



SpeakSnake: a serious game for teaching the pronunciation of Portuguese words

Lázaro S. Nascimento, UTFPR, laznas@alunos.utfpr.edu.br,  <https://orcid.org/0009-0005-3062-1347>

Otávio L. Hrubá, UTFPR, otaviohruba@alunos.utfpr.edu.br,  <https://orcid.org/0009-0008-0990-6091>

Maira B. Sanmartin, UTFPR, mairasanmartin@alunos.utfpr.edu.br,  <https://orcid.org/0009-0002-6694-1199>

Simone N. Matos, UTFPR, snasser@utfpr.edu.br,  <https://orcid.org/0000-0002-5362-2343>
Helyane B. Borges, UTFPR, helyane@utfpr.edu.br,  <https://orcid.org/0000-0002-9153-3819>

ABSTRACT. The advancement of digital technologies has enabled the development of serious games focused on inclusive education, particularly for students with intellectual disabilities. In this context, this paper presents *SpeakSnake*, a serious game designed to assist in teaching the pronunciation of Portuguese words. The game was implemented as a web-based application using speech recognition technology and covers three educational themes: sustainability, financial education, and healthy eating. The adopted methodology involved requirements gathering, game development, and evaluation with 25 students with mild and moderate intellectual disabilities from a special education school. The results showed that most of the words spoken and speech attempts were made by literate students; however, non-literate students also participated significantly, accounting for 43.9% of the words spoken and 40.4% of the attempts. Furthermore, 100% of the teachers positively evaluated the game's pedagogical suitability and accessibility, emphasizing the clarity of instructions, the relevance of the content, and its use in inclusive classrooms. These findings *SpeakSnake*'s a complementary tool for promoting literacy and speech development in inclusive educational contexts.

Keywords: serious game; intellectual disability; pronunciation; inclusive education, Portuguese.

SpeakSnake: um jogo sério para o ensino da pronúncia de palavras em Português

RESUMO. O avanço das tecnologias digitais possibilitou o desenvolvimento de jogos sérios voltados à educação inclusiva, especialmente para alunos com deficiência intelectual. Nesse contexto, este artigo apresenta o *SpeakSnake*, um jogo sério desenvolvido para auxiliar no ensino da pronúncia de palavras em português. O jogo foi implementado como um aplicativo web utilizando recursos de reconhecimento de fala e abrange três temas educacionais: sustentabilidade, educação financeira e alimentação saudável. A metodologia adotada envolveu o levantamento de requisitos, o desenvolvimento do jogo e a avaliação com 25 alunos com deficiência intelectual leve e moderada de uma escola de educação especial. Os resultados indicaram que a maioria das palavras pronunciadas e das tentativas de fala foi realizada por alunos alfabetizados; entretanto, os alunos não alfabetizados também participaram de forma significativa, representando 43,9% das palavras pronunciadas e 40,4% das tentativas. Além disso, 100% dos professores avaliaram positivamente a adequação pedagógica e a acessibilidade do jogo, destacando a clareza das instruções, a pertinência dos temas e o potencial de aplicação em sala de aula inclusiva. Esses resultados evidenciam o que o *SpeakSnake* é uma ferramenta complementar para o desenvolvimento da alfabetização e da pronúncia em contextos educacionais inclusivos.

Palavras-chave: jogos sérios, deficiência intelectual, pronúncia, educação inclusiva, Português.

1. Introduction

Serious games can be used as a learning resource, especially when combined with speech recognition. In the literature, the most frequently cited applications in language learning are Duolingo (2025), Babbel (2025), and Busuu (2025). These applications employ gamification elements, rewards, and progression features that stimulate student engagement throughout the learning process.

Duolingo, Babbel, and Busuu are applications designed for teaching foreign languages to individuals with no prior knowledge of the studied language. However, they do not offer specific features aimed at teaching the Portuguese language. A relevant aspect present in these applications is speech recognition, a technology that uses deep learning algorithms to convert human speech into text. This technology can be applied in several ways, such as automatic subtitle generation, voice typing, text-to-speech conversion, and interaction with virtual assistants (RELLA 2022).

Speech recognition allows users to convert pronunciation into text and transform textual input into audio, expanding its use across different contexts. An example is the TalkBack feature (2025), available on smartphones, which converts on-screen text into audio to assist people with visual impairments.

The speech recognition process consists of four main stages: spectrogram generation, use of an acoustic component, decoding, and scoring/capitalization (RELLA, 2022; SINGH *et al.*, 2023). An essential step for optimal performance is noise processing, which enables voice analysis and synthesis even in noisy environments with external interferences (NUNES; DUARTE, 2022).

It can be observed that this technology has been applied in different areas, such as in the rehabilitation of patients with speech difficulties and in educational settings for people with intellectual disabilities. In these contexts, it contributes to improving pronunciation, fluency, and conversational skills (DEBNATH *et al.*, 2023). Furthermore, it can be used in the literacy process to assist in evaluating reading fluency and word pronunciation during learning (FERREIRA *et al.*, 2022).

In this context, this paper presents the development of a serious game designed to support the practice of Portuguese language pronunciation through the use of speech recognition. Digital games purposes have proven to be effective pedagogical tools in supporting students with intellectual disabilities (NASCIMENTO *et al.*, 2024).

The proposed game, named SpeakSnake, uses the SpeechRecognition technology to enable speech recognition, similar to Duolingo, Babbel, and Busuu, but with a specific focus on teaching the Portuguese language. The game was developed as a website and implemented in an institution supported by a university extension project in southern Paraná, Brazil. The experiment involved 25 students distributed across four classes, all with mild or moderate intellectual disabilities, including both literate and illiterate participants.

2. Related Works

One of the relevant studies in the field of automatic speech recognition is by Debnath *et al.* (2023), who investigated the use of audiovisual speech recognition (AV-ASR) as a support tool for the education of people with physical disabilities. The study discusses the challenges related to accuracy in detecting lip movements in the visual modality and proposes an approach that combines appearance-based visual features with statistical co-occurrence measures, using the gray-level co-occurrence matrix (GLCM) and the local binary pattern in three orthogonal planes.

Another study worth mentioning is by Mao e Chen (2023), which proposed a solution aimed at addressing the needs of high school teachers and students regarding music examinations. With the inclusion of these exams in university entrance processes, the importance of music education has increased, creating a greater demand for tools that assist students in preparing for this type of assessment.

In addition to academic studies, it is important to mention well-established applications in the market that use speech recognition for language teaching, such as Duolingo (2025), Babbel (2025), and Busuu (2025). These platforms provide pronunciation and listening comprehension practice integrated with gamification strategies, rewards, and progression systems.

Table 1 presents a comparison among studies and applications related to the use of speech recognition. Three main aspects were considered: the platform on which each solution was implemented, the programming languages used, and the target audience. This analysis makes it possible to understand how different initiatives explore the technology in diverse contexts, ranging from specific academic proposals to adopted market applications.

Table 1 – Comparison between works and applications using speech recognition

Application	Platforms	Programming languages used	Target audience
[Mao <i>et al.</i> 2023]	Smartphones	Python, JavaScript, HTML, and CSS	High school students.
[Debnath <i>et al.</i> 2023]	Web browsers	C++, Python, and JavaScript	Educators and students with disabilities.
[Duolingo 2025]	Smartphones and web browsers	Python, Scala, Swift, Kotlin, JavaScript, HTML/CSS	All ages. Individuals interested in learning new languages.
[Babbel 2025]	Smartphones and web browsers	JavaScript, HTML/CSS, Python, Java	Adults. Focused on language learning for travel and business purposes.
[Busuu 2025]	Smartphones and web browsers	JavaScript, HTML/CSS, Java, Swift, Kotlin	All ages. Focused on language learning for social and practical use.
[Querida Floresta <i>et al.</i> 2023]	Web browsers	C#	Students with intellectual disabilities
[MemoLetrando <i>et al.</i> , 2024]	Web browsers	HTML/CSS; JavaScript	Students with intellectual disabilities

Other studies have also explored the use of serious games in inclusive education contexts. The game Querida Floresta applied machine learning techniques to analyze the interaction of students with intellectual disabilities, dynamically adapting the level of difficulty based on user performance (SILVA *et al.*, 2023). Similarly, MemoLetrando evaluated psychomotor and memory skills in students with intellectual disabilities through typing and memory activities using physical and virtual keyboards, contributing to the design of adaptive and accessible learning environments (PARIS *et al.*, 2024).

The analysis of Table 1 shows that, although there have been significant advances in the use of speech recognition in areas such as language learning and music education, a gap still exists regarding the teaching of the Portuguese language to students with intellectual disabilities. In this context, SpeakSnake emerges as proposal aimed at addressing this specific educational need.

3. Methodology

The methodology adopted in this study was organized into two complementary stages: the development of the game and the experiment conducted for its evaluation. This structure made it possible to understand both the technical aspects of implementation and the effectiveness of the game in pedagogical practice. Figure 1 provides an overview of these stages.

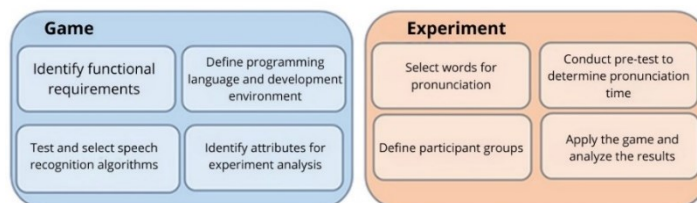


Figure 1 – Stages of the study methodology

As can be observed, the first stage focuses on the game development process, encompassing everything from the identification of requirements to the definition of mechanics and content. The second stage is related to the implementation of the game in an educational environment, involving students with intellectual disabilities and the collection of data for analysis. The two stages are described in the following descriptions.

3.1 Game

This section describes the development process of SpeakSnake. It considered the needs identified in the extension project, the selection of themes related to the Sustainable Development Goals (SDGs), and the definition of mechanics that distinguish SpeakSnake from the classic Snake game. This stage aimed to structure an accessible and motivating digital resource for students with intellectual disabilities.

3.1.1 Identify Functional Requirements

The initial stage consisted of identifying the needs and expectations for creating the game. The author's participation in an extension project over two and a half years made it possible to understand the specific characteristics of the students served—their limitations, difficulties, and abilities—which vary according to each student's level of intellectual disability.

This analysis revealed the need for a resource that could assist students in learning and practicing the pronunciation of Portuguese words. For this reason, it was decided that the themes addressed in the game would be the same as those developed in the extension project, which annually selects an educational focus aligned with one of the Sustainable Development Goals (SDGs) (UN, 2025). Three themes were chosen for the game: Sustainability, Financial Education, and Healthy Eating.

SpeakSnake was inspired by the classic Snake game, in which the player controls a snake on a grid board using directional keys. Items appear in random positions, and the objective is to collect them while avoiding collisions with the snake's own body, which grows with each collected item, gradually increasing the game's difficulty (WILSON; DEMARIA, 2004). The main difference between SpeakSnake and the original game lies in the additional mechanic introduced: when collecting an item, the player must correctly pronounce a word displayed on the screen, accompanied by its corresponding image. This strategy integrates the playful component with pronunciation practice, reinforcing the game's educational objective.

Figure 2 presents the game's flowchart, describing the actions performed during gameplay. It highlights the sequence of events—from item collection to the evaluation of word pronunciation—demonstrating how the speech recognition feature was incorporated in a pedagogical and interactive manner.

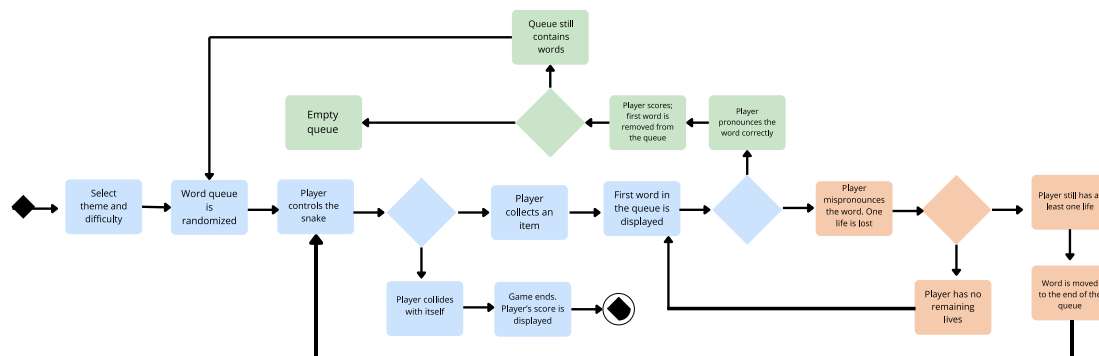


Figure 2 – Flowchart of the SpeakSnake game operation

3.1.2. Define Programming Languages and Development Environment

The application was developed as a website to facilitate student access, allowing the game to be run directly through a link without the need for installation on the computer. The programming languages were selected according to the system requirements, aiming to ensure integration among the different parts of the project and compatibility with the web browser.

Table 2 presents the programming languages used (HTML, CSS, JavaScript, and PHP) and their respective roles in the game's development, along with the tools that supported implementation and testing.

Table 2 – Programming languages and tools used in the development of the SpeakSnake game

Language	Purpose
HTML	Organize and structure the game screens.
CSS	Style the game screens.
JavaScript	Develop the algorithms that define the game's functionality and the transition between screens.
PHP	Handle data connection, sending, and receiving for the database.
Tool	Purpose
Visual Studio Code	Development environment used for programming and managing project files.
XAMPP	Application used to test database functionalities locally.
phpMyAdmin	Tool used for creating and managing the database.
SpeechRecognition	Speech recognition algorithm selected for the game.
Matplotlib	Tool used to generate the graphs presented in this work.

3.1.3 Test and Select Speech Recognition and Synthesis Algorithms

The selection of the speech recognition algorithm was a key aspect of SpeakSnake's development. The main criterion was to identify a solution capable of converting speech into text in a simple and accurate way, requiring minimal configuration from the user.

Three algorithms were tested: Google Speech-to-Text (2025), AssemblyAI (2025), and SpeechRecognition (SPEECHRECOGNITION, 2024a, 2024b). In this work, SpeechRecognition was chosen, as it is shown to be more suitable for the game context

and contains a native JavaScript function that runs directly in the browser without the need for additional installations.

Another factor influencing the choice of SpeechRecognition was the user experience: it only requires the student to grant microphone access during the first execution, making interaction simpler and more intuitive—an important consideration given the target audience of students with intellectual disabilities.

For speech synthesis, SpeechSynthesis (2025) was adopted, also native to JavaScript, as it provides clarity and naturalness in the generated pronunciation. This allows students to hear words clearly and have an appropriate model for imitation.

The combination of SpeechRecognition and SpeechSynthesis ensured that SpeakSnake offered two essential features: efficiently recognizing spoken words and providing immediate and clear feedback, allowing the game to serve as a pedagogical support tool for pronunciation teaching.

3.1.4 Identify Attributes for Experiment Analysis

The data collection performed by the game was designed to record information that would allow the evaluation of both student performance and system usability. The prior definition of attributes was essential to guide the analysis, enabling the identification of difficulties, the measurement of progress, and a more detailed understanding of how students interacted with SpeakSnake.

Table 3 presents the attributes collected during gameplay, specifying the name of each attribute, the type of data stored (integer, float, or boolean), its description, and the purpose of collection.

Table 3 – Attributes collected during gameplay and their purposes

Attribute	Type	Description	What it evaluates
Response time	Float	Time required to pronounce the word.	The player's speed in pronouncing the requested word.
Attempts	Integer	Number of attempts until success.	The player's difficulty in pronouncing the requested word.
Pronunciation	Boolean	Whether or not there was an attempt to pronounce the word.	Whether the player attempted to pronounce the word.
Listened again	Integer	How many times the user requested the word to be replayed.	The player's difficulty in understanding the requested word.

The defined attributes encompass aspects such as the number of attempts, response time, correct answers, errors, and word repetitions. These data allow the analysis the success rates of students' persistence in the face of mistakes and their progress throughout the sessions. Another relevant point is recording how many times students used the "listen again" feature, which may indicate greater difficulty in pronouncing certain words.

3.2 Experiment

The experiment aimed to evaluate the use of the SpeakSnake game in an educational environment, analyzing how students interacted with the proposed pronunciation challenges. To this end, several stages were defined detailed below.

3.2.1. Select Words for Pronunciation

The words used in the game were defined based on the content covered in the extension project classes between 2023 and 2024. For each selected theme, a list of fifteen

(15) words was created and distributed across two difficulty levels: easy and difficult. Since the game includes three themes — Healthy Eating, Financial Education, and Sustainability — and each has two levels, the total number of words used in the experiments was 90.

The classification of words by level was carried out in collaboration with teachers from the educational institution where the game was applied. The criteria considered included the number of syllables, articulation complexity, and word length. Short and simple-pronunciation words were placed in the easy level, while longer words or those with more complex phonetic structures were classified as difficult. Table 4 illustrates how the words from the Healthy Eating theme were distributed across the two difficulty levels, using nouns related to food. The same logic was applied to the selection of terms in the other themes, ensuring consistency in the construction of pronunciation challenges.

Table 4 – Examples of words by difficulty level – theme: healthy eating

Healthy Eating	
Easy Level	Difficult Level
Rice, Oats, Banana, Meat, Tea	Pineapple, Açaí, Acerola, Almond, Broccoli
Kale, Milk, Apple, Honey, Corn, Egg	Shrimp, Spinach, Guaraná, Jabuticaba
Bread, Fish, Salt, Tomato	Lentil, Pine Nut, Dragon Fruit, Okra, Pomegranate, Arugula

This categorization process was essential to balance the game's progression, allowing students with different skill levels to participate in the activities. Moreover, the thematic division made it possible to evaluate players' performance in different contexts, enriching the analysis of the results obtained during the experiments.

3.2.2 Conduct a pre-test to determine pronunciation time

To determine the average time required for a student to understand and pronounce a word, a pre-test was conducted. In this test, six words were selected—one easy and one difficult from each theme using words like: Cabbage, Jabuticaba, Goods, Investment, Water, and Agriculture.

The activity was carried out with eight students, and an audio recording captured the time from the display of each word to the completion of its pronunciation. It is important to note that some participants from the institution did not possess reading skills.

Based on the recordings, the average pronunciation time was calculated as 12.5 seconds. This value was rounded to 13 seconds and defined as the game's time limit (timeout). Thus, each player had up to 13 seconds to read, understand, and attempt to pronounce the word.

3.2.3 Define Participant Groups

Table 5 presents the participants of the experiment, identifying the class, period, number of literate and illiterate students, as well as the number of students with mild or moderate intellectual disabilities. The designation of each class was provided by the partner institution.

Table 5 – Experiment participants by class, literacy, and degree of disability

Class	Period	Students' literacy		Students' degree of disability	
		Yes	No	Mild	Moderate
C	Morning	1	5	2	4
D	Afternoon	0	8	0	8
E	Afternoon	6	1	6	1
F	Morning	4	0	1	3
Total		11	14	9	16

The experiment involved 25 students, 11 of whom were literate and 14 illiterates. Among them, 9 students had mild disabilities and 16 had moderate disabilities. These data were essential for characterizing the groups and understanding the profile of the participants involved in the game's application.

3.2.4 Apply the Game and Analyze the Results

The game was applied in an educational institution specialized in serving students with mild and moderate intellectual disabilities, all aged over 15. The experiments took place over four days, involving four classes, as shown in Table 5, totaling twenty-five participants.

For data analysis, two types of charts were used: bar and pie charts. These visualizations were designed to answer the questions defined in the analysis plan. For instance, the pie chart was used to identify the percentage of words pronounced by literate and illiterate students, as well as the percentage of attempts made.

4. Results

Figure 3 illustrates some of SpeakSnake's interfaces. Figure 3(a) illustrates the level interface and themes. Figure 3(b) illustrates the interface where the player will guide the snake until it reaches the object. Upon reaching the object, the pronunciation screen will be displayed as shown Figure 3(c).

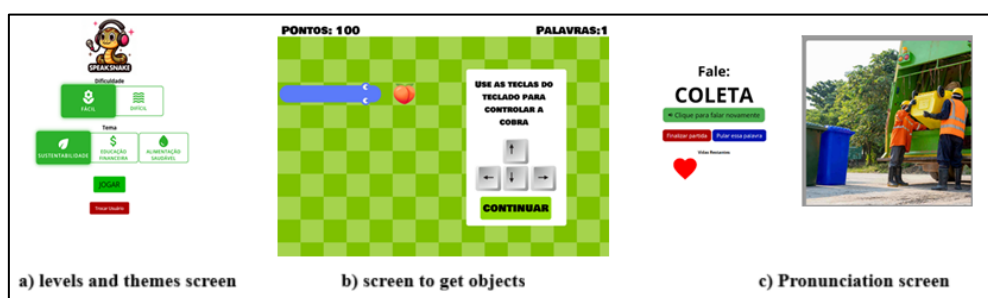


Figure 3- Examples of interfaces from the SpeakSnaker game

The analyses of the SpeakSnake game were conducted based on average scores, number of attempts, and number of words correctly pronounced by the students. The individual characteristics of each participant, such as literacy level and degree of disability, were also considered.

One of the aspects observed was the pronunciation attribute. In 100% of the cases, students attempted to pronounce the presented words, demonstrating that the game effectively stimulated speech practice. The number of attempts also proved to be a relevant indicator, as it reflected students' difficulty in understanding the words displayed and pronounced through speech synthesis. This allowed for a more accurate analysis of the challenges faced and helped identify potential improvements for the game.

During the application, all students initially played in easy mode to become familiar with the game's mechanics. The session ended when the snake collided with itself, signaling the end of the round. Table 6 presents the words with the highest success rate, addressing the question: "Which words have the highest success rate?"

Table 6 – Words with the highest success rates during gameplay

Word	Difficulty	Hits	Attempts	Success rate
Pineapple	Difficult	1	1	100%
Banknote	Difficult	2	2	100%
Expense	Difficult	1	1	100%
Donate	Easy	1	1	100%
Hybrid	Difficult	1	1	100%
Taxes	Difficult	1	1	100%
Investment	Difficult	1	1	100%
Plastic	Easy	1	1	100%
Advertising	Difficult	2	2	100%
Publicity	Difficult	1	1	100%

In Table 6, it can be observed that eight out of the ten words with the best performance belong to the difficult category. The success rate represents the proportion of attempts correctly recognized by the algorithm. When the rate reached 100%, it indicated that all pronunciations were considered correct. This pattern demonstrated that students were able to progress beyond the easy level and maintained satisfactory performance even with more complex words.

Table 7 presents the monosyllabic words with the highest number of attempts, reinforcing the difficulty encountered with this specific type of pronunciation.

Table 7 – Monosyllabic words with the highest number of pronunciation attempts

Word	Difficulty	Hits	Attempts	Success rate
Honey	1	7	12	58.3%
Bread	1	8	11	72.72%
Tea	1	5	11	45.45%
Salt	1	4	5	80%
Light	1	2	5	40%

The analysis of Table 7 revealed that the speech recognition algorithm had greater difficulty identifying monosyllabic words. This finding was based on both practical observation during the experiment and data analysis. While longer and more complex words were recognized with higher accuracy, monosyllables resulted in more errors and repetitions, indicating the need for future adjustments to the game.

The performance by class was also analyzed. Figure 4(a) shows the average number of words spoken per round for each class, addressing the question: “Which class had the highest and lowest average number of word pronunciations?”.

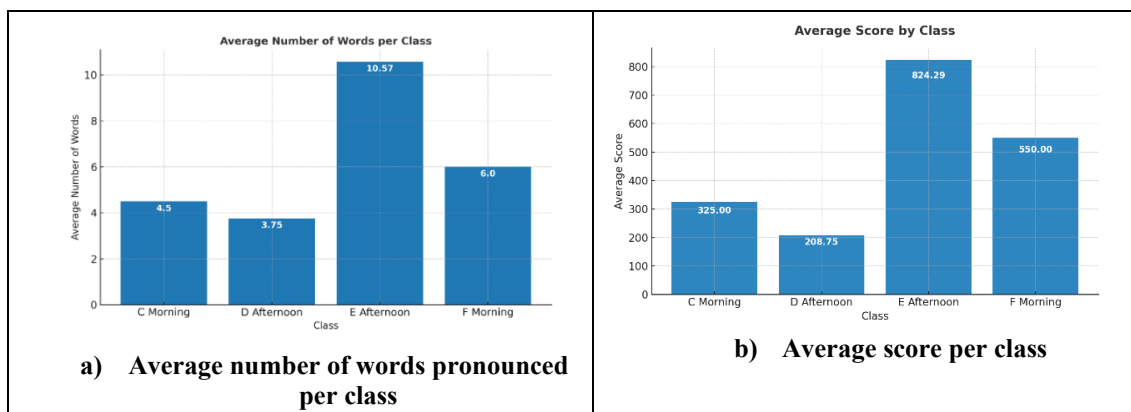


Figure 4 – Average number of words pronounced and per class

In Figure 4(a), it can be seen that Class E achieved the highest average number of words pronounced, which can be associated with the higher number of literate students and the predominance of mild disabilities in this group. Conversely, Classes C and D, composed mainly of illiterate students and those with moderate disabilities, showed the lowest averages. These results reinforce that literacy and the degree of disability directly influence student performance during the game.

Scores were also analyzed. Figure 4(b) illustrates the average score per round for each class, addressing the question: “Which class achieved the highest and lowest average scores?”.

The pattern observed in Figure 4(b) was similar to that in Figure 4(a). Class E once again stood out with the highest scores, reinforcing the relationship between greater ability to pronounce words and better game performance. Class F, composed of students with moderate disabilities, showed intermediate performance, which can be explained by the fact that all its members were literate, suggesting that literacy can partially mitigate the difficulties associated with the degree of disability.

Finally, Figure 5 presents the metrics of words pronounced and speech attempts by literacy level, addressing the question: “What percentage of words was pronounced by literate and illiterate students, and what was the percentage of attempts?”.

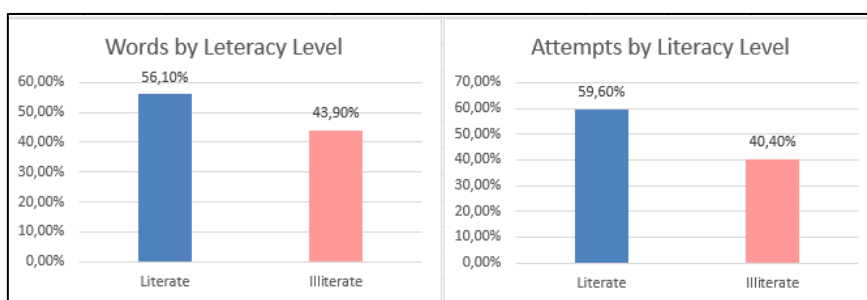


Figure 5 – Percentage of words and attempts by literacy level

Figure 5 shows that most of the words and attempts were made by literate students. However, illiterate students also participated significantly, accounting for 43.9% of the words spoken and 40.4% of the attempts. This result demonstrates that SpeakSnake successfully engaged both literate and illiterate students, reinforcing its inclusive nature as a tool to support Portuguese pronunciation practice.

5. Conclusion

The SpeakSnake game proved to be effective in engaging students, providing an interactive, engaging, and educational experience. The use of images corresponding to words was essential to facilitate understanding and increase participation, involving both literate and illiterate students. The analyses by word and by class revealed performance patterns that reinforce the importance of literacy for achieving better results. However, illiterate students also showed good performance, supported by the game's multimedia resources, such as a speech synthesis and images, which proved fundamental for inclusion.

The observations made during the application confirmed the students' motivation to overcome the challenges presented, highlighting the potential of the game as a pedagogical support tool. The study also revealed limitations, such as the algorithm's difficulty in recognizing monosyllabic words, pointing to opportunities for game improvement. These results provide a foundation for future research, which may include technical adjustments in speech recognition, vocabulary expansion, and application with different audiences. Thus, SpeakSnake can continue to evolve to meet the educational needs of people with intellectual disabilities, establishing itself as an inclusive resource for teaching Portuguese pronunciation.

References

ASSEMBLYAI. *Turn your voice data into transcripts with our leading Speech AI models*. Disponível em: <https://www.assemblyai.com>. Acesso em: 1 mar. 2024.

BABEL, B. *Aprenda um novo idioma de forma eficaz*. Disponível em: <https://www.babbel.com>. Acesso em: 27 mar. 2024.

BUSUU. *Plataforma de ensino de idiomas*. Disponível em: <https://www.busuu.com/>. Acesso em: 10 ago. 2025.

DEBNATH, S.; ROY, D.; PAL, S. *Gamified pronunciation training: an intelligent approach using speech recognition*. *Inter. J. of Art. Intelligence in Education*, v. 32, n. 1, p. 56–71, 2023.

DEBNATH, S. et al. *Audio-Visual Automatic Speech Recognition Towards Education for Disabilities*. *Journal of Autism and Developmental Disorders*, New York, jul. 2022, p. 1–15.

DUOLINGO. *Aplicativo de aprendizagem de idiomas*. Disponível em: <https://www.duolingo.com/>. Acesso em: 10 ago. 2025.

FERREIRA, A. L.; SILVA, C.; ASSIS, E.; SOUZA, J. *Avaliação de modelos para reconhecimento automático de fala aplicados para identificação da qualidade de leituras em voz alta de narrativas breves*. In: *SBIE*, p. 895–907, Porto Alegre, RS: SBC, 2022.

GOOGLE SPEECH RECOGNITION API. *Speech-to-Text overview*. Disponível em: <https://cloud.google.com/speech-to-text>. Acesso em: 8 ago. 2025.

MAO, X.; LI, T.; CHEN, Z. *Improving pronunciation learning through mobile serious games*. *Computers & Education*, v. 184, p. 104–145, 2023.

NASCIMENTO, A.; et al. *Adrie: um serious game imersivo para potencializar as habilidades cognitivas de pessoas com deficiência intelectual*. In: *Anais do XXXV Simpósio Brasileiro de Informática na Educação*, p. 2877–2886, Porto Alegre, RS: SBC, 2024.

NUNES, V.; DUARTE, J. *Avaliação de sistemas de reconhecimento de fala robustos a ruídos provenientes de maquinário da indústria do petróleo*. In: *Anais do XVI Brazilian e-Science Workshop*, p. 33–40, Porto Alegre, RS: SBC, 2022.

ONU. *Objetivos de desenvolvimento sustentável*. Disponível em: <https://brasil.un.org/pt-br/sdgs>. Acesso em: 8 jun. 2025.

PARIS, L. R. B.; CAMPOS, R. L. F.; NASCIMENTO, M. I. S.; TORRENS, I. C.; MATOS, S. N.; BORGES, H. B. *Aplicação do jogo MemoLetrando: um estudo de caso com pessoas deficientes intelectuais*. *Revista Novas Tecnologias na Educação – RENOTE*, Porto Alegre, v. 22, n. 1, jul. 2024.

RELLA, S. *What is Automatic Speech Recognition? NVIDIA Technical Blog*. Disponível em: <https://developer.nvidia.com/blog/what-is-automatic-speech-recognition/>. Acesso em: 27 mar. 2023.

SILVA, L. L.; MIZERSKI, H. J. C.; GUEIBER, E.; MATOS, S. N.; BORGES, H. B.; SANTOS JUNIOR, G. *Análise das atividades interativas de um jogo sério usando aprendizagem de máquina: um estudo para pessoas com deficiência intelectual*. *RENOTE*, Porto Alegre, v. 21, n. 1, p. 160–167, jul. 2023.

SINGH, A. et al. *An integrated model for text-to-text, image-to-text and audio-to-text conversions for Indian languages*. In: *2023 6th International Conference on Information Systems and Computer Networks (ISCON)*, Nova Délhi, Índia, p. 1–6, set. 2023. Disponível em: <https://ieeexplore.ieee.org/servlet/opac?punumber=10111836>. Acesso em: 25 maio 2023.

SPEECHRECOGNITION. *Using the Web Speech API*. Disponível em: <https://developer.mozilla.org/en-US/docs/Web/API/SpeechRecognition>. Acesso em: 1 mar. 2024a.

SPEECHRECOGNITION. *Using the Web Speech API*. Disponível em: <https://developer.mozilla.org/en-US/docs/Web/API/SpeechRecognition>. Acesso em: 1 mar. 2024b.

SPEECHSYNTHESIS. *SpeechSynthesis API*. Disponível em: <https://developer.mozilla.org/en-US/docs/Web/API/SpeechSynthesis>. Acesso em: 8 jun. 2025.

TALKBACK. *Ajuda da acessibilidade no Android*. Disponível em: <https://support.google.com/accessibility/android>. Acesso em: 26 abr. 2023.

WILSON, J. L.; DEMARIA, R. *High Score! The Illustrated History of Electronic Games*. New York: McGraw-Hill/Osborne, 2004.