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Master in Computer Science and Engineering

INVESTIGATING CHILD-GAME INTERACTION TOWARD IMPROVED ENGAGEMENT IN SERIOUS GAMES FOR SPEECH THERAPY

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”

“Children learn as they play. Most importantly, in play, children learn how to learn.”

— O. Fred Donaldson

ABSTRACT

Speech therapy aims to help individuals improve their communication and speech skills, but the exercises can often feel repetitive and tiring for children. Serious Games, which are games developed with purposes beyond entertainment, can make these exercises more engaging and enjoyable. This dissertation looks at how the design of such games can be improved so that children stay motivated and participate more actively during therapy sessions.

The work uses Fanima, a multi-platform prototype created to assess the pronunciation of European Portuguese phonemes, as a case study. By analysing literature, collecting feedback from Speech-Language Pathologists, and observing children's interactions with the game through questionnaires and testing sessions, the study identifies which game elements help children stay engaged and which distract them from the tasks. Results showed that animated and interactive features captured children's attention and improved motivation, while some visual elements caused distraction. Therapists valued the game as a useful complement to their practice but suggested improvements in personalization and feedback.

The main contributions of this dissertation are an updated version of Fanima that better supports children's engagement, a framework with design guidelines for future games, and insights into child-game interaction that can be useful for both researchers and practitioners. The testing is not yet complete, but the first results are promising and show potential for these games to support therapy in a meaningful way.

Future work will continue with more testing involving a larger and more diverse group of children, further refine the guidelines, and explore new features for Fanima such as character selection and automatic speech recognition to allow more independent use. These steps can help strengthen the role of serious games in clinical practice.

Keywords: Serious Games, Speech Disorders, Speech Therapy, Interaction Design and Children, Child-Computer Interaction, Gamification.

RESUMO

A terapia da fala tem como objetivo ajudar os indivíduos a melhorar as suas competências de comunicação e de fala, mas os exercícios podem muitas vezes parecer repetitivos e cansativos para as crianças. Os Jogos Sérios, desenvolvidos com finalidades para além do entretenimento, podem tornar estes exercícios mais envolventes e agradáveis. Esta dissertação analisa como o design destes jogos pode ser melhorado para que as crianças se mantenham motivadas e participem de forma mais ativa durante as sessões de terapia.

O trabalho utiliza o Fanima, um protótipo multiplataforma criado para avaliar a pronúncia de fonemas do português europeu, como caso de estudo. Através da análise da literatura, da recolha de feedback de Terapeutas da Fala e da observação das interações das crianças com o jogo, por meio de questionários e sessões de teste, o estudo identifica quais os elementos do jogo que ajudam as crianças a manter-se envolvidas e quais os que as distraem das tarefas. Os resultados mostraram que elementos animados e interativos captaram a atenção das crianças e aumentaram a motivação, enquanto alguns elementos visuais causaram distração. Os terapeutas valorizaram o jogo como um complemento útil à sua prática, mas sugeriram melhorias ao nível da personalização e do feedback.

As principais contribuições desta dissertação são uma versão atualizada do Fanima que apoia melhor o envolvimento das crianças, um framework com diretrizes de design para futuros jogos e conhecimentos sobre a interação criança-jogo que podem ser úteis tanto para investigadores como para profissionais. Embora os testes ainda não estejam concluídos, os primeiros resultados são promissores e revelam potencial para que estes jogos apoiem de forma significativa a terapia.

O trabalho futuro continuará com mais testes envolvendo um grupo maior e mais diversificado de crianças, permitirá refinar as diretrizes e explorará novas funcionalidades para o Fanima, como a seleção de personagens e o reconhecimento automático de fala, de forma a possibilitar uma utilização mais autónoma. Estes passos podem contribuir para reforçar o papel dos jogos sérios na prática clínica.

Palavras-chave: Jogos sérios, Distúrbios da fala, Terapia da fala, Design de interação e crianças, Interação criança-computador, Gamificação.

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ACRONYMS

- ASD** Autism Spectrum Disorder (*pp.* 18, 19, 21, 22)
- CBT** Cognitive Behavioural Therapy (*p.* 18)
- CCI** Child-Computer Interaction (*pp.* 6, 10–12)
- DG** Design Guideline (*pp.* 2, 4, 5, 13, 35, 36, 38, 39, 41–54, 74–84)
- HCI** Human-Computer Interaction (*p.* 10)
- IDC** Interaction Design and Children (*pp.* 6, 10, 12)
- LD** Language Disorder (*p.* 22)
- SD** Speech Disorder (*pp.* 1, 2, 4, 9, 22, 35, 36, 54, 82, 84)
- SDT** Self-Determination Theory (*pp.* 14, 15)
- SG** Serious Game (*pp.* 1–6, 9, 15–28, 32, 33, 35, 36, 39, 47–54, 59, 71, 75, 76, 78, 82–84, 94)
- SLP** Speech-Language Pathologist (*pp.* 1–5, 8–10, 23, 25, 27–29, 32, 35–37, 39, 40, 42–44, 47–52, 54, 55, 57, 66, 68, 69, 71, 72, 74, 77–84, 91, 94–96, 98, 107, 114)

INTRODUCTION

Video games have existed since early 1950s [14], in the beginning video games were made for academic purposes and for promoting devices. As years passed, video games started being made mostly for entertainment and relaxation. Most children with access to electronic devices (e.g., smartphones, computers, tablets, etc.) have played video games. Video games are a good form of distraction for children; the more fun the games are, the more entertained and engaged the children are while playing them.

In the 1970s, Clark C. Abt introduced the term Serious Game (SG), referring to games with educational purposes that are also entertaining [40]. While SGs have existed since then, it was only in the early 2000s that they became popularized. More and more SGs were being developed for various educational purposes.

1.1 Motivation

Speech Disorder (SD) is a condition where individuals have difficulties in speech communication, including problems pronouncing sounds correctly and speaking in a clear, organized manner [43]. Many children suffer from SD, and their guardians seek help to improve the children's speech. Speech-Language Pathologist (SLP)s are trained to assist those with SDs through speech therapy.

SLPs assess a child's SD through assessment sessions, which can involve various exercises. For instance, the SLP might point at an image or object and ask the child to describe what they see, or let the child play a video game while simultaneously asking questions about the game. As the child talks, the SLP assesses their speech difficulties. Each SLP has its own method for assessing its patients.

While speech therapy can be effective, the vocal exercises designed to help the child can often be tedious, repetitive, and demotivating. SLPs try to make these exercises resemble games to entertain and engage the child, encouraging them to keep trying. SGs made to assist in speech therapy can help overcome this problem.

SGs are designed with purposes beyond mere entertainment, aiming to teach players something or influence their behavior. They are utilized in various domains, including

education, health, business, and sustainability, offering a fun and immersive way to achieve learning and behavioral goals.

In the context of speech therapy, SGs can make vocal exercises more engaging and less monotonous for children. By incorporating therapeutic exercises into enjoyable gameplay, these games help maintain children's motivation and participation. The immersive and rewarding nature of SGs ensures that children are more focused and willing to perform the necessary exercises, leading to more effective speech therapy sessions. This approach helps SLPs assess and improve children's speech skills in a less pressured and more natural setting, ultimately aiding in better retention and application of the therapeutic practices.

1.2 Problem

Currently, some SGs can aid SLP in the assessment of SDs. While these games are helpful for the SLP, it is equally important that they remain engaging for children. SGs for speech therapy must strike a balance between entertainment and therapeutic support.

However, there is no structured framework that consolidates existing Design Guideline (DG)s and determines when they should be implemented in SGs for speech therapy. This lack of guidance creates uncertainty in game design, potentially leading to games that are either unengaging or too distracting for children.

We identified four papers that provide DGs for creating children's video games [2][4][41][54]. However, we are uncertain if all these guidelines will be useful in designing an engaging SG for children in speech therapy. This research seeks to address this gap by investigating how specific DGs influence children's engagement in SGs for speech therapy and whether a structured framework can improve game design in this field.

1.3 Research Questions

For this research, we address the questions:

- What makes an SG entertaining while effectively supporting therapy sessions?
- How can we improve an existing SG to make it more useful for autonomous use in therapy?
- Should all DGs recommended for SGs in speech therapy be implemented in the development of any SG for speech therapy?

1.4 Solution

The goal of this dissertation is to study children's interactions with SGs. This study aims to identify and enhance the aspects of SGs that can make them more enjoyable and motivating for children, thereby improving their overall utility in speech therapy. By

making the game more engaging, children would feel less pressured while playing. In speech therapy, this helps the SLP during the assessment session, as the child would be focused on the game rather than the session itself, resulting in more genuine performance. The information gathered could be useful for designing future SGs.

The proposed solution is to use the SG called *Fanima* as a base. *Fanima* is a multi-platform prototype game developed in Unity, designed to assist SLPs in assessing children's pronunciation of European Portuguese phonemes. The game is intended to be used during assessment sessions, with the child unaware of the evaluation process. While playing, the child's voice is recorded and saved on the *PLAY* platform. *Fanima* features two interfaces: a child interface for gameplay (as seen in Figure 1.1) and an SLP interface (as seen in Figure 1.2) for session management and phoneme error assessment. The game is divided into four main chapters, each focusing on different phonemes without increasing in difficulty. The chapters and interfaces will be further explained in section 3.1

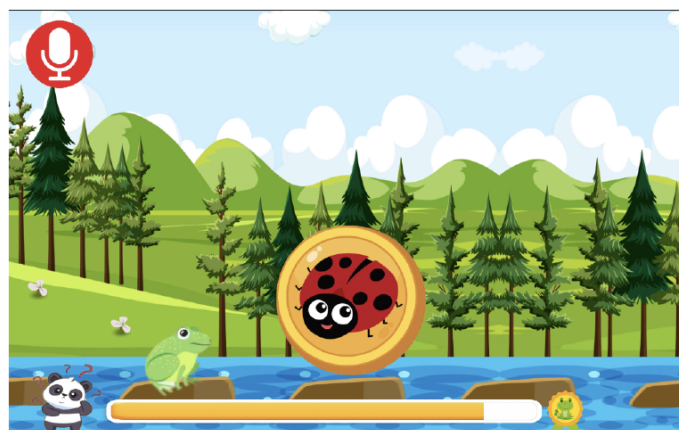


Figure 1.1: Child Interface

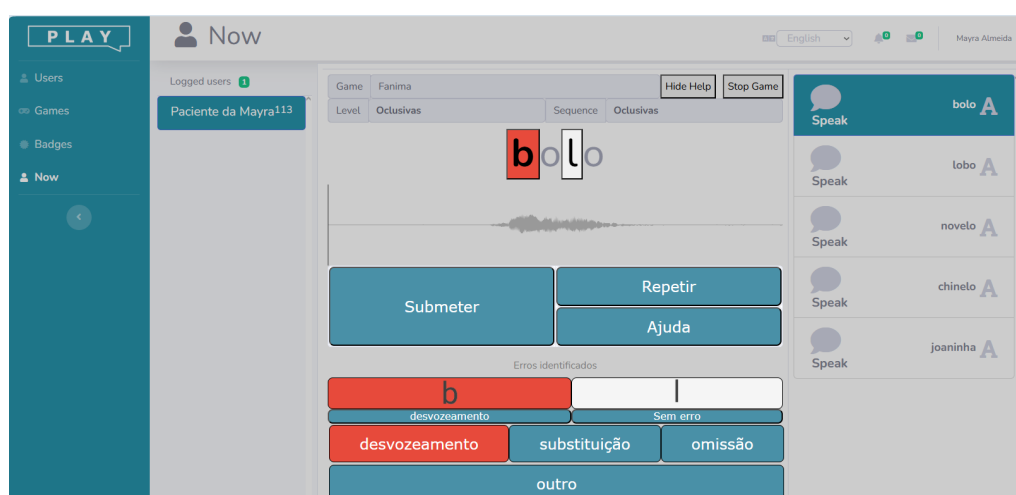


Figure 1.2: SLP interface

We contacted speech therapy clinics that work with children to explain the purpose of this research and demonstrate the *Fanima* game to SLPs. We invited them to partner

with us in testing the game with children who have SDs and in completing questionnaires that would help evaluate the game's effectiveness. Using this game, we would analyze children's interactions with it. The questionnaire would be answered by the child after playing the game, with the help of the SLP. This questionnaire should help us determine which parts of the game the children liked most and least. Besides the questionnaire, we also studied DGs that could improve the child's interaction with the game. Based on the DGs studied, we identify which designs should be considered for implementation in a SG for speech therapy and justify our choices. In section 4.3, we mention some possible questions that we analyzed, such as whether certain features (e.g., music, sound effects, etc.) are too distracting for the child. After the study is completed, we intend to enhance the features of Fanima and develop a framework that can serve as a foundation for designing and evaluating SGs for speech therapy.

1.5 Contributions

For this dissertation, we expect the main contributions of this research to be:

- **Framework for a SG in Speech Therapy:** A framework that can serve as a base or example for designing future SGs in speech therapy.
- **Improved prototype of Fanima:** A prototype that can better engage and entertain children during therapy sessions, ensuring a more accurate assessment of their speech problems.
- **Study of interaction of children with SG:** The publication of this dissertation could aid future research on children's interactions with SGs, serving as a foundation for those who wish to understand or further study how children engage with SGs.

1.6 Document Structure

This document has the following structure:

- **Chapter 1 - Introduction:** This chapter introduces a summary of this dissertation theme. It explains the motivation, objectives, the proposed solution and contributions for this dissertation.
- **Chapter 2 - Background and Related Work:** This chapter will explain in detail the important concepts that will help understand the context of this dissertation. In addition to the concepts, this chapter also discusses SGs created in similar research areas.
- **Chapter 3 - Fanima:** This chapter, presents the SG called Fanima, which served as the foundation for this dissertation. It provides a detailed explanation of the

game, its architecture, and an in-depth overview of each chapter of the SG and the PLAY platform [5]. Then, it compares Fanima with the related work previously studied. Finally, we explain the research process undertaken for this dissertation. It outlines the literature studied, details the consultation with SLP, and describes the preparations made for testing the game.

- **Chapter 4 - Design Guidelines and Enhancements for Fanima:** This chapter begins by presenting the DGs that were implemented in the SG before the start of this dissertation, followed by the new implementations added during this research. It then addresses several design-related questions and proposes additional DGs that could further enhance Fanima. Subsequently, it discusses additional DGs that, while not applicable to Fanima, are relevant to the broader framework. Finally, it introduces the proposed framework, explaining its structure and how it can be applied in the design and/or evaluation of SGs for speech therapy.
- **Chapter 5 - Validation of Fanima and the Framework:** This chapter aims to validate the results obtained from testing the Fanima prototype with children, as well as to assess the proposed framework based on the findings. It begins by describing the testing process, including the questionnaires and participants. The results of the questionnaires are then presented and analyzed. Following this, the framework's DGs are examined to determine which were validated through the collected data. Finally, the chapter concludes with a discussion of the insights gained from this validation.
- **Chapter 6 - Conclusion:** This chapter presents the conclusion of this research and discusses potential directions for future work.

BACKGROUND AND RELATED WORK

This chapter is divided into many subsections, where each explains important background information that will help the reader understand the importance of the theme of this paper. This chapter will explain speech disorders and how it is connected to speech therapy. Followed by a summary of the concepts of Interaction Design and Children (IDC), Child-Computer Interaction (CCI) and the importance of their study in the creation and design of SG and Gamification. Finally, there will be a demonstration of related works, which means serious games used to assist in therapy sessions.

2.1 Speech Disorders

Speech is a vital form of communication, but some individuals are born with conditions affecting their speech or develop speech impairments later in life. When communication is impaired, an individual's social, professional, or academic life can be negatively affected. In the following subsections, we will discuss the definition of speech disorders, their most common types, their causes, symptoms, and treatment.

2.1.1 Definition

Speech disorder is a condition where an individual has difficulty producing the correct sound when communicating. Individuals of all ages can have some sort of speech disorder. The best way to understand speech disorders is by explaining the most common types, such as stuttering, apraxia of speech, dysarthria, and cluttering [43][44].

- **Stuttering:** This occurs when the flow of speech is disrupted. Individuals may block, repeat, or prolong sounds or words involuntarily. Blocking refers to difficulty in starting a word despite knowing what they want to say, resulting in problems producing the necessary sounds [44]. Some causes of stuttering include genetics (it runs in families), stressful situations, and developmental issues such as motor, language, or learning difficulties in children [50];

- **Dysarthria:** Occurs when an individual has muscle weakness, paralysis, or lack of coordination in the muscles that produce sounds, such as the lips, tongue, face, lungs, throat, or chest [17][44]. These problems are caused by various forms of brain damage [17];
- **Apraxia of Speech:** Occurs when an individual has difficulty transitioning conscious speech into motor actions. When speaking, the brain sends signals to the muscles involved, instructing them on when and how to move. In individuals with apraxia, these signals are unclear, resulting in unclear or confusing speech for the listener [6][44][34][57]. While apraxia is also caused by brain damage, it differs from dysarthria. Dysarthria affects the muscles themselves, whereas apraxia affects the motor planning involved in speech [34];
- **Cluttering:** Occurs when an individual's speech is erratic or rapid, with unusual pauses, frequent interjections, and revisions. The speech may sound clumsy, rapid, unclear, and disorganized to the listener. Cluttering differs from stuttering because, in stuttering, the individual's thought pattern is intact but they have trouble producing sounds. In cluttering, both speech and thought patterns are affected. Those with cluttering may not even be aware that their speech is disorganized and unclear [12][11].

2.1.2 Causes

The causes of speech disorders vary based on the type of disorder. Based on the speech disorders mentioned above, we will explain the most common causes.

Stuttering: Some causes of stuttering include genetics (it runs in families), stressful situations, and developmental issues such as motor, language, or learning difficulties in children [50];

Dysarthria: This can be caused by various forms of brain damage, such as stroke, Parkinson's disease, brain tumors, traumatic brain injury, and more [17][44];

Apraxia of Speech: Can be caused by stroke, brain tumors, head/brain injuries, and illnesses that affect the brain [57]. It is important to note that these causes are similar, if not identical, to those of dysarthria.

Cluttering: Can be caused by genetics, neurological factors, and language development issues. Abnormalities and delays in developing language skills can have lasting effects, especially for children. Neurological factors involve irregularities in the timing and coordination of speech motor movements, leading to the rapid and disorganized speech characteristic of cluttering, this reference [13] notes.

2.1.3 Symptoms

Speech disorders can cause various symptoms, such as repetition or prolongation of words and sounds, syllable rearrangements, difficulty pronouncing words correctly, sound

distortions, speaking too softly or loudly, hoarseness or raspiness of the voice, and adding extra words [44][42]. Individuals with speech disorders may experience frustration and embarrassment when unable to speak clearly. If left untreated, these conditions can hinder learning to read and write, impact mental health, and lead to anxiety or depression [45].

2.1.4 Treatment

Now that we understand the meaning of speech disorders and some of their causes and symptoms, we pose the question: 'How are these disorders treated?' While children may initially struggle with certain sounds, they typically acquire the skills to pronounce more complex words and sounds as they grow. However, not all speech disorders can be outgrown. There are various treatments for speech disorders, which depend on the specific type of disorder an individual has [42]. Individuals with symptoms of speech disorders can sometimes be treated with medication. For example, someone with an anxiety disorder may experience stuttering, cluttering, or mispronunciation of words in stressful situations. In such cases, anxiety medication can help reduce the symptoms of speech disorders [44][43].

In most cases, speech disorders are treated with speech therapy and/or oral-motor therapy [44][43]. This dissertation focuses primarily on speech therapy, which will be explained in detail in Section 2.2. Oral-motor therapy specializes in physical exercises that train the oral muscles (lips, tongue, jaw, vocal folds). The goal of oral-motor therapy is to improve the individual's strength, control, and coordination of the oral muscles [35].

2.2 Speech Therapy

Speech therapy is a treatment that helps individuals with speech disorders improve their communication and express themselves in an organized and clear manner.

Speech therapy is provided by SLP, also known as speech therapists [43]. SLPs prefer to use the term 'client' instead of 'patient' [10]. They assist clients by having them perform vocal exercises, such as saying certain words, which helps in identifying the specific speech disorder. The type of speech therapy performed will vary based on the client's age, health condition, and the severity of their speech difficulties [49]. Anyone of any age can seek help through speech therapy, but studies show that the earlier one seeks help, the better. Children tend to have more success in speech therapy, as they are still at an age where it is easier to correct bad habits and improve communication skills [49].

2.2.1 Assessment

Assessment is a process where the SLP gives the client specific vocal exercises to identify speech problems.

The SLP may suggest that the client have their hearing checked, as some SDs can result from hearing loss [48]. It is also important to note that having an accent is not considered a SD [48]. An accent is simply a unique way an individual or group sounds [48].

Before the assessment begins, the SLP will explain the process to the client, if they are an adult, or to the guardian, if the client is a child. This explanation includes what will be done during the assessment, the duration of the sessions, and the number of sessions required [46]. The SLP will also encourage the client to seek clarification and ask questions at any time. The client's consent is needed before starting the assessment, and they can end the session early if they wish. Lack of motivation or extreme discomfort can hinder therapy, making it difficult or even impossible to help an unwilling participant.

Children are often asked to play games that require them to talk, as their performance will be more genuine if they do not realize they are being assessed [49]. Some SLP use video games for the assessment, asking the child to describe what they see and what is happening in the game. Nowadays, some SLPs are using serious games created specifically for speech therapy to assist in their sessions. Section 2.4 will explain in more detail what SGs are and how they can help in therapy, while Section 2.5 will provide examples of serious games used in therapy.

Children attend speech therapy because their guardians seek professional help for a speech disorder. Most children do not realize they are being assessed during the session. However, adults who actively seek help for themselves are aware that they are being assessed. Adults are given more formal exercises, and their sessions focus on improving speech and strengthening the coordination between brain and motor functions [49].

The assessment is conducted one-on-one between the client and the SLP [46]. Guardians and significant others can observe the session but are informed about what they can and cannot do during the session. Observers can bring objects that the client likes, such as toys, books, or games, to help the client feel more comfortable and to get to know the client better [46][56]. They can also bring water and snacks for the client to have during breaks. However, observers cannot prompt the client to respond by repeating the questions asked by the SLP. The session can last between 30 and 90 minutes, with the standard duration being 1 hour [46].

During the first assessment, the client is encouraged to speak to the best of their ability, and the SLP does not correct them or point out mispronunciations. The purpose of the first assessment is to identify the problems that occur during speech. During the assessment, the SLP will observe the client's speech and the movement of their lips and tongue [48]. They may ask the client to say specific words and long sentences. Identifying the problem is crucial, so the SLP must pay close attention and may even record the session to review what the client said. This helps in accurately assessing the most prominent issues.

After the assessment session, the SLP will report the client's strengths and weaknesses [46]. If the session was recorded, they can review it to ensure the accuracy of their report. With the report completed, the SLP will plan exercises and tasks for the following sessions. The SLP will then inform the client or guardian of their findings and the plan

for future sessions [46][56]. After at least three months, the SLP may prompt the client for another assessment session to verify the progress made up to that point. In some cases, assessments can be done more frequently based on the client's needs or other special circumstances [46].

2.2.2 Recovery Time

No one knows how long it takes for a full recovery, as it can sometimes take years for speech disorders to improve. Speech disorders may improve as the individual ages, or if the speech disorder is a result of a medical condition, it can improve as the individual recovers from the condition. The factors that determine recovery include the individual's age, type of speech disorder, severity of the disorder, medical condition, and the frequency of speech therapy sessions [49].

2.2.3 Benefits and Risks

While it has been proven that speech therapy is effective, there is no guarantee that it will work for everyone. However, there are many benefits to attending speech therapy, such as improvement in quality of life, increased independence and self-esteem, better communication, and the ability to express ideas, thoughts, and feelings [49].

2.3 Child-Computer Interaction (CCI)

The ACM Interaction Design and Children (IDC) conference¹ is a venue where many researchers present their work. An important field highlighted at the IDC conference is CCI, which stands for Child-Computer Interaction [1]. CCI is a branch of Human-Computer Interaction (HCI). While HCI studies human interaction with computers, CCI focuses solely on children's interactions with computers. CCI studies how computers affect children, as they have mental and physical skills that are still developing [1]. Even if an adult and a child are given the same computer, their interactions with it will vastly differ. What may seem simple or meaningless to an adult can be complex or interesting to a child.

2.3.1 Ethics

As time went on, researchers began to see the benefits of including children in the design of technology intended for them. However, this raised ethical considerations regarding the inclusion of children in research projects.

In article [29], 272 full papers related to CCI, released from 2005 to 2020, were studied to analyze the state of the art in interaction design methods for children. During the analysis, it was noted that more than half of the papers did not report receiving informed consent.

¹<https://dl.acm.org/conference/idc>

This was very concerning because papers that do not report informed consent could be subject to lawsuits for negligence, breach of contract, fraud, and ethical repercussions, as well as a decrease in trust in the researchers [36].

After many discussion between researchers in different panels [15][38][19], it was decided that when the inclusion of children was necessary, researchers would explain the concept of consent and its implications in a fun and understandable way. This included information about what the children would be required to do. Once the children understood what consent meant, they could give their informal consent to participate [18]. Additionally, the children's guardians would also be informed and would need to give their formal consent for their child to participate in the research. Children and their guardians would have the choice to participate in the research and the right to withdraw from participation or withdraw their data from the research if it had not yet been published. If they wished to withdraw after the research had been published, the researcher would try to honor their wishes. To ensure genuine participation, the research would have to be designed to be fun and memorable for the children [18].

2.3.2 Usability

In CCI, usability refers to how effectively, efficiently, safely, and engagingly a child can use a computer system or application. An application is effective if it allows the children to achieve their goals. It is efficient if the children are able to perform tasks with minimal effort. It is safe if it ensures that the interaction is appropriate and respects the children's privacy.

Article [31] mentions some usability heuristics that help verify the intuitiveness of an application:

- Are children able to know which module they are currently in, and can they recall aspects of the previous module? For example, can they remember the button they used to access the main menu?
- Are the menus and buttons intuitive or self-explanatory for children? For instance, does an icon help the child understand the button's function? Can the child play the app with little or no outside intervention?
- If the child stops playing mid-game or starts a new game after some time, can they recognize how to navigate the application or how to play it?
- Is there a help button that can assist the child when they need it?

These questions help determine what an application or game needs to be more engaging for children. If a child does not understand most of what is happening in a game, they may not enjoy it as much or may even give up playing.

2.3.3 Accessibility

In CCI, accessibility refers to whether the application or technology is usable by all children, including those with disabilities. It involves incorporating design principles that accommodate diverse needs, making interfaces flexible to adjust to different requirements (e.g., changing the lighting of the application or removing flashing lights for those with visual sensitivity and risks of seizures; adjusting volume of sound effects and music, etc.). Not all applications are suitable for all children, so it is important to gather feedback and information about those with special needs and use this information to design an application that can adapt to most children.

2.3.4 User Experience

User experience refers to the overall experience that a child has when interacting with an application or game. The more engaging and enjoyable a game is, the more positive the user experience. The experience that a child has when playing a game will differ from the experience that a teenager would have while playing the same game. Games made for preschool children may seem boring and simple to a teenager, while games made for teenagers will be confusing and difficult for children. This is because individual intellectual and perceptive abilities also play a part in the user experience.

Usability and accessibility also play an important part in the user experience. If a child cannot understand how to interact with an application, they may not enjoy it, and the experience they have may be negative. If a game does not accommodate children with special needs, they will have difficulties playing and enjoying the game, leading to feelings of frustration, sadness, or anger.

Applications that provide feedback or rewards, such as trophies when a task is completed, motivate a child to continue.

We can state that the user experience of a child when playing a game will vary based on their age, emotions, intellectual skills, perception, how accessible the game is, and the type of game they are playing.

2.3.5 Interaction Design and Children (IDC)

As technology progresses, there is increasing interest in how it affects the lives of children. In 2002, the first IDC conference was held, and since then, a new conference has been held annually across the globe [23]. IDC encourages the study and enhancement of the design, development, and use of interactive technologies for children [25]. The IDC conference is considered the leading international forum for studying children's needs when using technology [23]. IDC focuses on answering key questions, such as:

- How does technology affect children's lives?
- How can technology design be improved to better enhance children's lives?

- How can we create interactive products for and with children?

The conference gathers many researchers, educators, and practitioners who share their research, methodologies, and technologies to address these questions and improve on previous work [24].

N. Soni et. al. studied various design recommendations for children's touchscreen interfaces [41]. Using their findings, they created a framework called Touchscreen Interaction Design Recommendations for Children (TIDRC, pronounced 'tide-rock'). The framework was created based on 31 papers and 57 design recommendations gathered from these papers. The main criteria for choosing the papers were that they included empirical user studies of children under the age of 12. Papers that focused specifically on children with disabilities were excluded. They then used this framework to evaluate 50 popular iPad games for children, assessing how many followed the design recommendations.

For this dissertation, we will focus on the design recommendations, as they could prove useful in our studies. Table 2.1 demonstrates some of these design recommendations. The design recommendations are categorized into three dimensions:

- **Cognitive:** This dimension relates to the intellectual growth of a child. The design recommendations here will affect the child's skills such as attention, understanding, and reading.
- **Physical:** This dimension pertains to design recommendations that affect the physical abilities of the child. It mainly discusses recommended gestures and physical tasks that are not too demanding for the child to perform while playing video games.
- **Socio-emotional:** This dimension concerns contextual features in video games that make the child's experiences more enjoyable.

Most of the design recommendations are self-explanatory; however, the last two require further clarification. 'Use an open-ended app structure' refers to games that do not provide an explicit goal or task. These games allow players to perform tasks repeatedly without increasing difficulty or selecting levels of difficulty. Dress-up games are a good example of this feature. 'Avoid automated social interactions' means that it is recommended to avoid social-sharing features, such as sharing trophies or badges with others. This recommendation is mainly in place to respect laws protecting children's privacy.

N. Soni et al. study revealed a gap between recommended practices and what is actually implemented. They determined that this gap exists because most design recommendations are scattered across various research papers, and not all practitioners are aware of them [41].

Besides the TIDRC article [41], we found three other papers that identified DGs for children's video games [2][4][54]. Some of the recommendations/guidelines may overlap, such as those suggesting that the background should not be complex or that the interface

Design Recommendation	Dimension
Use consistent real-world metaphors	Cognitive
Use on-screen interactive cartoon characters	Cognitive
Avoid using visually complex application backgrounds	Cognitive
Use sound effects and vocalizations to draw attention	Cognitive
Avoid using textual prompts	Cognitive
Provide audio prompts with visual prompts support	Cognitive
Provide positive feedback	Cognitive
Avoid using in-app tutorials	Cognitive
Avoid adding external web links or advertisements	Cognitive
Avoid using rotate gesture	Physical
Avoid using pinch to zoom gesture	Physical
Design visually bigger interactive widgets	Physical
Provide customization features	Socio-Emotional
Use an open-ended app structure	Socio-Emotional
Avoid automated social interactions	Socio-Emotional

Table 2.1: Design Recommendations Related to Cognitive, Physical, and Socio-Emotional Needs of Children

should look and behave as realistically as possible. However, these four articles will serve as the foundation for studying new guidelines to be implemented in this dissertation.

2.3.6 Self-Determination Theory

As previously stated, therapy sessions require clients to perform specific tasks. For children, these tasks are often disguised as games. Whether the goal is to mentor, assess, or assist, maintaining motivation to complete tasks and achieve goals can be challenging.

Self-Determination Theory (SDT) is a psychological framework that explains human motivation, well-being, and personal growth [39][53]. According to SDT, certain conditions must be met to sustain motivation. The theory distinguishes between two types of motivation:

- **Intrinsic motivation** – The natural drive to engage in an activity because it is interesting, challenging, or enjoyable. Positive reinforcement enhances intrinsic motivation, while negative reinforcement diminishes it. When individuals feel secure and connected to what they are doing, their intrinsic motivation increases. Those who genuinely enjoy a task are more likely to achieve better results than those who do not [39][53].
- **Extrinsic motivation** – The drive to complete a task due to external factors, such as receiving a reward or fulfilling an obligation [39][53]. Children, for example, may have high extrinsic motivation if they feel supported and encouraged by parents or teachers.

SDT states that three psychological needs must be fulfilled for an individual to feel motivated:

- **Autonomy** – People enjoy tasks more when they feel they have chosen to perform them rather than being forced to do so [39][53]. For children, this could mean offering them a game-based task without pressuring them to participate. It may also involve giving them choices, such as selecting activities to explore or customizing their character in a game.
- **Competence** – Motivation arises when individuals feel capable of accomplishing a task or when they experience mastery in performing it. Positive reinforcement enhances a person's sense of competence, boosting their confidence and self-esteem. If someone is initially motivated by extrinsic factors, receiving positive reinforcement can help them develop a sense of capability, ultimately increasing their intrinsic motivation [39][53].
- **Relatedness** – People are more motivated to engage in tasks when they feel a sense of connection to them. For children, this can be fostered by allowing them to play games with others or by incorporating meaningful narratives that help them understand the purpose of a task. Feeling connected to an activity or those involved encourages continued engagement [39][53].

2.4 Serious Games and Gamification

In this section, we will explain the definitions of serious games and gamification in detail, followed by an explanation of how these two concepts differ from one another.

2.4.1 Serious Games

2.4.1.1 Definition

Games, in general, are created for the player's entertainment. However, SGs have a more important purpose beyond entertainment. SGs are designed to teach the player something or help them change their behavior towards something [40][55]. SGs mainly refer to video games used by researchers, companies, or educators. They use SG as a tool to help their target audience achieve their goals in an easier and more enjoyable way [26][40].

2.4.1.2 Types

SGs can be used in various areas, such as:

- **Education:** These SGs are used to teach students new subjects or languages [55][40]. The player performs tasks that gradually improve their knowledge of the given subject. Some SGs are designed for classroom use to test students in a fun way on

what they have learned. These video games can also be used to provide additional knowledge on the subject [26]. For example, article [3] mentions a game designed to help schoolchildren apply the Euclidean Division and remember its algorithm.

- **Health:** In this area, SGs can be used to teach people healthy lifestyles or simulate medical procedures to help the player train. Patients can even use SGs for rehabilitation and/or therapy [40][55]
- **Business:** Some SGs simulate business environments and tasks, such as managing budgets, creating new products, or developing marketing campaigns [40]. These video games challenge players to analyze situations, reflect on potential actions and consequences, and make tough decisions. These types of games can also be used in business schools to evaluate student performance.
- **Sustainability projects:** SGs can be used to teach players new good habits or tasks to encourage behavior change [55]. For example, article [8] discusses a SG designed for children that teaches different ways to conserve energy and the importance of doing so.

2.4.1.3 Benefits

SGs are beneficial because they provide a safe environment to test various tasks [55]. For example, SGs can test a player's knowledge of a medical procedure without the risks and stress associated with real-life practice. They allow the player to train in a secure setting with no risk of real-life danger to themselves or patients.

SGs are designed to be immersive and enjoyable, offering a sense of progression and rewards [55][26]. This approach ensures that players see the game as something they want to do rather than something they are forced to do. Players are more likely to remember what they learned while playing, achieving the main purpose of SGs. When learning is enjoyable, the knowledge gained is more likely to be retained.

2.4.2 Gamification

2.4.2.1 Definition

Gamification is the strategy of adding game elements to non-game environments to motivate certain behaviors and improve user engagement and productivity [20][59][58]. It can be recognized as a persuasive system used to promote positive feedback in the environment where it is applied.

2.4.2.2 Types

Gamification can be used in various areas:

- **Educational Environment:** Schools can implement a leaderboard system to display the top students of the year and/or reward the best performers. This encourages students to study and behave well. Both the leaderboard and reward system are game mechanics applied to a non-game environment (school) [20][59].
- **Business Environment:** Gamification is used to improve employee performance, attract more customers, and encourage customer loyalty by rewarding employees and customers [20][59][58]
- **Health Environment:** In the health sector, some applications use point systems and badges to reward users for exercising and improving their healthy lifestyle [20].

2.4.2.3 Game Elements

The various types of game elements used to improve productivity and engagement include:

- **Points and Badges:** These are awarded when people complete certain tasks or reach specific milestones. Seeing their accumulation motivates individuals to continue or enhance their efforts to earn more rewards, thereby simultaneously improving productivity [20][59].
- **Leaderboards:** These display the rankings of participants in a task or challenge. Leaderboards motivate individuals to improve their skills and performance to achieve a higher ranking. While the competitive nature of leaderboards can drive high performers, it can also sometimes discourage those at the lower end of the rankings [20][59].
- **Progression Graphs and Levels:** These provide individuals with information about their accomplishments thus far. As they advance through levels or see their progress increase, it indicates improvement over previous performances, encouraging them by showing their gradual progress towards mastering a skill [20][59].
- **Teammates:** This element enhances social interaction by allowing individuals to help each other with tasks and challenges, compete, and offer advice. It fosters a sense of community, reassuring participants that they are not alone in their challenges [20][59]. This communal aspect allows for the sharing of experiences and provides a support system where newcomers can seek advice and meet others.

2.4.3 Differences between Serious Games and Gamification

Both gamification and SGs aim to provide users with a sense of accomplishment and enjoyment, but they are not the same. SGs are designed as games with added educational or training value, while gamification involves incorporating game elements into everyday or work tasks [51][52].

As this reference [51] explains, "...one aims to bring fun into everyday tasks, the other aims to transform these tasks into games to increase their training value." The first refers to gamification, such as applauding a worker when they reach a milestone or using a leaderboard in a school to recognize the best student. The second refers to SGs, such as a game designed to help players learn and apply math algorithms.

In gamification, individuals feel a higher sense of accomplishment when they complete a task or receive a badge, as they are rewarded for their participation, motivating them to continue. In SGs, the primary reward for the player is finishing the game [51].

Gamification helps trainers track the progress of trainees, and for the trainees, it motivates and engages them in the tasks [51][52]. SGs, on the other hand, can be used in various tasks to introduce players to specific contexts or require them to develop high-level skills to complete the game [51].

2.5 Related Work

As explained before, SGs can be used in different areas, but for this dissertation, we will focus on works about SGs created to help in children's therapy. The SGs discussed will be presented in chronological order, from the earliest to the latest published papers. Not all SGs will be about children with speech disorders; we will also explore SGs designed for children with Down Syndrome and Autism Spectrum Disorder (ASD).

2.5.1 Using a Serious Game to Reduce Stress and Anxiety in Children with Autism Spectrum Disorder

Children with ASD may sometimes have difficulties in communicating, which can cause them to feel stressed and/or anxious. Cognitive Behavioural Therapy (CBT) is a form of therapy used to help clients reduce problematic behaviors, and it includes relaxation techniques to reduce stress and anxiety.

This paper [9] studies a SG called New Horizon, along with two mini-games that incorporate CBT techniques. New Horizon is a 2D mobile exploration game for Android, targeting children aged 6 to 10. The game features a main character traveling the universe in a spaceship, landing on planets to complete mini-games. Sound effects and background music are present in all mini-games except for the Breathing mini-game. However, in all other mini-games, audio and music can be turned off as they are optional.

The mini-games include:

- **Memory**(Figure 2.1(a)): In this mini-game, a number of stars light up in a specific order, and the player has to repeat the sequence before time runs out.
- **Platformer**(Figure 2.1(b)): In this mini-game, the player explores unknown territory by jumping on platforms and avoiding danger to get back to the spaceship.

The other two mini-games incorporate relaxation techniques:

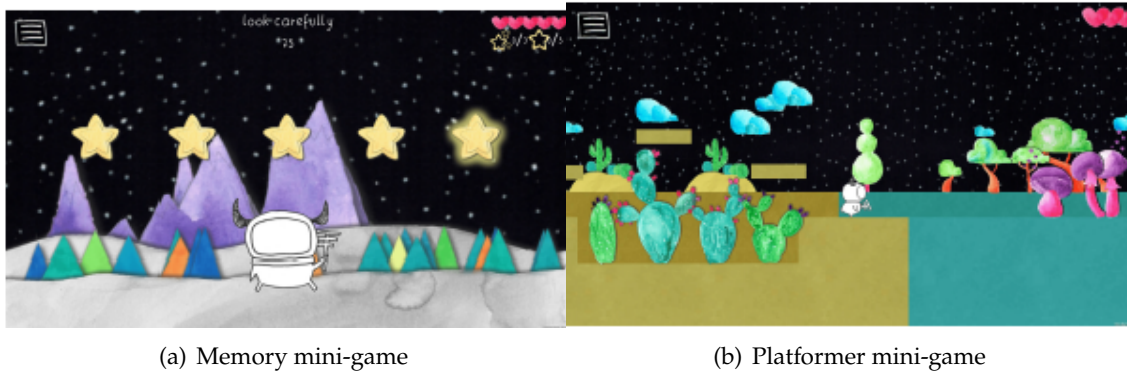


Figure 2.1: New Horizon

- **Senses Mini-game** (Figure 2.2(a)): This mini-game uses the Visualization or Guided Imagery relaxation technique. The goal is for the main character to regain energy by popping bubbles of the correct color and collecting stardust. Only the bubbles move, and there are sound effects when the correct bubble is popped.
- **Breathing Mini-game** (Figure 2.2(b)): This mini-game incorporates the Focused Breathing relaxation technique. The player rides a space whale and must inhale, hold their breath for at least two seconds, and then exhale while calmly saying 'oom'. When the microphone detects the 'oom' sound, the whale's blowhole rises, protecting it from a falling comet. To ensure the microphone accurately picks up the player's voice, the mini-game does not include background sound.

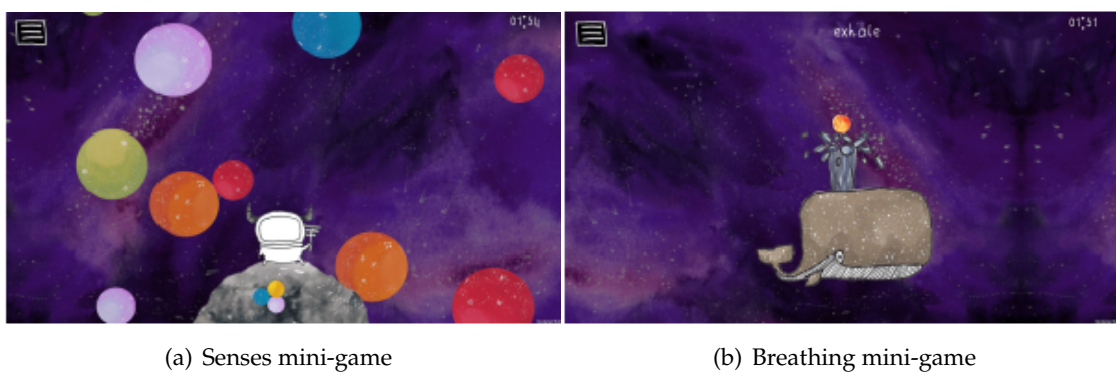


Figure 2.2: Mini-games with Relaxation Techniques

S. Carlier et al. concluded that while the games can be further modified and tested with more participants, the study shows potential in developing SGs for anxiety and stress reduction in children with ASD.

2.5.2 A Serious Videogame to Support Emotional Awareness of People with Down Syndrome

Children with Down Syndrome have various characteristics, including difficulties in identifying and expressing their emotions. Lara et al. [28] mention that while there are SGs that help children with Down Syndrome maintain attention and perform exercises to help motor coordination, there is a lack of SGs that support emotional awareness for people with Down Syndrome. This paper [28] presents an SG that addresses this need.

Lara et al. conducted a data collection study at four educational and therapeutic centers for people with Down Syndrome. They interviewed parents, teachers, and psychologists to understand the characteristics of the educational and therapeutic processes and the needs during them. Additionally, they conducted testing sessions by having individuals with Down Syndrome play four video games to identify the characteristics of those games that are appropriate for this population. After analyzing the collected data, they created a video game called Emotion4Down.

Emotion4Down is a touch-based video game designed for individuals with Down Syndrome, where they are prompted to perform activities based on emotions selected by the therapist. The game invites players to imitate different emotions through facial expressions.

The video game includes a customization menu where the therapist can adjust parameters according to the player's characteristics and preferences, such as choosing the emotions to work on, activities to perform, and the number of trials for each activity. The game features seven emotions: happy, sad, angry, bored, scared, tired, and pain, each practiced through six activities. Players have three opportunities to perform each activity correctly, and the game provides positive reinforcers (e.g., "Well done! Let's try again!") to motivate players to continue, regardless of whether the activity was done correctly or not [28].

As players progress through the game, they collect stars and earn a customizable trophy upon completion, tailored to their preferences by the therapist. The activities that s/he have to perform for each emotion selected are:

- **Activity 1** (Figure 2.3(a)): The player chooses the emotion they want to play based on those selected by the therapist.
- **Activity 2** (Figure 2.3(b)): A brief video explains the emotion in different contexts.
- **Activity 3** (Figure 2.3(c)): The player must drag the image that corresponds to the indicated emotion.
- **Activity 4** (Figure 2.3(d)): A scene is shown with a brief explanation, and the player must choose the emotion presented in the scene.
- **Activity 5** (Figure 2.3(e)): The player imitates the specified emotion, and the game uses the device's camera to take a picture of the player's imitation.



Figure 2.3: Emotion4Down

- **Activity 6** (Figure 2.3(f)): The player drags elements (e.g., eyes, mouth, eyebrows) to a specific area on the screen to create the emotion.

This structured approach helps individuals with Down Syndrome to better understand and express their emotions through engaging and interactive gameplay.

2.5.3 Gesture-based Video Games to Support Fine-Motor Coordination Skills of Children with Autism

In the first work [9] mentioned, the goal was to help children with ASD manage stress and anxiety. In [37], the SG is also designed for children with ASD, but it differs by aiming to help them with fine-motor coordination problems that they can sometimes experience. These issues can affect their daily activities. To improve fine-motor coordination skills, children typically attend occupational therapy, which requires them to perform repetitive motor activities. These activities can become boring and tedious due to the repetition involved. This SG aims to make these activities more engaging and enjoyable for children.

The game utilizes air gestures without the need for additional aides, making the activities as natural and intuitive as possible. It also allows the player to practice finger movements required for daily activities.

The SG created is called "The Busy Hands," a gesture-based video game designed to support fine-motor coordination skills for people with ASD. It uses a Leap Motion sensor to track the player's hand movements, allowing the player to 'grab' digital objects and place them in their corresponding locations on a digital screen. The game offers short and precise instructions using visual and verbal stimuli. The therapist selects one of three activities from the menu(Figure 2.4(a)) for the player. The player earns stars every time they complete an activity, with the number of stars personalized based on the selected number of trials for the activity. Additionally, the therapist can customize the reinforcer that the player receives upon earning all the stars. The three activities are:

- **Learn:** This activity teaches the player how to use the Leap Motion sensor and provides instructions on how to play the game.
- **Train(Figure 2.4(b)):** In this activity, the player performs air gestures to train fine-motor skills using the pincer grasp gesture.
- **Activity of Daily Living(Figure 2.4(c)):** The player practices a daily living activity and learns about the objects used in these activities.

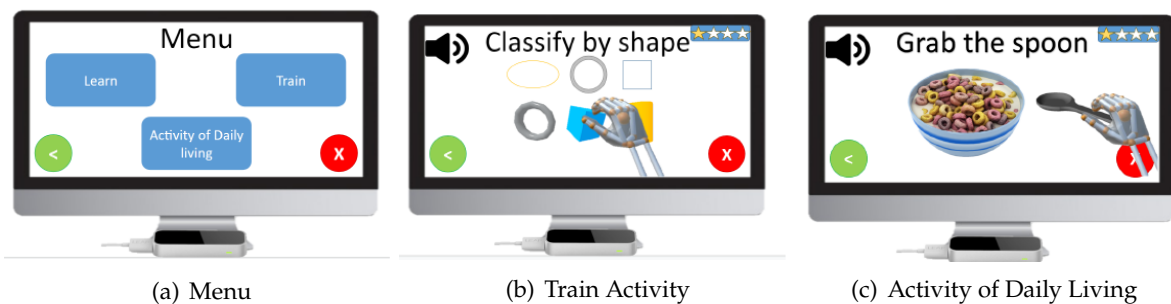


Figure 2.4: Busy Hands

2.5.4 Towards a Usable Serious Game App to Support Children's Language Therapy

SD, explained in section 2.1, differ from Language Disorder (LD) in that people with LD can produce correct sounds and speak clearly, but they may still have difficulties communicating effectively. In LD, individuals might have problems with expressing themselves, known as Expressive Language Disorder, or with understanding messages from others, known as Receptive Language Disorder [27]. It is possible, especially for children, to experience both types of difficulties. These issues may arise from challenges

in finding the right words, using correct grammar, or understanding and using language appropriately.

In this work [21], García-Ruiz et al. designed and developed a SG to support children in speech and language therapy, specifically targeting English language tenses. The SG, called "InTense", it is a video game app for iPad tablets that helps children develop their language skills, with a focus on verb tenses. The game presents a variety of questions for the player to answer, awarding virtual tickets for correct answers (see Figure 2.5(a)). These tickets can be spent on a carnival game (see Figure 2.5(b)) within the app, providing motivation to answer more questions correctly. Instructions are conveyed through voice-over audio.

This game, unlike the ones mentioned before, has both single-player and multiplayer modes. Only the SLP can access the settings menu. The game allows for player creation, where users can enter their names. Once a player is created, they can choose between Tenses and Questions. If more than one player is active, a multiplayer session begins. All tickets received are saved as long as at least two players remain active, but tickets reset if the game drops to a single player. Tickets also reset for each new session.

- **Single-player mode:** The player answers questions to gain tickets. They can jump to the 'level select' screen at any time to choose a game level if they have the required tickets.
- **Multiplayer mode:** Each player answers three questions and then passes the tablet to the next player. Tickets are spent on game levels designed for more than one player.

The game level (see Figure 2.5(b)) where tickets are spent is styled similarly to Angry Birds™. Tickets can be used to purchase more powerful ammunition. In single-player mode, the player has a limited number of shots to destroy all targets. In multiplayer mode, players take turns shooting from a collective pool of ammunition.

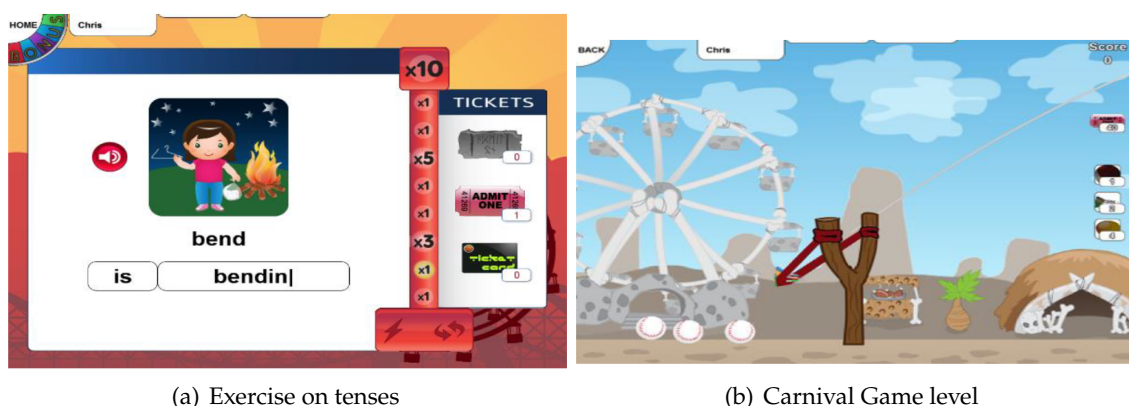


Figure 2.5: InTense

García-Ruiz et al. [21] mention that while the speech-therapy exercises and games are well-implemented, the menus and other interfaces still have room for improvement.

2.5.5 A Longitudinal Evaluation of Tablet-Based Child Speech Therapy with Apraxia World

In speech therapy, most SGs are not designed for long-term use. The SG created for this paper [7] aims to address this issue. Hair et al. studied and examined pronunciation improvements in children playing the game, child engagement over time, and the accuracy of automated pronunciation evaluation over a multi-month period.

The SG, called Apraxia World, is a 2D mobile platformer game for speech therapy, designed to give children more independence when playing for an extended period [7]. The game provides pronunciation feedback through an automated framework built into the game. It was built by customizing and expanding an existing game demo, Ekume Engine 2D. The game's controls are the standard ones used on tablets, which might pose difficulties for children with motor impairments.

The player controls a monkey-like character with the objective of reaching the finish line. The character navigates platforms, collects items (yellow stars and coins), and fights enemies. The player has an energy meter that depletes continuously, and they need to collect yellow stars to replenish it. When the energy runs out, the character starts to move slowly. Upon collecting a yellow star, an image pops up (see Figure 2.6(b)), and the player must say the name of the image shown. The game provides feedback on whether the pronunciation is correct or not. After a specified number of attempts, the star is added to the inventory regardless of pronunciation success. Correct pronunciation grants 10 seconds of energy, while incorrect pronunciation grants 5 seconds.

The game features an in-game store (see Figure 2.6(c)) where players can buy additional characters, items such as costumes, different weapons, or temporary power-ups using the coins collected. This store encourages players to personalize their characters. The game consists of 40 levels divided into 5 worlds(see Figure 2.6(a)), with each world containing 8 levels. The player's progress is saved when they leave a level. To limit therapy exposure and prevent game fatigue, players are only allowed to play one level per day.



Figure 2.6: Apraxia World

Hair et al. [7] reported that children enjoyed the game, with some continuing to play even after the study concluded. The limitation of daily gameplay created anticipation for the next session. Hair et al. determined that the study was a success, as the children showed improvement in their pronunciation. Additionally, the automated framework for pronunciation feedback outperformed traditional methods based on goodness-of-pronunciation scoring.

2.5.6 Articulation: Towards Assessing Motor Speech Disorders via Gamification

This SG has a goal similar to the one studied in this dissertation, as both are used for the assessment of speech disorders. Articulation is a non-intrusive, child-friendly SG designed specifically to assess motor speech disorders based on facial movement analysis [4]. It is a narrative-driven game where the child must keep their head within the frame, and complete speech tasks to progress in the story. The SLP has control over the game, with the ability to pause, request task repetition, skip tasks, calibrate head position, and set time limits for each task.

Before starting the game, the SLP selects one of two scenarios: a zoo exploration adventure or a space treasure hunt. They also set the duration for each task (see Figure 2.7 F).

- In the **space scenario**, the player takes on the role of a child astronaut who has discovered a galaxy treasure map. The goal is to find the hidden treasure in space.
- In the **zoo safari scenario**, the player embarks on a journey to reach a magical tree and earn strength and kindness badges.

Regardless of the chosen scenario, the child can select a character from six available options (see Figure 2.7 A). Before starting, head calibration is required, if the child's head moves out of the frame, the game pauses. This is explained through narration with an immersive justification:

- In the **space scenario**, the head calibration is done by "putting on a helmet". Removing the helmet (moving out of frame) prevents the player from continuing, as they cannot breathe in space.
- In the **zoo scenario**, the head calibration is done by making the child "stay inside the safari car". Stepping out of the frame stops the car, and it won't move until the player returns inside.

The first task in both scenarios requires the child to loudly say "Papa" as many times as possible in one breath. This action starts the engine of the spaceship or the car. As the journey progresses, the player meets a friendly character named Bobby— an alien in the space scenario or a monkey in the zoo scenario. The next task involves repeating the sentence "Buy Bobby a Puppy" five times. Completing this task rewards the player:

- The space astronaut receives a green gem and returns to Earth (see Figure 2.7 E).
- The zoo explorer reaches the magical tree and earns the strength and kindness badges (see Figure 2.7 J).

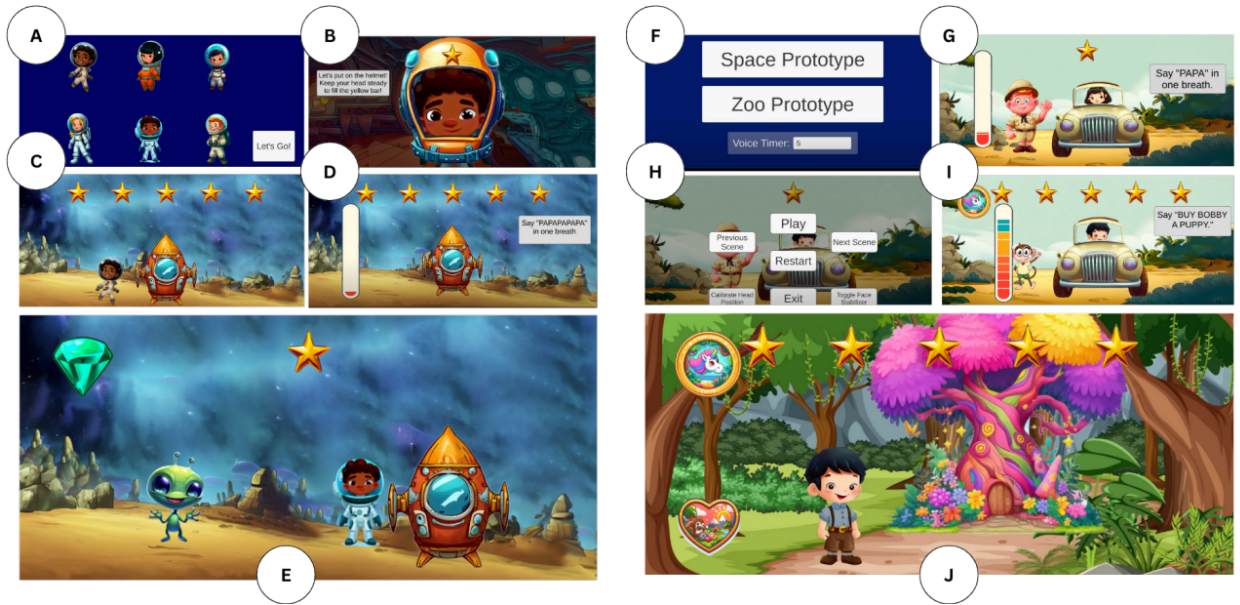


Figure 2.7: ArticuMotion

This SG was tested with nine children, each experiencing both scenarios. On average, the test lasted 12 minutes. Alsebayel and Nasri et al. concluded that the game was enjoyable and immersive for the children. While some preferred one scenario over the other, the space adventure was the most favored. Some children even engaged in role-playing as their chosen character. The researchers also noted that this tool, along with other similar games, could have a significant impact on the early assessment of speech disorders in young children [4]. This work [4] provides valuable insights into certain design implications, which will be further discussed in section 4.4.1.

FANIMA

In this chapter, we will present the SG called Fanima, which served as the foundation for this dissertation. We will provide a detailed explanation of the game, its architecture, and an in-depth overview of each chapter of the SG and the PLAY platform [5]. Then, we will compare Fanima with the related work previously studied. Finally, we explain the research process undertaken for this dissertation. It outlines the literature studied, details the consultation with SLP, and describes the preparations made for testing the game.

3.1 Fanima

The SG for this work is called Fanima. It is a multi-platform prototype game developed in Unity, designed to assist SLPs in assessing children's pronunciation of European Portuguese phonemes. The game is intended to be played during assessment sessions, with the child unaware that the SLP is evaluating them or controlling the chapters they play. While playing, the child's voice is recorded and saved on the PLAY platform.

Fanima has two interfaces: the child interface and the SLP interface. The SLP interface is a web-based platform (the PLAY platform) where the SLP manages the current game session, assesses phoneme errors, reviews recordings, and can re-assess errors or mistakes if necessary. The PLAY platform will be explained in detail in section 3.1.3 and the child interface in section 3.1.2.

The game is divided into four main chapters, numbered 0 to 3. We use the term "chapter" for each section of the game because there is no increase in difficulty as the game progresses. Table 3.1 shows the phonemes being considered and tested in each chapter.

Chapter	Phoneme articulation	Phonemes
Chapter 0	All	All
Chapter 1	Oclusives	/p/, /b/, /t/, /d/, /k/, /g/, /m/, /n/, /nh/
Chapter 2	Fricatives	/f/, /v/, /s/, /z/, /ch/, /j/
Chapter 3	Vibrants and laterals	/rr/, /r/, /l/, /lh/

Table 3.1: Phonemes considered for each chapter of the game

3.1.1 Architecture

The system architecture comprises several components, as illustrated in Figure 3.1. The Fanima application is where the child interacts with the system, while the SLP uses the PLAY frontend. Both the Fanima application and the PLAY frontend communicate bidirectionally with the API, which is the PLAY server. The server collects and saves data in the database. As shown in Figure 3.1, the server also communicates with a cloud service for data analysis and classification. However, auto-classification and analysis have not been implemented yet due to a lack of data samples with children’s voices in European Portuguese.

Requests made by the Fanima application are received by the server and redirected to the PLAY frontend, where the SLP selects a response and sends it back to the server, which then redirects it to the Fanima application. After the child logs in, the server waits for the SLP to log in as well. This initiates the communication flow until the game ends or an early termination request is made.

An example of this flow is when the application sends recording data to the server, which saves it in the database and forwards it to the SLP. In the PLAY frontend, the SLP manually analyzes and classifies the collected data without the child noticing, as it is done on a different device. Once classification is complete, the data is sent back to the server, which saves it in the database along with the recording. If the data is classified, the server instructs the application to continue the game. If not, the server waits for the SLP’s response, whether it’s a classification, a request to repeat the word, or to end the game.

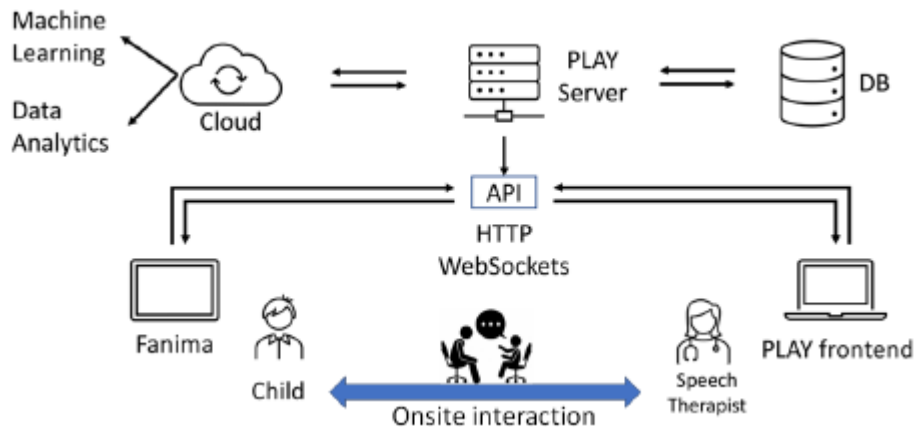


Figure 3.1: Fanima Architecture

3.1.2 Child Interface

To start the SG on the child interface, the SLP inputs the child’s username and password to log in (as seen in Figure 3.2). The game then waits for the SLP to log in to the PLAY platform. Once both the child and the SLP are logged in, the game begins.

Each chapter interface features a progress bar, an image of a microphone, an image of a panda, and a trophy board.

- **Progress Bar:** The bar increases as the child completes activities.
- **Microphone:** Initially highlighted in red to indicate it is not recording. When the highlight turns green, recording begins. Recording starts when an image appears for the child to identify, and it can restart if the SLP requests the child to repeat the word.
- **Panda:** This is the help function. When pressed, an audio clip plays, telling the child what is in the image and asking them to repeat the word.
- **Trophy Board:** After finishing a chapter, a trophy board appears, showing the trophy the child receives for completing that chapter.



Figure 3.2: Fanima login

Except for Chapter 0, all other chapters have an extra chapter. While playing Chapters 1, 2, or 3, if the SLP detects an error, the extra chapter will begin once the player finishes the current chapter. In all extra chapters, the player has to identify and say what they see in the image, repeating it three times. Afterward, they must perform an additional task, which varies depending on the specific extra chapter they are playing.

Chapter 0

This is the only mandatory chapter that all children must play and it is the only one that does not have extra tasks.

In this chapter, the player taps on shaking branches, which then reveals a board with an image on it. The child has to identify and say what they see in the image. This chapter is divided into two sections: words and sentences.

- **Words Section** (as seen in Figure 3.3(a)): This is mandatory for all children.
- **Sentences Section** (as seen in Figure 3.3(b)): This is played only after completing the words section and only if the SLP allows it. If the SLP decides that the child is not ready or capable of doing the sentences section, it is skipped, and the game moves to the next chapter.

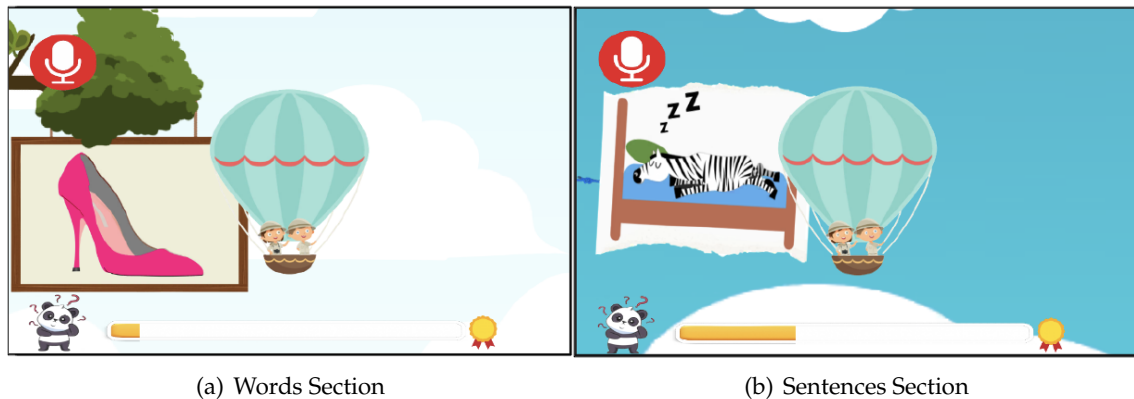


Figure 3.3: Fanima Chapter 0

Chapter 1

If the child has been identified with problems in occlusive phonemes, they are redirected to Chapter 1.

In this chapter, the player helps a frog collect coins (as seen in Figure 3.4(a)). When the player correctly identifies the image on the coin and says the word, the coin starts to shake, prompting the player to tap it. The frog then jumps towards the coin to collect it, and each coin collected increases the progress bar.

As mentioned before, an extra chapter starts if an error is found in the current chapter. In the extra chapter for Chapter 1, the player must say what is in the image three times(as seen in Figure 3.4(b)). After that, the player has to find and tap on a monkey that appears somewhere on the screen(as seen in Figure 3.4(c)).

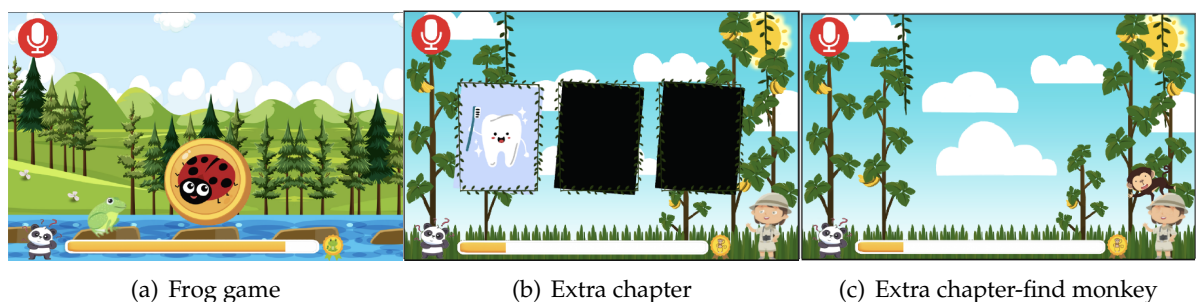


Figure 3.4: Fanima Chapter 1

Chapter 2

This chapter is designed for children with problems with fricative phonemes. The player helps a group of owls by popping balloons that appear on the screen. Once a balloon is popped, an image is revealed, and the child has to identify what it is(as seen in Figure 3.5). Each popped balloon increases the progress bar.

If errors are detected in this chapter, an extra chapter will begin afterward. In the extra

chapter, the player must say what they see in the image three times. After they repeat the word for the third time, a chameleon appears somewhere on the screen, and the player must find and tap it(as seen in Figure 3.6).

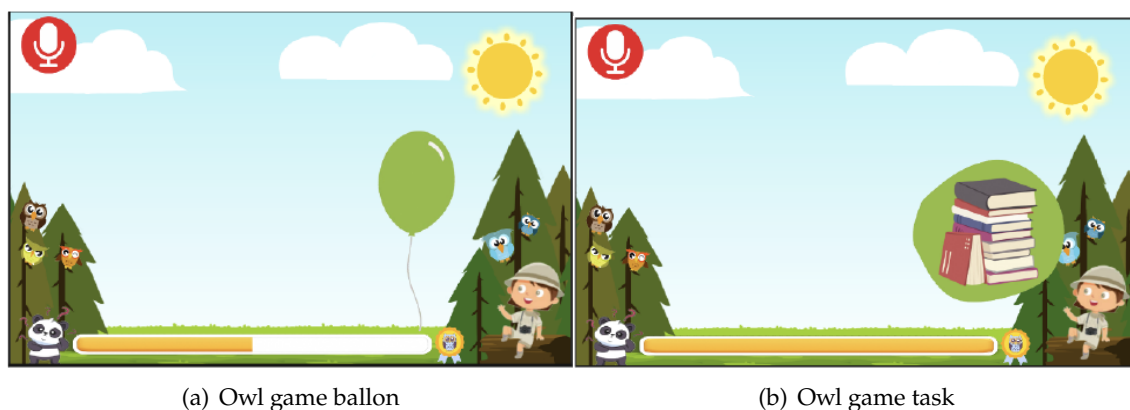


Figure 3.5: Fanima Chapter 2

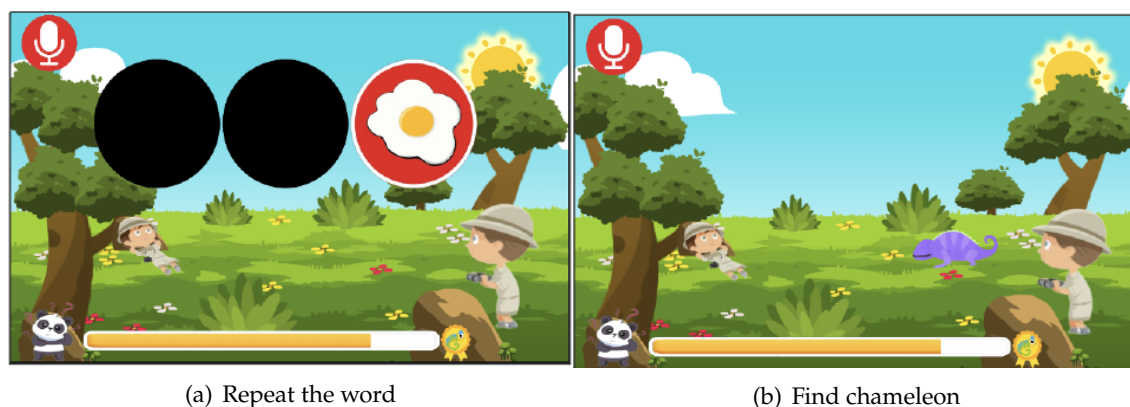


Figure 3.6: Fanima Chapter 2 extra

Chapter 3

This chapter is designed for children with difficulties with vibrant and lateral phonemes. The player's task is to help feed the fish. They must say the name of the item shown on the food container, which will cause the container to shake. When it shakes, the player taps on it, prompting the fish to move towards the food and eat it(as seen in Figure 3.7(a)). Each time the fish eats, the progress bar increases.

In the extra chapter, an image appears inside the octopus ink. After the player says what is in the image three times, they must match the ink, by dragging it, with the octopus of the same color(as seen in Figure 3.7(b)).

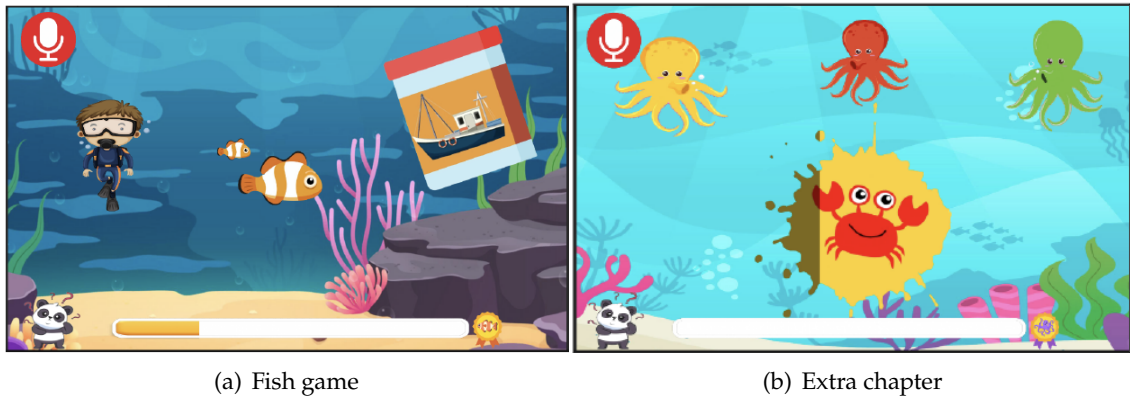


Figure 3.7: Fanima Chapter 3

3.1.3 Web Platform

As the web platform that supports the therapists, Fanima uses PLAY, which is a multiuser web-based platform for patients, therapists, and clinics, providing tools for several roles, allowing data analysis on multiple levels [5]. PLAY server has roles such as assuring backend functionalities, a frontend for each platform actor (in this case it is the SLP interface).

For the backend functionalities, PLAY saves the collected data and allows for the visualization and analysis of this data. It can create a profile for each child, where their recordings and session data are saved. With the collected data, it can show the child's progress and performance. Additionally, PLAY stores the game structure of Fanima and the repository of words, sentences, and phonemes.

For the SLP interface, PLAY shows the SLP only the profiles of the children they treat. During a game session, the SLP can control the flow of the game, for example, by requesting the repetition of a word, providing help, classifying the recorded word (as seen in Figure 3.8), or terminating the game early. With access to the child's profile, the SLP can review the saved recordings and re-classify them if necessary, visualize the child's progress and performance.

3.2 Comparison of Fanima with Related Work

Figure 3.9 presents a comparison between the studied games and *Fanima*.

When comparing the *Fanima* SG with the other studied SGs, it is essential to acknowledge that they are designed for different disorders and have varying objectives. *Fanima* shares the most similarities with *ArticuMotion* and *Apraxia World*, as all three focus on individuals with speech disorders. However, *Fanima* specifically targets the assessment of phonemes.

All the studied SGs are designed to assist children in their therapy. It is worth noting

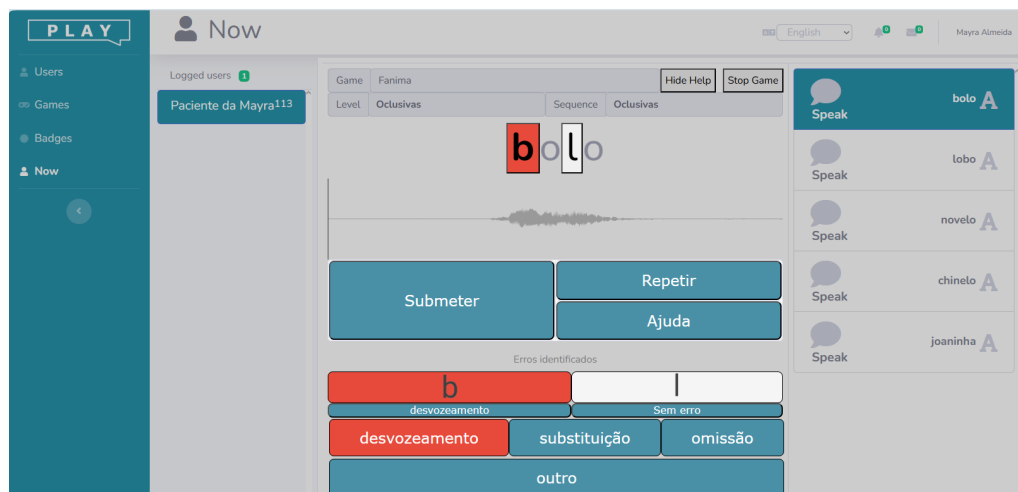


Figure 3.8: SLP interface during word classification

that while the *Emotion4Down* game was tested with individuals aged 15 to 34, the article highlights that for people with Down Syndrome, physical age does not always align with developmental age. Therapists who evaluated the game believed it could also be beneficial for children. Among the reviewed SGs, *Fanima* is one of the few designed specifically for younger children, targeting ages 3 to 7.

Regarding platform compatibility, most of these games are designed for mobile devices, particularly tablets. However, two notable exceptions are *The Busy Hands* and *ArticuMotion*, where players do not hold the device. In *ArticuMotion*, this is due to head calibration and the fact that the game is entirely voice-controlled. *The Busy Hands*, on the other hand, is played through hand-gesture recognition.

Fanima, like most of the SGs studied, does not follow a narrative story but instead consists of a set of tasks to achieve the game's goal. However, all the SGs analyzed have multiple levels (not referring to difficulty levels). *Apraxia World*, *ArticuMotion*, and *Fanima* feature different levels where the player performs similar tasks in varied scenarios. *Fanima* differs slightly, as some chapters require tapping or dragging objects to progress, but the core task—identifying and pronouncing an object—remains consistent across levels. In contrast, other SGs introduce different tasks at each level.

All SGs incorporate in-game rewards to motivate players, but not all offer customization features. Most include some form of customization, though there are inconsistencies. For example, in *New Horizon* and *Emotion4Down*, customization is both present and absent in different aspects. *New Horizon* allows modifications such as toggling audio and music in mini-games but lacks options for character customization or reward adjustments. In *Emotion4Down*, therapists can tailor game preferences to suit individual players.

Fanima currently does not offer customization, but implementing it could enhance player engagement. *Apraxia World* and *ArticuMotion* highlight customization as a design choice that significantly contributed to player immersion.

Most SGs incorporate some form of positive reinforcement when a player successfully

Serious Game	Disorder	Therapy Goal	Age Target	Platform	Story	Different Levels	Rewards	Customization	In-Game Positive Reinforces	Voice Detection	Audio Instructions	Tested with Target Audience	Therapist Assistance
New Horizon	ASD	Cognitive Behaviour Therapy	6 to 10 years old	Mobile tablet	Yes	Yes	Yes	Yes and No	Not specified	Yes	No	Yes	Yes (minor)
Emotion4Down	Down Syndrome	Support Emotional Awareness	Children and Adults (physical age does not correspond with development age for people with Down Syndrome)	Mobile tablet	No	Yes	Yes	Yes and No	Yes	No	Yes	Yes	Yes (minor)
The Busy Hands	ASD	Fine-Motor Coordination	Children, but no age mentioned	Not mentioned but uses Leap Motion sensor	No	Yes	Yes	No	Not specified	No	Yes	Yes	Yes (minor)
InTense	Language Disorder	Support in English language tenses	Children, but no age mentioned	Mobile tablet	No	Yes	Yes	Yes (character creation)	Yes	Yes	Yes	Yes	Yes (minor)
Apraxia World	Speech Sound Disorder	Speech Therapy	5 to 12 years old	Mobile	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
ArticuMotion	Speech Disorders	Speech Assessment	3 to 5 years old	Mobile but placed on a tripod	Yes	Yes	Yes	Yes (character selection)	No	Yes	Yes	Yes	Yes (minor)
Fanima	Speech Disorders	Speech Assessment	3 to 7 years old	Mobile	No	Yes	Yes	No	Yes	Yes	Yes	In progress	Yes

Figure 3.9: Comparison of Fanima with Related Work

completes a task. However, *New Horizon* and *The Busy Hands* do not specify whether they include this feature. In *ArticuMotion*, positive reinforcement is provided by the SLP rather than the game itself. In *Fanima*, encouragement is given through audio feedback when the child completes a task or finishes a level.

The majority of SGs utilize voice detection, requiring players to pronounce specific words to progress. *New Horizon* is an exception, as only one of its mini-games—the breathing exercise—incorporates voice detection. In all other SGs that use this feature, voice input plays a crucial role in speech or language therapy. Most games, except *New Horizon*, also provide audio instructions to assist players who may not be able to read. This ensures that children can engage with the game independently. Given that *Fanima* is designed for very young children, audio instructions are essential.

All SGs have been tested with their target audience, though many studies note that a larger sample size is needed to validate the game’s effectiveness. *Fanima* is currently undergoing testing with children with SDs, with only a small sample of results collected so far.

Regarding therapist involvement, all SGs except *Apraxia World* require some level of SLP assistance. In most cases, this involves adjusting settings or preferences, after which the child can play independently. *Apraxia World*, designed for home use, allows therapists to select words for the child to practice in their next session, requiring minimal intervention. In contrast, *Fanima* relies heavily on the SLP throughout gameplay. The therapist must initiate the game, assess the child’s mispronounced phonemes, and select the next chapters accordingly. These actions occur on the SLP’s computer without the child being explicitly aware that they are being assessed.

3.3 Research Approach

This dissertation aims to create a framework that identifies recommended DGs for developing a SG for speech therapy. To achieve this, we adopt a qualitative research approach to analyze and refine DGs that enhance engagement in SGs for speech therapy.

Until the start of this dissertation, *Fanima* had only been tested with SLPs and had not yet been evaluated by children with SDs. This study builds upon previous research on *Fanima*, a serious game co-designed with input from SLPs. Based on SLP feedback and DGs, we aim to refine *Fanima* by addressing potential design choices that may hinder a child’s engagement and enjoyment of the game.

To achieve this goal, the research follows a multi-step methodology:

- **Literature Review** – We examined existing studies on serious games, speech therapy, and engagement strategies for children to identify relevant DGs.
- **SLP Consultation** – We analyzed documentation from the previous thesis, which included SLP feedback on *Fanima*’s design and functionality. Additionally, we studied paper [4], which provided insights from other SLPs. Further consultations

with SLPs helped us better understand their therapeutic methods and the role of serious games in speech therapy.

- **Game Testing and Observation** – While Fanima had been tested by SLPs, it had not yet been evaluated by children with SDs. This dissertation involves testing Fanima with its target audience, gathering observational data, through questionnaires, and assessing engagement levels.
- **Design Evaluation and Refinement** – By comparing existing DGs with user feedback and test results, we aim to determine which guidelines contribute to an engaging SG for speech therapy and propose improvements for Fanima.

This structured approach ensures that our findings are grounded in both theoretical knowledge and practical application, ultimately contributing to the development of a framework for designing effective SGs for speech therapy.

3.3.1 Literature Review

The literature reviewed mainly focused on the DGs from three key papers [2][54][41] and the insights from paper [4]. The selected papers were chosen not only for their focus on designing games for children but also because they explicitly outlined DGs. Many papers discuss design implementations or suggestions within lengthy paragraphs, making it harder to extract clear guidelines.

Paper [2] identified 86 guidelines across 15 categories, focusing on how SGs can stimulate cognitive abilities in children with speech and language delays. The categories include interface design, reward/encouragement, performance feedback and guidance, personalization, motivation and engagement, among others.

Paper [54] which focused on SG design for children in general, presented 40 guidelines. Each guideline was assigned a relevance score, calculated as the average of clarity, agreement, and importance ratings. Experts considered these guidelines highly valuable [54].

Paper [41] offered design recommendations for touchscreen games for children, analyzing 50 popular iPad games. It identified 57 guidelines across three key dimensions: cognitive, physical, and socio-emotional (Table 2.1 provides examples). Finally, Paper [4] provided insights into how SLPs motivate children to engage with games.

Many of the DGs from these papers were already implemented in Fanima, but others, such as recommended text size and patterns, were not suitable. For example, children playing Fanima are not expected to read, so text size and patterns need to be adjusted accordingly. In Section 4.4, we will provide a detailed explanation of the guidelines proposed for Fanima.

3.3.2 Speech-Language Pathologist Feedback, and Preparations for Testing

During the study of previous feedback from SLPs, we found that some of the images used for assessments were considered too difficult or unsuitable. As a result, we created a repository of all words and images used. An online consultation was conducted with an SLP who had previously tested Fanima. During this consultation, we identified potential issues such as long testing periods and low internet connection, which could hinder gameplay. The SLP suggested changes to certain images and words. Additionally, the SLP mentioned using the Montessori Method, which respects the individuality of each child and encourages them to choose activities to foster intrinsic motivation [32][33]. The method also emphasized repetition to build confidence. The SLP provided suggestions for word and image changes, which were incorporated into a revised version of the Fanima repository.

To begin testing with children, we created a "Consentimento Informado" (Informed Consent) document for parents or guardians to sign. This document explained the purpose of the testing and outlined the process, including the right to withdraw at any time. It also assured guardians that any personal data collected would remain confidential. The document also informed guardians that they could request additional information before and after giving consent.

Next, we created questionnaires for both SLPs and children. The SLPs would fill out the questionnaire based on their observations of the child while playing the game, and the children, with the SLP's assistance, would answer questions about their experience and preferences during gameplay.

The questionnaire for children will gather their opinions on various aspects of the game, including graphics, interactions (such as tapping, dragging, and pronouncing the displayed objects), gameplay, and usability. They will also be asked what they liked most, what they found most challenging, and what they would add or change if possible.

The questionnaire for SLPs will document the chapters played and gather observations about the child's experience. It will assess whether the child had difficulties understanding the tasks, their level of motivation, whether they requested assistance, and if they appeared comfortable while playing, among other factors. The questionnaires can be viewed in Annex III.

With the questionnaires prepared, we contacted clinics and arranged an in-person consultation with clinic Acentuar. During the meeting, we explained the purpose of the dissertation to three SLPs and demonstrated how to operate the game. The SLPs realized that once the child understood how to play, they might pronounce the objects shown before the recording started. To address this, they suggested starting the recording before showing the object. After the consultation, we sent the "Consentimento Informado" document to the SLPs, allowing them to contact the guardians and select the children who would participate. We clarified that the only data required from the child was an identifier (e.g., a nickname), gender, and date of birth.

We aimed to analyze existing studies and formulate hypotheses regarding the proposed DGs for Fanima, as well as for the development of the framework. The Fanima prototype was then tested with children, and by the time this dissertation was finalized, only a small sample of results was available. Using the data collected, we performed a preliminary analysis of Fanima and assessed the extent to which the framework's DGs were validated.

DESIGN GUIDELINES AND ENHANCEMENTS

This chapter begins by presenting the DGs that were implemented in the SG before the start of this dissertation, followed by the new implementations added during this research. It then addresses several design-related questions and proposes additional DGs that could further enhance Fanima. Subsequently, it discusses additional DGs that, while not applicable to Fanima, are relevant to the broader framework. Finally, it introduces the proposed framework, explaining its structure and how it can be applied in the design and/or evaluation of SGs for speech therapy.

4.1 Overview of Fanima's Design Guidelines

Fanima is an SG co-designed with SLPs and follows a set of DGs. The guidelines were based on suggestions from SLPs of the clinic 'Cresce com Amor'. They aim to challenge the children without making the game too complex, as it is primarily designed for children aged between 3 and 7 years old. Additionally, the guidelines are intended to assist the SLP during the assessment. The prototype developed before this dissertation incorporated a total of 34 DGs, with Table 4.1 showing some examples of the DGs incorporated, while Annex I provides a complete list of all implemented guidelines.

Throughout this dissertation, various design-related questions were explored, particularly regarding potential new implementations and their benefits for Fanima. Examples of questions that were analyzed:

- Are the current sound effects and music compelling for the children or a distraction?
- Would adding a feature to turn off the music help the child concentrate?
- Is adding customization/personalization (e.g., for music, background, character, etc.) useful or will it deviate too much from the purpose of the game?
- Would adding a collaboration or competitive feature in the game motivate the children to do better?

ID	Description
G1	Create appealing and age-appropriate design
G2	Provide phoneme classification
G3	Provide feedback
G4	Suggest specific chapters based on wrong phonemes
G5	Do not transmit the error to the child
G6	Allow SLP to classify error
G7	Extra games could be played after a chapter
G8	Provide child capability to ask for hint
G9	Give SLP capability to ask for word repetition
G10	Repeat the same word 3 times for error consistency
G11	Have an indication to when the game is recording
G12	Stop the game and restore
G13	Images adapted to children's perception
G14	Auditory instructions whenever the child interacts with the game
G15	Reward system at the end of each chapter
G16	Child be aware of how close it is to end a task

Table 4.1: Some of the Guidelines used when Fanima was implemented

- Would incorporating a narrative storyline enhance the child's immersion in the game?

4.2 Development and Implementation

Through the analysis of previous feedback from SLPs, several design suggestions that had not yet been implemented were identified. Some of these aimed to assist the SLP during the assessment process, while others focused on improving the child's engagement and experience.

One suggestion was **adding an option to hide the help button**. This feature prevents children from relying too heavily on the help function and encourages them to attempt to name the object before requesting assistance. By allowing the SLP to control the visibility of the help button, it becomes easier to assess whether the child is genuinely trying to play the game or simply using the help feature as a shortcut. This implementation aligns with the design guidelines that emphasize **providing a challenge and allowing an adult to configure and control the game** [2][54].

Another improvement was **modifying the chameleons to appear gradually with each repetition of the target word**. The chameleon becomes more visible as the child repeats the word, but it cannot be selected until it is fully visible. This implementation follows the design guideline that suggests **using symbols and images that represent real-life situations and relating the interface metaphor to the children's world** [2][41][54]. The concept of a chameleon camouflaging and slowly revealing itself fits perfectly with this guideline.

Other improvements focused on **optimizing game performance** by improving the way data is managed. Previously, the game would recompile all data every time a new scene was loaded, which slowed down performance. In this updated version, a Data Manager was implemented to save the most crucial data locally. When transitioning to a new scene, the game retrieves the necessary data from the Data Manager rather than requesting it from the server, significantly improving loading times and ensuring faster feedback, which is another important design guideline [2][54].

While not fully implemented in the current prototype, **a character selection feature** was partially developed. Although this feature is not visible in the prototype, the code has been added to the game. Through the literature review, we identified that customization is an important DG that enhances motivation and immersion for children [2][4][41]. The idea is that when the child first plays Fanima, they select their preferred character, which is then saved in their account. Each time the game starts or restores a session, the PLAY server sends a message with the identification of the chosen character. Additionally, the child would have the option to change the character if desired.

We also improved the game's **restore feature**, allowing the game to stop and continue from where the child left off, even when starting from extra chapters, which previously caused a bug. A key improvement was **ensuring that the state of the help button is saved between sessions**. For instance, if the help button is hidden when the game is interrupted, it will remain hidden when the game is resumed.

Finally, extensive testing was conducted to identify and fix potential bugs, ensuring the stability and functionality of the new implementations.

4.3 Answers to Design-Related Questions for Fanima

During the development of this dissertation, we were able to answer several design-related questions:

- **Q1: Are the current sound effects and music compelling for the children or a distraction?** Fanima does not have background music to help the child concentrate on the instructions, but it does include sound effects that serve to attract attention (e.g., the sound of leaves shaking in Chapter 0) or to indicate changes in the game (e.g., a monkey sound to alert the child of a new character). Further testing with children is needed to fully answer this question.
- **Q2: Would adding a feature to turn off the sound effects or music help the child concentrate?** While further testing is needed to confirm whether sound effects are distracting, a mute button should be provided. The sound effects used occur before or after the word is pronounced. While a turn-off feature may not seem necessary, it's important to consider that some children may be sensitive to specific sounds. Therefore, including an option to mute the sound effects would be beneficial [2].

Proposed Guideline	Description
PG1	Relating the interface to real-world concepts
PG2	Allowing the SLP to hide/show the help button
PG3	Providing fast feedback and reducing loading time
PG4	Adding a character selection feature
PG5	Creating a mute option for sound effects
PG6	Avoiding social features, such as sharing rewards or leaderboards
PG7	Avoiding narrative storytelling
PG8	Start Recording Before Showing the Object

Table 4.2: Proposed Design Guidelines for Fanima from sections 4.2 and 4.3

The mute button should be available through the SLP account to avoid cluttering the child’s screen, giving the SLP control over its activation.

- **Q3: Is adding customization/personalization (e.g., for music, background, character, etc.) useful or will it deviate too much from the purpose of the game?** Yes it is useful, customization has been shown to improve the child’s motivation and imagination, making the game more engaging and entertaining for them [2][4][41].
- **Q4: Would adding a collaboration or competitive feature in the game motivate the children to do better?** While cooperation can promote social interaction [2][4], Fanima is designed as a solo game, so this feature might not be relevant here. A competitive element, such as a leaderboard ranking children by performance, was considered but deemed ineffective. Since children will play different chapters and words, comparing their performance would be difficult and unfair. Additionally, research [41] suggests that sharing social features like sharing reward badges do not enhance engagement and motivation, further supporting the decision to exclude a leaderboard feature.
- **Q5: Would incorporating a narrative storyline enhance the child’s immersion in the game?** A narrative could indeed enhance the child’s immersion, but due to the game’s structure, it may not be appropriate. Only Chapter 0 is consistently played; the selection of other chapters varies between children. Adding a narrative could result in children repeating chapters they’ve already completed, leading to longer sessions. Extending the game’s duration might counteract its purpose, as the SLP’s time is limited, and extended gameplay could lead to reduced interest or engagement.

4.4 Hypotheses of Proposed Design Guidelines for Fanima

In this section, we propose hypotheses of additional DGs for Fanima. Table 4.2 presents some of the DGs already suggested in previous sections.

Through the literature review, we identified additional DGs that could be implemented in Fanima. We began by analyzing the four main papers and selecting DGs that align with Fanima's goals.

4.4.1 Proposed Design Guidelines from Alsebayel and Nasri[4]

The research from [4] suggests adding a variety of reward stickers (or in this case, badges) and allowing the child to choose their preferred ones. This could be implemented by providing a selection of reward badges at the end of each chapter, where the child can select their favorite. Alternatively, the SLP could pre-select the badges based on the child's preferences. **Custom rewards** make the experience more meaningful for the child and create anticipation for rewards. This anticipation can encourage them to repeat tasks and may even motivate them to replay the game just to collect more rewards. The rewards help increase extrinsic motivation, which can be particularly beneficial for children who are not intrinsically motivated by the game itself. Over time, this extrinsic motivation—driven by the desire to earn rewards—could naturally transition into intrinsic motivation, fostering genuine interest in the game. Additionally, custom rewards serve as a form of personalization, a DG we have already highlighted as an effective way to increase children's motivation and engagement in Fanima.

While competitive features like leaderboards have been rejected, **competition can be introduced in a more subtle and positive way**. For example, the paper [4] suggests using playful challenges and exaggerated praise to boost the child's confidence and motivation. For example, phrases like:

- "I bet you can't do as many as I can!"
- "Wow! You did even better than me!"

This approach encourages the child to push themselves without direct comparison to others, keeping engagement high while avoiding stress. Additionally, using varied and playful compliments ensures that the child receives different forms of positive reinforcement, rather than hearing the same phrase repeatedly. This DG aims to increase intrinsic motivation by encouraging the child to outperform their previous attempts, strengthening their confidence and engagement.

Furthermore, the paper highlights the importance of **clear objectives and instructions** to avoid confusion and maintain the child's attention. The character selection feature and task-based challenges contribute to a **role-playing experience**, which can spark the child's imagination and make the game more engaging, distracting them from the repetitive nature of speech therapy exercises. A summary of the proposed DGs gathered from research [4] is presented in Table 4.3.

Proposed Guideline	Description
PG9	Variety of reward badges/stickers
PG10	Subtle competition through tasks
PG11	Clear objectives and instructions
PG12	Role-playing aspect through character selection

Table 4.3: Proposed Design Guidelines from Alsebayel and Nasri[4]

4.4.2 Proposed Design Guidelines from Zaki and Ahmad [2]

The research [2] suggests several DGs that can enhance the Fanima game, some of which are already subtly implemented or can be integrated in future updates. An important DG is to avoid adding excessive text to the game interface, making the game more accessible to younger children. Although the game has been designed and tested by SLPs, the only way to determine if the interface is cluttered for children is through testing. By observing the children's focus and ensuring that they are not overwhelmed by information, we can confirm if the interface needs further simplification.

In terms of visual design, the game's colors should harmonize with the interface to ensure that no image appears out of place. This consistency helps maintain the child's concentration and prevents distractions. In addition, the uniformity of the game's design will create a welcoming and child-friendly environment. Testing, including feedback from questionnaires, will provide valuable insights into how visually appealing the game is to children. In the future, we aim to have all the objects designed by a professional designer, which will further ensure consistency across the game.

A guideline also suggests that the game should capture the natural interest of the child without relying on rewards. However, we acknowledge the challenge of balancing this with the need for external motivation, especially for children who may not yet be intrinsically motivated. Therefore, in Fanima, the reward system is intended to serve as an initial motivator. Over time, our goal is for this extrinsic motivation to transition into intrinsic motivation as the child becomes more engaged with the game.

Another DG recommends having a demonstration to show children how to play the game. We plan to implement this by including animations or highlights that guide the child on what to do, with verbal instructions to reinforce the task. To prevent providing the solution immediately, we will introduce a timer: if the child does not complete the task within the given time, a demonstration will be triggered. This demonstration will only show how to perform tapping or dragging tasks, not how to verbally identify objects.

Finally, the game vocabulary must be adapted to the child's comprehension level, and the objects displayed should be recognizable. Feedback from SLPs revealed that some objects would not be easily recognizable by children, so we compiled a list of new objects to be added in the next prototype. Further testing with children will help us ensure that the vocabulary is appropriate and easily understood. A summary of the proposed DGs gathered from research [2] is presented in Table 4.4.

Proposed Guideline	Description
PG13	Ensure Color Harmony in the Game
PG14	Balance Intrinsic and Extrinsic Motivation
PG15	Provide Demonstrations on How to Play the Game
PG16	Adapt Vocabulary to the Child's Comprehension Level
PG17	Avoid Adding Excessive Text to the Interface

Table 4.4: Proposed Design Guidelines from Zaki and Ahmad [2]

Proposed Guideline	Description
PG18	Avoid Differentiating Left from Right
PG19	Emphasize Clickable Interface Elements
PG20	Offer a Variety of Themes and Skins

Table 4.5: Proposed Design Guidelines from Valenza [54]

4.4.3 Proposed Design Guidelines from Valenza [54]

In research [54], there are not many new DG to add, as several have already been suggested in previous studies. However, one new DG recommends avoiding the differentiation of left from right, as some children may still have difficulty distinguishing between the two. Another important DG emphasizes the need to highlight clickable interface elements. While the interface should remain harmonized, it is crucial to make clickable elements easy to spot. This can be achieved by using prominent borders or outlines, increasing the size of clickable objects, applying contrasting colors, or adding sound effects that activate when the object is selected. If a child cannot easily locate the target object, they may become frustrated and lose interest, which reduces the overall enjoyment of the game.

Finally, another DG suggests providing a variety of themes and skins in the game. This has already been partially implemented, as each chapter features different background themes—such as the sky, a forest, and the ocean. To enhance this further, we could introduce alternative versions of these backgrounds, with smoother textures and softer colors for children with sensory sensitivities. If character selection is added, we could also offer different character skins, further supporting this guideline. The inclusion of various themes and skins will help keep the game fresh, avoid monotony, and maintain long-term engagement. A summary of the proposed DGs gathered from research [54] is presented in Table 4.5.

4.4.4 Proposed Design Guidelines from Soni [41]

In research [41], many DGs focus on cognitive, physical, and socio-emotional needs. This study primarily considers the DGs related to cognitive and physical needs, while the socio-emotional DGs reinforce some of the previously proposed guidelines (such as PG4, PG6, and PG20).

One recommendation is to use child-like characters as guides in the game. Fanima

already incorporates background characters that align with this principle, and adding a character selection feature with child-like avatars would further support it. A child-like character serves as a friendly companion, making the game more inviting. Children may feel more comfortable and connected with a peer-like figure rather than an authority figure, reducing pressure and enhancing immersion by stimulating their imagination.

Another guideline suggests that clickable elements should be visually distinct from the rest of the screen, reinforcing the previously proposed DG (PG19). Additionally, small interactive elements should not be placed at the edges of the screen, as children may either overlook them or accidentally select them while holding the tablet. Animations, while useful for drawing attention, should be carefully controlled to avoid distracting the child from the task. To maintain focus, minimal or no animation should be used when the child is expected to pronounce an object's name, while more animations can be employed in complementary tasks such as finding the chameleon, monkey, etc.

Explicit scaffold prompts are also advised, supporting the previously proposed DG (PG15). Demonstrations and clear instructions can reinforce how to complete a task, improving the child's memory and understanding. Another recommendation is to place the most essential instructions at the end of a sentence, as children tend to forget the beginning of longer audio cues. This is particularly useful when introducing a chapter, ensuring that the main instruction is given last to help the child focus on what needs to be done.

A time-out for inactivity is another suggested feature, triggering a demonstration or repeating the audio instruction when the child loses focus. This helps them regain concentration and continue playing. The research also advises against using traditional tutorials, as children are unlikely to remember them. Instead, Fanima counteracts this by providing audio instructions before each task, and further support could be added through demonstrations.

Some interaction gestures should be avoided due to their difficulty for children, such as double-tapping, rotating, pinching and spreading, and even drag-and-drop actions. While Fanima does use drag-and-drop, it has been simplified by enlarging interactive elements and ensuring they do not reset to their original position if the child fails to place them correctly. The game should also support both single- and multi-touch input, allowing children to use multiple fingers during complementary tasks. This accommodates physical needs, as some children may struggle to use only one finger or may not naturally restrict themselves to single-touch actions.

Finally, the game should allow slightly out-of-bounds interactions by expanding the interactive area slightly beyond the required spot. This prevents frustration when children miss the target area multiple times, making the game more forgiving and enjoyable. Many of the DGs related to physical needs focus on reducing frustration and ensuring a smoother, more accessible experience for children. A summary of the proposed DGs gathered from research [41] is presented in Table 4.6.

Proposed Guideline	Description
PG21	Use Child-Like Characters as Guides
PG22	Avoid Placing Small Interactive Elements at the Edges of the Screen
PG23	Use Animations Carefully to Avoid Distraction
PG24	Place Essential Instructions at the End of Sentences
PG25	Implement a Time-Out for Inactivity with Assistance Prompts
PG26	Avoid Traditional Tutorials
PG27	Avoid Complex Gestures
PG28	Support Both Single- and Multi-Touch Input
PG29	Allow Slightly Out-of-Bounds Interactions

Table 4.6: Proposed Design Guidelines from Soni [41]

4.5 Laying the Groundwork for a Broader Framework

Throughout this dissertation, we explored various DGs and proposed new ones that could be implemented in Fanima. While some DGs are important or beneficial for SGs, they may not be directly applicable to Fanima. However, they could still be valuable for other SGs in speech therapy. In the following sections, we present these DGs and introduce a framework based on the DGs studied throughout this dissertation. Since Fanima’s testing is still ongoing, the framework will be grounded in theoretical research, literature review, and feedback from SLPs. The purpose of this framework is to serve as a foundation or reference for designing future SGs for children’s speech therapy.

4.6 Hypotheses of Proposed Design Guidelines for Serious Games in Speech Therapy

Throughout much of the research reviewed, we consistently found recommendations for incorporating a narrative story in children’s SGs [41][54]. A well-designed narrative can deepen a child’s immersion in the game, capturing their interest and sparking curiosity. This sense of curiosity motivates them to continue playing, eager to discover what happens next.

In addition to storytelling, SGs should encourage exploration [2][54]. The game’s interface should be engaging, inviting the child to experiment and explore different possibilities. This approach fosters curiosity and intrinsic motivation, shifting the child from passively following instructions to actively engaging with the game. By exploring and learning from their mistakes, children are more likely to retain what they learn. An example of a game that effectively promotes exploration is Apraxia World, which features multiple levels, character choices, and the ability to replay levels with different characters or new abilities [7]. This level of autonomy keeps children engaged. In contrast, a game that is too restrictive in what the child is allowed to do may quickly lead to a loss of interest.

The menu system should be simple and easy for children to understand, reducing confusion and frustration [2][41]. If a game is difficult to navigate, a child may lose interest. In *Fanima*, as in many other SGs studied, the menu system is primarily designed for SLPs rather than children. When designing SGs, it may be beneficial to either avoid complex menu systems altogether or ensure they are as simple as possible so that children can immediately understand their options. Using meaningful icons can help make the options clearer. Additionally, hierarchical menus should be avoided, as they can be difficult for young children to navigate.

While text should generally be avoided for younger children, when necessary, it should be presented in large, easy-to-read fonts, clearly distinguishable from the background [2][41][54]. If possible, an option to have the text read aloud (e.g., for labels, stories, or instructions) should be included. The vocabulary should be simple and appropriate for the child's comprehension level. These features enhance accessibility, benefiting children who can read but have hearing difficulties and potentially helping improve their reading skills.

Icons should be placed consistently throughout the game and be easily understandable without requiring text [2][41]. This makes the interface more intuitive and child-friendly.

For SGs that include scoring, the score should remain visible throughout the game [2][54]. This provides immediate feedback on the child's progress, giving them a sense of accomplishment and motivating them to improve their score. A visible score may also encourage children to replay the game in an effort to achieve a higher score.

Additionally, SGs should offer multiple difficulty levels [2][41]. This allows children with greater challenges to play at an easier level while more experienced children can push themselves with harder difficulties. Having adjustable difficulty levels helps maintain a balance between challenge and skill, preventing frustration if the game is too hard and boredom if it is too easy. This balance is crucial for keeping children engaged and entertained.

SGs should allow children to revisit previously explored areas or correct their mistakes [2][41][54]. While assessment SGs may not use the mistake-correction feature (since their purpose is to identify errors in pronunciation), other SGs could benefit from this feature, as it would enable children to practice and improve their skills. Research [41] suggests incorporating pop-ups or dialogues that help children correct mistakes. Allowing children to return to previously explored areas would also encourage further exploration of the game. This DG advocates for an interface that displays all explored areas, making navigation easier for the child.

Research [54] suggests hiding advanced levels (e.g., unexplored areas) to avoid overwhelming the child. This prevents them from skipping ahead to higher levels before completing earlier ones, maintaining a steady flow of progression. This DG helps keep children engaged and motivated by avoiding overload and maintaining curiosity about what lies ahead.

Research [41] also recommends horizontal scrolling over vertical scrolling. Horizontal

Proposed Guidelines for Framework	Description
PGF1	Incorporating a narrative story
PGF2	Encouraging exploration
PGF3	Simplifying the menu system for children
PGF4	Using large, easy-to-read text and simple vocabulary
PGF5	Using Consistent and Understandable (Intuitive) Icons
PGF6	Displaying the score throughout the game
PGF7	Offering multiple difficulty levels
PGF8	Allowing children to revisit previously explored areas
PGF9	Allowing children to correct mistakes
PGF10	Hiding advanced levels
PGF11	Using horizontal scrolling instead of vertical scrolling
PGF12	Promoting cooperation
PGF13	Creating an open-ended SG with multiple possibilities

Table 4.7: Proposed Design Guidelines for Framework

scrolling helps maintain a sense of game flow and progression, supporting the storytelling aspect of the game. Additionally, it is easier for children to swipe horizontally when holding a tablet, and it can encourage exploration.

SGs should, when possible, promote cooperation [54]. Allowing children to play with others fosters social interactions, teamwork, shared experiences, and a sense of security and support.

Finally, an open-ended SG with multiple possibilities will further promote exploration, supporting creativity and increasing engagement for the child [41]. A summary of the proposed DGs for the framework is presented in Table 4.7.

4.7 Application of Framework

The proposed framework consists of 61 DGs categorized into 10 sections. It was derived from literature reviews, SLP feedback, and theoretical research. The framework aims to support the design of future SGs for children's speech therapy, ensuring they are engaging and motivating for the child while remaining effective for therapy. Additionally, it serves as a tool for evaluating SGs within this field. The selected DGs focus on enhancing motivation, engagement, usability, and therapeutic effectiveness.

In Section 4.6, we presented hypotheses for proposed DGs within the framework. While these DGs were not specifically recommended for Fanima, they could still be valuable in the broader context of designing SGs for speech therapy. At the same time, many of the DGs that were either already implemented in Fanima or proposed for it are still highly relevant to the framework. This means that these DGs are not just beneficial for Fanima but can serve as general principles for SG design in speech therapy. Examples include:

- **Providing feedback:** Reinforces learning and keeps the child motivated throughout

the game.

- **Indicating when recording starts:** Prevents confusion by giving the child a clear visual cue on when to begin their speech tasks.
- **Using child-like characters as guides:** Creates a more child-friendly and stress-free interface, reducing anxiety and making the child feel more connected to the character.
- **Designing an appealing and age-appropriate interface:** Ensures the interface captivates the child with an attractive design while remaining easy to understand, preventing frustration.
- **Saving recordings:** Helps SLPs track progress and analyze mistakes over time.
- **Incorporating audio instructions:** Supports children who struggle with reading, making the game more accessible and less cognitively demanding.
- **Enabling character selection:** Gives children autonomy over their experience, making them feel more immersed in the game and encouraging imaginative role-play.
- **Balancing intrinsic and extrinsic motivation:** Ensures the game remains enjoyable because of its engaging tasks, not just external rewards.
- **Starting recording before showing the object:** Prevents situations where the child performs a task too early, reducing the need for repetition and minimizing frustration.

The DGs from Fanima can be reviewed in Annex I and Section 4.4. Some DGs are situational, such as allowing the SLP to classify errors or recommend a specific chapter based on the incorrect phoneme. These DGs are particularly relevant for SGs focused on assessing speech errors, as they assist the SLP and influence the game's progression. The framework we present will provide a generalized version of the recommended DGs, making them applicable to a broader range of SGs for speech therapy.

The framework presents a list of DGs derived from those implemented in Fanima, newly proposed ones for both Fanima and the framework. In case of any contradictions, the DGs from section 4.6 will take priority, as they are more generalized and account for Fanima's limitations (for example, the lack of a narrative story in Fanima, which is recommended for the framework). Table 4.8 lists some of the DGs recommended for the framework, categorized into 10 sections. The categories are ordered so that the first ones focus on DGs that directly impact the child's motivation and enjoyment, ensuring they stay engaged and continue the therapy. The later categories prioritize core therapeutic features and practical elements that ensure the game's effectiveness in speech therapy. Annex II presents all the DGs recommended for the framework. The framework categories are as follows:

- **Motivation and Progress Tracking:** Focuses on DGs that ensure the child stays motivated by fostering a sense of achievement and progression. This is the most important category for this dissertation, as it helps identify which DGs effectively engage children in SGs.
- **User Interface and Engagement Design:** Ensures that the SG is visually appealing, intuitive, and engaging, enhancing the child's overall experience with the game.
- **Game Flow and Usability:** Aims to prevent frustration and distractions by ensuring a smooth game flow.
- **Game Structure and Functionality:** Ensures that the SG remains clear and engaging without overwhelming the child.
- **SLP and Child Interaction Features:** Includes features that facilitate interaction between the SLP and the child, making the experience more engaging and personalized.
- **Learning and Adaptation:** Focuses on adapting the SG to the child's progress, maintaining an optimal balance between challenge and skill. This prevents boredom (if the game is too easy) and anxiety (if it is too difficult).
- **Feedback Systems:** Ensures that the child receives motivating and constructive feedback throughout the game to encourage improvement.
- **Phoneme Classification and Error Management:** Assists the SLP by identifying the child's mistakes during gameplay, helping to refine therapy sessions.
- **Support for Child Needs:** Provides options that accommodate children's individual needs and preferences, allowing them to play autonomously without excessive external assistance or overwhelm.
- **Data Collection:** Helps the SLP track the child's progress over multiple play sessions, aiding in speech disorder assessment and future therapy planning.

As stated previously, we aim for this framework to serve as a foundation or example for designing future SGs for children in speech therapy (as explained in section 4.7.1) but it could also be used in the evaluation of an already made SG (as explained in section 4.7.2).

4.7.1 Applying the Framework in Serious Game's Design

When using this framework to design an SG, the following key questions should first be addressed:

- What is the goal of the SG I want to design?

Design Guideline	Description	Category
DG1	Display progress to help the child understand how close they are to completing a task	Motivation and Progress Tracking
DG9	Relate interface elements to real-world concepts to make them more relatable and understandable for children	User Interface and Engagement Design
DG20	Highlight clickable interface elements to guide the child through the game	Game Flow and Usability
DG24	Use initial Chapter or level solely for error detection to avoid overwhelming the child with content	Game Structure and Functionality
DG27	Allow the SLP to select specific phonemes and play sentence sections tailored to the child's therapy needs	SLP and Child Interaction Features
DG37	Adapt images and visuals to match children's cognitive abilities, ensuring clarity and ease of recognition	Learning and Adaptation
DG42	Offer immediate feedback to help the child understand their performance	Feedback Systems
DG50	Allow repetition of the same word to check for error consistency	Phoneme Classification and Error Management
DG56	Implement a mute option for sound effects to accommodate different environments or preferences	Support for Child Needs
DG61	Differentiate between samples collected with repetition or assistance, tracking the child's independent progress versus guided help	Data Collection

Table 4.8: Some of the Design Guidelines for the Framework

- What is the target age group of the children who will play the game?
- What skills are they expected to have?
- How will they interact with the game to perform their tasks?
- Will the game be fully autonomous, or will it require assistance from a SLP?

Once these questions are answered, the game designer can study the framework and select the most suitable DGs for their SG. It is crucial to determine the most relevant DGs before beginning prototype development. This helps avoid unnecessary features, resource waste, and inefficient development cycles.

Additionally, when creating an SG for speech therapy, it is essential to study speech therapy practices and collaborate with SLPs in the co-design process. This ensures the game remains aligned with its intended therapeutic goals.

4.7.2 Applying the Framework to Evaluate an Existing Serious Game

When using the framework to evaluate an existing SG, the following approach should be followed:

1. Study the framework – Understanding the framework beforehand allows for a clear and efficient analysis, leading to a more objective assessment.
2. Define an evaluation checklist – Identify key features to examine within the game.
3. Play the game – A prior understanding of the framework helps evaluators look beyond first impressions and focus on identifying key design elements.
4. Compare the game systematically against the framework – Assess how well the game aligns with the DG by checking whether key features support engagement, feedback, and skill development.
5. Document the results – Provide a structured evaluation based on the findings.

4.7.3 Future Refinements of the Framework

Once Fanima's testing with children reaches a sufficiently large sample size, the results will be analyzed to determine whether additional DGs should be incorporated into the framework and whether any findings contradict existing guidelines. In addition to testing with Fanima, the framework should, in the future, be evaluated using other SGs focused on supporting children in speech therapy. If discrepancies are identified, their underlying causes will be investigated.

At present, testing of Fanima is still ongoing; however, results have already been collected from the children tested thus far. In Chapter 5, these preliminary results are analyzed to assess whether the framework's DGs are supported by the data collected to date. As additional data become available, the framework will be refined accordingly.

VALIDATION OF FANIMA AND THE FRAMEWORK

This chapter aims to validate the results obtained from testing the Fanima prototype with children, as well as to assess the proposed framework based on the findings. It begins by describing the testing process, including the questionnaires and participants. The results of the questionnaires are then presented and analyzed. Following this, the framework's DGs are examined to determine which were validated through the collected data. Finally, the chapter concludes with a discussion of the insights gained from this validation.

5.1 Evaluation Methodology

This chapter presents feedback from testing the Fanima SG with children with SDs. As previously stated in section 3.3.2, a consultation was conducted with SLPs from Clinic Acentuar, during which Fanima was presented and the testing procedure was explained. The objective was to assess the game's effectiveness with children by observing how they interacted with it and collecting the children's and SLPs's impressions of these interactions. This feedback provided insights into which elements were most engaging for the children and what captured their attention, as well as guidance for refining the proposed framework.

For the testing phase, accounts were created in PLAY for both the SLPs and the children. The children's accounts were generated using their identifiers (e.g., a nickname), dates of birth, and gender, as provided by the SLPs after obtaining permission from the children's guardians. In this dissertation, only the age and gender of the participating children are reported, in order to respect their privacy. The SLPs were given tablets with Fanima installed, along with additional accounts to test the game themselves prior to conducting sessions with the children. However, only the tests carried out with children are analyzed in this study.

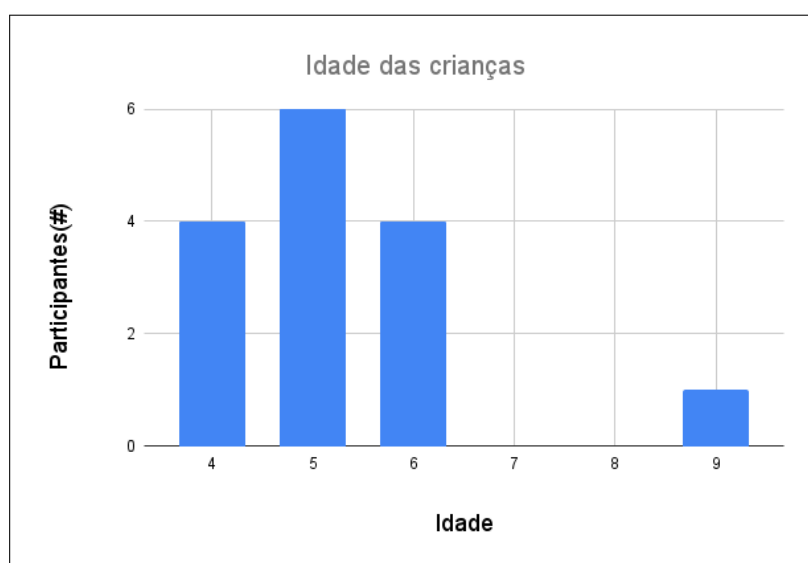


Figure 5.1: Age of children

5.1.1 Protocol

For each testing session, the SLP logged into their own PLAY account on a computer and then accessed the child's account in Fanima, linked to the same PLAY credentials, on one of the provided tablets. The child then played the game without knowing that the SLP was monitoring and analyzing their performance. Each child was allowed to play as much as possible, until either completing the game or being interrupted by the SLP. After the session, two questionnaires were completed: one by the SLP, based on their observations of the child's interaction with Fanima, and the other by the child, with assistance from the SLP, who read and explained the questions.

5.1.2 Participants

The participants in this evaluation were three SLPs, all female, and 24 children (14 boys and 10 girls). By the time this dissertation was written, 2 SLPs and 15 children (11 boys and 4 girls) had tested the game. Figure 5.2 presents a graph showing the gender distribution of the children tested. Their ages ranged from 4 to 9 years, as shown in Figure 5.1.

Graph 5.3 shows that, among the children who participated in the tests, 10 were identified with a Speech Sound Disorder, characterized by difficulties in producing speech sounds [47], and 5 with a Developmental Language Disorder, characterized by difficulties in understanding language and/or expressing themselves through words and sentences [16]. Of these children, 5 presented additional pathologies, as illustrated in Graph 5.4. Table 5.1 further specifies that 3 of the children with Developmental Language Disorder are on the autism spectrum, while 2 of the children with Speech Sound Disorder also show difficulties related to language, including comprehension, expression, or writing.

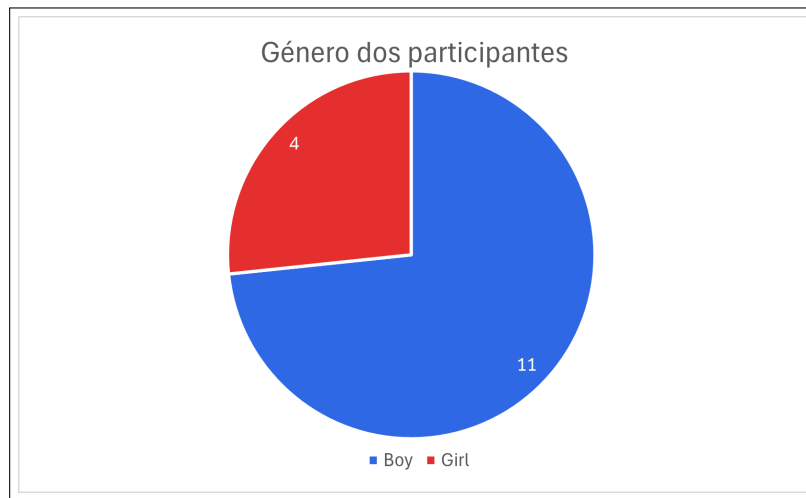


Figure 5.2: Gender of Children

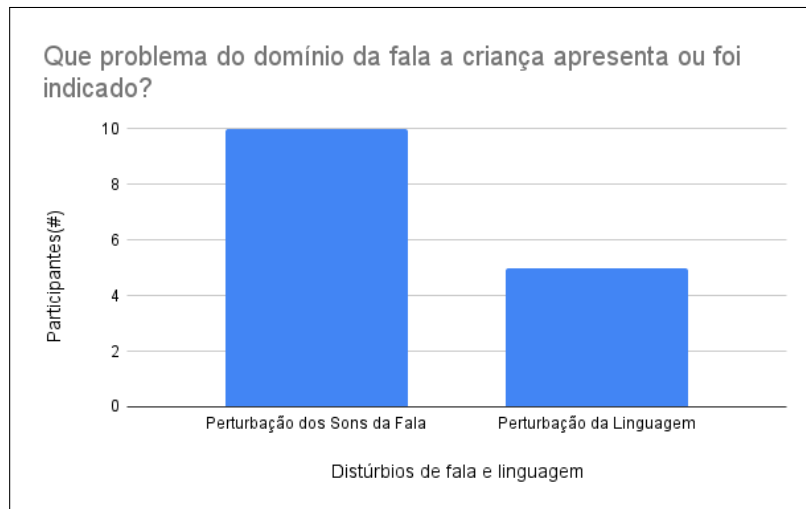


Figure 5.3: Problem in the speech domain

Pathology	Participants	Problem in the speech domain
Autism Spectrum Disorder	3	Developmental Language Disorder
Difficulties in all domains of language – oral and written	1	Speech Sound Disorder
Difficulties in oral language development – comprehension and expression	1	Speech Sound Disorder

Table 5.1: Pathology of Children



Figure 5.4: Distribution of children with pathologies outside the speech domain

5.1.3 Questionnaires

Three questionnaires were provided to the SLPs. Two were to be completed after each testing session, as previously explained, while the third was designed to be completed after all children had participated. The latter questionnaire aimed to capture the SLPs' overall impressions of how the game engages children and its perceived effectiveness. Since the testing phase is still ongoing, this dissertation analyzes only the results from the questionnaires completed after individual sessions, reflecting feedback from both the children and the SLPs. The full versions of all questionnaires are presented in Annex III.

The questionnaires were written in Portuguese. For the SLPs, responses were mostly based on a seven-point Likert scale (1 = totally disagree to 7 = totally agree), while for the children, a five-point scale was used (1 = totally disagree to 5 = totally agree). The reduced scale for the children was intended to avoid confusion and make the options easier to explain. This choice also aligns with common research practices, where children's questionnaires often adopt five-point scales, sometimes supported by visual icons of emotions to facilitate understanding [22]. The children's questions were further adapted to be easily comprehensible for their age group. In addition to Likert-scale responses, the SLPs' questionnaires included a section for additional comments, and the children's questionnaires incorporated open-ended questions to allow for qualitative feedback.

5.2 Results from Children Questionnaire

In the following section, the results of the questionnaire "FANIMA – Questionário adaptado para crianças" (Annex III.3) are analyzed. The analysis is divided into four parts: the first three correspond to the Likert-scale categories, while the final part presents qualitative insights. The Likert-scale used ranges from 1 (totally disagree) to 5 (totally agree). The first category addresses the children's perceptions of the game's **visual appeal** and overall enjoyment. The second focuses on their opinions regarding **gameplay**, followed by the third, which concerns **usability**. Finally, the **open-ended feedback** category summarizes the children's opinions and suggestions for improving the game. To analyze the results, for each category, we created one graph displaying the percentage distribution of responses and two complementary tables: the first reports the number of valid responses per question (as some questions were answered only by children who had played the chapter referenced), and the second presents the median, average, and standard deviation for each question shown in the graph. In the graphs, a score of 3 represents neutrality, with values above indicating agreement and values below indicating disagreement. For the open-ended feedback, the results are presented in tables to provide a visual summary, but most of the findings are described in the text without additional graphs or charts.

5.2.1 Children's Perceptions of Visual Appeal

In video games, the visual appeal is a key factor influencing children's initial engagement. To evaluate their perceptions of Fanima's visual design, the following questions were formulated (in the original questionnaire, the questions were presented in Portuguese):

- Q1- In Chapter 0, in the words activity, the child liked the graphical elements of the game environment.
- Q2 – In Chapter 0, in the sentences activity, the child liked the graphical elements of the game environment.
- Q3 – In Chapter 1 (the chapter with the frog that collects coins), the child liked the graphical elements of the game environment.
- Q4 – In Chapter 1 extra (the chapter where the child has to find the monkeys), the child liked the graphical elements of the game environment.
- Q5 – In Chapter 2 (the chapter where the child has to pop the balloons), the child liked the graphical elements of the game environment.
- Q6 – In Chapter 2 extra (the chapter where the child has to find the chameleons), the child liked the graphical elements of the game environment.
- Q7 – In Chapter 3 (the chapter where the child has to feed the fish), the child liked the graphical elements of the game environment.

5.2. RESULTS FROM CHILDREN QUESTIONNAIRE

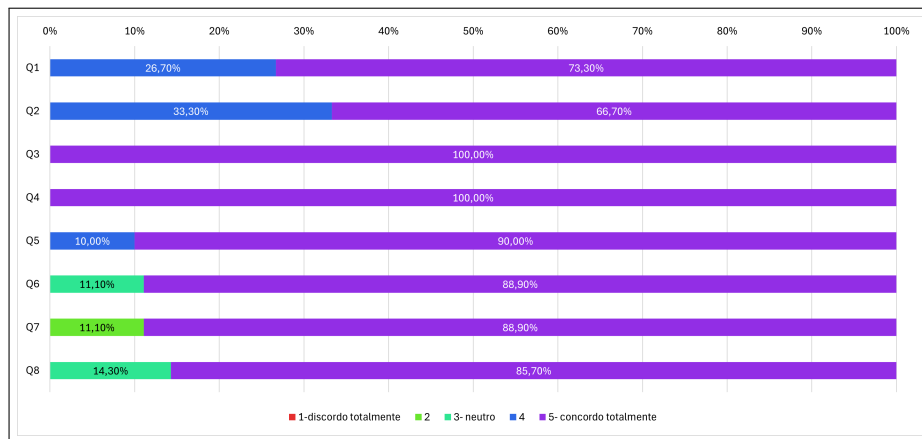


Figure 5.5: Questionnaire results for Fanima visual appeal

Question	Total number of valid responses
Q1	15
Q2	3
Q3	1
Q4	1
Q5	10
Q6	9
Q7	9
Q8	7

Table 5.2: Number of valid responses per questions (Q1-Q8)

Question	Median	Average	Standard Deviation
Q1	5	4,73	0,46
Q2	5	4,67	0,58
Q3	5	5	0
Q4	5	5	0
Q5	5	4,9	0,32
Q6	5	4,78	0,67
Q7	5	4,67	1
Q8	5	4,71	0.76

Table 5.3: Summary statistics for children's responses to visual appeal questions

- Q8 – In Chapter 3 extra (the chapter where the child has to match the paint with the octopuses of the same color), the child liked the graphical elements of the game environment.

As previously explained, Fanima is a SG in which the chapters played vary according to the phoneme errors made by each child; consequently, not all chapters are experienced by every participant. As a result, some questions were answered by fewer children than others. Table 5.2 presents the number of participants who responded to each question. Since not all questions were answered, missing responses were excluded when generating Figure

5.5, which shows the percentage distribution of results for each question. Accompanied with the figure we have Table 5.3, which presents a numerical summary of the responses.

The results indicate that the visual appeal of Fanima was highly valued by the participating children. A more detailed analysis of each chapter shows the following:

- **Chapter 0:** the words section was particularly well-liked, while the sentences sections showed slight variation, with most children liking them a lot and a few liking them a little.
- **Chapters 1 and 1 extra:** only one child played each chapter, and they liked the visuals a lot.
- **Chapter 2:** the majority of children liked the visual appeal a lot, with only a very small number liking it a little; in Chapter 2 extra, one child (corresponding to 11.1%) reported a neutral opinion.
- **Chapter 3:** most children liked the visuals a lot, with one child (corresponding to 11.1%) not liking it very much; in Chapter 3 extra, one child (corresponding to 14.3%) expressed a neutral opinion, while the rest liked the visuals a lot.

5.2.2 Gameplay

For the evaluation of Fanima's gameplay, the questionnaire included the following questions:

- Q9- The child enjoyed the interaction of speaking/naming the objects they saw.
- Q10 – The child understood the narration/instructions of the game.
- Q11 – The child remembered to name the objects only after the microphone turned green.
- Q12 – The child enjoyed the interaction of selecting the objects (branches, coins, balloons, and/or fish food, corresponding to Chapters 0, 1, 2, and/or 3).
- Q13 – The child enjoyed the interaction of finding the animals (monkey and/or chameleon, corresponding to Chapters 1 extra and 2 extra).
- Q14 – The child enjoyed the interaction of dragging the paint to the octopus (corresponding to Chapter 3 extra).
- Q15 – The child was satisfied after seeing the trophies they won in the game.
- Q16 – The progress bar helped the child understand their progression in the game.
- Q17 – The child felt immersed while playing the game

5.2. RESULTS FROM CHILDREN QUESTIONNAIRE

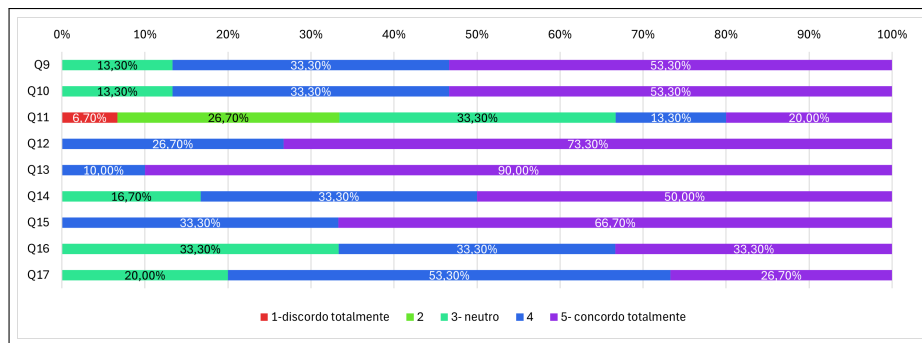


Figure 5.6: Questionnaire results for Fanima gameplay

Question	Total number of valid responses
Q9	15
Q10	15
Q11	15
Q12	15
Q13	10
Q14	6
Q15	15
Q16	15
Q17	15

Table 5.4: Number of valid responses per questions (Q9-Q17)

Question	Median	Average	Standard Deviation
Q9	5	4,4	0,74
Q10	5	4,4	0,74
Q11	3	3,13	1,25
Q12	5	4,73	0,46
Q13	5	4,9	0,32
Q14	4,5	4,33	0,82
Q15	5	4,67	0,49
Q16	4	4	0.85
Q17	4	4,07	0.7

Table 5.5: Summary statistics for children's responses to gameplay questions

The results for this section of the questionnaire are shown in Figure 5.6, accompanied by Tables 5.4 and 5.5, which presents a numerical summary of the responses. After analyzing the results, we observed that there was greater variation in responses compared to the previous section. Most children liked the interaction of naming the objects they saw, with only a small percentage reporting a neutral response. The narration and instructions of the game were understood by most children, with none disagreeing. For question 11, responses were mixed: about one-third of children were neutral about waiting for the green microphone signal, one-third agreed that they waited, and the remaining children disagreed. Due to this spread, it is difficult to determine a clear majority; this question could be simplified to a “Yes” or “No” format in future evaluations.

Most children also liked the interactions of selecting objects (e.g., coins, balloons) and finding hidden animals. The interaction of dragging an object to the octopus was similarly well-received, with only a small percentage reporting a neutral response. Most of the children were satisfied after seeing the trophies they earned. Most children agreed that the progress bar helped them understand their progress, with only some being neutral. Finally, most children reported feeling immersed while playing the game, with only a small percentage expressing a neutral opinion.

5.2.3 Usability

For the evaluation of the Fanima’s usability, the questionnaire included the following questions:

- Q18- The child would like to play this game more often.
- Q19 – The child thought the game was very difficult to play.
- Q20 – The child thought the game was easy to play.
- Q21 – The child needed help to play the game.
- Q22 – The child knew what to do during the game.
- Q23 – The child thought that some things in the game did not make sense.
- Q24 – The child thought their friends would enjoy this game.
- Q25 – The child felt they had to make a big effort to play.
- Q26 – The child thought they played well.
- Q27 – The child felt they had to learn a lot in order to play.
- Q28 – The child thought the game was fun.
- Q29 – If the child had more time, they would have liked to keep playing.

5.2. RESULTS FROM CHILDREN QUESTIONNAIRE

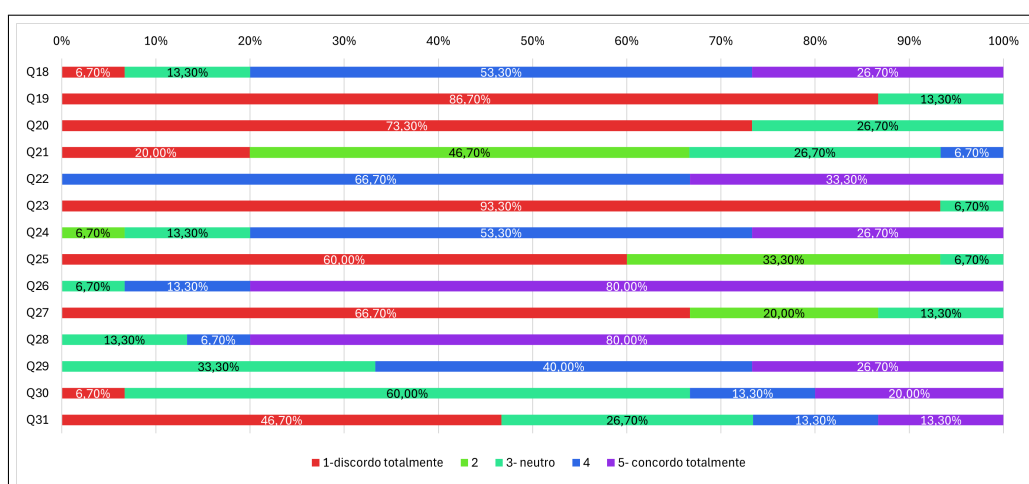


Figure 5.7: Questionnaire results for Fanima usability

Question	Median	Average	Standard Deviation
Q18	4	3,93	1,03
Q19	1	1,27	0,7
Q20	1	1,53	0,92
Q21	2	2,2	0,86
Q22	4	4,33	0,49
Q23	1	1,13	0,52
Q24	4	4	0,85
Q25	1	1,47	0,64
Q26	5	4,73	0,59
Q27	1	1,47	0,74
Q28	5	4,67	0,72
Q29	4	3,93	0,80
Q30	3	3,4	1,06
Q31	3	2,47	1,55

Table 5.6: Summary statistics for children's responses to usability questions

- Q30 – The child will tell their friends about this game.
- Q31 – The child thought the game was too long.

The results for this section of the questionnaire are shown in Figure 5.7, accompanied by Table 5.6, which presents a numerical summary of the responses. This section does not include a table showing the number of valid responses per question, as all questions in this section were answered by the same number of children ($n = 15$). The results indicate that more than half of the children agreed that they would like to play Fanima again, with two reporting neutral responses and one disagreeing. The majority did not find the game too difficult, although two were neutral. Most disagreed with the statement that the game would be easier to play, suggesting that the difficulty level was appropriately balanced. Regarding independence in gameplay, most children reported not needing help, with only

a few neutral responses and one child requiring some assistance. All children stated that they understood what needed to be done while playing; most agreed a little, and the rest agreed strongly. Similarly, most children considered the game coherent and meaningful. More than half believed that their friends would enjoy playing Fanima, while two were neutral and one disagreed. The majority disagreed that the game required too much effort, with one neutral response. Most children felt that they performed well in the game, with one neutral response. Most children indicated that they did not need to learn much in order to play, although two were neutral. Overall, the game was perceived as fun, with only one child reporting neutrality. Most children also agreed that, if given more time, they would have liked to continue playing, though one third were neutral. Finally, when asked whether they would tell their friends about the game, most responded neutrally, one third agreed, and one child disagreed. Most children did not feel that the game was too long, with the remaining responses split between neutral and agreeing that it was too long.

5.2.4 Open-ended Feedback

To collect qualitative feedback, the questionnaire also included the following open-ended questions:

- Q32- Which part of the game did the child like the most?
- Q33 – Which part of the game did the child consider the most difficult and/or boring?
- Q34 – Why did the child find that part of the game boring or difficult? (If the child cannot explain or does not know, the therapist may write a supposition or leave it blank).
- Q35 – If the child could change or add something to the game, what would it be? (If the child has no answer, write “Nothing”).
- Q36 – Are there any notes you would like to add? (Leave blank or write “Nothing” if not).

When asked which aspect of the game they liked the most, the most frequent responses indicated that children enjoyed Chapter 3, particularly the interaction with the fishes. They also expressed appreciation for the complementary tasks, such as tapping objects, dragging items, and finding hidden objects. Other notable mentions included receiving medals, interacting with the chameleons in Chapter 2 Extra, engaging with the balloons in Chapter 2, or simply enjoying the general interaction with the platform. Overall, these responses suggest that the game was perceived as fun and offered engaging interactive elements. Table 5.7 provides a summary of these responses.

Responses	N
Game with the fishes	4
Complementary tasks	3
Receiving the medals	2
Chameleons	2
Balloons	1
Naming the objects	1
General interaction with the platform	1
Everything	1

Table 5.7: Summary of children's responses about their favorite aspect of the game (Q32)

Responses	Motive	N
Nothing	-	10
Game with the octopuses (Chapter 3 extra)	Game was too long	2
Game with the trees (Chapter 0)	Visually less interactive	1
Game with the balloons (Chapter 2)	-	1
Game with the chameleons (Chapter 2 extra)	Boring due to repetition of words	1

Table 5.8: Summary of children's responses about which aspect of the game was the most difficult/boring (Q33 and Q34)

While it is important to know what the children enjoyed, it is equally important to understand what they found boring and/or difficult. Table 5.8 shows that more than half of the children did not identify any aspect of the game as boring or difficult. Among those who did, two children mentioned that Chapter 3 Extra with the octopus was too long, another noted that Chapter 0 was visually less interactive compared to other chapters, one child referred to Chapter 2 with the balloons but did not specify a reason, and another reported that Chapter 2 Extra with the chameleons was boring due to the repetition of words. Overall, the children provided little negative feedback regarding Fanima. The limited negative responses primarily related to the pacing and repetition present in some chapters. When asked in Question 35 whether they would like to add or change anything in the game, most children did not suggest any modifications. Of the two who did, one recommended adding cars to the game, and the other commented that the game was too long. Finally, no additional information or annotations were provided in response to Question 36.

5.3 Results from SLPs Questionnaire

In this section, the results of Questionnaire III.1 are analyzed. The analysis is organized into six categories: Technical and Environmental Conditions, Gameplay, Usability, Emotional Response, Motivation, and Open-ended Feedback. Most categories include questions with Likert-scale responses. As previously mentioned, the Likert scale for this questionnaire

ranges from 1 ('totally disagree') to 7 ('totally agree'). To provide a clear visual summary of the results, a combination of graphs and tables will be used. In the graphs, a score of 4 represents neutrality, with values above indicating agreement and values below indicating disagreement.

5.3.1 Technical and Environmental Conditions

Since Fanima requires an internet connection to function, this category focuses on how the SLPs interacted with the game from a technical standpoint. To evaluate this, the following questions were included in the questionnaire:

- Q7- Where was the test conducted?
- Q8 – Was the internet connection provided through the establishment's Wi-Fi (school/daycare/clinic)?
- Q9 – I believe I experienced problems with the internet signal.
- Q10 – I believe the response time between PLAY (therapist interface) and Fanima (child interface) allowed for a smooth session, without "dead times" that could have negatively affected the session.
- Q11 – Add any observations regarding problems you noticed during the session.
- Q12 – If you answered "yes" to the previous question, please specify the reason.

The SLPs were free to perform the tests in the setting that best suited their needs. From the results gathered, one SLP conducted a test with one child in a school, while all other tests were carried out at Clinic Acentuar. During the 15 tests performed, two did not use the Wi-Fi of the establishment where the sessions were conducted. The records do not specify whether mobile data or a wired connection was employed as an alternative. For most tests, the SLPs reported no problems with the internet signal; one was neutral, and another indicated experiencing some issues, as summarized in Figure 5.8. Similarly, most tests were reported to have smooth response times between PLAY and Fanima, with no "dead" times that could disrupt the session. However, three tests were noted to have experienced some dead times, as summarized in Figure 5.9. Among these, one test also had issues with the internet signal. When asked to provide observations regarding problems detected during the sessions, one SLP reported difficulties in eliciting linguistic stimuli from the sentences in a single test. In another test, the SLP noted that the game occasionally froze, which affected both the fluidity of the application and the integration of the platform.

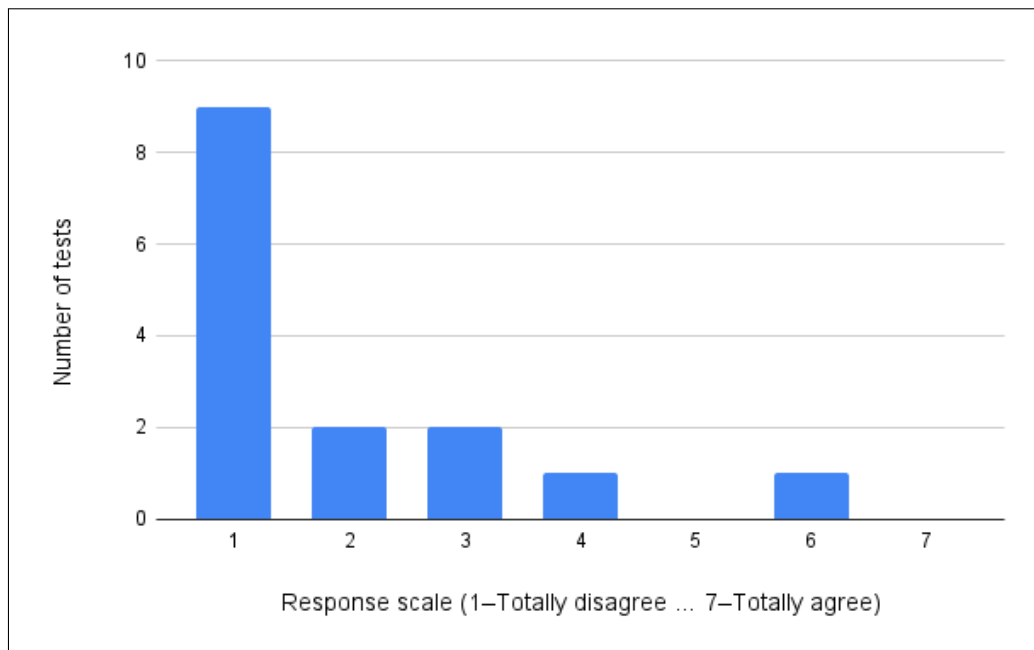


Figure 5.8: SLP-Reported Internet Signal Problems

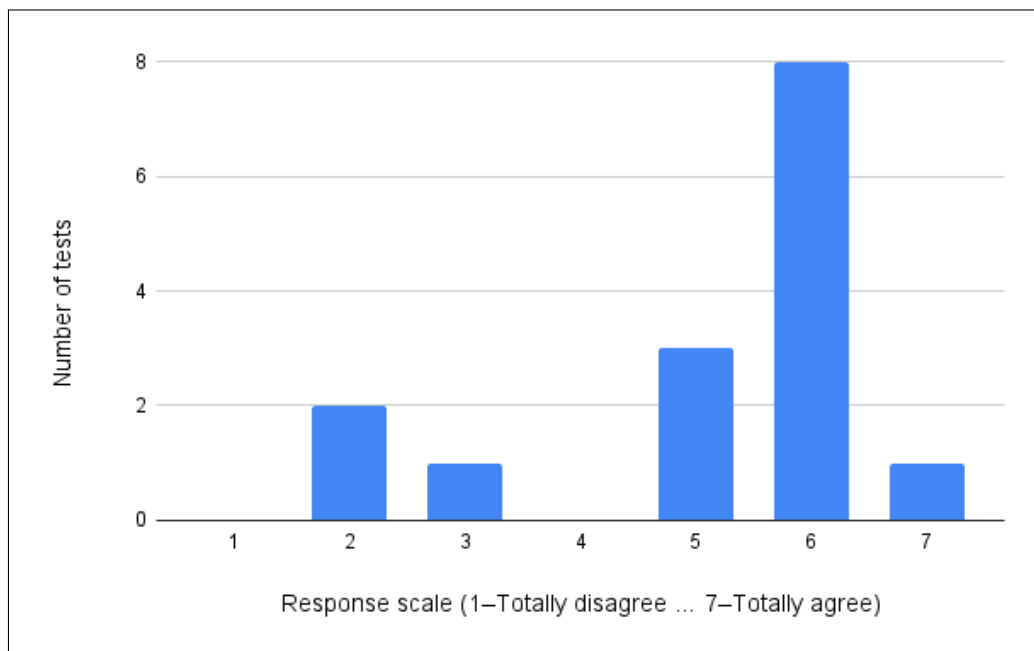


Figure 5.9: SLP Evaluation of Session Flow (Dead Times)

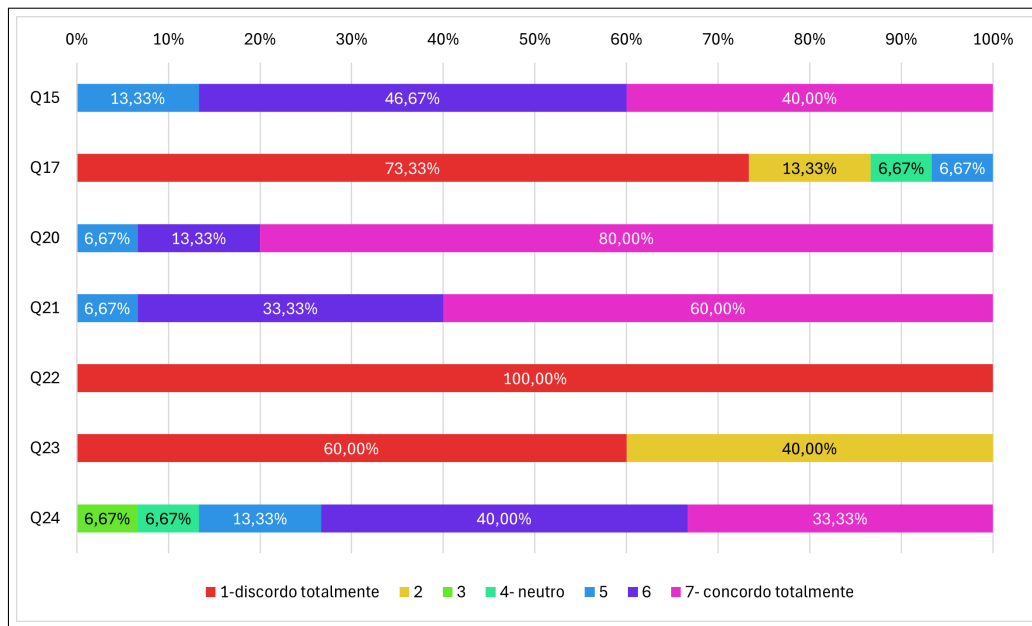


Figure 5.10: SLP Assessment of Children's Gameplay in Fanima

5.3.2 Gameplay

Although we have the children's perspective on their gameplay experience, it is equally important to understand the SLPs' observations of how the children performed during the sessions. To capture this, we included the following questions:

- Q15- I believe the child was able to correctly interpret the main tasks (e.g., naming what they see in the illustrations).
- Q17 – I believe the child had difficulty performing the proposed main tasks (e.g., naming what they see in the illustrations).
- Q20 – I believe the child enjoyed carrying out the complementary tasks (e.g., tapping objects, dragging objects, finding objects).
- Q21 – I believe the child was engaged in carrying out the complementary tasks (e.g., tapping objects, dragging objects, finding objects).
- Q22 – I believe the child had difficulty performing the proposed complementary tasks (e.g., tapping objects, dragging objects, finding objects).
- Q23 – I believe the complementary tasks (e.g., tapping game objects, dragging objects, finding objects) are distracting from the performance of the main tasks (e.g., naming what they see in the illustrations).
- Q24 – I believe the child showed interest in the different environments presented in the chapters (balloon environment, frog, monkey, owls, fish, etc.).

Question	Median	Average	Standard Deviation
Q15	6	6,27	0,7
Q17	1	1,6	1,24
Q20	7	6,73	0,59
Q21	7	6,53	0,64
Q22	1	1	0
Q23	1	1,4	0,51
Q24	6	5,87	1,19

Table 5.9: Summary statistics for children gameplay questions from the SLPs perspective

From Figure 5.10 and Table 5.9, we can see that most children had a good understanding of the main tasks in the game, while a few showed only partial understanding, indicating that overall they knew what needed to be done to play. Most children showed no difficulties in performing these tasks, with only one being neutral and another showing slight difficulty. The majority of children had a great deal of fun completing the complementary tasks, while the rest had some fun; none showed signs of not enjoying them. Overall, children were engaged and dedicated while performing the complementary tasks, and none experienced difficulties in completing them. Across the 15 tests conducted, the SLPs did not consider the complementary tasks to be distracting for the performance of the main tasks. Most children also showed interest in the different environments presented in the chapters, with only one being neutral and another not showing much interest.

5.3.3 Usability

To evaluate the usability of the game, we included the following questions:

- Q14- I believe the child had difficulty understanding the tasks proposed by the game's narration (instructions given at the beginning of each chapter).
- Q25 – I believe the child independently used the help button (panda).
- Q26 – I believe the child had difficulty understanding the voice instructions.
- Q32 – I believe the child had difficulty understanding the game.
- Q33 – I believe the child was easily distracted while using the game.
- Q37 – Did I have to interrupt the game session?
- Q38 – It was necessary to intervene many times to assist the child in performing the main tasks.
- Q39 – I believe the child was able to successfully finish the game (even in cases where the session was interrupted).

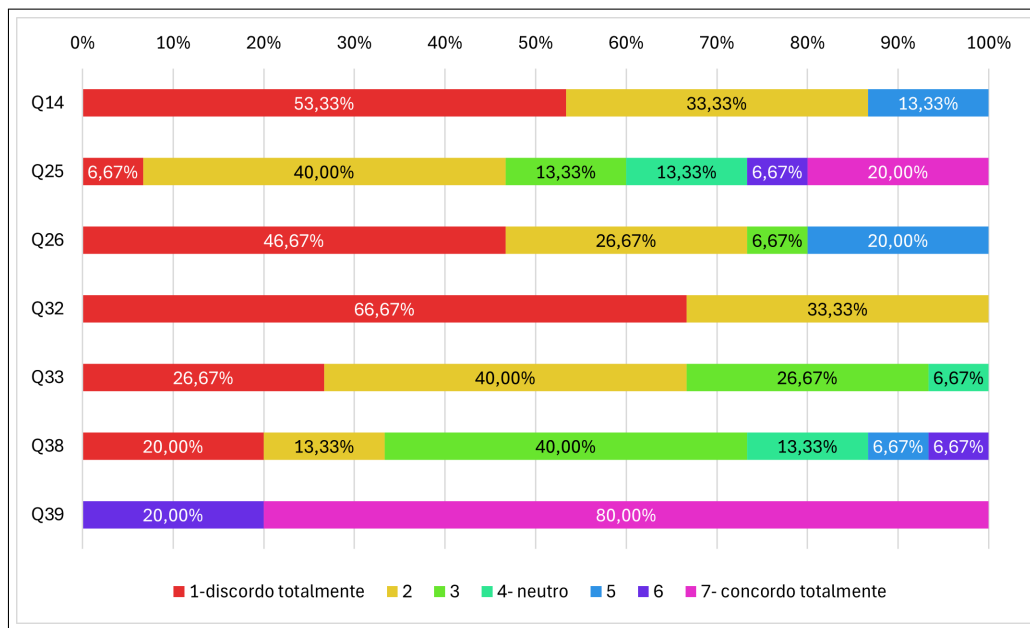


Figure 5.11: SLP Assessment of Children's Usability in Fanima

Question	Median	Average	Standard Deviation
Q14	1	1,87	1,36
Q25	3	3,6	2,13
Q26	2	2,2	1,57
Q32	1	1,33	0,49
Q33	2	2,13	0,92
Q38	3	2,93	1,44
Q39	7	6,8	0,41

Table 5.10: Summary statistics children usability questions from the SLPs perspective

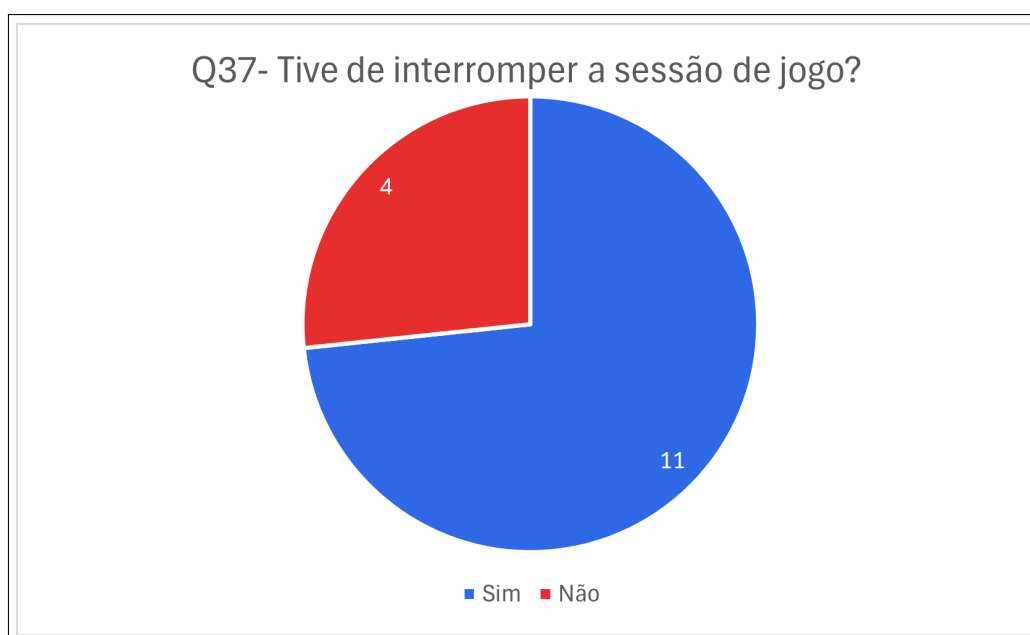


Figure 5.12: Frequency of Session Interruptions During Gameplay

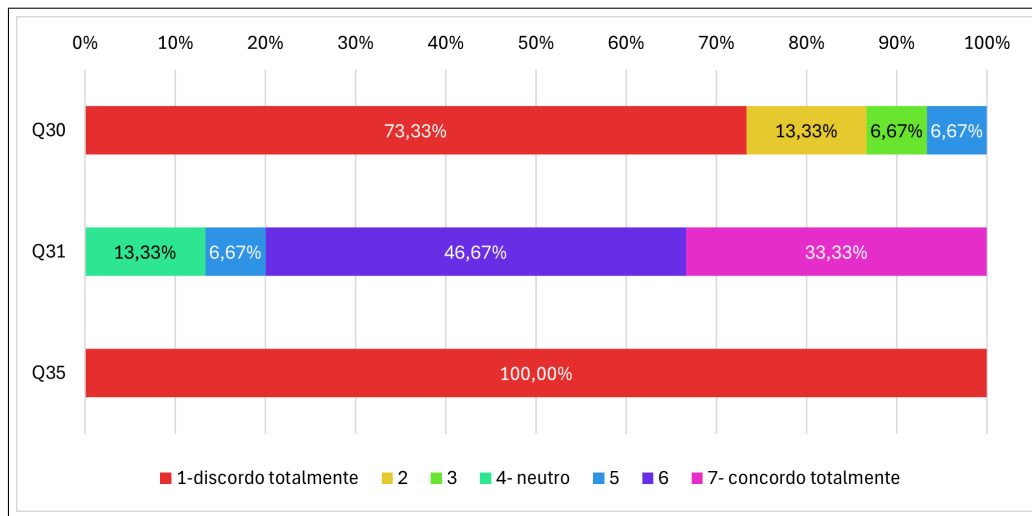


Figure 5.13: SLP Assessment of Children's Emotional Response in Fanima

From the results presented in Figure 5.11 and Table 5.10, the SLPs reported that most children did not have difficulties understanding the tasks narrated at the start of each chapter, with only two children showing slight difficulties. Most children did not use the help button independently; two were neutral, and four used it on their own. Similarly, most children did not experience difficulties understanding the voice instructions, with only three showing some difficulties. Overall, SLPs considered that the children understood the game well. Most children were not easily distracted while playing, with some showing no distraction at all and one being neutral. When asked about the need for intervention, the SLPs reported that most children required little assistance, with three needing none, and two requiring more frequent interventions. In general, children were able to complete the game, even when a session was interrupted. As shown in Figure 5.12, most game sessions had to be interrupted, with only four being completed in a single session.

5.3.4 Emotional Response

In SGs, it is important to understand the child's emotional reactions while playing. To investigate this, we included the following questions:

- Q30- I believe the child showed signs of frustration while playing.
- Q31 – I believe the child felt enthusiastic while playing.
- Q35 – I believe the child appeared nervous/anxious while playing.

While observing the children play Fanima, the SLPs reported that the majority of children did not exhibit frustration during gameplay, with only one child showing a small degree of frustration. Most children appeared enthusiastic while playing, with only two reporting a neutral level of enthusiasm. Additionally, the SLPs noted that none of the children displayed signs of anxiety or nervousness during the sessions. The results for this

Question	Median	Average	Standard Deviation
Q30	1	1,53	1,13
Q31	6	6	1
Q35	1	1	0

Table 5.11: Summary statistics children emotional responses questions from the SLPs perspective

section of the questionnaire are shown in Figure 5.13, accompanied by Table 5.11, which presents a numerical summary of the responses. Overall, the children enjoyed playing the game and exhibited mostly positive emotional responses, with minimal frustration and no signs of anxiety, suggesting that Fanima is a fun and stress-free game.

5.3.5 Motivation

In this section, we analyse the results of questions that focus on both extrinsic and intrinsic motivations. From the SLPs' perspective, we aimed to understand whether the children enjoyed the game and felt comfortable while playing it (intrinsic motivation), and whether external elements such as medals, trophies, or feedback served as motivators (extrinsic motivation). To address this, we included the following questions:

- Q16- I believe the auditory feedback was motivating for the child (e.g., after therapist validation, when an object appeared to be found, when an object was touched, when completing a chapter, or when finishing the game).
- Q18 – I believe the auditory feedback was excessive (e.g., “Say it again,” “What do you see on the board?”).
- Q19 – I believe the child felt comfortable with the game interacting during repetition/help requests.
- Q27 – I believe the progress bar (located at the bottom of the screen) was a motivating element for the child to complete the tasks proposed in the chapter.
- Q28 – I believe the progress bar (located at the bottom of the screen) helped reduce the child’s anxiety regarding the expectation of finishing the proposed tasks.
- Q29 – I believe the rewards (medals) motivated the child to complete the chapter.
- Q34 – I believe the child needed encouragement to continue playing.
- Q36 – I believe the child made an effort to complete the proposed tasks.
- Q40 – I would like to use the Fanima tool frequently with this child.
- Q41 – How much did the child enjoy playing the Fanima game?

5.3. RESULTS FROM SLPS QUESTIONNAIRE

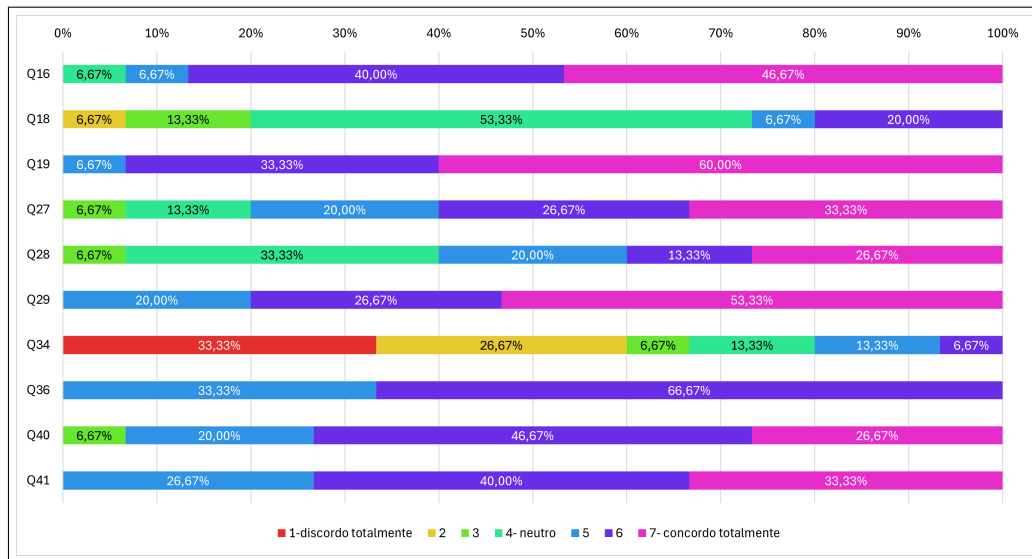


Figure 5.14: SLP Assessment of Children's Motivation in Fanima

Question	Median	Average	Standard Deviation
Q16	6	6,27	0,88
Q18	4	4,2	1,15
Q19	7	6,53	0,64
Q27	6	5,67	1,29
Q28	5	5,2	1,37
Q29	7	6,33	0,82
Q34	3	2,67	1,72
Q36	6	5,67	0,49
Q40	6	5,87	1,06
Q41	6	6,07	0,8

Table 5.12: Summary statistics children motivation questions from the SLPs perspective

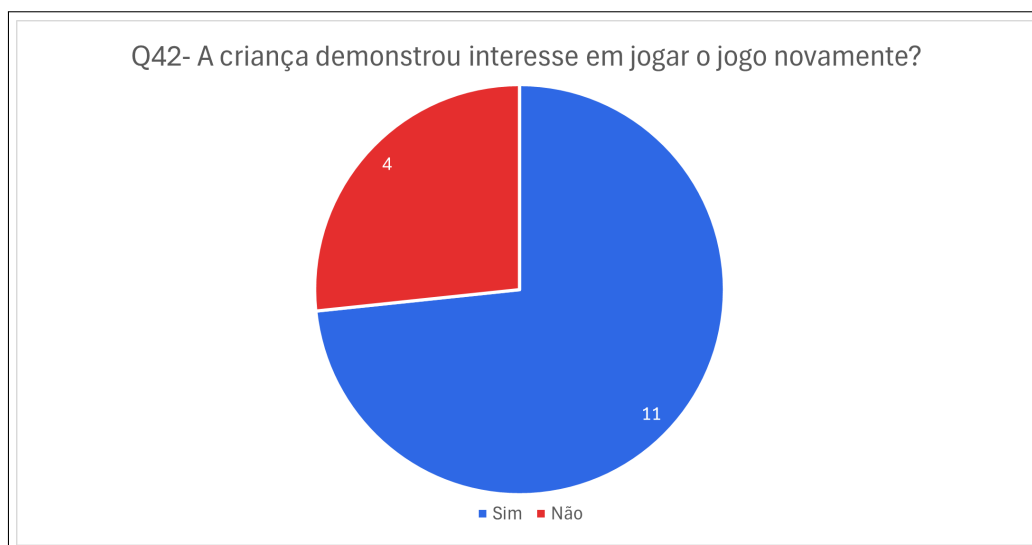


Figure 5.15: Child's Interest in Playing Fanima Again

- Q42 – Did the child show interest in playing the game again?

Based on Figure 5.14 and Table 5.12, the following results can be highlighted. Most children were motivated by the audio feedback, with only one showing neutrality. Regarding whether the audio feedback was excessive, SLPs reported mostly neutral responses, with some children finding it excessive and a smaller number not perceiving it as such. Children were generally comfortable with the game prompting them to repeat words, with the majority being comfortable and none uncomfortable.

Most children considered the progress bar a motivating factor while completing tasks, though two were neutral and one was less motivated by it. In terms of reducing anxiety, the progress bar received mostly positive responses, several neutral ones, and only one negative response. Medals were also seen as motivators when completing chapters, with varying levels of motivation but none reporting a lack of motivation.

Question 34 showed the most variation: while most children continued playing without encouragement, two were neutral, and three needed to be encouraged. Children were also reported to make some effort to finish the tasks given.

Finally, SLPs appreciated the idea of using Fanima frequently with most children, and they also considered Fanima to be suitable for regular use. From the SLPs' perspective, children enjoyed playing Fanima, with no disagreement reported for any child. Figure 5.15 shows that most children expressed interest in playing Fanima again, with only four not showing interest.

5.3.6 Open-ended Feedback

For the open-ended feedback, one SLP suggested that it would be interesting to have the option to skip the extra chapters and proceed directly to the following main chapters.

5.4 Validation of Framework

In Chapter 4.7, we presented a framework designed to assist in the creation and validation of serious games for speech therapy with children. As described in Chapter 4.5, the framework was developed based on theoretical research, literature review, and feedback from SLPs. The practical case study with Fanima now provides an opportunity to validate some of the DGs from the framework. In the following sections, we will examine each category of the framework and assess whether Fanima contributed to validating the corresponding DGs. It is important to note that some DGs were not applicable to Fanima and, therefore, could not be validated practically.

5.4.1 Motivation and Progress Tracking Category

This category focuses on DGs that support children's motivation by fostering a sense of achievement and progression. Table 5.13 provides an overview of the DGs that were

DG	Description	Validation Status
DG1	Display progress to help the child understand how close they are to completing a task	Validated
DG2	Introduce a reward system that provides positive reinforcement at the end of each chapter	Validated
DG3	Use a variety of reward badges or stickers that align with progress in the game	Implicitly Validated
DG4	Introduce subtle competition through tasks, such as timed challenges or completing tasks with minimal errors	Partially Validated
DG5	Incorporating a Narrative Story	Not applicable
DG6	Displaying the Score Throughout the Game	Not applicable
DG7	Encouraging Exploration	Not applicable

Table 5.13: Validation of Motivation and Progress Tracking DGs with Fanima

confirmed during the validation with Fanima, alongside those that could not be assessed due to their non-applicability to the game. The results from Fanima confirm that the display of progress encouraged children to complete the tasks, with both the progress bar and the reward system reported as motivating. This validates DG1 and DG2. DG3 is also implicitly confirmed, as the children enjoyed the medals, varied themes, and chapter-based rewards. DG4 was only partially validated: while each main task included a time limit for pronouncing objects, we could not verify whether subtle competition or completing tasks with minimal errors served as motivating factors, since these features were not present in Fanima. DGs 5 through 7 were not assessed, as they are not applicable to this game.

5.4.2 User Interface and Engagement Design Category

This category ensures that the SG is visually appealing, intuitive, and engaging, thereby enhancing the child’s overall experience with the game. Table 5.14 presents the DGs associated with this category. A visually appealing game appears to contribute positively to children’s enjoyment. Fanima was reported as engaging and intuitive, with tasks that were easy to understand and where most children could play without requiring external encouragement. These findings support the validation of DGs 8, 9, 11 and 18.

DG12 is also considered validated. Although the questionnaire did not directly address whether the game was overstimulating, results indicated that children were mostly enthusiastic, showed minimal frustration, and exhibited no signs of anxiety—opposite indicators of overstimulation, which would typically include frustration, anxiety, restlessness, or loss of focus. DG13 is implicitly validated as child-like character guides were included, and children reported enjoying the visuals, even though no specific question addressed their opinion of the characters themselves.

DG14 is validated through observations regarding the placement of interactive elements. For example, the microphone icon could be easily overlooked: some children did not wait for it to turn green, either because they did not notice it or because they had already understood the task and answered prematurely. This highlights the importance of carefully considering the placement of interactive elements. DG15 is validated as well, since the complementary tasks used minimal animations that were not reported as distracting to the children.

DG	Description	Validation Status
DG8	Ensure the design is appealing and age-appropriate with bright colors, playful elements, and engaging visuals	Validated
DG9	Relate interface elements to real-world concepts to make them more relatable and understandable for children	Validated
DG10	Allow the child to select characters, adding personalization and making the game more fun	Not applicable
DG11	Offer a variety of themes and skins to keep the game engaging	Validated
DG12	Ensure color harmony throughout the game to prevent overstimulation	Validated
DG13	Use Child-Like Characters as Guides	Implicitly Validated
DG14	Avoid Placing Small Interactive Elements at the Edges of the Screen	Validated
DG15	Use Animations Carefully to Avoid Distraction	Validated
DG16	Simplifying the Menu System for Children	Not applicable
DG17	Using Large, Easy-to-Read Text and Simple Vocabulary	Not applicable
DG18	Using Consistent and Understandable (Intuitive) Icons	Validated

Table 5.14: Validation of User Interface and Engagement DGs with Fanima

DG	Description	Validation Status
DG19	Provide fast feedback to maintain engagement and reduce loading times	Validated
DG20	Highlight clickable interface elements to guide the child through the game	Validated
DG21	Use horizontal scrolling instead of vertical scrolling to align with natural user behavior and improve ease of navigation	Not applicable
DG22	Support Both Single- and Multi-Touch Input	Implicitly Validated
DG23	Allow Slightly Out-of-Bounds Interactions	Implicitly Validated

Table 5.15: Validation of Game Flow and Usability DGs with Fanima

DGs 10, 16, and 17 were not applicable to Fanima, as they are not implemented in it and therefore could not be verified.

5.4.3 Game Flow and Usability Category

This category focuses on DGs that help keep the game flow smooth, preventing frustration and distractions. Table 5.15 presents the DGs validated in this section. On occasions when the game froze, the fluidity was affected, resulting in delayed feedback and interaction with the platform, which in turn reduced engagement. This supports DG19, which states that providing fast feedback helps maintain engagement and reduce loading times.

Children showed no difficulties interacting with clickable objects, as small animations and audio feedback highlighted what to do and where to click. These prompts validate DG20, which emphasizes the importance of highlighting interactive elements.

DG21 was not applicable to Fanima, since it refers to manual scrolling, while the game relies on auto-scrolling. DGs 22 and 23 were implicitly validated: although they were not directly assessed in the questionnaires, they were implemented in Fanima, and children did not report difficulties with complementary tasks, being free to interact with the game as they wished.

5.4.4 Game Structure and Functionality Category

This category focuses on ensuring that the SG remains clear and engaging without overwhelming the child. Table 5.16 presents the DGs in this category. In Fanima, Chapter 0 implements DG24, as the initial assessment occurs early in the gameplay, with further assessments integrated into subsequent chapters as needed. The only feedback received about this chapter was that it was less interactive and therefore somewhat boring; however, this does not suggest that it was overwhelming for children. Thus, DG24 is validated.

DG	Description	Validation Status
DG24	Use initial Chapter or level solely for error detection to avoid overwhelming the child with content	Validated
DG25	Hiding Advanced Levels	Implicitly Validated
DG26	Creating an Open-Ended SG with Multiple Possibilities	Not applicable

Table 5.16: Validation of Game Structure and Functionality DGs with Fanima

DG	Description	Validation Status
DG27	Allow the SLP to select specific phonemes and play sentence sections tailored to the child's therapy needs	Implicitly Validated
DG28	Enable the SLP to provide hints when needed for word recognition and pronunciation	Implicitly Validated
DG29	Allow the SLP to request word repetition if required	Implicitly Validated
DG30	Ensure the game records all repetitions for analysis and feedback	Implicitly Validated
DG31	Provide clear indications when the game is recording, ensuring transparency	Implicitly Validated
DG32	Starting recording before showing the object	Future Work
DG33	At the end of each session, allow the child to revisit chapters for reinforcement and further practice	Not applicable
DG34	Provide extra games for further reinforcement or for review of difficult concepts	Implicitly Validated
DG35	Place Essential Instructions at the End of Sentences	Implicitly Validated
DG36	Promoting Cooperation	Not applicable

Table 5.17: Validation of SLP and Child Interaction Features DGs with Fanima

Although Fanima does not feature a difficulty system, the sentence section in Chapter 0 represents a more advanced level, which is only introduced if the SLP selects it after the child has completed the word section. Since the child is unaware of this option unless required, this design implicitly validates DG25 while also reinforcing DG24, as it prevents overwhelming the child with unnecessary content.

DG26 is not applicable to Fanima and therefore could not be verified. Fanima is not an open-ended game that allows exploration; instead, it provides a defined goal and structured tasks. Even the choice of chapters is determined by the SLP rather than the child.

5.4.5 SLP and Child Interaction Features Category

This category includes features that facilitate interaction between the SLP and the child, making the experience more engaging and personalized. Table 5.17 presents the validated DGs. DGs 27 through 31, as well as DG34 and DG35, were all implemented in Fanima. The SLPs indicated that the game was useful and suitable for regular use, which implicitly validates these DGs, as they relate to features that support the assessment of phonemes. One point for improvement is that the indicators showing when the game is recording should be made more visible to children. Nevertheless, this still validates DG31, as it demonstrates the necessity of such indicators.

DGs 32, 33, and 36 were not applicable to Fanima and therefore not verified. DG32 is planned for future implementation and could be validated in later testing. DG33 was not implemented because Fanima's primary goal is the assessment of phoneme errors, not their correction. DG36 was also not implemented, as Fanima is designed for solo play by the child, without explicit awareness of outside assistance.

DG	Description	Validation Status
DG37	Adapt images and visuals to match children's cognitive abilities, ensuring clarity and ease of recognition	Implicitly Validated
DG38	Avoid social features such as sharing rewards or leaderboards to focus on individual learning without external comparisons	Implicitly Validated
DG39	Balance intrinsic and extrinsic motivation	Validated
DG40	Allowing Children to Revisit Previously Explored Areas	Partially Validated
DG41	Offering Multiple Difficulty Levels	Not applicable

Table 5.18: Validation of Learning and Adaptation DGs with Fanima

DG	Description	Validation Status
DG42	Offer immediate feedback to help the child understand their performance	Validated
DG43	Avoid displaying captions on pictures that the child needs to name to encourage active recall	Implicitly Validated
DG44	Use auditory instructions to guide the child through each step when they interact with the game to enhance learning	Validated
DG45	Avoid transmitting error directly to the child and prevent any negative feedback; this can be done by using encouraging language or positive reinforcement	Validated

Table 5.19: Validation of Feedback Systems DGs with Fanima

5.4.6 Learning and Adaptation Category

This category focuses on adapting the SG to the child's progress, maintaining an optimal balance between challenge and skill. Table 5.18 shows the DGs validated. DG37 and DG38 are implicitly validated, as results showed that children were able to understand and play the game with minimal help, while still having fun and feeling immersed. DG39 is validated, since the game effectively balanced intrinsic motivation (genuine engagement and enjoyment) with extrinsic motivation (progress bars, audio feedback, and trophies). DG40 is only partially validated due to a limitation: children cannot freely revisit chapters exactly as they previously experienced them. While replay is possible, it requires selecting a different phoneme. To redo the same phoneme, the entire game must be restarted. Therefore, the DG cannot be considered fully validated. Finally, DG41 is not applicable to Fanima, as it does not have difficulty levels.

5.4.7 Feedback Systems Category

This category ensures that the child receives motivating and constructive feedback throughout the game to encourage improvement. Table 5.19 shows the DGs validated. Audio feedback proved to be a beneficial feature of Fanima, helping children understand both instructions and progress, which validates DG42 and DG44. DG43 is implicitly validated, as children were able to perform the main tasks (naming the objects shown) with little difficulty, even though the objects did not include captions. Errors were never directly communicated to the child, allowing them to continue playing without requiring much encouragement, which validates DG45.

5.4.8 Phoneme Classification and Error Management Category

This category assists the SLP by identifying the child's mistakes during gameplay, helping to refine therapy sessions. Table 5.20 shows the DGs validated. DGs 46–53 were all implemented in Fanima to facilitate the assessment of phonemes. The fact that SLPs considered Fanima suitable for regular use validates these DGs, demonstrating their usefulness and relevance. DG54, however, presents a gray area: on one hand, children

DG	Description	Validation Status
DG46	For assessment, provide clear and accurate phoneme classification during each task to guide the child's progress	Validated
DG47	Allow the SLP to classify errors based on their assessment and provide appropriate interventions	Validated
DG48	On substitution errors, register the substitute phoneme to track the progress	Validated
DG49	Ensure a fixed number of mandatory stimuli per test to maintain consistency	Validated
DG50	Allow repetition of the same word to check for error consistency	Validated
DG51	Perform an error consistency test on detected phonemes to ensure accurate error classification	Validated
DG52	Accurately identify and classify substitute phonemes when errors occur to track phonemic progress	Validated
DG53	Add an "OTHER" error option for cases that don't fall under predefined categories, allowing the user to enter free text for additional feedback	Validated
DG54	Allow the children to Correct Mistakes	Partially Validated

Table 5.20: Validation of Phoneme Classification and Error Management DGs with Fanima

should not directly correct mistakes since the game's main purpose is error assessment. On the other hand, when errors involved speaking too softly, naming objects incorrectly, or not responding, Fanima allowed the SLP to request a repetition or provide some assistance, enabling the child to try again. Therefore, DG54 can be considered partially validated.

5.4.9 Support for Child Needs Category

This category provides options that accommodate children's individual needs and preferences, allowing them to play autonomously without excessive external assistance or overwhelm. Table 5.21 shows the DGs validated. Fanima included a help button that children could autonomously use when needed. As stated earlier, most children did not use it, while a small number did. Since the majority were able to play the game with little assistance, we can conclude that they did not require it. However, the option was still available for those who needed it, which validates DG55.

DG56 is not applicable to Fanima, as the only sound effects used are linked to specific in-game actions (e.g., a chameleon or monkey appearing on screen, a balloon popping, or leaves shaking to prompt interaction). Text is almost entirely avoided in the game, appearing only during the child's login, which is performed by the SLP. The cognitive load (mental effort) of playing Fanima appeared to be balanced. SLPs observed that while children made some effort to play the game, they were not overwhelmed and were reported having fun. This implicitly validates DG57.

DG58 is not implemented in Fanima but would be a useful feature to include in future versions.

Traditional tutorials (with step-by-step instruction sequences) are not used in Fanima, which instead relies on audio instructions. Children were able to follow these instructions without major difficulties, validating DG59.

Finally, most of the complex gestures mentioned in DG60 (zoom, pinch, double tapping) were avoided, with the exception of drag-and-drop, which appeared in Chapter 3 Extra. The objects involved in this gesture were intentionally designed larger to make it easier to perform. Children did not report drag-and-drop itself as problematic — the only complaint about Chapter 3 Extra concerned its length, not the gesture. This suggests that drag-and-drop may not be too complex for Fanima's target age group. For this reason, DG60 can be considered partially validated, with the recommendation that further testing with more children is needed to confirm this finding.

DG	Description	Validation Status
DG55	Allow the child to ask for hints during the game to help with phoneme production	Validated
DG56	Implement a mute option for sound effects to accommodate different environments or preferences	Not applicable
DG57	Minimize text in the interface, especially for younger children, to reduce cognitive load	Implicitly Validated
DG58	Implement a Time-Out for Inactivity with Assistance Prompts	Future Work
DG59	Avoid Traditional Tutorials	Validated
DG60	Avoid Complex Gestures for younger children (zoom, pinch, drag and drop, double tapping)	Partially Validated

Table 5.21: Validation of Support for Child Needs DGs with Fanima

DG	Description	Validation Status
DG61	Differentiate between samples collected with repetition or assistance, tracking the child's independent progress versus guided help	Validated

Table 5.22: Validation of Data Collection DGs with Fanima

5.4.10 Data Collection Category

This category helps the SLP track the child's progress over multiple play sessions, aiding in speech disorder assessment and future therapy planning. Table 5.22 shows the DG validated. DG61 is implemented in Fanima, and as stated earlier, SLPs expressed a favorable opinion of the game's usefulness for regular use. The samples gathered will assist the SLP in keeping the child's progress in check throughout their time in speech therapy. This validates DG61.

5.5 Discussion

The testing of Fanima with children, although slow-paced, proved to be highly valuable. It provided insights into the Fanima prototype while also supporting the validation of the framework's DGs.

Fanima was generally well received. Children found the game to be visually appealing, age-appropriate in difficulty, immersive, engaging, and easy to understand. The usability, gameplay, and motivational aspects were consistently praised. The feedback was mostly positive, with minor criticisms regarding the pacing and repetition in the extra chapters. SLPs also viewed the game as suitable for use in therapy sessions and indicated that it could be applied more regularly. Their main concern was the lack of an option to skip the extra chapters. Importantly, they confirmed that Fanima supported the assessment of phonemes during therapy.

Fanima also served as a means of validating the framework's DGs. Most guidelines were confirmed, particularly those related to motivation and engagement — such as providing rewards, positive feedback, and maintaining a balance between challenge and accessibility. Some DGs, however, could not be verified, as they were not implemented in Fanima due to the game's specific structure and/or therapeutic goals. This includes guidelines related to exploration, player freedom, and the use of a narrative storyline. The results suggest that all DGs in the framework have potential value for serious games in speech therapy, though not all can or should be applied universally. Certain guidelines

may need to be adapted or excluded depending on the purpose of the game. Playtesting with the target age group remains essential for ensuring the success of any serious game.

While the results were overall positive, it is important to acknowledge the limitations of this study. Testing involved only 15 children and two SLPs, and the evaluation of Fanima is still ongoing. Additional features could be integrated into the prototype, and it would be beneficial to validate the framework further by applying it to other serious games. Nonetheless, the data collected so far has provided valuable insights into both Fanima and the framework.

In conclusion, this validation process proved beneficial, highlighting areas of strength while identifying opportunities for improvement. It confirmed many of the framework's DGs and demonstrated how a serious game, even in prototype form, can support therapy sessions for children. Furthermore, the study indicates that the framework has strong potential to become a useful tool for guiding the development of future serious games. Ultimately, this validation contributes to bridging the gap between theoretical recommendations and the practical implementation of serious games in speech therapy.

CONCLUSION

This chapter presents the conclusion of this research and discusses potential directions for future work.

6.1 Conclusion

Designing a SG for speech therapy is a complex task that requires careful consideration of both therapeutic and engagement factors. Game designers must understand how an SG will assist SLPs and what elements should or should not be included to ensure the game benefits the child. While many game design strategies can enhance engagement, not all are suitable for SGs. There is a gap in understanding between what game designers implement and what is recommended in the literature for SGs in speech therapy. This dissertation aims to bridge that gap.

The primary objective of this dissertation was to create a framework that identifies the most effective DGs for developing SGs for children in speech therapy. Through a review of existing literature and analysis of Fanima as a case study, numerous DGs were identified. The Fanima prototype was improved based on prior SLP feedback and relevant literature. This study aimed to validate these improvements by testing the game with children with SDs and collecting their feedback through questionnaires. The goal was to determine which DGs contribute to engagement and motivation and compare these with those found in the literature to refine the framework further. If Fanima was found to lack engagement and motivation, additional improvements would have been considered. The results from testing with children, however, indicated that the game was fun, engaging, and immersive, providing a good balance between extrinsic and intrinsic motivation. Furthermore, the SLPs expressed satisfaction with the game and showed interest in its regular use with children. Negative feedback was minimal and primarily concerned the length and repetition of the extra chapters.

The framework currently consists of 61 DGs categorized into 10 sections, ordered to prioritize those that enhance motivation and engagement, followed by more technical aspects. This dissertation also contributes to the understanding of how different DGs

influence the entertainment value of an SG and how certain DGs, while beneficial in some contexts, may be detrimental in others.

This dissertation set out to investigate how children interact with serious games in speech therapy and how design elements affect engagement. The findings addressed the research questions by showing that: (i) engaging elements such as animations and rewards can enhance motivation when balanced with therapeutic goals, (ii) improvements to Fanima's design based on child and therapist feedback increase its usefulness in therapy, and (iii) not all design guidelines are equally suitable, as some may conflict with therapeutic objectives. Together, these insights demonstrate that serious games can be both engaging and clinically meaningful if their design is carefully aligned with therapy needs.

Therefore, this dissertation has provided answers to the research questions:

1. **What makes an SG entertaining while effectively supporting therapy sessions?** An SG must balance intrinsic and extrinsic motivation, appealing to children who enjoy gameplay itself and those who are driven by rewards. It should be intuitive to prevent frustration and confusion but not so easy that it causes boredom. The challenge level should support skill improvement without inducing anxiety. Additionally, an SG should be visually appealing, promote autonomous use, encourage imagination, and offer flexibility to accommodate children with different needs. Most importantly, DGs should align with therapy goals rather than hinder them.
2. **How can we improve an existing SG to make it more useful for autonomous use in therapy?** To enhance an SG, thorough testing and analysis are essential. Both adults (preferably those familiar with DGs) and children should test the game. Adults can provide an objective evaluation, while children's feedback can offer insights into engagement and usability. Testing should be supervised by an SLP, who can observe how children interact with the game. Before making improvements, it is crucial to identify where the SG falls short—is it lacking content? Is it not engaging enough? Is it intuitive? Is the difficulty level appropriate? Answering these questions guides the improvement process.
3. **Should all DGs recommended for SGs in speech therapy be implemented in every SG for speech therapy?** The answer is no. Not every recommended DG is suitable for every SG. For example, while narrative storytelling is an effective DG for engagement, implementing it in Fanima could interfere with therapy sessions. A narrative structure might lengthen gameplay beyond what is practical for therapy and become repetitive due to chapter-based phoneme repetition, leading to reduced interest. Therefore, before development begins, it is essential to carefully select DGs that align with the game's purpose and therapeutic objectives.

In conclusion, this research highlights the importance of making SGs engaging and motivational for children and demonstrates how different DGs can improve adaptability and accessibility. This dissertation reinforces the value of SGs in speech therapy and

encourages further development in this field. The framework was developed based on the literature review and SLP feedback, and the current test results helped validate its relevance and applicability, making it a valuable tool for designing and evaluating SGs for children in speech therapy.

6.2 Future Work

As stated multiple times throughout this dissertation, testing was still ongoing at the time of submission. Although the results gathered so far were limited due to the small sample size, they proved useful in providing preliminary insights. A key area of future work is to conduct extensive testing of Fanima with a larger number of children with SDs and to compare these results with the proposed framework. The framework should then be refined to incorporate any new DGs that emerge from testing. Additionally, if any results contradict existing DGs, further study should be conducted to understand the reasons behind these discrepancies.

Based on the current results, some DGs could already be added to Fanima. These include providing the option to skip extra chapters, starting the recording before showing the objects, and implementing a time-out for inactivity accompanied by assistance prompts. As more test results are gathered, they should be compared with the current findings, and Fanima should be refined where necessary. Even if no major issues are identified, it would be beneficial to fully implement a character selection feature, as our study indicated this would serve as a strong motivational factor for children.

Another important goal is to enhance Fanima so it can be used independently, without requiring SLP assistance. Achieving this would require the development of an automatic classification system through a model capable of understanding Portuguese children's voices.

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ALL DESIGN GUIDELINES FOR THE FANIMA

Table I.1: Design Guidelines already implemented on Fanima

ID	Description
G1	Create appealing and age-appropriate design
G2	Provide phoneme classification
G3	Provide feedback
G4	Suggest specific chapters based on wrong phonemes
G5	Do not transmit the error to the child
G6	Prevent negative feedback
G7	Allow SLP to classify error
G8	On substitution error, register the substitute phoneme
G9	An x number of mandatory stimuli must appear in each test
G10	Repeat the same word 3 times for error consistency
G11	Perform error consistency test for detected error phonemes
G12	Extra games could be played after a chapter
G13	Use chapter zero just for error detection
G14	Do not put captions on pictures that the child has to name
G15	Allow SLP to provide word hints
G16	Provide child capability to ask for hint
G17	Provide the possibility to identify errors in different phonemes
G18	Allow SLP to select to play sentences section
G19	Give SLP capability to ask for word repetition
G20	Repeat the same word 3 times for error consistency
G21	Be able to save the recordings of all repetitions
G22	Have an indication to when the game is recording
G23	Stop the game and restore
G24	At the end of the game select the chapters again
Continued on next page	

Table I.1 – continued from previous page

ID	Description
G25	Choose the phonemes to play on in the main chapters
G26	Images adapted to children's perception
G27	Mark/classify all phonemes (even repeated)
G28	Identify the substitute phoneme in case of error
G29	Add "OTHER" error with the possibility of entering free text
G30	Differentiate samples obtained with repetition or help
G31	Auditory instructions whenever the child interacts with the game
G32	Reward system at the end of each chapter
G33	Child be aware of how close it is to end a task
G34	Use of PCC (percentage of correct consonants)

ALL DESIGN GUIDELINES FOR THE FRAMEWORK

Table II.1: All of the Design Guidelines for the Framework

ID	Description	Category
DG1	Display progress to help the child understand how close they are to completing a task	Motivation and Progress Tracking
DG2	Introduce a reward system that provides positive reinforcement at the end of each chapter	Motivation and Progress Tracking
DG3	Use a variety of reward badges or stickers that align with progress in the game	Motivation and Progress Tracking
DG4	Introduce subtle competition through tasks, such as timed challenges or completing tasks with minimal errors	Motivation and Progress Tracking
DG5	Incorporating a Narrative Story	Motivation and Progress Tracking
DG6	Displaying the Score Throughout the Game	Motivation and Progress Tracking
DG7	Encouraging Exploration	Motivation and Progress Tracking
DG8	Ensure the design is appealing and age-appropriate with bright colors, playful elements, and engaging visuals	User Interface and Engagement Design
DG9	Relate interface elements to real-world concepts to make them more relatable and understandable for children	User Interface and Engagement Design
DG10	Allow the child to select characters, adding personalization and making the game more fun	User Interface and Engagement Design
Continued on next page		

Table II.1 – continued from previous page

ID	Description	Category
DG11	Offer a variety of themes and skins to keep the game engaging	User Interface and Engagement Design
DG12	Ensure color harmony throughout the game to prevent overstimulation	User Interface and Engagement Design
DG13	Use Child-Like Characters as Guides	User Interface and Engagement Design
DG14	Avoid Placing Small Interactive Elements at the Edges of the Screen	User Interface and Engagement Design
DG15	Use Animations Carefully to Avoid Distraction	User Interface and Engagement Design
DG16	Simplifying the Menu System for Children	User Interface and Engagement Design
DG17	Using Large, Easy-to-Read Text and Simple Vocabulary	User Interface and Engagement Design
DG18	Using Consistent and Understandable (Intuitive) Icons	User Interface and Engagement Design
DG19	Provide fast feedback to maintain engagement and reduce loading times	Game Flow and Usability
DG20	Highlight clickable interface elements to guide the child through the game	Game Flow and Usability
DG21	Use horizontal scrolling instead of vertical scrolling to align with natural user behavior and improve ease of navigation	Game Flow and Usability
DG22	Support Both Single- and Multi-Touch Input	Game Flow and Usability
DG23	Allow Slightly Out-of-Bounds Interactions	Game Flow and Usability
DG24	Use initial Chapter or level solely for error detection to avoid overwhelming the child with content	Game Structure and Functionality
DG25	Hiding Advanced Levels	Game Structure and Functionality
DG26	Creating an Open-Ended SG with Multiple Possibilities	Game Structure and Functionality
DG27	Allow the SLP to select specific phonemes and play sentence sections tailored to the child's therapy needs	SLP and Child Interaction Features
DG28	Enable the SLP to provide hints when needed for word recognition and pronunciation	SLP and Child Interaction Features
Continued on next page		

Table II.1 – continued from previous page

ID	Description	Category
DG29	Allow the SLP to request word repetition if required	SLP and Child Interaction Features
DG30	Ensure the game records all repetitions for analysis and feedback	SLP and Child Interaction Features
DG31	Provide clear indications when the game is recording, ensuring transparency	SLP and Child Interaction Features
DG32	Starting recording before showing the object	SLP and Child Interaction Features
DG33	At the end of each session, allow the child to revisit chapters for reinforcement and further practice	SLP and Child Interaction Features
DG34	Provide extra games for further reinforcement or for review of difficult concepts	SLP and Child Interaction Features
DG35	Place Essential Instructions at the End of Sentences	SLP and Child Interaction Features
DG36	Promoting Cooperation	SLP and Child Interaction Features
DG37	Adapt images and visuals to match children's cognitive abilities, ensuring clarity and ease of recognition	Learning and Adaptation
DG38	Avoid social features such as sharing rewards or leaderboards to focus on individual learning without external comparisons	Learning and Adaptation
DG39	Balance intrinsic and extrinsic motivation through internal rewards (like progressing through levels) and external rewards (like stickers and badges)	Learning and Adaptation
DG40	Allowing Children to Revisit Previously Explored Areas	Learning and Adaptation
DG41	Offering Multiple Difficulty Levels	Learning and Adaptation
DG42	Offer immediate feedback to help the child understand their performance	Feedback Systems
DG43	Avoid displaying captions on pictures that the child needs to name to encourage active recall	Feedback Systems
DG44	Use auditory instructions to guide the child through each step when they interact with the game to enhance learning	Feedback Systems
Continued on next page		

Table II.1 – continued from previous page

ID	Description	Category
DG45	Avoid transmitting error directly to the child and prevent any negative feedback; this can be done by using encouraging language or positive reinforcement	Feedback Systems
DG46	For assessment, provide clear and accurate phoneme classification during each task to guide the child's progress	Phoneme Classification and Error Management
DG47	Allow the SLP to classify errors based on their assessment and provide appropriate interventions	Phoneme Classification and Error Management
DG48	On substitution errors, register the substitute phoneme to track the progress	Phoneme Classification and Error Management
DG49	Ensure a fixed number of mandatory stimuli per test to maintain consistency	Phoneme Classification and Error Management
DG50	Allow repetition of the same word to check for error consistency	Phoneme Classification and Error Management
DG51	Perform an error consistency test on detected phonemes to ensure accurate error classification	Phoneme Classification and Error Management
DG52	Accurately identify and classify substitute phonemes when errors occur to track phonemic progress	Phoneme Classification and Error Management
DG53	Add an "OTHER" error option for cases that don't fall under predefined categories, allowing the user to enter free text for additional feedback	Phoneme Classification and Error Management
DG54	Allow the children to Correct Mistakes	Phoneme Classification and Error Management
DG55	Allow the child to ask for hints during the game to help with phoneme production	Support for Child Needs
DG56	Implement a mute option for sound effects to accommodate different environments or preferences	Support for Child Needs
DG57	Minimize text in the interface, especially for younger children, to reduce cognitive load	Support for Child Needs
DG58	Implement a Time-Out for Inactivity with Assistance Prompts	Support for Child Needs
DG59	Avoid Traditional Tutorials	Support for Child Needs
Continued on next page		

Table II.1 – continued from previous page

ID	Description	Category
DG60	Avoid Complex Gestures for younger children (zoom, pinch, drag and drop, double tapping)	Support for Child Needs
DG61	Differentiate between samples collected with repetition or assistance, tracking the child's independent progress versus guided help	Data Collection

III

QUESTIONNAIRES FOR FANIMA

III.1 Questionnaires for the therapist - Session

The following figures represent the questionnaires that the SLP has to answer after the child has done a gameplay session.

FANIMA - Ferramenta baseada em Jogo
Sério digital para Teste Fonético-
Fonológico

A informação que recolhemos
sobre si é anónima e será apenas utilizada para o nosso uso interno no
âmbito da nossa investigação. Não será partilhada com terceiros.

[Mudar de conta](#)

Não partilhado

* Indica uma pergunta obrigatória

Figure III.1: SLP questionnaire after each session (Page 1/10)

III.1. QUESTIONNAIRES FOR THE THERAPIST - SESSION

Informações da criança

Por favor, preencha alguma informação demográfica básica da criança.

Qual o ID da criança? *

Sua resposta

Qual a idade a criança? (insira um número em anos) *

Sua resposta

Qual é o género da criança? *

☐ Masculino

☐ Feminino

☐ Prefiro não responder

☐ Outro: _____

Que problema do domínio da fala a criança apresenta ou foi indicado?

Sua resposta

Figure III.2: SLP questionnaire after each session (Page 2/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

A criança apresenta alguma patologia fora do domínio da fala? *

☐ Sim

☐ Não

Caso tenha respondido afirmativamente à questão anterior, qual a patologia em questão?

Sua resposta _____

Onde realizou o teste? *

Sua resposta _____

A **internet** utilizada foi Wi-Fi de um estabelecimento (escola/cresce/clínica)? *

☐ Sim

☐ Não

Considero que tive problemas com o sinal da **internet**. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que o tempo de resposta entre a PLAY (interface do terapeuta) e o Fanima (interface da criança) permitiu uma sessão fluida sem tempos "mortos" que tivessem prejudicado o bom funcionamento da sessão. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Adicione observações relativamente a problemas que detetou durante a sessão .

Sua resposta _____

Se respondeu que sim à questão anterior, indique a razão.

Sua resposta _____

Figure III.3: SLP questionnaire after each session (Page 3/10)

Fanima

Por favor, responda a algumas questões sobre a aplicação Fanima.

Capítulo 0 - palavras



Que capítulos foram jogados? *

- ☐ Capítulo 0 - Palavras
- ☐ Capítulo 0 - Frases
- ☐ Capítulo 1 - Oclusivas
- ☐ Capítulo 1 - Extra
- ☐ Capítulo 2 - Fricativas
- ☐ Capítulo 2- Extra
- ☐ Capítulo 3 - Vibrantes e Laterias
- ☐ Capítulo 3 - Extra

Figure III.4: SLP questionnaire after each session (Page 4/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

Considero que a criança sentiu dificuldades em entender as tarefas propostas pela **narração do jogo** (instruções dadas no início de cada capítulo). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança conseguiu fazer uma boa interpretação das **tarefas principais** (ex: nomear o que vê nas ilustrações). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que o **feedback auditivo** foi motivador para a criança (ex: após a validação do terapeuta, quando aparece um objeto para encontrar, quando toca num objeto, quando termina um capítulo, quando termina o jogo). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança teve dificuldade em realizar as **tarefas principais** propostas (ex: nomear o que vê nas ilustrações). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.5: SLP questionnaire after each session (Page 5/10)

III.1. QUESTIONNAIRES FOR THE THERAPIST - SESSION

Considera que o **feedback auditivo** foi excessivo. (ex: "Diz mais uma vez" "O que vês no quadro?"). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança sentiu-se **confortável** ao ter o jogo a interagir consigo nos momentos de solicitação de repetição/ajuda. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança achou divertido em realizar as **tarefas complementares** (ex: tocar em objetos, arrastar objetos, procurar objetos). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança sentiu-se empenhada em realizar as **tarefas complementares** (ex: tocar em objetos, arrastar objetos, procurar objetos). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.6: SLP questionnaire after each session (Page 6/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

Considero que a criança teve dificuldade em realizar as **tarefas complementares** *
propostas (ex: tocar em objetos, arrastar objetos, procurar objetos).

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que as **tarefas complementares** (ex: tocar em objetos do jogo, arrastar
objetos, procurar objetos) são distrativas à realização das tarefas principais (ex:
nomear o que vê nas ilustrações)?

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

Considero que a criança mostrou interesse pelos **diferentes ambientes** *
encontrados nos capítulos (ambiente do balão, do sapo, do macaco, das corujas,
dos peixes, etc.).

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança tenha utilizado autonomamente o **botão de ajuda** *
(panda).

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.7: SLP questionnaire after each session (Page 7/10)

III.1. QUESTIONNAIRES FOR THE THERAPIST - SESSION

Considero que a criança teve dificuldades para entender as **instruções de voz**. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a **barra de progressão** (localizada na parte inferior do ecrã) foi um elemento motivador para a criança realizar as tarefas propostas no capítulo. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a **barra de progressão** (localizada na parte inferior do ecrã) ajudou a reduzir a ansiedade da criança em relação à expectativa de terminar as tarefas propostas. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que as **recompensas** (medalhas) motivaram a criança a concluir o capítulo. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.8: SLP questionnaire after each session (Page 8/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

Considero que a criança demonstrou **frustração** enquanto jogava. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança se sentiu **entusiasmada** enquanto jogava. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança teve dificuldades em perceber o jogo. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança se distrai muito durante a utilização do jogo. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança precisou de ser incentivada para continuar a jogar. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança parecia nervosa/ansiosa enquanto jogava. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança se esforçou em terminar as tarefas propostas. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Tive de **interromper a sessão** de jogo? *

☐ Sim

☐ Não

Figure III.9: SLP questionnaire after each session (Page 9/10)

Foi necessário intervir muitas vezes para dar **auxílio** à criança na realização das **tarefas principais**. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a criança conseguiu terminar o jogo com sucesso (mesmo no caso de ter sido interrompida a sessão). *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Gostaria de utilizar a ferramenta Fanima com frequência com esta criança. *

1 2 3 4 5 6 7

☐ ☐ ☐ ☐ ☐ ☐ ☐

O quanto a criança gostou de jogar o jogo Fanima? *

1 2 3 4 5 6 7

Não gostou ☐ ☐ ☐ ☐ ☐ ☐ ☐ Gostou muito

A criança demonstrou interesse em jogar o jogo novamente? *

☐ Sim

☐ Não

Feedback

Dê-nos feedback adicional sobre a sua experiência com o Fanima.

Tem algum feedback adicional sobre experiência com o Fanima?

Sua resposta

Figure III.10: SLP questionnaire after each session (Page 10/10)

III.2 Questionnaires for the therapist - Global

The following figures represent the questionnaires that the SLP has to answer after all child testing was done.

FANIMA - Ferramenta baseada em Jogo Sério digital para Teste Fonético- Fonológico

A informação que recolhemos será apenas utilizada para o nosso uso interno no âmbito da nossa investigação. Não será partilhada com terceiros.

[Mudar de conta](#)

Não compartilhado

* Indica uma pergunta obrigatória

Qual o seu ID? *

Sua resposta

Fanima

Por favor, responda às seguintes questões sobre interação das crianças como jogo Fanima

Capítulo 0 - Palavras



Considero o jogo bem concebido no que diz respeito às **idades** das crianças que o testaram *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.11: SLP questionnaire after all testing (Page 1/7)

III.2. QUESTIONNAIRES FOR THE THERAPIST - GLOBAL

Considero que o jogo é mais adequado a crianças de um determinado género. *

☐ Masculino

☐ Feminino

☐ Indiferente

Considero que uma criança com outras limitações para além da fala consegue facilmente interagir com o jogo. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que esta ferramenta permite um melhor desempenho das crianças durante a sessão. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a utilização deste jogo sério tem vantagens em relação a jogos que utilizo durante as sessões para manter as crianças motivadas. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que o uso desta ferramenta ajuda à concentração das crianças na realização das tarefas propostas. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que os elementos como **medalhas, procurar objetos, arrastar objetos, clicar em objetos, barra de progressão, fazer correspondência entre objetos** ajudam a manter as crianças motivadas durante a sessão. *

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.12: SLP questionnaire after all testing (Page 2/7)

ANNEX III. QUESTIONNAIRES FOR FANIMA

PLAY

Por favor, responda a algumas questões sobre a interface do Terapeuta

Considero que a integração da Fanima com a PLAY, como suporte à actividade do Terapeuta, está bem conseguida.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

O fluxo de jogo permite suportar a avaliação de diagnóstico adequada do utente, podendo assim verificar o conjunto de fonemas onde o utente apresenta dificuldades.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Acho que as opções de "Repetir", "Ajuda" e "Submeter " são adequadas para conseguir manipular o decorrer do jogo.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.13: SLP questionnaire after all testing (Page 3/7)

Considero que as possibilidades de classificação são adequadas para conseguir registar os erros detectados.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Considero que a possibilidade de introduzir uma anotação é adequada para classificar erros atípicos.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Após o teste, os resultados apresentados na PLAY representam o tipo de perfil que idealizei.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Acho que a visualização dos resultados do teste de diagnóstico é feita de forma adequada.

1 2 3 4 5 6 7

Discordo totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.14: SLP questionnaire after all testing (Page 4/7)

Usabilidade da Ferramenta

Lembre-se da sua experiência aquando da utilização do Fanima e diga-nos o quanto concorda ou discorda com cada uma das seguintes afirmações.

Acho que gostaria de utilizar a ferramenta Fanima com frequência. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Considerarei a ferramenta Fanima mais complexa do que necessário. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Achei a ferramenta Fanima fácil de utilizar. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Figure III.15: SLP questionnaire after all testing (Page 5/7)

III.2. QUESTIONNAIRES FOR THE THERAPIST - GLOBAL

Acho que necessitaria de ajuda de um técnico para conseguir utilizar a ferramenta Fanima. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Considereei que as várias funcionalidades da ferramenta Fanima estavam bem integradas. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Achei que a ferramenta Fanima tinha muitas inconsistências. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Suponho que a maioria das pessoas aprenderia a utilizar rapidamente a ferramenta Fanima. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Considereei a ferramenta Fanima muito complicada de utilizar. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Senti-me muito confiante a utilizar a ferramenta Fanima. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Tive que aprender muito antes de conseguir lidar com a ferramenta Fanima. *

1 2 3 4 5 6 7

Discordo Totalmente ☐ ☐ ☐ ☐ ☐ ☐ ☐ Concordo Totalmente

Figure III.16: SLP questionnaire after all testing (Page 6/7)

The screenshot shows a section titled "Feedback" with an orange header. Below the header, there is a text prompt: "Dê-nos feedback adicional sobre a sua experiência com o Fanima." This is followed by a question: "Tem algum feedback adicional sobre a sua experiência com o Fanima?". At the bottom of this section is a text input field with the placeholder text "Sua resposta".

Figure III.17: SLP questionnaire after all testing (Page 7/7)

III.3 Questionnaires for the children

The following figures represent the questionnaires that the child has to answer, with the assistance of the SLP, after doing a gameplay session.

The screenshot displays a questionnaire for children titled "FANIMA - Ferramenta baseada em Jogo" and "Sério digital para Teste Fonético-Fonológico". It includes a privacy notice: "A informação que recolhemos sobre si é anónima e será apenas utilizada para o nosso uso interno no âmbito da nossa investigação. Não será partilhada com terceiros." Below this is a greyed-out text box and a blue link "Mudar de conta". A status indicator shows "Não compartilhado" with a lock icon. A red asterisk note states: "* Indica uma pergunta obrigatória". The final section, "Elementos gráficos", explains: "As seguintes questões referem-se aos elementos gráficos do jogo, como por exemplo a paisagem, e os personagens que aparecem. Por favor, responda apenas as perguntas referentes aos Capítulos que a criança jogou."

Figure III.18: Child questionnaire after each session (Page 1/10)

No **Capítulo 0**, nas **palavras**, a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

No **Capítulo 0**, nas **frases**, a criança gostou dos elementos gráficos do ambiente do jogo.



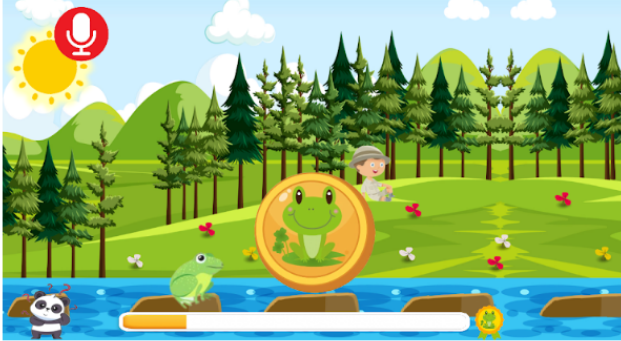
1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.19: Child questionnaire after each session (Page 2/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

No **Capítulo 1** (o capítulo com o sapo que apanha moedas), a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

No **Capítulo 1 extra** (o capítulo onde a criança tem de encontrar os macacos), a criança gostou dos elementos gráficos do ambiente do jogo.

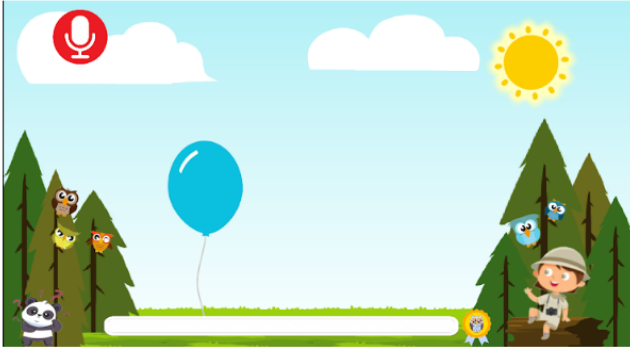


1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.20: Child questionnaire after each session (Page 3/10)

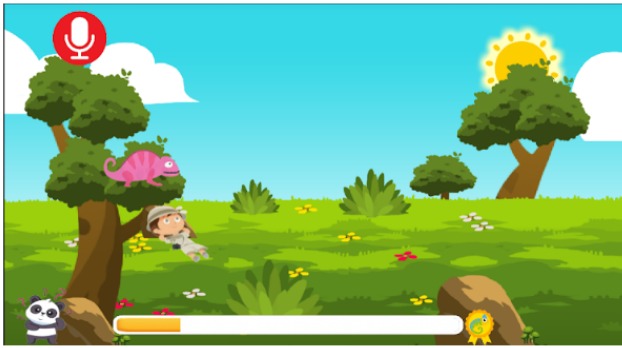
No **Capítulo 2** (o capítulo onde a criança tem de estoirar os balões), a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

No **Capítulo 2 extra** (o capítulo onde a criança tem de encontrar os camaleões), a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.21: Child questionnaire after each session (Page 4/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

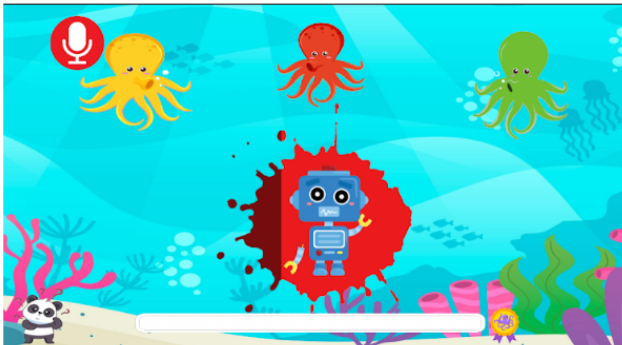
No **Capítulo 3** (o capítulo onde a criança tem de alimentar os peixes), a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

No **Capítulo 3 extra** (o capítulo onde a criança tem de combinar a tinta com os polvos da mesma cor), a criança gostou dos elementos gráficos do ambiente do jogo.



1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Jogabilidade
As questões seguintes focam na interação das crianças com o jogo, se foi divertido, imersivo e/ou intuitivo.

A criança gostou da interação de falar nomear os objetos que via.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.22: Child questionnaire after each session (Page 5/10)

A criança entendeu a narração/instruções do jogo.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança lembrava de nomear os objetos apenas depois do microfone ficar verde.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança gostou da interação de selecionar nos objetos (ramos, moedas, balões e/ou comida de peixe, referentes aos **Capítulos 0, 1, 2 e/ou 3**).

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança gostou da interação de encontrar os animais (macaco e/ou camaleão, referentes aos **Capítulos 1 extra e 2 extra**).

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.23: Child questionnaire after each session (Page 6/10)

A criança gostou da interação de arrastar a tinta para o polvo (referente ao Capítulo 3 extra).						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança ficou satisfeita após ver os troféus que ganhou no jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A barra de progressão ajudou a criança perceber a sua progressão no jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança ficou imersa ao jogar o jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

Figure III.24: Child questionnaire after each session (Page 7/10)

III.3. QUESTIONNAIRES FOR THE CHILDREN

Usabilidade
Por favor, responda às seguintes questões mediante as respostas das crianças ao questionário adaptado.

A criança gostaria de jogar este jogo mais vezes.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança achou que o jogo foi muito difícil de jogar.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança pensava que o jogo era mais fácil de jogar.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança precisou de ajuda para jogar o jogo.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Figure III.25: Child questionnaire after each session (Page 8/10)

ANNEX III. QUESTIONNAIRES FOR FANIMA

A criança sabia o que era preciso fazer durante o jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança achou que algumas coisas não faziam sentido no jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança achou que os seus amigos iriam gostar deste jogo.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança precisou esforçar-se muito para conseguir jogar.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança achou que jogou bem.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança precisou de aprender muito para conseguir jogar.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

A criança achou o jogo divertido.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

Se a criança tivesse mais tempo, teria gostado de jogar mais.						
	1	2	3	4	5	
Discordo totalmente	☐	☐	☐	☐	☐	Concordo totalmente

Figure III.26: Child questionnaire after each session (Page 9/10)

III.3. QUESTIONNAIRES FOR THE CHILDREN

A criança vai falar aos seus amigos sobre este jogo.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

A criança achou que o jogo foi muito longo.

1 2 3 4 5

Discordo totalmente ☐ ☐ ☐ ☐ ☐ Concordo totalmente

Qual parte a criança **mais gostou** no jogo? *

Sua resposta _____

Qual parte do jogo a criança considerou **mais difícil e/ou entediante**? *

Sua resposta _____

Qual o motivo pelo qual a criança achou essa parte do jogo **entediante** ou **difícil**?
(Caso a criança não consiga explicar ou não saiba, o terapeuta pode escrever uma suposição ou deixar em branco).

Sua resposta _____

Se a criança pudesse mudar ou acrescentar algo no jogo, o que seria? (Se a criança não tiver uma resposta, responda 'Nada'). *

Sua resposta _____

Existe alguma anotação que queira adicionar? (Deixe em branco ou responda "Nada" se não)

Sua resposta _____

Figure III.27: Child questionnaire after each session (Page 10/10)



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