of connectivity is necessary. The pre-printed templates will serve as a marker to be recognized by the Vuforia add-on, and play the associated video showing the word in sign language, see Fig. 2.

Fig. 2.Students using the learning module in class.

B. Quiz module.

The multiple-choice quiz module used a total of 52 questions, generating 10 random questions each time the module is entered. Each question plays a video showing a word in sign language with two images that are the possible answers, one of them being correct, it is based on the content of the preinstalled topics, see Fig. 3. The student's name and score are sent to an online document which can be used for subsequent evaluations, as a result, the internet data usage required for this function was significantly reduced.

Fig. 3.Quiz module.

V. IMPLEMENTATION

The didactic material selected for the development of the application prototype in both modules were: the numbers, the parts of the human body, and the alphabet. The pre-printed templates of these topics will serve as Vuforia's image target in the learning module, see Fig. 4. The application was installed on the mobile phones of the teacher and parents, training them for its later use in the classroom, and for learning in the students' homes. This stimulates parent-child participation so that the topic learned can be solidified.

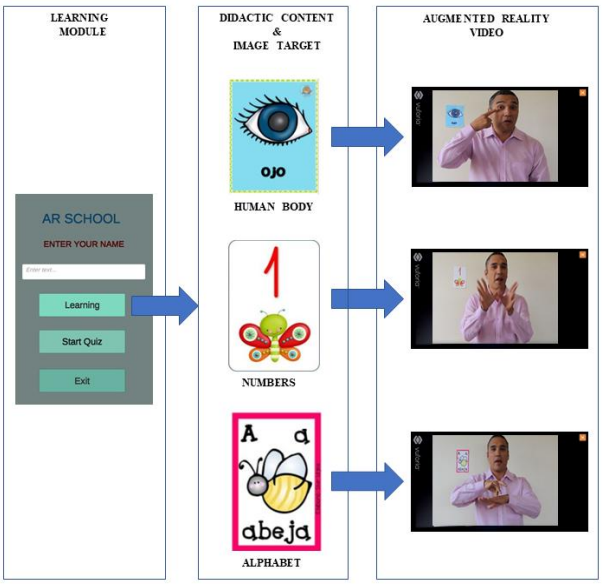

Fig. 4.Didactic content.

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VI. RESULTS

Once the application was developed, it was tested both in a school and home environment, in which teachers and parents made children with hearing disabilities interact. It was measured considering 3 primary factors: effectiveness, efficiency and satisfaction, using a perception questionnaire, see Table I, and analyzing the data obtained, see Table II and Fig. 5.

A. Perception Analysis.

The results of the teachers and parents' perception questionnaire showed that the effectiveness, efficiency and satisfaction of the mobile application reached values well above a median of 3.5.

In the effectiveness, maximum values were obtained in indicators Q1 and Q3, being an easy to use application, with clear content related to the subject, while the quality of the content and the performance of the application were not affected in a perceptible way by the specifications of the mobile devices that each participant possessed. In efficiency, maximum values were obtained in indicators Q6 and Q7, demonstrating that the exercises implemented were friendly, easy to understand by having to choose between only two images as multiple options, and obtaining all the attention or focus on the part of the student. Although being a prototype application with a limited number of random questions, it did not have more topics from other subjects or other types of exercises. In satisfaction, all indicators obtained maximum values, demonstrating that the application was considered a useful tool, encouraging teachers, parents and students with disabilities to continue using it.

VII. CONCLUSION AND FUTURE WORK

Through this project, we have implemented a mobile application based on augmented reality which is designed and adapted for school-age children with hearing impairment as a support for the initial learning of sign language in Ecuador. With this application school-age children interact with two modules, the learning module will automatically activate the mobile device's camera which will recognize the selected pre-printed template, then play the associated video showing the word in sign language. The quiz module developed as a game where sign language is displayed, the school-age children selects the correct option between two buttons.

Once the application was implemented in an educational institution located in Guayaquil city, a survey was carried out on the parents and teachers of the children of the selected course to evaluate the effectiveness, efficiency and satisfaction generated by the application when used.

The observed and evaluated results allow us to conclude that this mobile application creates a positive impact as it is considered intuitive and useful tool that encourages students with hearing impairment the initial learning of sign language in Ecuador. The future work would be the integration of new content that would adapt to the pedagogical methodology of the different subjects.

Table- I: Perception Questionnaire

Measurement	Indicator	Question
Effectiveness	Was it easy to understand the operation of the application?	Q_1
	The topics implemented in the application had good quality and presentation?	Q_2
	The selected topics were clear and consistent with the language course?	Q_3
	Did the application work properly during the time of use?	Q_4
Efficiency	The amount of exercises implemented were sufficient?	Q_5
	Was the student able to solve the exercises implemented?	Q_6
	The application encouraged student attention?	Q_7
	Does the application meet the purpose for which it was designed?	Q_8
Satisfaction	Was the course and training materials to use the mobile application adequate?	Q_9
	Was the use of the application useful?	Q_{10}
	Would you use this type of application again in the education of students with hearing impairment?	Q_{11}

Table- II: Results of perception analysis

		Totally Disagree	Disagree	Neither Agree or Disagree	Agree	Totally Agree
Effectiveness	Q_1	0	0	0	0	8
	Q_2	0	0	0	2	6
	Q_3	0	0	0	0	8
	Q_4	0	0	0	3	5
		0%	0%	0%	16%	84%
Efficiency	Q_5	0	0	0	6	2
	Q_6	0	0	0	0	8
	Q_7	0	0	0	0	8
	Q_8	0	0	0	1	7
		0%	0%	0%	22%	78%
Satisfaction	$Q_{9, 10, 11}$	0	0	0	0	8
		0%	0%	0%	0%	100%

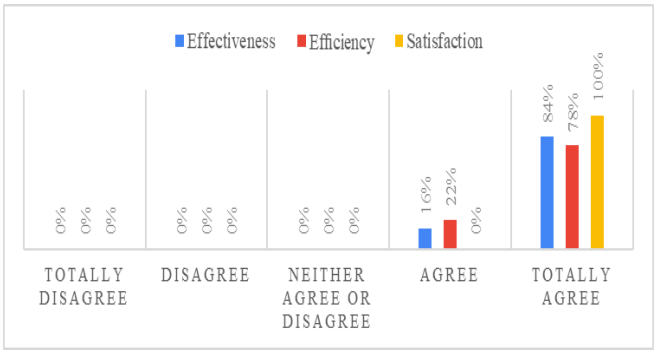

Fig. 5.Results of perception analysis.

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