Journal on Interactive Systems, 2025, 16:1, doi: 10.5753/jis.2025.4090

Construction of a mobile game for learning Libras - Guess teaching

João A. F. Furquim [**Federal Technological University of Paraná** | ***joaofurquim97@gmail.com***]
Flávia B. Blum Haddad [**Federal Technological University of Paraná** | ***flaviahaddad@utfpr.edu.br***]
Débora G. Ribeiro Dias [**Federal Technological University of Paraná** | ***deboradias@utfpr.edu.br***]

Department of Computing, Federal Technological University of Paraná, Av. Alberto Carazzai, 1640, Centro, Cornélio Procópio, PR, 86300-000, Brazil.

Received: 02 February 2024 • **Accepted:** 26 August 2024 • **Published:** 01 January 2025

Abstract: The social inclusion of people with disabilities depends on everyone. To collaborate with the inclusion of deaf people, this article addresses the construction of a game available on mobile platforms to assist in learning Brazilian Sign Language (Libras). The game proposes challenges and rewards through questions and answers and also presents Libras signs created by an avatar. As a background, it comments on the importance and emergence of educational games and highlights the history of Libras, presenting concepts, definitions, and curiosities of this little-explored language. The methods and tools for building the game are detailed so that they can be replicated in other related projects. The results present the game's prototypes up to the final version, in addition to the performance and results of usability tests to improve the game and performance tests to evaluate the user's learning curve.

Keywords: Educational Games, Libras, Learning, Social inclusion

1 Introduction

According to the Brazilian Institute of Geography and Statistics, the Brazilian deaf community is equivalent to approximately 5% of the country's population [IBGE, 2010]. Few hearing people care about breaking the communication barrier in social life and the same happens in the professional world. Society makes deaf people completely dependent on companions, taking away their freedom, autonomy, and equality [Silva, 2018].

The Brazilian Sign Language (Libras), a communication and expression resource originating from communities of deaf people in Brazil, emerged to reduce the communicative barrier between both deaf and deaf-hearing people, and even though it proved to be fundamental for the social coexistence of deaf people, it is not widespread in society [Schlunzen *et al*., 2012].

A survey collected statements from deaf people regarding access to services and public places, where they revealed that they perform simple tasks without a companion using resources such as mimicry and facial expressions and giving preference to places where people are already accustomed to serving them. When it comes to more important matters, such as banking operations, medical appointments, and signing documents, they point out the need for a companion, configuring a limitation on their autonomy [Marin and Góes, 2006].

There is difficulty in entering the job market, due to employers' resistance to hiring deaf people, who often lose opportunities due to prejudice. Even after getting the job, they find it difficult to build relationships with hearing employees and understand the rules and dynamics of work, as there is no presence of interpreters in everyday work activities [Marin and Góes, 2006].

There is a clear need for training so that people can communicate effectively with deaf people for effective social inclusion. However, taking these professionals to a conventional classroom is not the best option for spreading Libras [Ramos and Almeida, 2017].

From the last century to the present day, when it comes to teaching-learning, one quickly imagines a classroom composed of an individual carrying knowledge, sharing verbally and textually for a group of students to memorize and repeat a set of rules and formulas to obtain approval.

This traditional mechanized method, in which everyone receives knowledge equally, does not take into account the student's learning particularities regarding which method makes it easier for them to understand, directly implying their motivation to dedicate themselves, reflecting negatively on their performance in the evaluations [Setúbal, 2010].

An alternative that emerged with the advancement of technology was educational games, which serve very well as a complement to traditional methods, as they change the pedagogical action traditionally used, presenting the content in a more didactic and fun way, moving away from the formality of the classroom. , can be a differentiator in gaining students' attention [Castro and Oliveira, 2016].

One of the tools used to apply these educational games in the digital environment is mobile devices, which are increasingly present in people's daily lives. In this scenario, the concept of *Mobile learning* emerges, which includes the use of mobile devices in the teaching-learning process, which makes the student's access to educational resources more flexible about time, as they have access at any time, and space since the student can study from anywhere [Sanches *et al*., 2020].

Motivated to propose a solution that contributes to the dissemination of Libras teaching, through active teaching methodologies, the project presents an educational game aimed at learning Libras.

2 Background

This section presents the theoretical basis necessary for the development of the project, highlighting the relevance of the topic to society.

2.1 Traditional teaching methods

The teaching-learning process is a complex system of behavioral interactions between teacher and student, which must occur in the best possible way, aiming at the student's high-level understanding of the content covered. It is up to the teacher to plan their classes and the student to be interested in past teachings, and what relates and aims to improve the efficiency of this process is the [Sá and Moura, 2008] teaching methodology.

According to [Traversini and Buaes, 2009], the study of teaching methodologies reveals them as "pedagogical practices operationalized through sets of school activities proposed by teachers, with a view to achieving the learning of certain knowledge, values and behaviors." These are resources developed to serve as a tool for the teaching-learning process carried out by the teacher, who in turn is responsible for deliberating the best alternative for each content.

In a world of constant evolution, educational institutions in Brazil are still mostly dominated by traditional methodology. Characterized as a passive teaching methodology, it occurs in such a way that the teacher transmits all the content verbally and textually through theoretical classes or practical activities restricted to the teaching location, leaving the responsibility for assimilating the knowledge passed on to the student, who will be subsequently evaluated through tests [Pereira *et al*., 2020].

This methodology, according to [Kruger, 2013], stands out negatively because it does not stimulate critical thinking and most of the time impedes students' initiative and creativity.[Weintraub *et al*., 2011] add that in this method there is low interaction between the student and the object studied, little promotion of reflection and they claim that the traditional method must be complemented by other methods, to become suitable for teaching.

An alternative to meeting the needs that traditional methodology leaves behind is the use of active methodologies, which makes the student the protagonist of their learning, encouraging them to analyze and verify solutions to their problems and encouraging decision-making. Examples of this type of methodology include problem-based learning, the flipped classroom, learning in groups, and also educational games, which is one of the fundamental bases for the development of this article, and is covered in subsection 2.2 [Backes *et al*., 2010].

2.2 Educational games

The game is a fun and productive activity that works the player's intellect and emotions and can be adopted as an important learning tool. Even though the game is a closed space with its own rules and without consequences in the outside world, the experiences lived by the player can reflect outside the game environment [Pereira *et al*., 2009].

Specifically, educational games are support tools that can be used to enhance the learning process. Educational games present a dynamic language that attracts the student's attention and implies that they associate the activity with a moment of leisure and not with tasks, placing them in a situation of little dispersion and a lot of concentration, an ideal scenario for absorbing knowledge [Pereira *et al*., 2009].

[Lara, 2003] reports in her book *Playing with Mathematics from 5th to 8th grade* the classification of educational games into 4 modalities: construction; training; of deepening; strategic. According to the author, construction games are those that deal with unknown subjects and allow the construction of learning, forcing the student to seek new knowledge to solve the questions in the game. Training games address subjects of the player's prior knowledge, and their practice exercises familiarization with the content. In-depth games are games that serve to apply content already studied in simulated situations. And strategy games are those in which decision making and strategic thinking are the main tools.

Even knowing that Lara's classification was developed for teaching mathematics, this classification is relevant to this project, since some of these concepts apply to the proposed game. The construction and training modalities directly apply to the Libras game by presenting signals to users who have never had contact with the language, providing the construction of learning and reinforcing the previously acquired knowledge of those who have already studied Libras, exercising familiarization with the language. content. As for the in-depth and strategy modalities, the application requires adaptations because of the linguistic nature of Libras, which differs from the mathematical challenges. This reflects a limitation in the application, as the current game does not address these modalities. Future work can explore ways to incorporate them, adapting their approaches to meet the needs of teaching Libras and provide a better learning experience.

[Santiago, 2020] deals with a study applied to the use of educational games in teaching multiplication tables, in which he used a Quiz-type game, a questionnaire game that aims to assess knowledge on a given subject, called [Santiago, 2020] *Playing with Ariê*, with 5th-year elementary school students. After a conventional expository class on the multiplication tables, an assessment was carried out. Subsequently, the students were exposed to the software in question and another assessment similar to the first was applied. The research results showed an improvement in 70% of students, with 20% obtaining maximum marks in both tests and 10% maintaining the number of correct answers.

Although Santiago's work is focused on teaching multiplication tables, it was used as a basis for developing the game for teaching Libras, as both studies use Quiz-type games to facilitate learning. Santiago demonstrated that, after using Quiz *Playing with Ariê*, there was a significant improvement in student performance compared to a conventional expository class, and this evidence highlights the value of using quizzes as an educational tool. The evaluation of the effectiveness of this methodology applied to learning Libras is carried out in the learning tests section.

[Passerino, 1998] states that when using digital educational games in the teaching-learning process it is important

to take into account aspects beyond the content of the game and how it is applied, as there are factors essential to its efficiency, such as the age group of the target audience for example, which must be considered. The author states the need to evaluate the educational game, analyzing both software quality aspects and pedagogical aspects, to verify its contribution to teaching.

The scope of educational games has been constantly evolving over the years, especially after the COVID-19 pandemic, with the emergence of remote teaching applications. A recent research paper titled 'Identifying challenges for elementary school teachers in building digital games through a workshop' explores the possibility of creating educational games by teachers. The authors examine the use of a game-authoring tool aimed at non-programmers, namely GDevelop, by elementary school teachers, highlighting the challenges and skills encountered. The results showed that many teachers faced difficulties due to a lack of digital literacy and the complexity of the tool's settings, especially in understanding concepts within the tool, indicating a need for improved usability. The study also provides valuable recommendations for developing new tools tailored to this audience Souza and Prates [2024].

2.3 Brazilian Sign Language

The history of the emergence of the Brazilian Sign Language can be found in Paris, France, with the founding of the first public school for the deaf in 1760 [Estimado and Sofiato, 2019]. Initiated by Charles-Michel de l'Épée, an 18th-century French philanthropic educator known as the "Father of the Deaf", it was called the National Institute of Deaf-Mutes in Paris [Mori and Sander, 2015].

About a century later, Emperor D. Pedro II invited Ernest Huet, a deaf priest and professor at the National Institute for Deaf-Mutes in Paris, to come to Brazil and educate deaf children in the first school for the deaf in the country. , named the Imperial Institute of Deaf-Mutes, today the National Institute of Education for the Deaf – INES, founded in 1857 in Rio de Janeiro. From the mixture of French Sign Language - LSF, brought by Huet, with the signs that were already used among Brazilian deaf children, Brazilian Sign Language emerges, an important tool for social inclusion officially recognized by law in 2002 [Strobel, 2009].

As established in Law No. 10,436/2002: "Brazilian Sign Language - Libras is understood as the form of communication and expression in which the linguistic system of a visual-motor nature, with its own grammatical structure, constitutes a linguistic system for transmitting ideas and facts, coming from communities of deaf people in Brazil" [Brasil, 2002].

According to the law reported, it is noted that Libras is a natural language like any other spoken language, but it differs in its modality, while languages use hearing and orality for communication, Sign Language is worked in a visual way. and spatial, so that the visual acts as the receiver of signals, while the spatial behaves as a transmitter, using signals, facial and body expressions [Schlunzen *et al*., 2012].

According to [Senado, 2021] the teaching of Libras has been increasingly widespread in the country due to the public policies adopted. Article 3 of Decree No. 5,626/2005, provides for the inclusion of Libras as a mandatory curricular subject in teacher training courses for teaching, at secondary and higher education levels and in Speech Therapy courses, and requires Libras as optional subject in other higher and professional education courses in the country [Brasil, 2005].

The dissemination of Libras is supported by items IV, XI, and XII of Art. 28 of Law No. 13.146/2015, the Brazilian Law of Inclusion of Persons with Disabilities, which respectively mandate: the provision of bilingual education in Libras as the first language and written Portuguese as the second language in bilingual and inclusive schools and classes; the training and availability of teachers for specialized educational services for translators and interpreters of Libras; and the offering of Libras teaching to enhance students' functional abilities, promoting their autonomy and participation.[Brasil, 2015].

A 2020 case that brought visibility to Libras occurred during the COVID-19 pandemic, an acute respiratory infection caused by the new coronavirus SARS-CoV-2, potentially serious, highly transmissible, and globally distributed, when Marília Mendonça, a singer Brazilian country music band, which is highly successful in the country, performed a live broadcast singing their songs to bring entertainment to the population facing this calamity. Although other singers had already performed these broadcasts, Marília was the first to worry about interpreting her show in Libras and the feat had a positive impact due to the social inclusion that the act caused and the surprise of the population when seeing Libras interpreters for entertainment purposes, who was accustomed to interpreters only for important communications, was amused by the facial and body expressions they performed to convey to the deaf community the same energy that a hearing person receives. This feat was extremely important for the inclusion of the deaf community in these events and to encourage other artists to bring interpreters to their broadcasts [Lorentz, 2020].

Igor Nascimento (2021), and the other authors, discuss in their article that digital games have proven to be effective tools in education; however, there is a scarcity of apps focused on early childhood education. Additionally, most educational materials available online use Libras signs predominant in the Southeast region, overlooking the linguistic variations of the Northeast. Just like in spoken language, Brazil, being a vast country, also presents regional differences in Libras. These dialectal variations reflect the cultural and linguistic diversity of the different regions of the country, making it important to develop educational materials that respect and incorporate these regional particularities [Nascimento *et al*., 2021].

It can be noted that public policies have brought educational advances to the deaf community, but for inclusion actually to occur, it is necessary to spread the teaching of Libras to the entire population. These mechanisms are efficient, but the deaf person's social interaction depends on the learning of the hearing person [Senado, 2021].

2.4 Related works

The most relevant existing related works are:

- Hand Talk is a company that provides digital accessibility by providing translation services for websites and applications from Portuguese to Brazilian Sign Language through the Hand Talk Plugin. Developer of the Hand Talk app: Translator for Libras, a free mobile application, with more than 1 million downloads in the Play Store app store. Awarded worldwide, it helps in learning and translating Libras through animated characters that perform signs on the screen using Artificial Intelligence to translate from Portuguese to Libras and from English to ASL - American Sign Language HandTalk [2022]. Hand Talk: Translator for Libras allows you to change the speed of the character's signals, customize it with clothes, accessories and background. It allows translation by voice command, has a dictionary divided into themes to serve as a study and offers explanatory video classes on specific themes and situations such as "Restaurant Signs", Musical Instrument Signs", "School Material Signs", where the Classes are entirely in Libras with subtitles in Portuguese HandTalk [2022].
- Quiz de Libras is a free question and answer game, developed by CE Produções that helps the user learn fingerwriting, a system for representing the letters of the alphabet using the hands, in the Brazilian Sign Language. The App works in two categories, with the question in typing and the answer in Portuguese and vice versa Francisco and Castro Júnior [2023]. After choosing the category, the game presents a list of themes such as objects, names, animals, among others, for the user to choose from. Each theme has a series of levels that the player advances by completing the current level. When starting, the game presents the word and 4 alternatives for the player to select the correct option before the time limit runs out. The game offers 4 items as a form of help, namely: "50:50" which excludes 2 alternatives (loses 4 coins); "Skip question" goes to the next question without losing points (lose 2 coins); "Public poll" which shows the percentage of other users choosing each alternative (lose 4 coins); "Reset Timer" which restarts the timer if you need more time (loses 2 coins). These coins are earned by watching commercials within the app. When completing the level, the game displays your percentage of correct answers, the number of points acquired and provides the option to review the answers, to show the correct alternatives for questions answered incorrectly. The game features a tutorial that explains how it works and has a ranking, which classifies users based on their points acquired Francisco and Castro Júnior [2023].
- A de Libras is a Quiz-type game developed by students from the Federal Institute of Paraíba IFPB - Campus João Pessoa, for teaching Brazilian Sign Language. This work uses short videos of translators of Libras interpreters, performing language signs as questions, through the use of GIF - Graphics Interchange Format, an image format that allows animations to be reproduced. The game offers 4 alternatives, only one of which corresponds to the signal shown by the interpreter. The game operates in two areas of knowledge: Introduction to Libras, where basic signs are dealt with: greetings, numbers, among others and offers an area for knowledge in Biology AdeLibras [2022].

Table 1 shows the differences and innovations that the project brings, about existing work.

Related works	Hand Talk	A de Libras	Quiz de Libras	Guess ensino
Mobile application	■	■	■	■
Educational game		■	■	■
Libras theory				■
Libras fingerwriting	■		■	■
Libras signs	■	■		■
Libras dictionary	■			
Performance analysis			■	■
Error pointing		■	■	■
Gradual levels			■	■
Tutorial		■	■	■

Table 1. Comparison of related works

To detail the functionalities of each criterion used in Table 1 when comparing related works:

- Mobile application: software designed to be installed on a mobile electronic device such as a cell phone, smartphone, tablet;
- Educational game: games designed to teach and test knowledge on a given subject;
- Libras theory: covers theoretical topics that will contribute to understanding the importance of this language;
- Libras fingerwriting: brings the manual alphabet, treats the signs of letters and numbers with your hands;
- Libras signs: treats the signs in Libras of Portuguese words;
- Libras dictionary: refers to a dictionary with words from Portuguese to Libras;
- Performance analysis: evaluates the player's performance in terms of his knowledge;
- Error pointing: informs the player of errors made in the game;
- Gradual levels: offers game levels that add difficulty when passing the level;
- Tutorial: explains how to play the game step-by-step.

3 Materials and methods

This section presents the proposed methods for developing this software and the tools and technologies that were used in the project.

3.1 Methods

3.1.1 Kanban

Kanban is a factory floor control system, responsible for transmitting production information to interconnected workstations about how it should be done, how much should be done, and when it should be done [Moura, 2003].

According to [Espinha, 2022], Kanban is an agile task management method, responsible for organizing the workflow into columns and cards, so that the entire team can view

the project from start to finish and can change the status of the task accordingly. current needs.

Composed of three main elements, the cards represent the tasks and activities within a project, where it is possible to define priority levels for the tasks and classify them by person responsible, by type of activity, or any other classification that meets the user's needs. The columns represent the different states of a task during the development process, the cards must be moved between the states until the last column of the board, mostly represented by the completion of the task. The Kanban board is the structure that will hold all columns and cards [Espinha, 2022].

3.1.2 Prototyping

Prototyping is a way of visualizing ideas, taking them from the abstract world to the material world. Prototyping details the project's functionalities and allows you to simulate the user experience before even starting development. Widely used for facilitating communication, whether between team areas or with the client and for collecting *feedback* and suggestions that add to the client's experience, which will not have surprises at the end of the project, thus avoiding wasted time and work caused by communication failures [Piazza, 2021].

When developing mobile applications, the interface is one of the most important factors for the success of applications, and adopting a development method that emphasizes this stage is essential. Prototyping helps in the development of these applications by allowing the evaluation of the software from the initial phases, adding requirements gathering and fault detection with a general view of the application at all times. It guarantees greater customer involvement, which increases their confidence and expectations with the project [Santos *et al*., 2018].

In this project, the Evolutionary Prototyping Model is used, which consists of a cycle of steps where the prototype is submitted until the final result is achieved, illustrated in Figure 1.

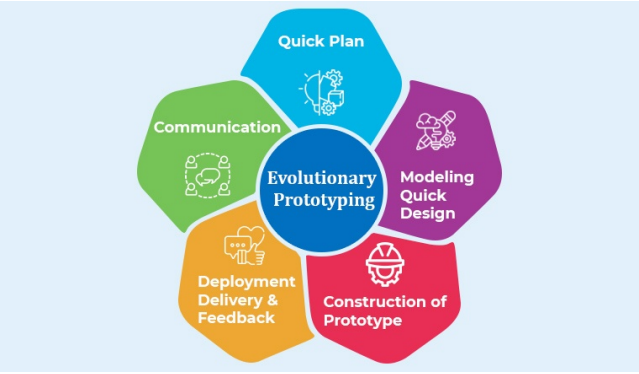

Figure 1. Evolutionary Prototyping Model
[Sharma, 2022]

According to [Gatto, 2017], the stages of the Evolutionary Prototyping Model can be described as:

- Communication: Team meeting for defining objectives and gathering requirements;
- Quick Plan: Planning prototyping interactions for modeling;
- Modeling Quick Design: Representation of the software aspects that will be visible to the user;
- Construction of prototype: Actual construction of the prototype;
- Deployment, Delivery, and Feedback: Delivery of the prototype to the involved teams for evaluation, and the feedback is used to refine the requirements;

3.2 Software Testing

Software testing is the process of running a product to determine whether it meets all imposed specifications and functions properly in the environment for which it was designed. Its purpose is to reveal failures in the application to determine the cause of these failures and correct them before final delivery [Neto, 2006].

The author [Neto, 2006] classifies the testing stage as a process of a "destructive" nature within development activities, since its applicability can delay the delivery of the application, but on the other hand, it is essential for the success of the project, as delivering a project with defects is far from ideal.

Software testing, within a wide variety of types, is responsible for finding defects: an act committed by an individual when trying to understand certain information, using a method or tool, such as an incorrect command. Errors: a concrete manifestation of a defect in the software, for example, when a value obtained is different from what was expected. And the failures: which is the behavior of the software different from what was expected, but in this case for the user [IEEE, 1990].

Among the already consolidated software tests, usability testing is used for this project to focus on interface interactions, one of the main steps for a successful mobile application.

3.2.1 Usability testing

"Usability testing is a research technique used to evaluate a product or service. Tests are carried out with users representative of the target audience. Each participant tries to perform typical tasks while the analyst observes, listens, and takes notes" [Volpato, 2014].

It is a technique for evaluating a product or service, be it a *site* or application, which generally consists of a task script and an analyst observing usage. It is used to observe the use of a product and investigate issues involving navigation and understanding the [Volpato, 2014] interface.

In this application, usability testing was used in two forms: Problem Discovery and Learning Testing.

Problem discovery usability testing aims to evaluate and discover problems in both usability and the general functioning of the application and make improvements to the platform, providing a better user experience. Carried out by exposing the application to the target audience and processing the feedback received regarding the problems encountered [Woebcken, 2021].

Usability tests, for the most part, evaluate first-time use of the application, where the results describe the initial use of the application, rather than use over time. The learning test is used when asking participants to perform the same tasks repeatedly in a study, allowing the learning curve to be quantified. In this type of test, the interest is in performance data, such as the level of knowledge acquired, rather than initial impressions and problem discovery [Woebcken, 2021].

3.3 Tools and technologies

In this section, the tools and technologies used in this project are explored. Each tool was selected based on specific criteria to improve application efficiency and compatibility. Unity, in addition to being an excellent development platform, was chosen due to the authors' experience gained in previous projects. Microsoft Visual Studio was selected for its integration with Unity, ensuring performance and simplified processes. Axure RP, one of the main prototyping tools in existence, was essential for designing the project's interfaces. Finally, Trello was adopted due to its effectiveness in applying the Kanban methodology, facilitating project management and task organization. These tools contributed to a cohesive and productive development environment, allowing the project's objectives to be achieved.

3.3.1 Unity

Unity is a *game engine* platform, a set of libraries capable of bringing together and building all the elements of a game in real-time, created by Unity Technologies for game development. Responsible for more than 50% of the games already created in the world, the tool stands out for enabling the development of 2D and 3D games, with different styles of mechanics, and graphics, among other actions, whether for mobile devices, video games, computers, and even virtual reality devices.

The tool uses the C# programming language, an object- and component-oriented programming language, developed by Microsoft. In its free form, it includes many of its functionalities and is available to any user or company, including for royalty-free commercialization, as long as they do not exceed annual gross revenue of 100,000 dollars [Technologies, 2022b].

The company relies on the Unity Asset Store, a growing library of assets created and published by Unity Technologies and community members. It includes several resources such as textures, animations, audio, and tutorials, including some free ones, which make the development of small and medium-sized projects even easier [Technologies, 2022a].

3.3.2 Microsoft Visual Studio

Microsoft Visual Studio is an integrated development environment, created by Microsoft, widely used for building high-performance software for multiplatform Web, Desktop, and Mobile projects [Microsoft, 2022].

The IDE has some tools specific to Unity that include a set of features that enhance writing and debugging projects, providing documentation that ranges from Visual Studio configuration to information about written code, and IntelliSense code completion, among others. These tools are available for free and support Visual Studio 2017 and newer [Microsoft, 2021].

3.3.3 Axure RP

Axure RP is a quick tool for creating diagrams, wireframes, prototypes, and specifications for websites. With a low learning curve, the software stands out mainly for connecting to other tools and services to enable team collaboration, for having interaction events, which allows the use of mouse, keyboard, and touch events to trigger interactions, and has conditional logic that allows the addition of conditions and variables to the [Axure, 2022] prototype.

Although we do not offer a free version for everyone, the PRO version of Axure RP 10 is available to students and teachers upon request on the product website.

This tool was used in this work to develop the initial prototypes of the application, which are described in section 5.

3.3.4 Trello

Trello is an activity management tool in lists that can be adjusted according to the project's needs. The tool uses boards, lists, and cards to obtain a clear view of the project as a whole. The tool ranges from individuals managing personal projects to large projects and teams [Junior *et al*., 2019].

The tool stands out for being cloud-based, so an internet connection is enough to have full access to managing your projects, without the need to install software. It attracts users by using the ideas of the Kanban system, through boards that contain lists that represent statuses, and cards that contain tasks that are passed from one list to another, to represent their progress [Trello, 2022].

In this research, the tool was used to apply concepts from the Kanban method, explained in subsubsection 3.1.1, so that it organizes and manages the activities defined for the development of this monograph and application from its beginning to the final result.

4 The game

The game was proposed to be accessible and useful for anyone interested in learning Libras, even without prior knowledge of the language. Its context of use ranges from lay individuals to educational environments, such as schools, where it can serve as a dynamic tool to introduce or improve Libras skills among young people and adults.

The choice of the Quiz type for the game was motivated by the effectiveness of this method as an educational tool and by similar approaches, such as that found in Santiago's work, which provide an interactive and dynamic environment for learning. The definition of all Libras content that the game addresses and the representation of words with signs through GIFs were carried out with the support of a language specialist, professor of Brazilian Sign Language Débora Dias, from the Federal Technological University from Paraná, Cornélio Procópio.

This section presents some game screens with content in Portuguese, as the game does not allow the selection of another language. Therefore, explanatory texts were added regarding the content of some figures.

The game takes place through questions prepared in 3 formats: text; typing; GIF. As shown in Figure 2, the questions in text, (a), explore theoretical subjects of Libras such as the meaning of the acronym, data on its origin, among others. The typing questions, (b), cover the entire alphabet of the language and the numerals, essential introductory signs for learning the language, and the GIFs, (c), cover words and expressions. For the 3 types of questions, the player is presented with 4 alternatives, where only one represents the correct alternative.

English description Figure 2: Screens “a”, “b” and “c” show the total of rights and wrongs and the number of question. At scream “c”, for example, the player has to choose the right answer to the image and the options being “SORRY”, “PLEASE”, “THANK YOU” and “EXCUSE ME”.

(a) (b) (c)

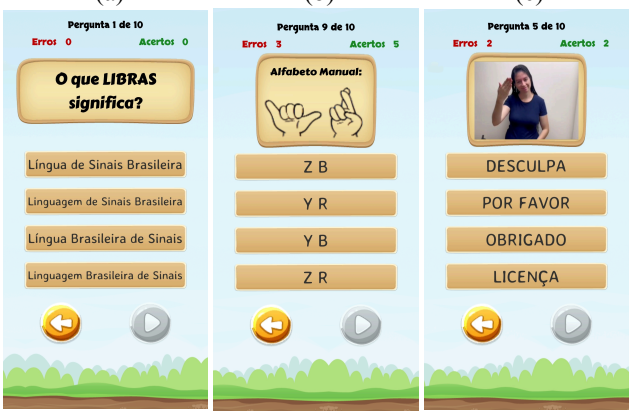

Figure 2. Play screen in different formats

4.1 Game levels

The game was structured into 9 levels, containing 10 questions each, which were judged sufficient to cover the main aspects of Brazilian Sign Language. Level selection is represented in Figure 3. This quantity was determined based on the teaching material used as reference, material prepared by teacher Débora and used in the Libras 1 discipline. The progression of levels was planned to start with basic concepts and gradually progress to more advanced topics, aligning with the order didactics established by the specialist teacher. This approach ensured a natural progression of difficulty, allowing players to gradually acquire knowledge throughout the game.

- Level 1 of the game is responsible for presenting questions in text, to introduce concepts and inform players of important information about the language.
- Levels 2, 3, and 4 of the game include typing questions, enabling the user to learn the entire alphabet and numbers.
- Level 5 of the game deals with names written in typing, to exercise the alphabet learned in levels 2 and 3.
- From level 6 onwards, the game addresses Libras signs, starting with the basics and gradually advancing as the levels increase.

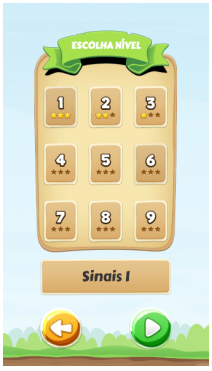

Figure 3. Choose level screen

4.2 Mechanics

The game has a simple and unique mechanic, where the user needs to select the alternative they believe to be correct with a ”tap on the screen” and confirm the choice, then they will receive *feedback*: with green in the alternative correct and red for the other alternatives, allowing the player to learn from his mistake, as shown in Figure 4.

English description Figure 4: In this screen, the question is “What does LIBRAS means?

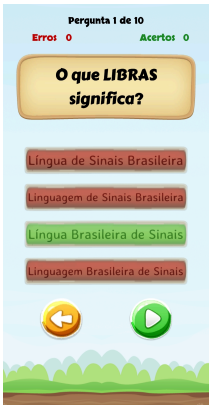

Figure 4. Play Screen

4.3 Rewards

The game has a star system, which rewards the player based on their hit percentage when finishing the level in question. The rules define the rewards and are valid for all game levels:

- If the player reaches 90% or more, he will receive 3 stars as a reward, maximum reward reached;
- If the player achieves 60% to 89% accuracy, he will receive 2 stars, representing an average performance;
- If the player achieves 10% to 59% accuracy, they will receive 1 star, a result of low performance at the level;
- If the player’s success rate is less than 10%, he will not receive stars.

Figure 5 shows an example of a possible game outcome. English description Figure 5: The “Results Screen” shows the total that the player guessed right: “You guessed 7 out of 10 questions.”.

Figure 5. Results screen

5 Results

This section presents the results of the work, showing the evolution of the prototypes, the tests applied, and their improvements.

5.1 Prototypes

In this section, the concepts of the evolutionary prototyping model seen in subsubsection 3.1.2 are applied, making a comparison from the initial prototype to the final version of all screens of the application.

Figure 6 presents the prototypes of the interface that the user will find when opening the application, called the Home screen. In the initial prototype, (a), the screen has an area for the project logo and 4 buttons: ”play”, ”tutorial”, ”article” and ”about” where each of them has the function of directing the user to specific screens that are described throughout this section, and a button to close the application.

Note, in (b), the evolution of the initial prototype, where textures and images were inserted into the application and one of the button names was changed, from ”article” to ”study”, to make it a more intuitive button function.

In (c), the final version of this screen, the application logo was changed enhanced aesthetically in the application and a new ”reset points” button was also inserted, to give the user the option to start the game from the beginning, removing all previously acquired points, if you want to test your knowledge again.

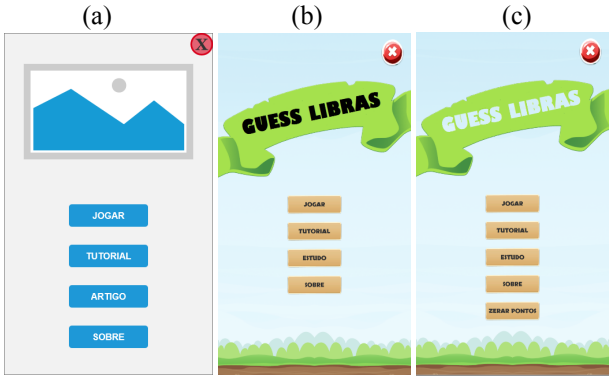

Figure 6. Home screen prototypes

Figure 7 presents the prototypes of the Study screen, responsible for directing the user to the PDF file, which deals with the contents that will be covered in the game, in a theoretical way. In the initial prototype, (a), the screen contains a space for an image that represents the document, along with a link address and a button to return to the Home screen.

In (b), the evolution of the prototype can be seen, which has an image taken from the cover of the document in question and the name of the author, in addition to the local city and a button titled ”pounds 1” which gives access to the file.

In the final version, (c), the logo of the Ministry of Education and UTFPR was inserted,along with some additional information, transmitindo credibilidade e confiança aos usuários no contexto educacional, and presents the figure of an interpreter performing the sign for the word Libras, para representar o matérial que será acessado pelo botão, agora chamado ”clique aqui”, alteração proporcionada pelo feedback no teste de descoberta de problemas.

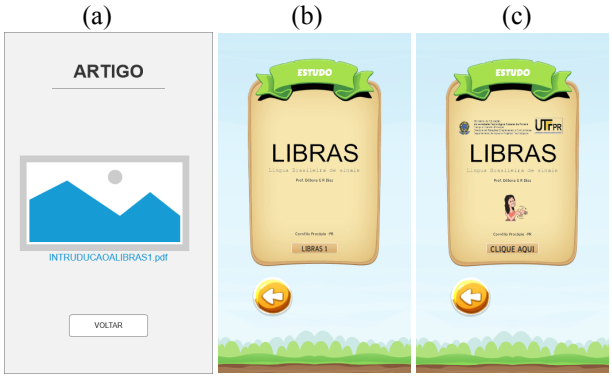

Figure 7. Study screen prototypes

Figure 8 displays the Tutorial screen, which provides a brief explanation of how to play the game. In the initial prototype, (a), the screen contains explanatory text and a button to return to the Home screen. For the final version, (b), textures were inserted and the text underwent small changes for better understanding to facilitate user comprehension.

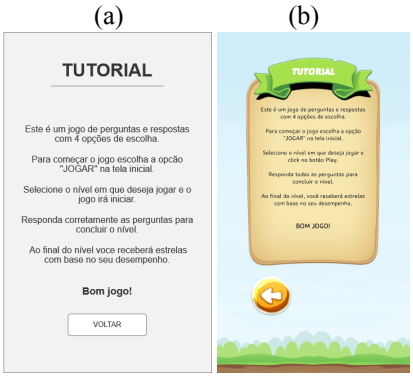

Figure 8. Tutorial screen prototypes

Figure 9 displays the About screen prototypes, with the developer's personal information and their motivation for carrying out the project. In the initial prototype, (a), the text is presented, along with a contact email and a button to return to the Home screen. For the final version, (b), as well as on the Tutorial screen, textures were inserted and the text underwent small changes.

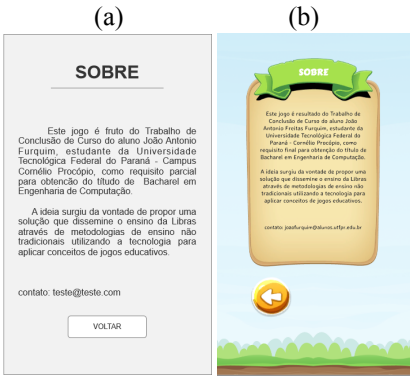

Figure 9. About screen prototypes

Figure 10 presents the prototypes of the Choose Level screen, the screen responsible for allowing the user to choose which level they want to play. In the initial prototype, (a), the available levels are presented for the user to select and immediately after choosing, they start the game and use the back button to return to the Home screen.

In the second version, (b), we can see the insertion of textures and images into the project, based on the initial prototype.

In the final version, (c), information on the user's result was added to each level through reward stars. If you have not yet completed the level in question, you will notice the stars turned off, this change greatly enhanced the application as it now allows tracking the player's progress in each level and also monitoring which levels have been completed or not. An informative menu was inserted that shows the theme of the selected level, which ensures that the user will access the level they really want by verifying the theme, and finally, a "play" button that must be pressed to start the game after the user selects the desired level, which prevents the user from accidentally clicking on a level they do not wish to start.

Figure 10. Choose Level screen prototypes

Figure 11 displays the prototypes of the Play screen, the game's main screen, responsible for displaying questions and alternatives to the user.

In (a), the initial prototype of the Play screen is presented, where the question with the 4 alternatives is displayed, the number of errors and correct answers by the user is also informed, which number of the questions the player is currently in and a back button to return to the Choose Level screen.

In the second version, (b), textures, images, and fonts are inserted into the project, using the initial prototype as a basis, where the back button was removed, as a forced attempt for the user to complete the level from start to finish.

In the latest version, (c), after some research and discussions with the evolution of the prototypes, the back button removed in the previous version returns to the prototype, to give the user free choice. A "next" button was also inserted so that, after answering the current question, the user clicks to go to the next question and another feature of the screen in question will be discussed next, in comparison to the removed screen, called review.

Figure 11. Play screen prototypes

Figure 12 displays the prototypes of the Result screen, the final screen of the game, responsible for showing the user their performance at each level.

In (a), the initial prototype of the Result screen is shown, where the user's percentage of correct answers on the level in question and the reward stars are displayed. The level in question also comprises the screen, two buttons, namely "review", which would take the user to the Review screen, which will be covered in Figure 13 and "return", which returns to the Choose screen Level.

In (b), the second version of the Result screen is shown, where the textures, images, and fonts are applied. The "review" button was removed and the "back" button was

changed to a ”menu” button that takes you to the Choose Level screen.

In the latest version, (c), an informative text is added, which describes how many questions the user got right, out of a total of 10 questions, ensuring the delivery of information about their performance, and the ”redo” button is inserted, which restarts the level in-question, if the user wishes, allowing the user to replay the level if they feel they did not perform well.

Figure 12. Result screen prototypes

Figure 13 displays the prototypes of the removed Review screen and the Play screen. The review screen was responsible for presenting the user with the correct alternative in green and the one they selected, if wrong, in red. With the evolution of the prototypes and the project, the screen in question was discarded and the gaming screen was responsible for performing the function in question.

In (a), the initial prototype of the Review screen is presented, which displays a prototype identical to the initial prototype of the play screen, however, with emphasis on alternatives to provide the user with learning through error.

In (b), the Play screen is displayed, performing the function that would be the Review screen, which is displayed immediately after the user selects an alternative, where the correct alternative is highlighted in green and the wrong alternatives are highlighted in red. This change was made so that the user wouldn't need to review all the questions at the end of the level on the Review screen. With the prototype's evolution, the user receives feedback on their answer immediately after responding to it on the Play screen.

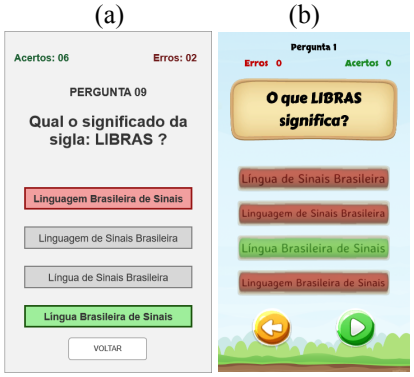

Figure 13. Review and Play screens prototypes

5.2 Usability testing

This section deals with the execution of the tests mentioned in subsubsection 3.2.1, the actions performed, and the results obtained.

For both types of tests, a sample of 10 people was used within the target audience of this application.

5.2.1 Problem discovery

To carry out this test, the first final version of the application was exposed to sampling. Participants downloaded the APK file, Android Application Pack, the standard file format used by the Android operating system for distributing and installing mobile applications, on their own devices. Each person used their personal cell phone, which included different models of devices with the Android operating system. The test allowed users to freely navigate through all of the game's features and screens. Subsequently, complete feedback was requested on their experience, with a focus on identifying problems and points for improvement in the application.

Next, an evaluation of the data received was carried out with the aim of evaluating the possibility of implementation, relevance and benefit of each problem and suggestion presented, prioritizing the changes that would bring the greatest improvement to the user experience.

The problems identified during this usability test, plus their severity classified as high, medium and low, are listed in the Table 2.

Screens	Problems	Severities
Home	Absence of confirmation when clicking the "Zerar Pontos" button	High
Play	Absence of indication of the total number of questions per level	Medium
Study	Images of logos outside the designated area	Medium
Study	Use of different fonts, colors and text sizes, confusing users	Low

Table 2. Identified problems

Among the problems identified, users highlighted the need to know not only which question was being displayed on the Play screen, but also how many questions made up the current level. This suggestion was received as a means of improving time management and offering a clearer view of progress in the game. Based on this feedback, a modification was made to the application to include the information ”Question 1 of 10”, allowing users to more easily assess the time needed to complete the level or decide when to return to the game.

Figure 14 presents an example of this modification, where the information ”Question 1” is changed to ”Question 1 of 10”.

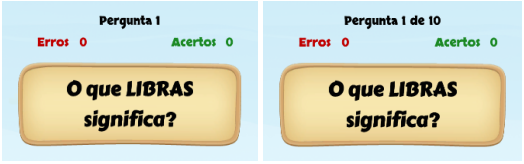

Figure 14. Play screen improvements

On the Study screen, two problems were identified during the development process. Firstly, it was observed that the logo images were positioned outside the designated area in the final version of the application, a problem that did not occur during the tests being carried out. This change was made to ensure adequate visual presentation.

Furthermore, a difficulty in understanding the way the texts were presented was identified. Differences in fonts, colors and text sizes were causing confusion in the transmission of information and making actions that should be intuitive difficult, such as identifying the PDF access button, originally named ”Libras 1”. In response to this feedback, some adjustments were made: the logos were readjusted to be within the designated area, and the font, size and position of the texts were standardized. In addition to changing the text of the ”Libras 1” button, it was replaced by ”Click here”, making the button’s function clearer and more intuitive for users.

Figure 15 exemplifies these modifications, illustrating how logos were relocated and improvements in textual presentation were implemented to improve usability and the overall user experience.

Figure 15. Study screen improvements

One last improvement was implemented on the Home screen, taking into account sampling feedback. It was observed that the ”Reset Points” button presented a usability problem, the absence of a confirmation before deleting all accumulated points from the game. This could result in the accidental loss of points due to an unintentional click or a click out of curiosity about the button’s functionality.

In response to this feedback, a confirmation pop-up has been added to the ”Reset Points” button. This modification aims to ensure that the user is confident in their decision when deleting their game process, providing an additional layer of security and preventing the unintentional loss of their points.

Figure 16 exemplifies this change, illustrating how the confirmation pop-up was integrated with the ”Reset Points” button on the Home screen.

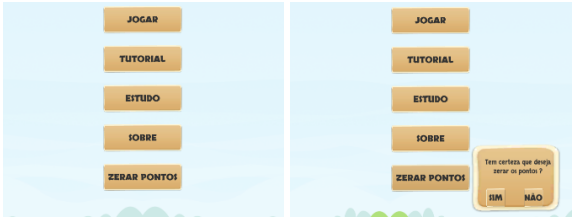

Figure 16. Home screen improvements

Tests to discover project problems followed an organized structure to ensure success in implementing the mentioned improvements. Initially, a representative sample participated in exploratory usability tests, offering general feedback about the application. Based on this feedback, problems and opportunities for improving the user experience were identified. Each improvement was then implemented and tested internally before being validated by the users who presented the problems. The results included screen adjustments, improvements to text readability and implementation of additional security measures, such as the confirmation pop-up for the ”Reset Points” button. These changes reflected an improvement in usability and the overall experience of the application.

5.2.2 Learning Test

Renata Pasinotto (2008) explores in her article ”Error in the teaching-learning process” the concept of learning through one’s own mistakes as an effective strategy in the educational context. The approach highlights that student errors should not be seen just as flaws to be corrected, but rather as valuable opportunities for learning and knowledge development. This method not only promotes greater autonomy and responsibility in the learning process, but also contributes to a more reflective and adaptive education, where errors are seen as a natural part of students’ intellectual growth [Pasinotto, 2008].

Learning curve is a mathematical representation of users’ performance when performing a task repeatedly. As users interact with the game’s phases several times, they begin to take less time to perform and make fewer mistakes, whether through the knowledge acquired with the game’s subjects, through adapting to its mechanisms or through discovering more efficient strategies. . By analyzing the data generated, it is possible to identify which activities have seen the greatest and least progress, points of ease and difficulty, and areas that require special attention. This approach allows users to evaluate their progress over time, helping them make decisions to improve learning effectiveness [Anzanello and Fogliatto, 2007].

To evaluate users’ learning, the sample was asked to complete each level of the game three times, sending their percentage of correct answers after each attempt, with intervals of one day between them. The collected data was then organized into a table, in order to analyze and obtain insights into the users’ learning level.

Table 3, Table 4 and Table 5 respectively present the sampling performance in terms of percentage of correct answers for each user at each level of the game during the first, second and third attempts.

	1	2	3	4	5	6	7	8	9
Alex	40%	40%	50%	60%	40%	30%	30%	50%	60%
Bruna	30%	30%	40%	70%	30%	40%	40%	50%	50%
Carla	20%	50%	50%	60%	30%	30%	50%	30%	30%
João	40%	30%	40%	60%	20%	20%	20%	40%	20%
Leonardo	30%	70%	70%	90%	80%	40%	60%	60%	50%
Lucas	30%	30%	60%	50%	40%	30%	40%	30%	20%
Matheus	50%	30%	40%	60%	30%	30%	20%	40%	50%
Pedro	30%	40%	40%	60%	20%	50%	30%	30%	30%
Tales	40%	60%	70%	80%	20%	50%	30%	50%	40%
Victor	20%	50%	60%	70%	50%	20%	60%	30%	40%

Table 3. Sampling performance on its first attempt

	1	2	3	4	5	6	7	8	9
Alex	60%	60%	60%	80%	60%	70%	30%	70%	80%
Bruna	50%	60%	60%	100%	40%	50%	80%	80%	70%
Carla	50%	70%	60%	90%	30%	70%	60%	80%	80%
João	50%	70%	50%	60%	30%	70%	50%	60%	70%
Leonardo	60%	80%	100%	100%	100%	80%	90%	90%	100%
Lucas	50%	60%	60%	60%	80%	40%	40%	70%	40%
Matheus	70%	60%	50%	70%	40%	40%	40%	70%	70%
Pedro	60%	60%	60%	90%	30%	80%	40%	80%	60%
Tales	50%	100%	100%	100%	60%	90%	70%	50%	40%
Victor	30%	70%	90%	80%	70%	30%	70%	40%	50%

Table 4. Sampling performance on its second attempt

	1	2	3	4	5	6	7	8	9
Alex	80%	90%	100%	100%	90%	100%	60%	100%	100%
Bruna	70%	100%	100%	100%	70%	80%	90%	100%	90%
Carla	100%	100%	100%	100%	70%	100%	100%	100%	100%
João	90%	100%	100%	90%	80%	100%	80%	90%	100%
Leonardo	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lucas	80%	90%	100%	90%	100%	80%	90%	90%	90%
Matheus	100%	90%	90%	100%	80%	70%	90%	100%	100%
Pedro	100%	80%	90%	100%	70%	100%	70%	100%	90%
Tales	90%	100%	100%	100%	100%	100%	100%	70%	80%
Victor	80%	100%	100%	100%	100%	70%	100%	70%	90%

Table 5. Sampling performance on its third attempt

Through data analysis, it was possible to identify the average percentage of correct answers for the sample in all disciplines and levels of the game. In the first attempt it was 42.44%, in the second attempt 64.67% and in the third attempt, the average sampling performance was 92.22%.

There is an average performance improvement of 22.22% from the first to the second sampling attempt, from the second to the third attempt an average of 27.56% was obtained, totaling an average improvement of 49.78

With the data exposed, it is possible to notice an improvement in the performance of users, who acquired knowledge about Libras through the error correction learning method. Although this study provided valuable insights into user performance, it is important to recognize its limitations. This evaluation focuses on game results only and does not include an external evaluation or comparison with other learning methods. Future studies could explore other evaluation methods for a more comprehensive assessment of the educational effectiveness of the application.

6 Conclusion

This article presented a mobile application for learning Libras, using an active teaching methodology, which places the student as an active subject of their learning. The application consists of a question-and-answer game to teach Libras signs in which the player is subjected to a series of questions with alternatives and their mistakes and successes are counted in which they will be evaluated regarding their knowledge of the language and rewarded with stars in the game, based on your number of hits.

The game offers everything from initial signs, such as the alphabet and numerals in typing, to words used in everyday life. It presents the theoretical contents of the language, to contextualize and transmit important information about the origin of Libras, and the rights of deaf people and uncover myths created about this community.

By carrying out the learning test, it was possible to observe that the game conveys knowledge about the topic covered, considering the universe evaluated. A significant performance improvement was noted for users who carried out the test using the error correction learning method, presenting a satisfactory result and making the application a viable alternative for learning Libras.

6.1 Future works

A valuable complement to the application is the extension of the content covered within the game. The current game has a limitation of topics covered, since Libras, like any other language, contain a multitude of words, therefore increasing the vocabulary covered will enrich the application.

Another implementation that would increase the game's functionalities is the creation of an online score table, where users can compare their performances and be rewarded, to further encourage learning through competitiveness.

To increase the reach of the application, in terms of reaching as many target audiences as possible, making the application available beyond the Android operating system is important. Although the system, according to [StatCounter, 2022], dominates the global market with 71.94% of users, making the application available for the two largest current operating systems is relevant.

The creation of other game mechanics in the application in order to make it more interactive for users, such as the use of a help button, where the user can use game "coins" to eliminate one or two wrong alternatives, to facilitate a question that is in doubt. The use of a timer to encourage the user's quick thinking when answering questions, either to reward users who respond in less time or to set a maximum time to answer each question. A button to skip a question, also using "coins" from the game to advance without losing points, adding even more to the gamification of the application.

Finally, in addition to the improvements mentioned, an important aspect of the continuous evolution of the application is the incorporation of user feedback. Collecting and analyzing user feedback can provide valuable insights into areas in need of improvement. For example, by identifying recurring patterns in suggestions regarding the lack of diversity of topics covered in the application, it is possible to adjust the level of difficulty of the questions and add new topics of interest. Furthermore, implementing the feedback system within the game itself is of great value for the evolution of the software, as it facilitates this information collection, allowing users to

report their experiences directly. This process improves the player's experience and strengthens the relationship with the user community. User feedback, therefore, is not only an evaluation tool, as was used in testing this application, but also a guideline for the future development of the application, ensuring that it remains relevant and effective in teaching Libras.

Declarations

Acknowledgements

We thank UTFPR for the academic support to carry out this project and for the financial support to present the article at SBGames 2023. We also thank the SBGames 2023 reviewers for the award for best complete article in the education track.

Authors' Contributions

JF was the creator of the project and contributed to the discovery and implementation of the requirements, as well as writing the text. FB guided JF during the project execution process, collaborated with writing the article and presented the article on SBGames. DD collaborated with the creation of the game's avatars, as a Libras teacher at UTFPR.

References

AdeLibras (2022). Adelibras: Aprenda libras brincando. Play Store. https://abrir.link/JdgzU Access on 24 December 2024.

Anzanello, M. J. and Fogliatto, F. S. (2007). Curvas de aprendizado: estado da arte e perspectivas de pesquisa. *Gestão Produção*, 14(1):109–123. DOI: https://doi.org/10.1590/S0104-530X2007000100010.

Axure (2022). Interações infinitas, poder ilimitado. https://www.axure.com/. Access on 24 December 2024.

Backes, D. S., Marinho, M., Costenaro, R. S., Nunes, S., and Rupolo, I. (2010). Repensando o ser enfermeiro docente na perspectiva do pensamento complexo. *Revista Brasileira de Enfermagem*, 63(3):421–426. DOI: https://doi.org/10.1590/S0034-71672010000300012.

Brasil, P. D. R. C. C. (2002). Lei nº 10.436, de 24 de abril de 2002. *Planalto do Governo Brasileiro*, page 1. https://abrir.link/jFdQf. Access on 24 December 2024.

Brasil, P. D. R. C. C. (2005). Decreto nº 5.626, de 22 de dezembro de 2005. *Planalto do Governo Brasileiro*, page 1. https://abrir.link/fXaNa. Access on 24 December 2024.

Brasil, P. D. R. C. C. (2015). Lei nº 13.146, de 6 de julho de 2015. *Planalto do Governo Brasileiro*. https://abrir.link/UBr01. Access on 24 December 2024.

Castro, M. P. D. and Oliveira, M. R. F. D. (2016). Os jogos como metodologia de ensino e aprendizagem com alunos da sala de recursos multifuncional tipo i: Multiplicação dos números naturais. *Universidade Estadual de Londrina - UEL*, 1:22. https://abrir.link/HRNmX. Access on 24 December 2024.

Espinha, R. G. (2022). Quadro kanban: 7 modelos para você se inspirar. https://artia.com/blog/quadro-kanban-modelos/. Access on 24 December 2024.

Estimado, R. B. and Sofiato, C. G. (2019). A educação de surdos e cegos na frança e no brasil. *Revista Educação Especial*, 32. DOI: https://doi.org/10.5902/1984686X33087.

Francisco, G. and Castro Júnior, G. (2023). Acessibilidade em libras nas áreas de saúde e biossegurança na forma de aplicativo. *Revista Communitas*, 7. DOI: https://doi.org/10.29327/268346.7.17-15.

Gatto, E. C. (2017). Modelos de processo de software. *Universidade Tecnológica Federal do Paraná - Cornélio Procópio UTFPR - CP*. https://pt.slideshare.net/elainececiliagatto/modelos-de-processo-de-software-parte-3. Access on 24 December 2024.

HandTalk (2022). Hand talk: Tradutor para libras. *Play Store*. https://www.handtalk.me/br/. Access on 24 December 2024.

IBGE (2010). Instituto brasileiro de geografia e estatística. https://www.ibge.gov.br/. Access on 24 December 2024.

IEEE (1990). Ieee standard glossary of software engineering terminology. https://ieeexplore.ieee.org/document/159342. Access on 24 December 2024.

Junior, E. F. Z. P., Schroeder, E. A., and Dolci, D. B. (2019). Limitações digitais, causas e consequências na efetividade do uso do site trello no planejamento estratégico de uma secretaria de educação a distância de uma universidade federal. *Revista de Educação a distância - Universidade Federal do Rio Grande*, 6(1):17. http://repositorio.furg.br/handle/1/7983 Access on 24 December 2024.

Kruger, L. M. (2013). Método tradicional e método construtivista de ensino no processo de aprendizagem. *UNIVERSIDADE FEDERAL DE SANTA CATARINA*, page 158. https://abrir.link/WJNnd Access on 24 December 2024.

Lara, I. C. M. D. (2003). *O jogo como estratégia de ensino de 5ª a 8ª série*. SBEM - Sociedade Brasileira de Educação Matemática, Univates - RS / FAPA – RS. https://abrir.link/vdkOQ Access on 24 December 2024.

Lorentz, G. B. (2020). Intérprete de libras da live de marília mendonça fala sobre repercussão após performance. *Globo*. https://abrir.link/NvOou. Access on 24 December 2024.

Marin, C. R. and Góes, M. C. R. d. (2006). A experiência de pessoas surdas em esferas de atividade do cotidiano. *Cadernos CEDES*, 26(69):231–249. DOI: https://doi.org/10.1590/S0101-32622006000200007.

Microsoft (2021). Ferramentas do visual studio para unity. https://abrir.link/lKoJl. Access on 24 December 2024.

Microsoft (2022). Bem-vindo ao ide do visual studio. https://abrir.link/QgorI. Access on 24 December 2024.

Mori, N. N. R. and Sander, R. E. (2015). História da educação dos surdos no brasil. *Universidade Estadual de Maringá - UEM*, page 16. https://abrir.link/xPIzq. Access on 24 December 2024.

Moura, R. A. (2003). *Kanban. A Simplicidade do Controle da Produção*. IMAM, São Paulo, SP, 7 edition.

Nascimento, I., Oliveira, A., Lima, J., Bezerra, L., and Filho, G. C. (2021). Um jogo para dispositivos móveis com o objetivo de auxiliar o ensino de libras e português. In *Anais Estendidos do XX Simpósio Brasileiro de Jogos e Entretenimento Digital*, pages 628–637, Porto Alegre, RS, Brasil. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2021.19697.

Neto, A. C. D. (2006). Introdução a testes de software. *Engenharia de Software Magazine. Edição 01*, page 7. https://abrir.link/GgZXv. Access on 24 December 2024.

Pasinotto, R. (2008). O erro no processo de ensino-aprendizagem. *Universidade Regional Integrada do Alto Uruguai e das Missões - Campus de Erechim*, page 35. https://abrir.link/aOPFJ. Access on 28 December 2024.

Passerino, L. M. (1998). Avaliação de jogos educativos computadorizados. *Taller Internacional de Software Educativo 98 (TISE'98), Santiago/Chile*.

Pereira, R. F., Fusinato, P. A., and Neves, M. C. D. (2009). Desenvolvendo um jogo de tabuleiro para o ensino de física. *VIIEnpec - Encontro Nacional de Pesquisa em Educação em Ciências*, page 23. https://abrir.link/ocsAX. Access on 24 December 2024.

Pereira, R. J. B., Azevedo, M. M. R., and Sousa, E. T. F. (2020). Método tradicional e estratégias lúdicas no ensino de biologia para alunos de escola rural do município de santarém - pa. *Revista Experiências em Ensino de Ciências*, 15(2):158. https://abrir.link/zoSCv. Access on 24 December 2024.

Piazza, L. (2021). Prototipação: o que é, quais são os tipos e 10 ferramentas. https://49educacao.com.br/startup/prototipacao/. Access on 24 December 2024.

Ramos, T. S. and Almeida, M. A. P. T. (2017). A importância do ensino de libras: Relevância para profissionais de saúde. *Revista de psicologia*, 10(33):11. DOI: https://doi.org/10.14295/idonline.v10i33.606.

Sanches, R. M. L., Batista, S. C. F., and Marcelino, V. D. S. (2020). Jogos educacionais para dispositivos móveis: seleção e avaliação por alunos da educação básica. *Congresso Internacional de Educação e Tecnologias*, 5(1). https://abrir.link/tjQxQ. Access on 29 December 2024.

Santiago, D. E. (2020). Estudo aplicado sobre o uso de jogos educativos no ensaio da tabuada. *Revista Lumen*. DOI: https://doi.org/10.32459/revistalumen.v5i9.122.

Santos, L. C., Neves, D. F., Filho, H. C. D. M., dos Santos Menezes, F., and Silva, L. F. S. D. (2018). Prototipação de aplicativos como método de aprendizagem na informática em saúde: Um relato de experiência. *Universidade Federal de Sergipe*. DOI: https://doi.org/10.5753/cbie.wie.2018.90.

Schlunzen, E. T. M., dos Santos Di Benedetto, L., and do Nascimento Santos, D. A. (2012). O que é LIBRAS? *Universidade Estadual Paulista - UNESP*, 11:4. https://abrir.link/Ioqcs. Access on 24 December 2024.

Senado, A. (2021). Obrigatoriedade da oferta de libras na educação básica passa na cdh. https://abrir.link/ivdpF. Access on 24 December 2024.

Setúbal, O. A. D. M. (2010). Resquícios da pedagogia tradicional na prática docente: um relato de experiências a partir do pibid ifto-campus palmas. *Instituto Federal do Tocantins - IFTO*, page 7. https://abrir.link/dEXHU. Access on 24 December 2024.

Sharma, I. (2022). What is software prototyping and its types. https://abrir.link/iAjXX. Access on 29 December 2024.

Silva, C. B. M. (2018). Os surdos no cotidiano: um público consumidor "invisível". https://blog.signumweb.com.br/curiosidades/os-surdos-publico-consumidor-invisivel/. Access on 24 December 2024.

Souza, J. G. R. D. and Prates, R. O. (2024). Identifying challenges for elementary school teachers in building digital games through a workshop. *Journal on Interactive Systems*, 15(1):13. DOI: https://doi.org/10.5753/jis.2024.3951.

StatCounter (2022). Mobile operating system market share worldwide. https://gs.statcounter.com/os-market-share/mobile/worldwide. Access on 24 December 2024.

Strobel, K. (2009). História da educação de surdos. *Universidade Federal de Santa Catarina - UFSC*, page 49. https://abrir.link/gcSDW. Access on 24 December 2024.

Sá, M. G. D. and Moura, G. L. (2008). A crítica discente e a reflexão docente. *Cadernos EBAPE BR*, 6(4):10. DOI: https://doi.org/10.1590/S1679-39512008000400009.

Technologies, U. (2022a). A loja da principal plataforma de criação de conteúdo em tempo real do mundo. https://assetstore.unity.com/. Access on 24 December 2024.

Technologies, U. (2022b). A principal plataforma de criação de conteúdo em tempo real do mundo. https://unity.com/pt. Access on 24 December 2024.

Traversini, C. S. and Buaes, C. S. (2009). Como discursos dominantes nos espaços daeducação atravessam práticas docentes? *Revista Portuguesa da Educação*, 22(2):18. DOI: https://doi.org/10.21814/rpe.13969.

Trello (2022). O trello facilita a gestão de projetos e tarefas para os times. https://trello.com/tour. Access on 24 December 2024.

Volpato, E. (2014). Teste de usabilidade: o que é e para que serve? https://abrir.link/NfCTP. Access on 29 December 2024.

Weintraub, M., Hawlitschek, P., and João, S. M. A. (2011). Jogo educacional sobre avaliação em fisioterapia: uma nova abordagem acadêmica. *Fisioterapia e Pesquisa*, 18(3):7. DOI: https://doi.org/10.1590/S1809-29502011000300014.

Woebcken, C. (2021). Entenda o que é teste de usabilidade, para que serve e como é feito. https://rockcontent.com/br/blog/teste-de-usabilidade/. Access on 29 December 2024.