# Inclusive Education: Mobile App for Students with Hearing Impairment

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**Abstract—**Currently in Latin America hearing impairment is one of the main problems of society, especially in Peru, where there is a large percentage of hearing-impaired children without receiving some kind of adequate and viable education for their growth, being the main reason the little support by the government and the lack of technological tools to support inclusive education. For this reason, the present research work is generated, which has as main motive to support and help the benefit of educational inclusion and even better technological development for fundamental problems in society, especially those that affect the educational life. Therefore, the development of a mobile application aimed at educational inclusion for students, whether or not they are hearing impaired, was proposed. Therefore, a form was applied to 40 people, including parents of hearing-impaired students and teachers, in order to collect main requirements. In addition, the cascade methodology was used, being the most appropriate for the development of the mobile application, providing agility of development by having clear and precise requirements. Finally, it was concluded that the mobile application will generate different adequate and viable benefits for an inclusive educational environment for students with hearing impairment, through the development of a form established and directed to 50 people, among them the 40 people of the first form and 10 people specialized in the development and design of mobile applications.

**Keywords—**cascade methodology, hearing impairment, mobile application, educational inclusion

## 1 Introduction

The hearing sense is one of the senses with the highest percentage of disability worldwide, comprising about 430 million people living with hearing loss, among these 34 million are children. Furthermore, this disability detrimentally affects different aspects of human life, including mental and physical well-being and socio-economic status, as it is directly related to educational and work opportunities [1]. On the other hand, hearing impairment causes in children an inadequate development regarding their communication and spoken language skills, critically affecting different stages of their growth and having repercussions in their adult life [2]. Therefore, hearing impairment

significantly influences a person's employment status, either to enter or remain in the job.

For this reason, the educational environment has undergone a great incremental change in recent years, bringing about a transformation in the school environment and the pedagogical regime. However, not all countries in the world have adapted to the change to inclusive education, especially most Latin American countries [3]. One of these countries is Peru, because it has a great lack of technological development for the support and backing of inclusive education. That is why this country has less than 2,000 hearing impaired children who are in an educational center, which refers to 6,000 children with hearing impairment, according to data collected by the National Council for the Integration of Persons with Disabilities (CONADIS).

The Peruvian government does not provide adequate attention and support for the education of deaf students, nor for the rest of the hearing-impaired community [4]. This is why, without appropriate educational support, hearing impaired students may slow down the course of the class and even delay their learning. In other situations, they receive little adequate material for a correct educational development for blind students, critically obstructing their learning in such a way that they are left at a lower level than other students.

In Peru, there is only one book published by the Peruvian government which was created to function as a guide for learning sign language, but this is not enough. Despite the existence of Article 7 of the Peruvian Constitution, which supports the protection and support of the entire community with disabilities, it is important to note that the following articles are included in the constitution of Peru [5].

For this reason, it is essential to carry out viable planning and strategies for the development of inclusive education for students with hearing impairment. In such a way that the advancement of technology is used as the main source of development and support, in order to provide adequate growth to students. For this reason, the present research work is focused on the development of a mobile app that provides benefits and promotes educational inclusion for students with hearing impairment, with the main objective of improving and establishing a better structure of the educational environment.

The present research work is established by different sections. Section 2 shows the literature review. Likewise, section 3 determines the methodological phase oriented to the development of the project. On the other hand, section 4 shows the results and discussion of the research work oriented to the established methodology. Finally, the last part is section 5, which is defined by the conclusion.

## 2 Literature review

This research work is oriented to the realization and implementation of a mobile application to promote the educational inclusion of students with hearing impairment, establishing as an objective to develop a better quality of educational teaching. For this reason, feedback on research works that can provide different benefits with a better perspective on this problem was carried out in order to generate an improvement through the limitations of the works analyzed.

Many Latin American countries need to rely on technological progress to improve and solve social problems, especially in the area of educational inclusion. For this reason, the authors [6], developed a mobile application for blind students, in order to provide greater benefit and integration among blind students over sighted students in order to reduce the number of blind students who drop out of education for lack of inclusive quality education. In the authors' research work they were supported under the Scrum methodology. Concluding that this type of technologies helps to promote and benefit inclusive education.

On the other hand, the authors [7], developed a mobile application focused on augmented reality in order to benefit the learning of sign language, through the Mobile-D methodology. For this, they used a sample of 30 people to perform a control, based on performance results. The authors [7], in their research work, concluded that their mobile application managed to reduce the learning time of sign language.

However, the application developed by the authors is not focused on inclusive learning or interactive learning among students for quality learning, and it is only focused on translating and not on teaching or various forms of learning, making it unsuitable for the educational environment [8,9,10].

Likewise, there is a study focused on the development of a digital orthographic system for sign language, seeking to benefit students with hearing disabilities, through the entry of a paragraph of text with the information required by the student with a disability and shown in sign language through a video, the authors' work [11], The result is uncertain as to the viability of the software's operation and has the scarcity of a previous analysis, in addition to having unattractive interfaces for the software's target audience.

On the other hand, there is a mobile application that provides assistance to visually impaired students, oriented to the learning of the periodic table and the electronic configuration developed with the purpose of improving the accessibility and quality of learning of visually impaired people through interactions of vocal commands and gestures, this mobile application was developed by the authors [12], concluding that the integration of new technological advances can aid in better educational inclusion capable of providing adequate education for blind students.

In support of inclusive education, the authors [13], developed a mobile edutainment application developed to generate literacy skills for the blind and sighted student population. They also used a proprietary development methodology which consisted of the presentation of two iterations covering the design and implementation of the system. Concluding that for the contribution and growth of inclusive education it is essential to rely on technological progress.

On the other hand, other technologies implemented for inclusive education were the use of Smartwatches together with the portable application Weli, which was developed and studied by the authors [14], with the objective of supporting students with intellectual disabilities, composed of 8 study modules and developed through a methodology based on prototype design and pilot study of the implementation of the application. Concluding that the development of the Weli application provided a better quality of study to students with intellectual disabilities, generating greater self-confidence in them.

In the same way, there is a chatbot for educational inclusion for the population with intellectual disabilities due to the limitations of social life and the little support that inclusive education has in certain social aspects. This tool was developed by the authors [15], with the objective of improving social skills, through a conversation between the user and the chatbot, facilitating the learning of social skills through innovation, inclusion and quality. Concluding that this type of tools helps to focus and enhance the skills of people with social disabilities, such as communication and social skills.

Through this study feedback to the different research works presented, it is concluded that technological progress and its implementation in the educational field provide improvements to quality education, as well as promoting educational inclusion. However, it has not yet been possible to adequately cover one of the disabilities with the highest percentage worldwide, such as hearing impairment. Therefore, the development of an application or the use of technology to promote or assist the educational inclusion of students with hearing impairment would provide a better lifestyle for these people, helping to improve their motivational and educational status. That is why the present research work was born.

## 3 Methodology

### 3.1 Cascade methodology

The methodology applied for this research work was the cascade methodology, which is defined or characterized by the sequential development of processes through the requirements established for the project [16], this type of methodology is more suitable for projects that need a development without time limits based only on meeting the requirements in short deadlines, allowing flowcharts, coding, implementation, debugging and verification [17], as shown in Figure 1, which shows the processes covered by the cascade methodology [18].

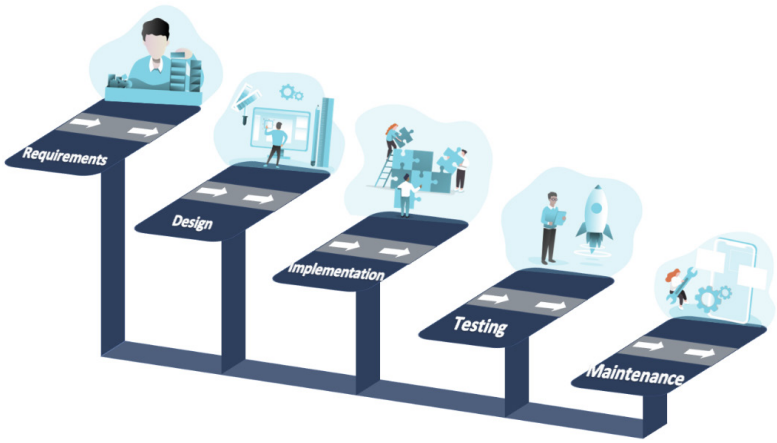


**Fig. 1.** Stages of the cascade methodology

### 3.2 Development tools

**Android Studio** is known as a tool for the development of mobile applications which gives the possibility to learn under the ubiquity of Android operating systems [19]. In addition, Android Studio is one of the most used tools by developers because it is easy to use and understand, having among its most important features the mobile emulator, a flexible compilation system, robust code compilation and multiple debugging variants [20], [21].

**Java** is one of the most active languages in the world due to the breadth of IDEs that cover its use in their platforms, which is based on computer development [22]. Another benefit of using this programming language is that it is very simple and easy to understand [23], including high-performance development functions, sub-processes and requirements elicitation according to user needs [24],[25].

**Marvel App** is one of the best web platforms which is used as a tool for mobile and web prototyping, it contains flexible and communicative functionalities [26]. Also, these prototypes can be adapted to many mobile devices and operating systems, in order to obtain a realistic and adaptable result [27].

**SQLite** es una de las mejores bases de datos orientada a la gestión de aplicativos móviles, se caracteriza por ser de código abierto y contar con una funcionalidad practica y fácil de entender [28]. In addition, it is also characterized as a database that provides reliability, accessibility and stability by providing consistency [29], [30].

### 3.3 Methodology development

**Requirements.** After analyzing the main requirements of the problem presented in this research work, a form was filled out and sent to 40 people, including parents of hearing impaired and non-hearing-impaired students, as well as teachers at an educational center in metropolitan Lima. Due to the fact that the main objective of this research work is that the mobile application covers its usability for all types of students to consolidate the two types of students through the use and application of sign language. The user stories shown in Table 1 were obtained by means of the form presented.

**Table 1.** Requirements

| N$^{ro.}$ | User Stories |
|---|---|
| 1 | As an administrator, I would like the mobile application to contain different topics separated by modules so that the student can learn more about sign language. |
| 2 | As an administrator, I would like the mobile application to have the possibility to select the level of difficulty applied in each learning process so that the student has the possibility to adapt the app according to his or her level of knowledge. |
| 3 | As an administrator, I would like that within the mobile application it is possible to take exams so that the student or teacher can take into account the level of their learning. |
| 4 | As an administrator, I would like the mobile application to have the option to perform tests so that the student can study according to the selected topic. |
| 5 | As an administrator, I would like the mobile application to provide the results of the tests and exams so that the student or teacher has the knowledge of the level of the student who took the exam. |

| | |
|---|---|
| 6 | As an administrator, I would like the mobile application to contain different types of interactive questions so that the student can feel comfortable with the development of their educational growth. |
| 7 | As an administrator, I would like the mobile application to be easy to use so that the student or teacher can interact with the mobile application without any problems. |

**Internal design.** For the design of the mobile application, two different perspectives oriented to its internal and external usability were established. For internal usability, the architecture of the mobile application was established. The 3-layer architecture aligned to SOA, which is composed of 11 phases of internal compliance of the software architecture, as shown in Figure 2.

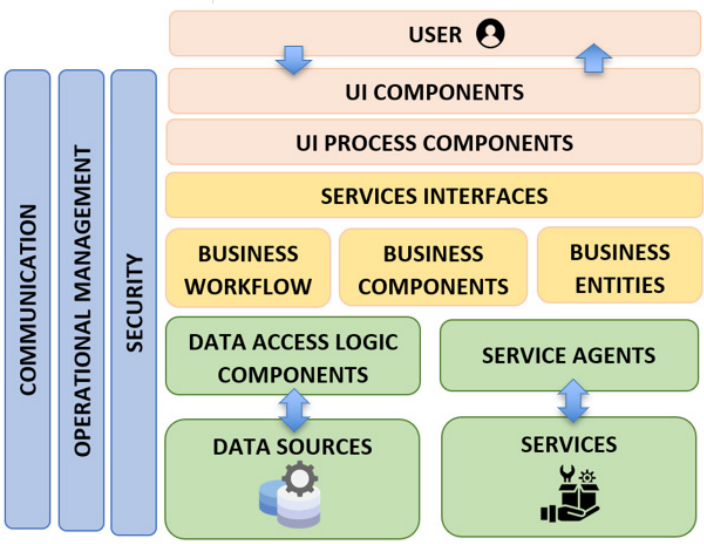


**Fig. 2.** SOA software architecture stages

The first three phases of the architecture, the user phase, the user interface (UI) components phase and the UI process components phase, are focused on user interaction with the application interfaces. These three phases have the function of implementing and deploying the architecture's interactions with the user and implementing processes that interact with the user interface.

Continuing with the interactions of the internal phases of the software architecture, the service interfaces phase follows, allowing to establish the definitions, actions and operations that will provide the services located in the software architecture. Consequently, the service interfaces phase interacts with 3 phases, the business workflow phase, the business components phase and the business entities phase, all three focused on the implementation, encapsulation and inclusion of mechanisms that allow structuring the processes and information of the mobile application.

Immediately, the analysis phases continue, which are the phase of data access logic components and service agents, oriented to access and transfer data, as well as reuse

functions and encapsulated tests that minimize maintenance and maximize the viability of the mobile application.

Finally, there are the application backup and support phases, the communication phase, the security phase and the operational management phase. These phases pass through all the layers of the software architecture, to administer, authorize and manage certain actions during the development of the application activities or within other added services.

**External design.** The external design is oriented to the usability of the mobile application between teachers and students, as a first stage it is required that the teacher provides information and interaction of the mobile application to students, whether or not they have hearing impairment, because the purpose is to unite and include all students to sign language and achieve a collaborative work, as the next stage is to use the mobile application with the supervision of the teacher and evaluate the development of students with the results obtained in the application, (see Figure 3).

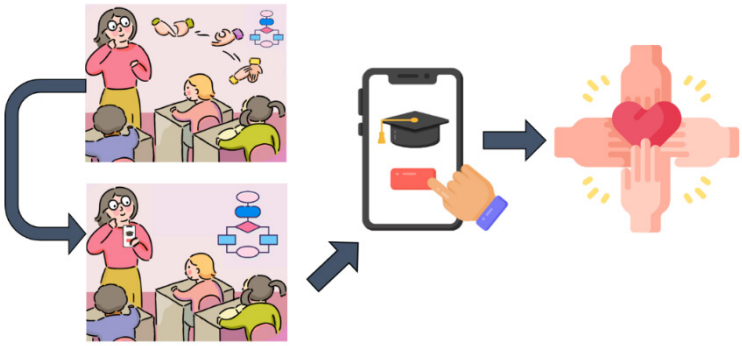

**Fig. 3.** External operating flow

## 4 Results and discussions

This section is divided into three subsections, the results shown below are represented through the development of the prototypes of the mobile application, its different functionalities and interactivity modules. The results of the satisfaction survey are also shown. And finally, the study and analysis of the methodological selection.

### 4.1 About the prototypes and application requirements

The prototypes and functionalities directed towards the mobile application were developed through the requirements previously analyzed. As can be seen in Figure 4, there are two prototypes, as the first prototype was developed and established 6 main modules based on primary topics in student learning. As the second prototype in Figure 4, the method of entry or learning was established, either to develop an exam according to the selected topic or to access the application in practice mode, in the case of the image

presented, a black border is displayed in the learning option, indicating that the user wants to enter this mode.


**Fig. 4.** Mobile prototypes I

On the other hand, internally we worked on the division and differentiation of the two types of entry methods to the mobile application, in Figure 5, you can see the learning mode, where the student can develop and enhance their academic degree according to the previously selected topics, in the figure shows the literacy module and the numerical module. Likewise, Figure 6 shows the easy level exam mode in which 4 selection options are provided for the student to indicate the correct answer according to the criterion located inside the rectangular symbol.


**Fig. 5.** Mobile prototypes II - Learning mode


**Fig. 6.** Mobile prototypes III - Easy level test mode

Finally, two more levels were developed within the test. The advanced level represented by the interaction of related images, as can be seen in the first prototype in Figure 7, in which each selected image will be framed by a color, the purpose is to find

its pair. On the other hand, the second level is the difficult one, which is focused on the combination of interactions in addition to two new evaluation activities as can be seen in the second and third prototype in Figure 7, where they have to structure the answer with the options provided at the bottom in order to place the answer referring to the rectangular symbol criterion.


**Fig. 7.** Mobile prototypes IV - Advanced and difficult level test mode

### 4.2 About the satisfaction of the mobile application

In this phase, a survey was conducted among 50 people, 40 of whom were the same people to whom the form was addressed to obtain the requirements. Likewise, the remaining 10 were people dedicated to the development and design of mobile applications. The purpose of the survey is to take the information collected to provide feedback and improve future updates regarding the mobile application and user comfort. The results of Table 2 were obtained by means of the form, for which 7 evaluation criteria and 4 scoring criteria were established, the content of the table has the sum of the people who marked the evaluation criteria (Excellent, well, regular and deficient). On the other hand, a percentage analysis of the result obtained through the form was developed as shown in Figure 8.

**Table 2.** Criteria evaluation

| Criteria | Excellent (5) | Well (3) | Regular (2) | Deficient (1) |
|---|---|---|---|---|
| Persistence | 15 | 33 | 2 | |
| Ease of Use | 24 | 16 | 10 | |
| Customization | | 25 | 14 | 11 |
| Thinking Skills | 35 | 13 | 2 | |
| Authenticity | 44 | 4 | 2 | |
| Collaborative Work | 20 | 16 | 14 | |
| Motivation | 15 | 30 | 4 | |

The evaluation criteria were defined as follows:

1. Persistence: evaluates whether the application is really related to the purpose for which it was developed, as well as whether it is suitable for students.
2. Ease of Use: evaluates whether the use of the mobile application is very intuitive, in addition to the criteria and ease of navigation.
3. Customization: evaluates whether the mobile application is customizable, if the student can configure different aspects related to his/her needs or profile.
4. Thinking skills: evaluates whether the mobile application promotes the development of thinking, evaluation and analytical skills.
5. Authenticity: evaluates whether the mobile application allows the development of educational activities, general educational growth and student skills.
6. Collaborative Work: evaluates whether the mobile application generates or encourages students to work mutually including everyone in future activities or interacting through what they have learned.
7. Motivation: evaluates whether it generates motivation in the student to use the mobile application for their educational development.

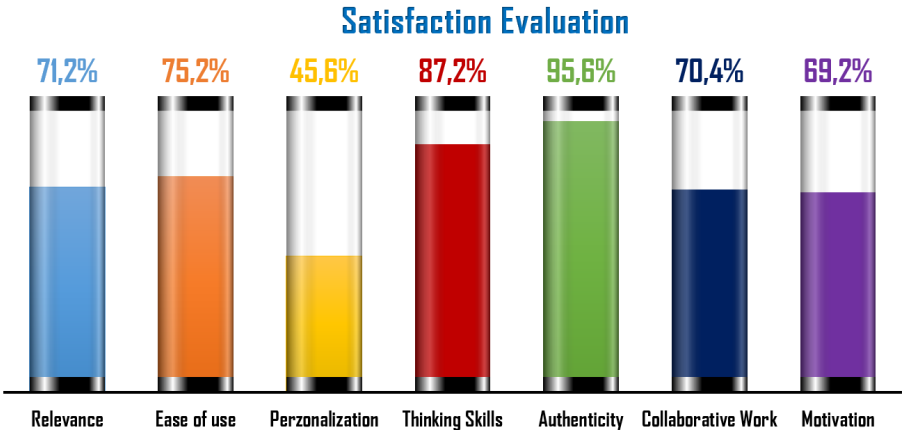


**Fig. 8.** Evaluation of percentage satisfaction

Likewise, through the graph presented in Figure 8, it is determined that the development of the mobile application through the presentation of its prototypes obtained 71.2% of persistence, allowing to know that it has a great relationship with the objectives for which it was created, being highly suitable for students. In turn, it obtained 75.2% on the ease of use it provides, showing that the mobile application is really intuitive. It was also possible to show that the teamwork criterion has an acceptable margin with 70.4%, determining that future interaction and inclusion between them and the teaching mode is encouraged. However, despite obtaining a high percentage of acceptance in these 3 evaluation criteria, there is still room for improvement in order to increase user satisfaction and the achievement of adequate comfort of use.

On the other hand, it was determined that one of the factors that should be improved further is the personalization criterion, since it covers only 45.6% of the evaluation compliance.

Finally, on Figure 8, it can be observed that two highly acceptable characteristics were obtained, which are the thinking skills with 87.2%, highlighting that the mobile application allows promoting the growth and increase of analytical skills. And the criterion of authenticity 95.6%, evaluating that the mobile application generates adequate educational growth through different development activities.

### 4.3 About the methodology

This stage will show the reasons and evaluations developed for the selection of the methodology of the current research work, based on two main methodologies with less development time, which allow obtaining highly viable results for software development. The two methodologies compared are the waterfall methodology and the spiral methodology, as can be seen in Table 3, which were compared and evaluated by 5 criteria. For the reasons presented in the table, the selection was directed towards the cascade methodology because it is focused on a development more appropriate to the needs of the current research project, having clear and precise objectives and requirements.

**Table 3.** Methodological comparison

| Criteria | Cascade Methodology | Spiral Methodology |
|---|---|---|
| Definition | Methodology oriented to manage projects with fixed, conclusive and stable processes. | It contains scalable and incremental phases through development cycles. |
| Phases | Its stages are linear, based on the logic of having to finish to start, once a phase is finished it is not possible to go back [31]. | It contains sequences at an iterative level, it is possible to go back to previous phases or stages. |
| Uses | It is ideal and suitable for projects containing stable requirements or when working on a technical basis as well as when rapid development is needed [32]. | It is applied when a large project is uncertain about its needs, for which it is necessary to analyze the possible risks for the next cycles [33]. |
| Risks | It is established for speed, in order to reduce risks. | It is not focused on time; it is always evaluated through risks [34]. |
| Planning | Oriented to previously analyzed and determined requirements. | It contains uncertainty, the requirements are not established at a clear level cycle [35]. |
| Customer Involvement | It is limited to minimum participations in each phase at the beginning. | It contains a more active participation in each cycle [36], [37], [38],[39]. |

## 5 Conclusion

Finally, a mobile application was developed which meets the objectives of the requirements established through the questionnaires addressed to 40 people, and rated by 50 people with criteria highly corresponding to the development of the mobile application. Likewise, this mobile application will be able to provide a better inclusive educational environment for all students with hearing impairment and allow them to interact

with students without hearing impairment. Also, it is concluded that the use of the cascade methodology is one of the most appropriate methodologies when the requirements are detailed and established in an adequate and precise way. The application developed in the present research work will provide different benefits for the inclusive social development, especially in the way of teaching and the relationship of the teachers towards the students, eliminating the standards of the society where the hearing impaired have a great percentage of unemployment. Likewise, as a future work, we want to implement the arterial intelligence to the mobile application to improve the relationship and interrelation of the students. On the other hand, this study should be the beginning of the inclusive educational improvement, generating incentives for the development of technological tools that support the educational improvement of different disabilities for the inclusion of all students, not only in Peru but throughout the world, in order to avoid that in adulthood they live in an exclusive environment, so it depends on society to contribute step by step to improve our social environment and grow through a unified and inclusive development.

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