Design, Implementation and Evaluation of a Technical Platform that Supports Spanish Speaking Children with Intellectual Disabilities Learn English as a Second Language

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Abstract. Recent Chilean legislation established a curriculum focused on children with cognitive deficits, adapting the original English curriculum to a specialized one that can be used in Special Education Needs (SEN) schools. However, currently, Chilean SEN schools are not making use of these methods to support students to learn a new language such as English. Furthermore, the research of similar mobile applications available indicated a focus on native English speaking children with intellectual disabilities, however, did not support Spanish speaking children. Therefore, this study was created to observe the impact of mobile activities in English language instruction in the setting of a Chilean SEN school. The proposed solution was designed, developed, and implemented in conjunction with specialist teachers. Prototypes of the mobile application were installed on tablets specifically for this study and deployed in an experimental group. Students were assigned to two groups, control and experimental, where the same pre and post-tests were conducted. This included activities such as writing an English word from the image displayed, matching an image with the associated English word, and completing the missing letters of an English word (which was proven to be the most difficult activity). This experiment resulted in a significant impact on the learning achieved in the experimental group. The Cohen D resulted in 0.92 with a p-value of <0.001. Furthermore, the analysis of the standard deviation of time usage in each activity provided insights into the difficulty levels supporting modifications of future activities.

Keywords: Learn english · Second language · Intellectual disabilities · Special Education Needs

1 Introduction

Today software platforms have played an important role in society, facilitating access to information and providing tools for people with intellectual disabilities. These applications support students to learn in a didactic way and with new methods, to better develop

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their thinking skills and abilities [1, 2]. In the initial years of education, it is relevant to instill training in the use of English as a second language [3–5]. In these years, the brain is more susceptible, enabling students to learn faster, more easily, and achieve better performance in the future [6]. This is especially relevant in children with cognitive deficits because it allows them to generate early stimulation. However, teaching English as a foreign language to people with intellectual disabilities (ID) presents complications, requiring specific techniques and methods [7].

Recently, Chilean legislation, through Decree 83/15, established technical-pedagogical norms to carry out a curriculum focused on children with cognitive deficits, adapting the original English curriculum to a specialized one that can be used in Special Education Needs (SEN) schools. However, currently, these schools are not making use of these methods to learn a new language such as English. Therefore, the main objective of this work is to address the problem of poor development of English language comprehension in Spanish-speaking children with cognitive deficits at an early age; through the design, implementation, and evaluation of a software platform to support the process of learning.

This work aims to describe and analyze the process of design, construction, and implementation of Inclusive2L. Design-based research, widely used in learning sciences, was used as a methodology. As a source scenario for the design requirements and subsequent implementation, a Chilean SEN school was engaged, with whom the pedagogical and technological design was co-constructed, to adapt to the needs and particular characteristics of the target students. With this, the development of a set of interactive activities to be carried out individually was procured. The evaluation and reflection process consisted of two stages: usability evaluation and learning achievement evaluation. For this, a 6-month experimentation was carried out, using a pre-post pseudo-experimental design with a control group. Regarding usability, the quantitative analysis of the effectiveness and efficiency attributes was analyzed. Meanwhile, in the pedagogical field, the efficacy and impact of technology in achieving the learning objectives were defined.

This paper is organized as follows. Section 1 introduced the motivation of our work through the problem identified and the proposed solution. Section 2 presents related work. Section 3 describes the details of our proposed solution. Section 4 describes the experiment accomplished to implement and evaluate the proposed solution in a real environment. Section 5 reports the learning and user outcomes obtained. Finally, Sect. 6 presents conclusions and future work.

2 Related Work

The purpose of this section is to present the condition of relevant applications related to the topic addressed by this project. Therefore, representative applications designed for working with children with ID who are learning English as a second language will be investigated.

The Abaplanet [8] application, developed by the Lovaas Foundation [9], provides learning activities, aimed at children with Autism Spectrum Disorders (ASD) and those with other SEN. The application utilizes play activities and the Applied Behavior Analysis (ABA) method in exercises such as matching or receptive language. In addition,

it has an intelligent system to adapt the level of the learning sessions according to the student's progress. In this way, the application records the activity carried out by the student and also assesses learning [10]. However, none of its adapted activities allow for English language learning for Spanish-speaking children with ID.

The Learn English for Kids [11] application is aimed at teaching English to children and is available for free on iOS and Android platforms. This application provides various images to help with vocabulary, audio files to practice listening, and recording functions to practice speaking. Teaching is done through lessons that are structured first with easy words and phrases, which gradually become more difficult.

Similarly, Special Words [12] enables teaching various English words to native speakers. The application is intended for children with SEN, ensuing a simple and intuitive interface. In addition, it presents a way to engage children with technology using both traditional and holistic teaching methods [13]. The application provides activities to develop and stimulate different skills, such as manual-vision coordination, improvement in fine motor skills, communication, speech stimulation, expanding the child's vocabulary and personal, social and emotional development. Notably, the words, photos and audio can be customized to make it a more friendly environment for the child to develop different skills.

However, the proposed English activities of these applications ([11] and [12]) are focused on native English speaking children, proving difficult to adapt to children with ID where Spanish is their native language.

Lingvist [14] is an application that adapts in real time to the user and the learning habits. This is done through linguistic analysis methods, that is, the application adapts to the existing knowledge of the learner, providing personalised lesson plans. In this way, the language learning experience is contextualised for the individual users needs. The application has additional features such as monitoring of user statistics, voice recognition system, grammar aids providing flexibility, virtual voices to replicate words, examples of real situations created by expert linguists, grammatical challenges and a simple to understand interface [15]. However, despite these attributes, the application does not provide elements to adjust its contents to the learning needs of children with ID.

The PICAA [16] application provides various activities for children with SEN, designed as a classroom support application. The user interface and educational contents have been designed to be adaptable to the needs and abilities of the student. The application offers individualized teaching with the customization to support group activities, stimulating the execution of activities. This provides the opportunity to personalize the learning experience for each individual user.

Similar to the Lingvist application, PICAA stimulates vocabulary, memory and eye-hand coordination improvements by incorporating teaching methods of word and image association, puzzles and exploration, order and memory activities, vocabulary comprehension, and cause and effect learning [10]. While this application provides various activities to support the education of children with SEN, it does not offer activities to learn English as a second language.

Azahar [17] is a set of free and customizable applications that allow people with ASD and ID to improve their communication and planning tasks, in order to enjoy their leisure activities. Azahar is composed of a set of 10 applications, with different contents

including concepts of time, personal communication, access and management of music, hours of the day, and stimulating games. These applications use the Treatment and Education of Autistic and Related Communication-Handicapped Children (TEACCH) methodology and are available for computers and some Android applications. Amongst the characteristics presented in the Azahar project, pictograms, photos and voices are also utilized. Similar to PICAA, this application provides content and materials suitable for students with learning disabilities however is not focused on learning English as a second language.

Generally, it is evident that these English teaching applications offer suitable activities that support the learner in forming comprehension and expression skills. Furthermore, apart from The Learn English for Kids, all applications contain monitoring tools that provide a record of progress. Additionally, the applications adapted to work with a neurodevelopmental disorder [8, 12, 16] and [17], such as ASD, SEN and ID, are customizable, except for the PICAA application. However, these proposals focus on native English speaking students or do not provide adaptations for children with ID. However, unfortunately for this study, the applications explored are not intended for Spanish speaking students with ID who are learning English as a second language.

When working with children with ID, the American Association on Intellectual and Developmental Disabilities (AAIDD) notes that it is critical to consider factors such as the child's environment and culture, as well as linguistic diversity and cultural differences in the way people interact, communicate, move and behave. Therefore, it is evident that the explored applications do not consider the adequacy nor the suitability of its materials and methods for English language learning in Spanish-speaking children with ID.

3 Proposal

To address the aforementioned limitations, a software platform with activities adapted to teach the English language to Spanish-speaking children with ID is proposed. Specifically focusing on the impact of implementing didactic instructions via a mobile application in an SEN school.

The proposed activities were designed by specialists in SEN. The proposal was implemented and validated in a real environment during an academic semester, in an SEN school located in Santiago, Chile.

Using a mobile application, each student independently completed activities for the development of skills in the areas of listening and reading, and comprehension and spoken expression. The teacher has access to all activities and designs customized plans based on the students' ID level. Also, parents and guardians have access to the individual student results obtained via the mobile application.

The proposed solution was developed through four phases before being released for testing. Firstly, a study was carried out on the ID present in SEN schools, including an investigation of the current teaching methods implemented by ID specialist teachers.

Secondly, design guidelines [18, 19] and methodologies [20] were outlined to guide the development process of the proposed mobile application. Thirdly, from these two phases, activities were designed in conjunction with a specialist in SEN. It was vital at this stage that the activities achieved the topic of this study, that is, activities designed to

have a positive impact on learning English as a second language for Spanish speaking students with ID.

The fourth phase was to create a prototype from the aforementioned design activities, which were installed on tablets owned by the school. This allowed for constant feedback from teachers, students, and parents or guardians.

Finally, a control group and an experimental group were established, carrying out a pre-test and a post-test, to see the impact of the application on the students' learning process throughout the semester.

3.1 Activity Description

The activities were co-created with specialists, following a learning methodology according to the children's needs. These activities focused on the development of the four English language skills: listening, speaking, reading, and writing. Additionally, the activity design of the proposed application endeavors that children acquire cognitive skills that enable them to organize and internalize the information they obtain through language practice.

Resembling the benefits of customizable lessons in the related work section, the mobile application facilitates customizable plans. The ID specialist teachers assign activities to students' tablets that have difficulty levels ranging from low to difficult. The detailed configuration the teacher deployed was determined by both the student's ID level and their preferred activity type (based on previous performance).

The activities types carried out consisted of the following tasks:

- Write the word: the student must write the concept illustrated by the image using the keyboard of the tablet.
- Match: the student must match a written word with its associated image.
- Complete with the missing letter: the student must complete a word with the associated missing letter.

3.2 Software Description

The software platform monitors various interactions (i.e. attempts, decisions, times, and clicks) of individual students in the activities (i.e. colors, family, and greetings). This permits access to relevant information about the children's learning process and the possibility of monitoring, evaluating, and making timely decisions about the activities that were proposed by the teachers.

The purpose of this application is to digitalize activities that are carried out with traditional tools such as paper, pencil, and blackboards. The advantage is to have all activities and their associated records unified within a single application. An important factor in the decision to use a mobile application is its degree of accessibility [21] ensuring its ease of use for students with ID.

Amongst the characteristics of the mobile application is:

- Activities executor: contains the activities that each student must undertake, according to the units of the corresponding subject. The student has two possibilities to advance:

at their own pace, or the teacher's discretion. The teachers reviewed the student's progress to intervene with adaptations as appropriate.
- Activity log: stores the results of the students' execution to evaluate their performance.
- Vocabulary: a fixed repository of visual and auditory material, with the vocabulary that the students can use in the activities. The repository was organized into categories of vocabulary which was constantly available for the student to access.

In the construction of the application the following resources were used:

- Balsamiq Mockups 3 is a tool to design interface mockups, which was used to design the prototypes of the interfaces of the mobile application.
- Unity is a multiplatform video game engine, which uses scripting for objects called "GameObjects". This engine was used to develop the software platform, due to its ease of orienting and working with the objects required for the activities.
- Google Cloud Platform (GCP) is a platform that amalgamates Google applications for web development. Therefore, this platform was used to manage the database. Within this platform 3 resources were used, which are:
- Storage was used to store the ".sql" file generated in "MySQL Workbench 8.0 CE".
- SQL was used to mount the ".sql" file that is in "Storage" and manage the database.
- Compute Engine was used to have a virtual machine directly connected to the database and, thus, be able to work as a "root" user and all related permissions.

Final Interface Design. This section presents an array of final interfaces to illustrate concrete examples of the designed activities. Notably, the design decisions (i.e. typeface, size, background color, images, extension, and contrasts) were conducted per the guidelines provided by SEN specialists.

As can be identified in Fig. 1, the activity instructions were presented in Spanish alongside an image, facilitated by the Spanish translation of the English word to be completed. The student is provided with a selection of vowels to complete the English word. This activity (Fig. 1) has an associated medium level. In cases of a low or difficult level, the number of missing vowels would decrease or increase (respectfully). Additionally, the difficult level does not include the Spanish translation after the instructions.

If the student's response is correct, the word will be completed and the vowel button will turn green. On the contrary, if the student's response is incorrect, the word will not be completed, and the selected vowel would turn red, indicating that it is not the correct vowel to complete the word. Finally, when completing the word, a window will be displayed on the image, which consists of a correct message and an 'ok' button, to proceed to the next activity.

An activity to match and associate words with pictures is presented in Fig. 2. The activity instructions were presented in Spanish followed by a selection of English words and their associated images that the student was required to join.

When completing the activity, if the student response is correct when the word is matched with its associated image, both will disappear from the screen. However, incorrectly matching a word to an image (for example, the student matches the word "Lion" to the image of a sheep) will prevent the two selected objects from disappearing.

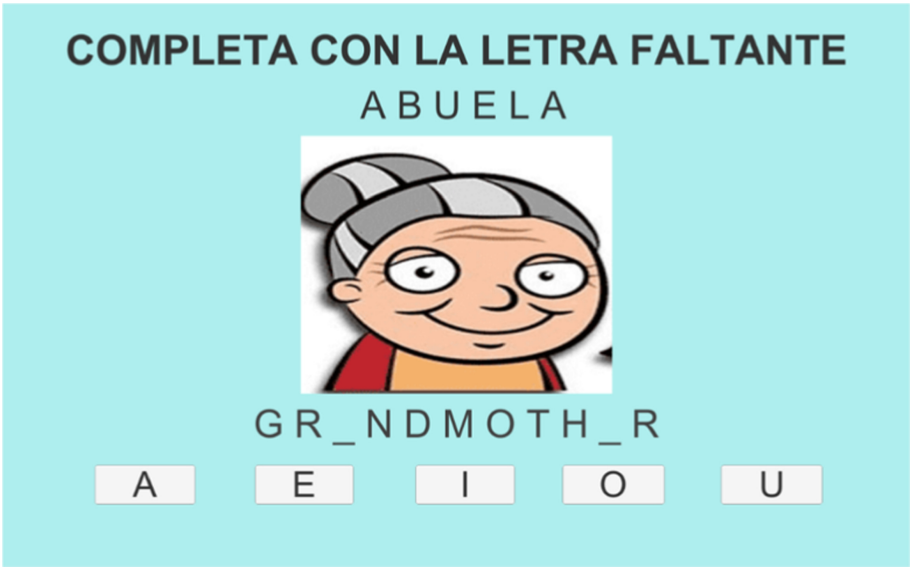

Fig. 1. Activity to complete the word with the missing letter/s.

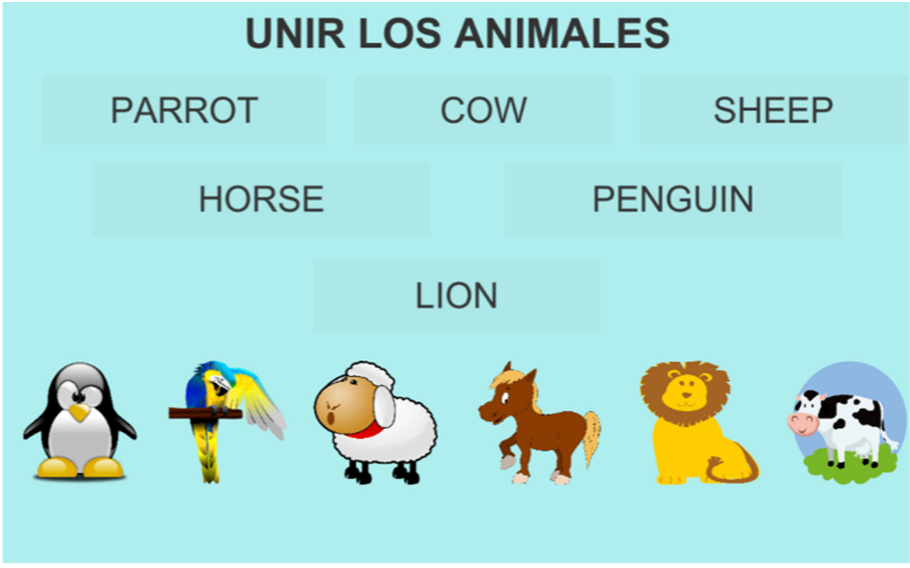

Fig. 2. Activity to match the word with the associated image.

The activity is regarded at a difficult level. For lower levels, the words and images are decreased. For example, a medium level will display four words with associated images, while at the lower level only 3 options will be available. Finally, by completing

the activity correctly all words and pictures will disappear and the same feedback as the previous activity in Fig. 1 will follow.

4 Implementation and Evaluation

In order to validate the proposal, a pre-post quasi-experimental study with two groups was designed:

- Group A: with the technological intervention (9 students).
- Group B: without the technological intervention (6 students).

All students across both groups correspond to the 6th-grade level, all with intellectual disabilities. To evaluate the impact on learning, an initial test was applied to both groups, prior to the intervention, and an equivalent final test. The tasks of the initial and final test were divided into 5 items, which represent the 5 units of the course to be evaluated:

I. Colors

1. Join the color and associated name together with a line.
2. Color each star according to the indicated color.
3. Write the color of each shape on the provided line.

II. Greetings

1. Look at the picture and mark the correct option with a cross.
2. Name the type of greeting displayed in each image.
3. Look at the image and paint the correct option in each option.

III. Numbers

1. Match the number and associated name together with a line.
2. Write the number and circle the associated number.
3. Listen and write the numbers heard.

IV. Family

1. Write the name of the images displayed.
2. Listen to the name of the family members and circle the correct. choice in each option.

V. Animals

1. Write the animal name of the images displayed.
2. Match the animal and associated name together with a line.

3. Listen to the names of the following animals and mark a cross on the associated images.

To evaluate the success of the activities, the results between pre and post-tests for both groups were compared respectfully. To effectively compare the results, the Student's t-test was applied to observe the distribution of results and identify significant differences. Additionally, to quantify the effect size of the differences observed the Cohen's D statistic was implemented.

5 Results

This section describes and analyzes the learning results obtained during the implementation of the mobile application (Sect. 5.1). Furthermore, the usage times of the designed activities are reviewed in detail (Sect. 5.2).

5.1 Learner Results

For the analysis, group A (with technological intervention) included 9 students while group B (without technological intervention) included 6 students. All students of the two groups completed the pre and post-test, with a maximum score of 75 points.

The highest score of the pretest for group A was 72 points, while the lowest was 18 points. The average score was 46.44 (SD = 5.55), which is greater than the expected 50% of the ideal test score (36 points). Whereas for group B, the highest score was 74 points while the lowest was 5 points. Group B has an average of 36.33 (SD = 26.65), which shows a greater dispersion in the results for this group.

In regards to the post-test, in group A, the highest score was 74 points while the lowest was 36, with an average of 59.67 (SD = 12.82). In group B the highest score was 61 points, and the lowest 26, with an average of 47.50 (SD = 15.63).

A summary of the results can be seen in Table 1, where an increase in the averages for both groups was attained. Furthermore, a decrease in the respective standard deviations demonstrates a higher concentration of students scoring an average result.

Table 1. Descriptive summary of learner results.

	Pre test		Post test	
	Mean	Std. Dev	Mean	Std. Dev
Group A (with intervention) Students = 9	46.44	15.55	59.67	12.82
Group B (without intervention) Students = 6	36.33	26.65	47.5	15.63

As mentioned, to compare the results from the pre and post-tests, the student's T-test was applied alongside the Cohen's D statistic to observe if there were significant differences between the two tests.

Table 2 shows the result for the p-value of the T-test, where a significant difference is considered when a p-value of less than 5% (<0.05) is evident. In the case of group A, a significant difference was observed, which is supported by Cohen's D calculations to measure the impact of the intervention. A value greater than 0.6 is considered to indicate that the intervention had a successful impact. The value achieved for group A was 0.92, indicating that the intervention had a high impact.

Table 2. Significant data in the learner results.

	T-test - p-value	Cohen's D
Group A (with intervention) Students = 9	<0.001	0.92
Group B without intervention) Students = 6	0.1010	N/A

5.2 Time Usage Results

The time of use of the application by each student was reviewed to check how long it took the students to work with the different activities (as outlined in implementation and evaluation). Table 3 displays the average usage times by the students in group A (with technological interventions).

Table 3. Time usage results.

Activity	Average time (minutes)	Standard deviation (minutes)
Write the word	06:29	05:13
Match	07:17	05:27
Fill in the missing letter	05:14	04:03

As the data presents, the average times of each activity is similar to the accompanying standard deviations, approximately one minute apart. However, the matching activity presented the most dispersed times, with a difference of almost two minutes. This may be attributed to two factors. Firstly, the difficulty or lack of previous knowledge of the vocabulary studies, or, secondly, the cognitive load of the student's interaction with the application.

In addition to the usage time of each activity, Table 4 presents the average number of attempts, correct responses, and errors for each activity.

From these results, it is apparent that the average number of correct responses and errors are similar, indicating that a successful outcome upon the first attempt is infrequent.

Table 4. Usages results in regards to attempts, correct responses, and errors.

Activity	Average number of attempts	Average number of correct responses	Average number of errors
Write the word	1	1	0
Match	5	3	2
Fill in the missing letter	2	1	1

The matching activity exhibits the highest average numbers for each finding suggesting that for every five attempts, three attempts will be correct while 2 will be incorrect. While "complete with the missing letter" indicates a ratio of one correct and one incorrect for every two attempts, a fifty percent success rate. Evidently, the best performing activity for children is the "write the word" activity, demonstrating that each attempt results in a correct response.

Overall, this experiment resulted in a significant impact on the learning achieved in the experimental group. The Cohen D resulted in 0.92 with a p-value of <0.001. Furthermore, the analysis of the standard deviation of time usage in each activity provided insights into the difficulty levels supporting modifications of future activities.

6 Conclusion and Future Work

In exploring relevant applications that support English practice for students with ID, a gap was identified that these applications did not support the practice of English as a second language. Thus, the experiment to observe the impact of mobile applications in an SEN school of native Spanish speakers practicing English as a second language was initiated.

Alongside ID specialist teachers, three different types of lessons ranging in three difficulty levels were designed and implemented. Students of both control and experimental groups participated in pre and post-tests to determine the impact of the application.

It was observed that there was a quantifiable impact regarding the learning achieved in the experimental group (Cohen's $D = 0.92$, p-value <0.001). The results were further analyzed by identifying the standard deviation of the time used in each activity, demonstrating that the matching activity was the most difficult eliciting more attempts with higher errors.

In pursuing the topic addressed by this project, it is evident that a significant impact is achieved when implementing mobile applications in SEN schools of Spanish speaking students with ID practicing English as a second language.

As for future work, we expect to create more activities to address different themes and situations of the English language. Additionally, we expect to integrate activities that promote socialization and self-care through the English language. We want to explore situations in which the activities can be adapted automatically depending on the interaction between the children with ID and the mobile application. Finally, we expect to carry out real case studies that analyze both in-depth and qualitatively [22] how difficult it is

for children with ID to interact with the different functionalities designed in the mobile application.

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