Mobile Application with Augmented Reality to Improve the Process of Learning Sign Language

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Michael Cabanillas-Carbonell[1(✉)], Piero Cusi-Ruiz[2], Daniela Prudencio-Galvez[3], José Luis Herrera Salazar[4]
[1]Computer Systems Engineering, Universidad Privada del Norte, Lima, Perú
[2,3]School of Systems Engineering, Universidad Autónoma del Perú, Lima, Perú
[4]School of Engineering, Universidad Norbert Wiener, Lima, Perú
mcabanillas@ieee.org

Abstract—Language has long been an indispensable tool for society, as it allows communication and interaction between people. The learning of sign language is a very big problem, either because access to information is scarce, there are no interpreters of this language or because the learning of this language is not taught from an early age. This document shows the development of a mobile application with augmented reality to improve the learning process of sign language following the Mobile-D methodology, taking as indicators the level of learning, time required for learning and information level of Peruvian Sign Language (PSL), for which results were obtained from a sample of 30 users as a control group and an experimental group. It was based on a performance percentage of 23%, subsequently improving the student's learning of sign language by 65%. It was determined that, with the implementation of the mobile application with augmented reality was achieved to reduce the time required for the level of learning of the PSL, starting from an average time of 132.67 hours after an average time of 44,633. Finally, it was possible to improve the level of information of the PSL, starting from an average score of 2,2667 and then an average score of 9,067. Allowing to conclude that the mobile application with augmented reality to significantly improve the process of learning sign language.

Keywords—augmented reality, mobile application, sign language, Mobile-D

1 Introduction

People with profound hearing loss commonly communicate through sign language, this is because they hear very little or nothing. According to the WHO [1], among the most common factors that lead to loss of audition are genetic, complications in the perinatal period, some infectious diseases, loud noises, chronic otitis, aging, among others. Today, more than 1500 million people are at a hearing loss, this disability increases with age, resulting in 25% of people over 60 years of age suffering from hearing loss; in the case of young people, more than 1 billion are at risk of permanent hearing loss due to poor hearing practices [1]. In that sense, sign languages are a set of languages where

deaf people rely on to protect their linguistic identity and to be able to communicate with other people, either through international sign language, which is a mixed language that is used for travel, international meetings, etc., or through the sign language of their country [2]. Peruvian Sign Language (PSL) is used by the entire Peruvian deaf community [3], making use of movements and expressions transmitted with the hands, eyes, mouth and body, and even has its own grammar and way of structuring sentences. Discrimination against the Peruvian deaf community continues to be a problem, either because of the lack of interpreters, the lack of education on Peruvian sign language with society and organizations, or because most of them are unable to communicate adequately with society because they speak a language different from their own.

Thanks to technology and mobile devices, education has made great strides [4], [5], which in other countries has lowered the communication barrier between people with hearing disabilities and people without disabilities [1], [6]; however, in Peru there is still no good use of these technologies such as augmented reality, either because they are not known or because society is not encouraged to use them [7].

The use of technology in deaf-mute people increases their cognitive abilities and broadens their knowledge [8], increasing their ability to learn a second language [9]. Augmented reality (AR) is an emerging technology that is based on the use of visual orientation techniques [10], this orientation is useful for many applications, such as teaching abstract concepts in the learning of a subject. The combination of augmented reality and learning is a new stereotype of automated applications that acts to improve the effectiveness and attractiveness of learning for students in a real environment [11], since augmented reality provides the best resources to the educational world, facilitating the most basic aspects such as the definition of a syllabus, its necessary elements, types, among others [12]. Research [11]–[16], through their studies conducted, justify that the use of emerging technologies such as augmented reality creates powerful learning opportunities for students, but time, tools and expertise have been a barrier for teachers. The research results indicate that mobile applications with augmented reality have the potential to facilitate the learning experiences of students in different areas of education, including deaf students. According to [13], after studying different research, it is concluded that it is possible to integrate AR in both primary and higher education. The objective of this work is to use AR as a technological tool on which to base the development of an application to improve the PSL learning process, which aims to increase the level of knowledge of people with respect to this language and contribute to breaking communication barriers for people with hearing loss. This is done by improving the level of language learning, optimizing the time spent learning the language, and improving the level of information about the PSL. This will generate new solutions, having a great impact on education and language learning, providing a technological tool for people with hearing loss to improve their knowledge or learn the PSL.

This research is organized as follows. Section 2 contains a bibliographic study of previous research, results and the impact they have had on end users. Section 3 formulates the methodology to be used detailing its different phases implemented to the developed application. Section 4 is the results phase and discussions, which details the results obtained in the tests before and after the implementation of the application, with respect to the indicators studied, and also details a report of the post-implementation

summary of the application. Finally, in section 5, some brief conclusions are made that enhance the proposed objective of the mobile application.

2 Literature review

Technologies for education strengthen teaching and learning in students of different ages, achieving new knowledge efficiently and in less time [17], [18]. In that sense, mobile devices have been predominant for teaching different subjects [19], in the case of language learning it has served as an interactive tool, promoting easy comprehension [20].

There are different technological research developments focused on facilitating the learning of sign language for people with deafness; in this section, a compilation and study of previous research works of great relevance to the subject is carried out, including a study of the objectives, results and conclusions.

An application was developed to translate sign language [3], and the algorithm was trained using image processing, thus generating the text in Kannada language, finally demonstrating the effectiveness of the developed model. However, the algorithm was trained with videos, but not tested with people, so it was not possible to evaluate whether it is interactive and easy to use for the end user, not being able to evaluate its effectiveness completely.

The research [7], proposes the development of an educational and friendly desktop software that allows exercising Peruvian sign language through levels of difficulty depending on the learning level of the person using it, obtaining the following results, 50% of the 30 respondents considered it as good and 27% as very good, followed by the results of the summary of the model of the variables concluded that the mobile application facilitates and strengthens the teaching-learning process compared to previous years. The software is used in the classroom as didactic material in the classes, which results in it being used only in the presence of the teachers and the learning can only be obtained some days being at school, so it does not promote self-learning of deaf children, nor their families for their proper support.

The scientific article [21], the objective was to increase the level of autonomy of the hearing impaired person through the use of a 2D application, reducing the language learning time, resulting in an easy manipulation of the system and the user, however, there were some disagreements regarding the difference in the presentation of the signs. It was concluded that the system serves as a complement to the learning process, reaffirming that ICT contributes favorably to the process of learning sign language.

Finally, in the research [22] a mobile application with AR was proposed for teaching the Quechua language through the interaction of different 3D objects, providing a new language learning experience, in addition to teaching basic topics. Evidencing a 30% improvement in the learning of this language by the students. The application was used as didactic material in the classrooms, as well as at home, due to the technology with which it was developed, such as AR, which allowed easy handling.

The studies shown allow us to evaluate the technological works that were developed to provide support to the hearing impaired, although the contributions have been good and with favorable results, cases have been identified in which the student could not

develop with autonomy in the proposed software; emphasizing that in the research works on language learning where augmented reality and the use of mobile applications were implemented, they achieved a better understanding and ease of use for users, demonstrating that AR has made and continues to make a great contribution to education.

3 Methodology

The mobile-D methodology is an agile methodology that improves the development process of a mobile application [23], [24], achieving quality through the use of verifications and validation methods. It consists of 5 phases (exploration, initialization, production, stabilization and testing).

3.1 Exploration

Establishment of interested parties or Stakeholders:

Stakeholders. For this research, the study population was taken to be the Adults and youth of the "Iglesia Bautista Efata" located in Villa El Salvador, Lima – Peru.
Users. Students in an age of 18 years to 40 years.
Developers. Authors of this paper.

3.2 Initialization

In this phase, both physical and technological resources are necessary for the development of the application. The tools that are used are detailed in the following points that are separated by hardware and software:

Hardware

- 2 PC'S Core i5 with 8GB RAM (minimum). Windows or Mac. 1TB HDD or 480GB SSD.
- 1 mobile device LG G6 with Android 7.0 (minimum). Snapdragon 821 processor. 4GB RAM (minimum). 32GB RAM of storage.

Software

- SQL Server: Relational database management system (RDBMS) produced by Microsoft, supports transactions, scalability, stability and security, and allows working in client and server mode [25].
- C#: C Sharp is a language designed by Microsoft for its .NET platform providing simplicity when writing code [26], it is modern since it incorporates an understandable syntax of code and it is object-oriented.
- Postman: It is a tool that allows you to create requests based on the HTTP protocol in a very simple way, as well as to test them [27].
- Flutter: It is a UI toolkit made by Google to make mobile applications with better designs, compiled natively [28]. Currently supports all platforms such as iOS, Android, Web and Desktop.

- Blender: It is a comprehensive open-source 3D program that supports 3D modeling, animations, simulations, rendering, and video game development among others [29].
- Photoshop: It is a program developed by Adobe [30], it allows you to edit different types of animations, photos, portraits, 3D models, among others.
- Bizagi: It is a tool that allows modeling and documenting the business processes of an organization, it complies with the global standard known as Business Process Model and Notation [31].
- Microsoft Office: It is a package of office computer programs developed by Microsoft, it allows to automate and improve activities that are executed in an office [32].

3.3 Production

The architecture is based on the Mobile RESTFUL architecture, which has the same similarity to the Model, View, Controller architecture, it separates the data layer, the application layer and the business layer. Figure 1 shows the interaction of each of the components:

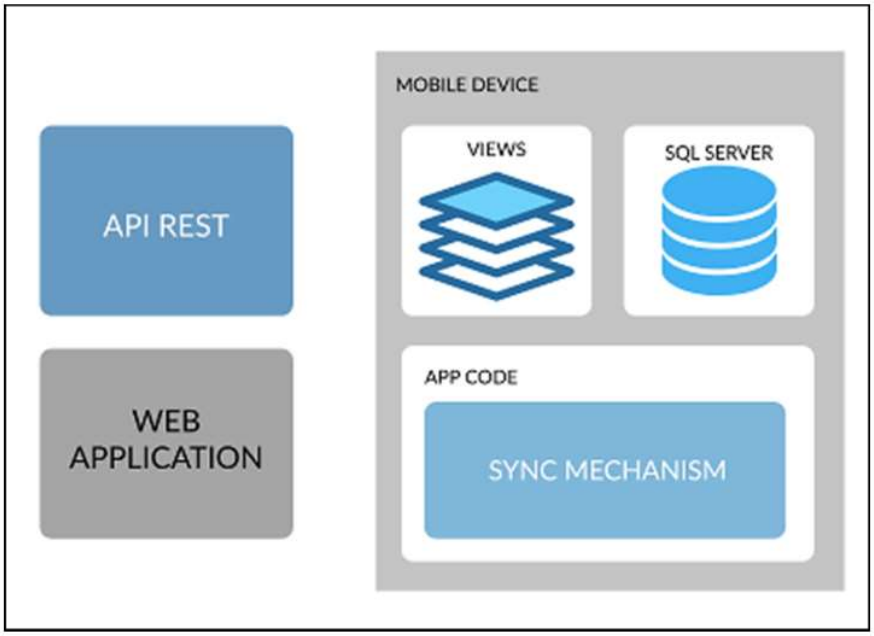

Fig. 1. Project architecture

Under this architecture it is important to know the structure of the database developed for the application, in this case the logical model of the database was designed, shown in Figure 2, where the main tables are evidenced. After structuring the database, the development of the database in SQL was started.

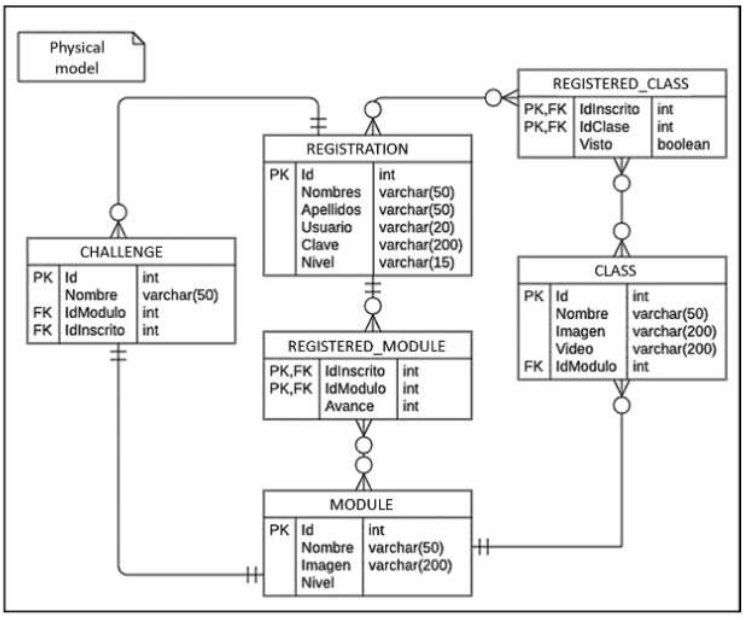

Fig. 2. Physical data model

3.4 Stabilization

The 3D models were designed from scratch with the use of the Blender program, this development required more than 30 days, this ensures the quality and reality of the models, Figure 3 shows the development of the 3D models.

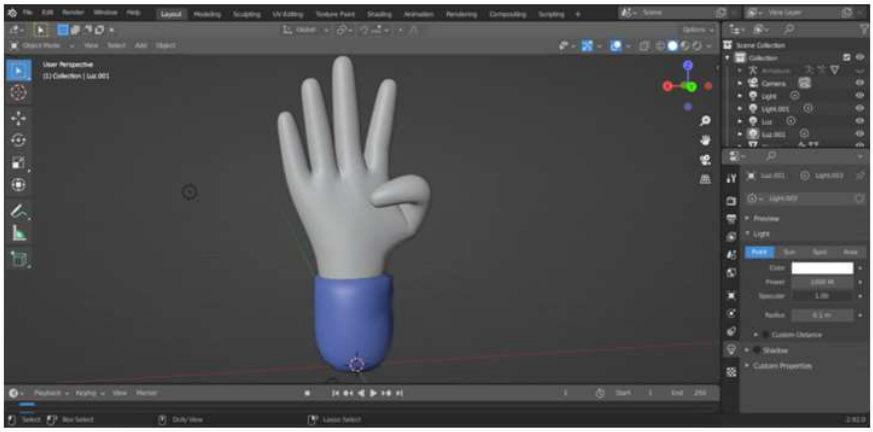

Fig. 3. 3D models—abecedary

The prototype of the application was designed from scratch with the use of the Figma tool, a detailed study was made on the use of the application, Figure 4 shows the main screens where the user interacts; the operation and navigation of windows are developed with an easy handling and understanding to provide the best user experience. On the other hand, the overall system has the function of improving the learning of sign language using modern technologies such as mobile applications and augmented reality.

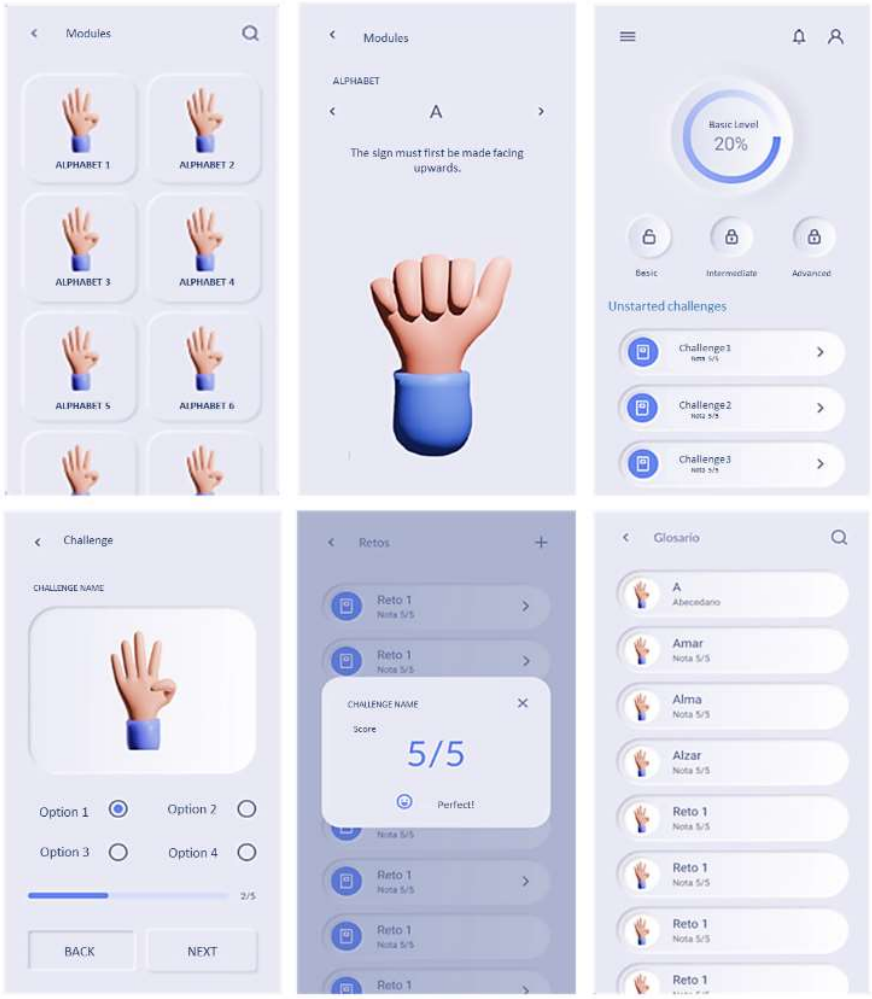

Fig. 4. Main components of the application

3.5 Tests

For this study there was a sample of 30 people in the range of 18 to 40 years of age from the "Iglesia Bautista Efata" The design of this paper was pre-experimental, taking into account the pre- and post-test, the control group and the experimental group, also following the pre-experimental research formula 1.

$$GO_1XO_2 \tag{1}$$

Where:
G: Represents the experimental group that receives the stimulus
O_1: Represents the group pre-test.
O_2: Represents the group's post-test.
X: Represents the stimulus.

4 Results and discussions

The objective of this research is to determine to what extent a mobile application with augmented reality improves the learning process of Peruvian sign language.

Considering three important criteria which are: (1) Level of learning, (2) Learning time, (3) Information level. Surveys collected without the app. Table 1 details the three criteria mentioned above, according to the surveys carried out.

Table 1. Results obtained

Indicators	Pre-Test	Post-Test
Level of learning of Peruvian sign language	4.133	9.6667
Time required to learn Peruvian Sign Language	123.67	44.633
Peruvian Sign Language Information Level	2.2667	9.067

The means obtained in the pre-test and post-test are defined in Table 1. The graph in Figure 5 shows the histogram, observing on the blue side that the experimental group has a given mean in each of the criteria, and on the orange side there is an average progress with the application.

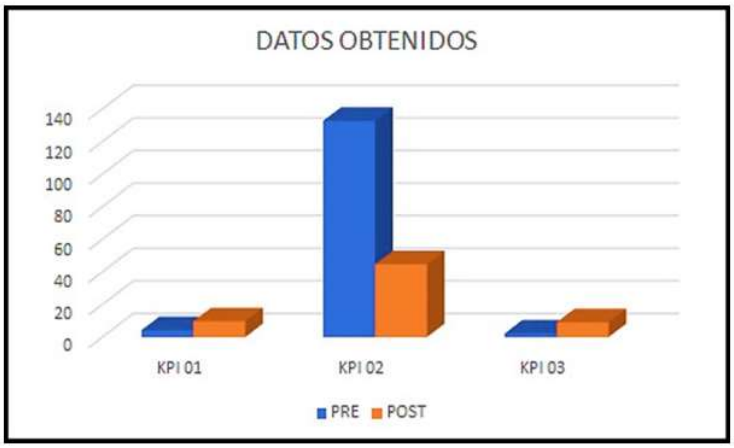

Fig. 5. Average obtained in the pre-test and post-test of the group

4.1 Detailed results of indicators

KPI-1, Figure 6 shows the graph developed in SPSS, which shows the Post-Test of the PSL Learning Level indicator (KPI-1), highlighting that about 95% of the scores obtained in the indicator are within 2 standard deviations with respect to the mean, between 9.3 and 10.0 scores. Evidencing that the implementation of a mobile application with augmented reality improves the level of learning of the PSL.

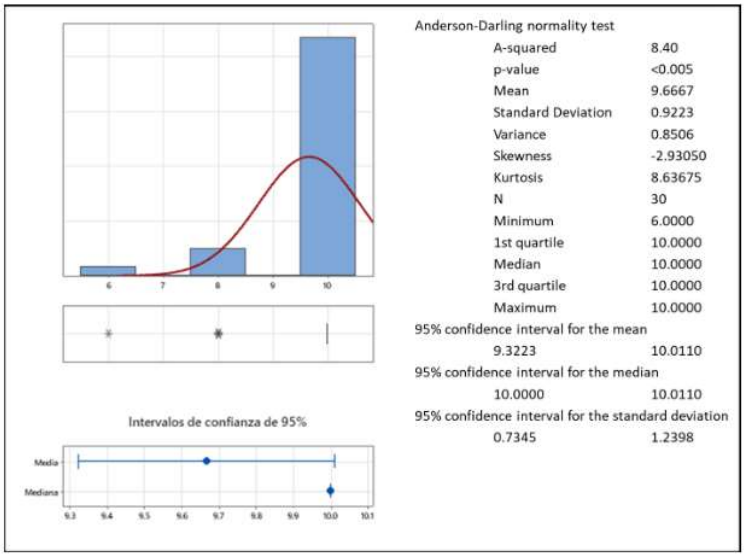

Fig. 6. Post-test KPI-1 summary report

KPI-2, Figure 7 shows the graph developed in SPSS, which shows the Post-Test of the indicator Time required for learning the PSL (KPI2), showing that the average distance of the score obtained for the indicator in the Post-Test, with respect to the mean is 6,780 points. About 95% of the scores obtained in the indicator are within 2 standard deviations with respect to the mean, between 42,102 and 47,165 points. Evidencing that the implementation of a mobile application with augmented reality reduces the time for learning the PSL.

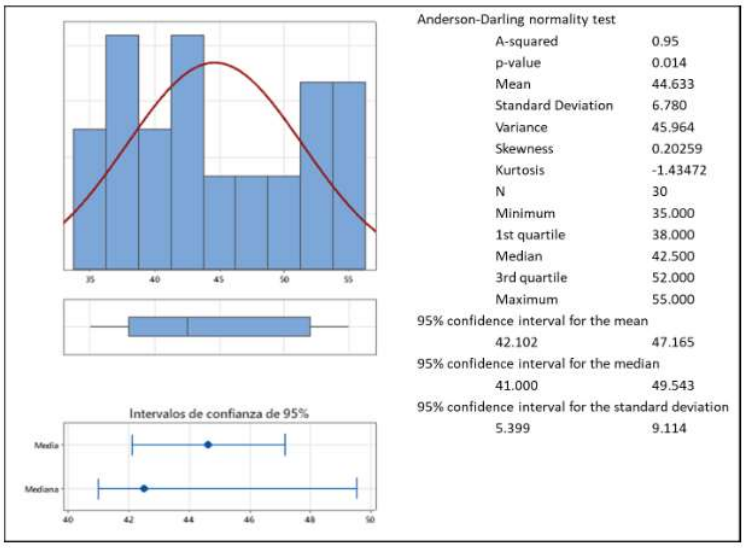

Fig. 7. Post-test KPI-2 summary report

KPI-3, Figure 8 shows the graph developed in SPSS, which shows the Post-Test of the PSL Information Level indicator (KPI-3), showing that about 95% of the scores obtained for the indicator are within 2 standard deviations of the mean, between 8.6877 and 9.4456 scores. Evidencing that the implementation of a mobile application with augmented reality, improves the level of PSL information.

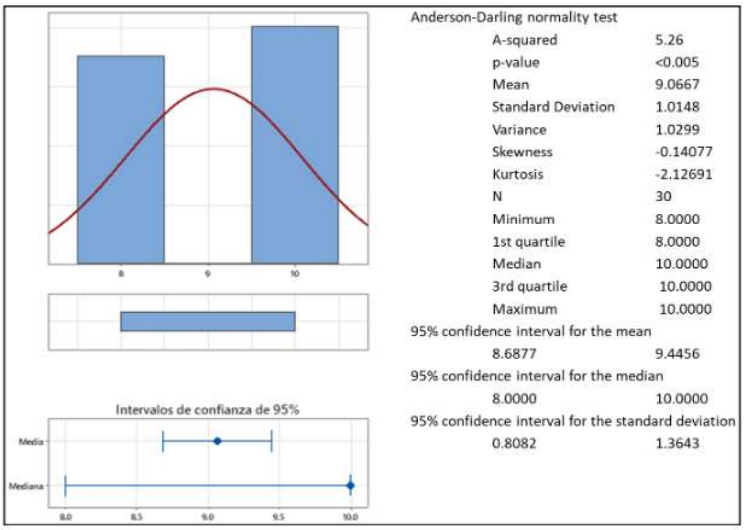

Fig. 8. Post-test KPI-3 summary report

5 Conclusions

It is necessary to promote social awareness towards the understanding of people with hearing disabilities, favoring communication between hearing and deaf people. There are many mobile applications focused on teaching in different fields and areas, however, with this project we want to stop excluding people with disabilities and introduce them to the world of technology, likewise, we also want to provide free possibility of learning sign language from home and through a mobile application that does not limit the user to do-it since today they are one of the most used devices both regionally and worldwide.

The main focus of this research was the development and implementation of a mobile application with augmented reality to improve the learning process of Peruvian Sign Language, taking as a sample 30 users between 18 and 40 years old, noting that the application meets the proposed objectives, achieving to increase the level of knowledge of people regarding this language, reduce the learning time and increase the level of information of the PSL.

According to the results obtained, of the total number of users studied, we start from a performance percentage of 23%, visualizing an important change when using the mobile application, significantly improving user performance by 65% with respect to the PSL, which exceeds the percentage of the applications studied previously mentioned in section 2. According to the visualization and control, through the mobile application with augmented reality it is possible to learn about the PSL in less time and in a didactic way, allowing the user to understand the modules created for the application which is downloaded and installed on their mobile devices. Finally, we conclude that a mobile

application with augmented reality is beneficial to improve the level of learning and information about sign language, as well as to reduce the learning time of PSL.

The scientific contribution provided by this research work is very important in the scientific environment since it is the basis for future projects that want to implement technologies such as Augmented Reality, which has a great impact on education and language teaching. For which this study should be applied to other areas linked or associated with learning and the inclusion of people with disabilities who are the daily object of discrimination and social exclusion, to the technological field.

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7 Authors

Michael Cabanillas-Carbonell is a qualified researcher by the National Council of Science, Technology and Innovation – Peru. Professor of Computer Systems Engineering at Universidad Privada del Norte. President of the IEEE-Peru Education Society Chapter. Conference Chair EIRCON (Engineering International Research Conference). (email: mcabanillas@ieee.org)

Piero Cusi-Ruiz is a graduate of the professional school of Systems Engineering at the Universidad Autónoma del Perú, with extensive experience in software development. (email: pcusi@autonoma.edu.pe)

Daniela Prudencio-Galvez is a graduate of the professional school of Systems Engineering at the Universidad Autónoma del Perú, with extensive experience in mobile application development. (email: dprudencio@autonoma.edu.pe)

José Luis Herrera Salazar is Academic Director of the Professional School of Engineering at Norbert Wiener University, has extensive experience in virtual and augmented reality, and has several international publications. (email: joseluis.herrera@uwiener.edu.pe).

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