Task Complete: A gamified solution to exercise positive habits in players with Intellectual Disabilities

Pedro Afonso F. Michalichem[1], **Leonardo Tórtoro Pereira**[1,2], **Kamila Rios da Hora Rodrigues**[1]

[1]Instituto de Ciências Matemáticas e de Computação (ICMC)
Universidade de São Paulo (USP)
São Carlos/SP – Brazil

[2]Instituto de Geociências e Ciências Exatas - (IGCE)
Universidade Estadual Paulista (UNESP)
Rio Claro/SP, Brazil

darknighmare1@usp.br,leonardo.t.pereira@unesp.br,kamila.rios@icmc.usp.br

Abstract. *This paper describes creating and evaluating a gamified solution called Task Complete, which aims to support productivity and encourage positive habits in its players, especially people with Intellectual Disabilities. The solution transforms everyday tasks into motivational elements, engaging users through virtual rewards. It was designed following principles of User-Centered Design, as well as developed and evaluated considering accessibility and usability requirements. The PENS model and Web Content Accessibility Guidelines (WCAG)*[1] *were considered in the project, seeking to make the solution inclusive for various user profiles.*

Keywords *Gamified Web Solution, Task Complete, Game Design, Game Evaluation, Accessibility, Intellectual Disability.*

1. Introduction

Gamification, defined as the use of game elements outside a game context [Deterding et al. 2011, Marczewski 2015], has been widely explored in various contexts such as health [Lewis et al. 2016], software development [Pedreira et al. 2015] and education [Bai et al. 2020]. Gamification is used to improve users' motivation and engagement, once the insertion of playful elements directly affects these users.

Popularly, gamification is considered a way to make tasks or activities more fun and attractive, using game elements such as scoring, rewards, challenges, and progression [Marczewski 2015].

Planning and developing gamification is not a trivial task, which has driven the emergence of a field to study ways of gamifying an environment, whether virtual or non-virtual. To assist in planning, several frameworks, methods, processes, and related processes have been developed over the years [Mora et al. 2017], all to help developers, technicians, specialists, and researchers to plan and implement gamification in a specific context.

This paper describes the "Task Complete" gamified web solution. This solution was designed as an alternative to help children and teenagers with Intellectual Disabilities

[1]Available at: https://www.w3.org/TR/WCAG22/

(ID)[2] practice healthy and positive habits and get involved in their daily tasks more fun and stimulating. It is a solution based on completing tasks to obtain virtual coins, which can be spent on accessories for a virtual avatar.

The project results from a partnership with the ACORDE Institution[3], which supports people with ID and has sought to complement its pedagogical activities with technologies such as digital games and gamified systems.

The design and development of Task Complete considered accessibility requirements supported by the Web Content Accessibility Guidelines (WCAG) and GAIA Recommendations [Pichiliani 2020] (specific for children on the autistic spectrum), thus implementing recommendations and standards to make the solution more accessible and able to provide a more positive experience for the user, here considered a player.

The paper is divided as follows: Section 2 describes the related work, Section 3 describes the process of building the Task Complete gamified application, Section 4 brings a discussion about the importance of thinking about accessibility in computational solutions, and Section 5 describes the final considerations and future works.

2. Related Works

The works listed below refer to gamified platforms in different contexts or games developed for people with intellectual disabilities. It should be highlighted that our solution was designed to support children and teenagers from ACORDE institution, which offers pedagogical activities in a second shift to Down Syndrome and Autism Spectrum Disorder (ASD) people.

Hosseini *et al*. (2022) investigate the effects of gamification on task performance. A between-group experimental design was used concerning the Covid-19 pandemic, where the participants were asked to carry out tasks related to: a) hygiene and infection (e.g., washing hands, keeping distance, etc.); b) routines (e.g., walking every day, being social with friends, cleaning the house, etc.); c) personal issues (e.g., learn something new, check in with a friend, etc.).

According to the authors, gamification has increased the quality of work in task performance and subsequent deliveries over time. In addition, gamification has positively affected on-time deliveries.

Giacobo and de Souza (2023) present a gamified Web solution that seeks to engage and encourage students to deliver the proposed activities inside and outside the classroom, within the proposed deadline, in a playful, fun, and competitive way. The solution uses gamification elements like levels, rewards, and competitions. The preliminary results of a pilot study carried out with the solution showed that it was well received by students, who were more motivated and engaged in the proposed activities.

Domingos Filho and do Vale (2017) present a gamified solution for teaching physics to young people and adults. The project uses gamification elements, such as levels, rewards, and competitions, to increase students' interest and motivation in learning.

[2]Term used according to the Protocol for the Etiological Diagnosis of Intellectual Disability: `https://www.gov.br/saude/pt-br/assuntos/pcdt/arquivos/2020/deficiencia-intelectual-protocolo-para-o-diagnostico-etiologico.pdf`.

[3]`https://institutoacorde.org.br/`

Simões-Silva *et al.* (2022), point out that gamification can benefit autism spectrum disorder, "which is a persistent neurodevelopmental disorder that can be characterized briefly by deficits in verbal and non-verbal communication, difficulties in interaction, and manifestation of stereotyped movements or interests". According to the authors, in the case of ASD, the programs, software, or mobile applications should focus on developing intrapersonal (such as motivation) and interpersonal/social skills.

da Cruz Netto *et al.* (2020) present the virtual environment "Our Life", which was developed to assist children with Down Syndrome memorize action sequences of their daily routine. The work involved a multidisciplinary team, and the effectiveness of the test was assessed by 30 children with Down Syndrome from a special education school for children with intellectual disabilities (APAE, acronym in Portuguese).

The children were separated into two groups (experimental - EG, and control - CG). The results indicated that the EG presented significance concerning the CG, and the evolution mean of the children in the EG was 81.82% higher. According to the authors, the playful activities implemented in this virtual environment created interest in children, who had fun, tested hypotheses, and questioned them about the sequences of actions performed in their daily routine.

Neves and Kand (2016) present the results of research that developed two educational games for intellectually disabled people. The games were evaluated through usability tests carried out with students from an APAE. The results indicated that the games were well received by students and are a promising tool for reinforcing the learning of intellectually disabled people.

Venturelli and Ferraz (2019) present the results of research that investigated the conceptions of teachers who teach children with intellectual disabilities about using digital games mediating mathematics teaching. The research suggested that teachers have positive conceptions about using digital games in teaching mathematics to students with intellectual disabilities.

Mori *et al.* (2017)'s research presents results investigating the contributions of games to the development of memory and attention in students with intellectual disabilities. The study showed that students who participated in recreational activities carried out better on memory and attention tasks than students who did not participate in these activities. The authors conclude that games can effectively develop these skills in students with intellectual disabilities.

Finally, Jadán-Guerrero *et al.* (2023) conducted a review of 66 studies regarding gamification in inclusive education for children with disabilities. They identified that game-based learning, educational games, e-learning, gamification, and serious games were keywords commonly present in such works. Moreover, they identified that this research is conducted in different parts of the world (e.g., USA, Europe, Brazil, and Mexico), with almost 200 identified authors from diverse universities, publishing in various venues. Their review suggests that this is a relevant and diverse field of research.

There are yet, some additional works concerning games to instilling healthy and positive habits in children with ASD and Down Syndrome [Viveiros et al. 2023], serious game as a tool to intellectual disabilities' therapy [Martins et al. 2011], serious games for helping children with Intellectual Disability to understand healthy eating habits with an

IPad [Isasi et al. 2013].

Although the works mentioned above highlight positive results in their use, most of the solutions are no longer available or do not meet important accessibility requirements for the context, which was a demand requested by our partner institution. Thus, we employed User-Centered Design (UCD) techniques, specifically for games [Pagulayan et al. 2002], to design and evaluate a gamified solution to exercise positive habits in children or adolescents with ID. This solution must be used with the mediation of an education professional from the partner institution.

3. Accessible Gamified Solution - Task Complete

This section describes the design, development, and evaluation stages of the "Task Complete" solution. The process is summarized in Figure 1 and described in the next sections.

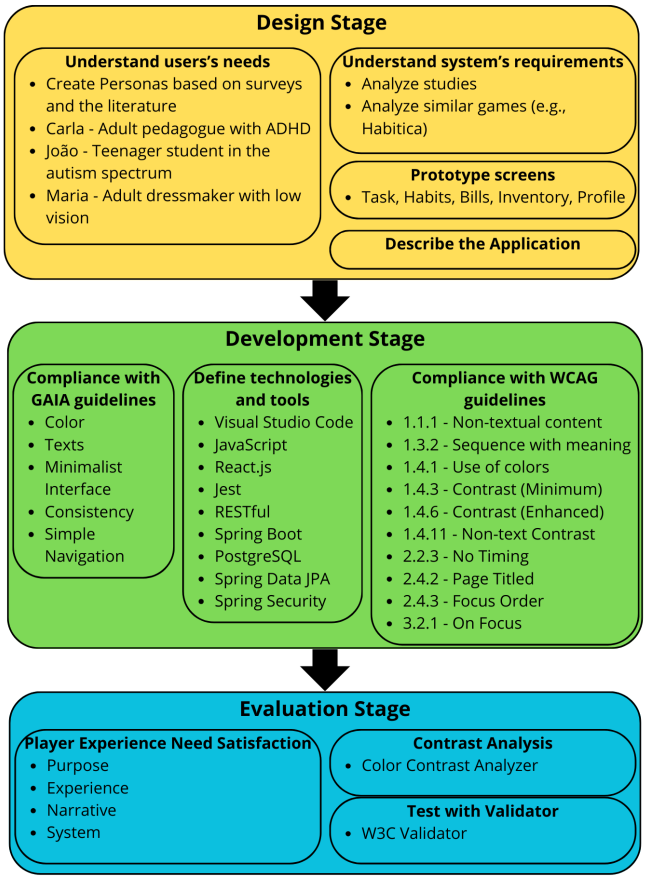


Figura 1. Summary of the design, development, and evaluation stages of Task Complete.

3.1. Design Stage

At this stage, according to the literature in the Human-Computer Interaction (HCI) area [Helen et al. 2019], designers must understand users' needs and the system's desired requirements.

Initially, to collect the application requirements, the studies presented in Section 2 were analyzed, as well as some similar commercial games, such as Habitica[4] and Uno in its colorblind version[5].

Moreover, by considering the knowledge gained from studying literature, Personas [Cooper 1999, Pruitt e Grudin 2003] were created to represent the target users of the solution. Personas are fictitious characters created from different sources that allow designers to identify the target user's demographic characteristics, preferences, and behaviors [Pruitt e Grudin 2003].

In the academic environment, the Persona's technique is widely used when there is no access to the target audience in the requirements gathering and understanding of the design problem stage. In this project, at that stage, there was still no approval from the Research Ethics Committee, so personas were created to understand the context and advance in the development stage. The knowledge informed by the personas enabled us to make design decisions, define mechanics for the gamified solution, and define the narrative and accessibility resources.

Therefore, three personas were created, covering the characteristics of the stakeholders (children or adolescents with ASD, caregivers, and Education professionals). These personas also were created based on information and surveys about the characteristics of people with disabilities described by Valle and Connor (2014). It is noteworthy that the first focus group of this work is people with ASD who are supported by the partner institution.

The personas created were:

- **Carla Marin:** represented in Figure 2, she is a pedagogue who greatly values inclusive education. She is a 30-year-old who constantly seeks to strengthen her skills, actively participating in activities at the school where she teaches in the special education class. She also participates in courses offered by the education department in her city in this context. Carla also engages in creative activities such as community theater, adapted dance, and crafts and explores innovative ways to make the teaching-learning process more accessible, inclusive, and engaging. She was diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) as a teenager and has difficulty focusing on activities that are not engaging her. This characteristic has helped her to closer to her students;
- **João Silva:** represented in Figure 3, is a curious teenager with a 14-year-old, diagnosed on the autism spectrum, who likes digital games. João has difficulty following routine activities and does not like environments with many people;
- **Maria Oliveira:** represented in Figure 4, is 42-year-old, a self-employed seamstress, and a single mother. She lives in a poor community in Rio de Janeiro/Brazil, and has a 6-year-old son who was recently diagnosed on the autism spectrum. Maria seeks ways to help her son communicate at home and regular school. She learned that a social institution in her community was carrying

[4]Available at: `https://habitica.com/`. It is a productivity and task management application that uses gamification to motivate users to achieve their goals and create healthy habits.

[5]Available at: `https://shop.mattel.com/products/uno-coloradd-hpp33`. This is a special edition of Uno aimed at people with color blindness, in which the cards are marked with the universal color code seal for color blindness, known as *ColorADD*.

out activities with educational games and was interested in taking her son to participate. Maria has low vision and uses special glasses to carry out her daily activities.

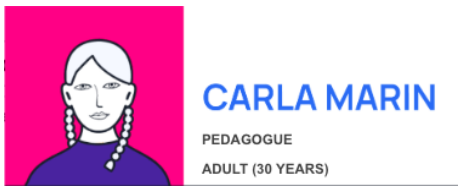


Figura 2. *Persona* - Carla Marin.

Figura 3. *Persona* - João Silva.

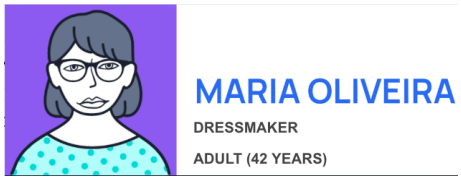


Figura 4. *Persona* - Maria Oliveira.

The personas helped the time in making design decisions, such as:

- For Maria Oliveira, as she has low vision and wants to follow her son's activities in the gamified solution, a high-contrast color palette was designed. The visual elements were chosen to facilitate identification and interaction with the interface elements and provide a more accessible and welcoming experience. Furthermore, the application was designed with the possibility of increasing and decreasing font, and changing the screen contrast;
- For João Silva, the solution needed to be understandable and not uncomfortable for users on the autism spectrum. João will use the gamified solution to support his daily life activities. Thus, the interface follows a cleaner and more simplified visual presentation and the adoption of rounded edges. This approach aimed to minimize cognitive overload, making the platform easier to understand and use for this profile of players;
- For Carla Marin, the same accessibility elements mentioned above were considered. Since she has ADHD, she must understand the solution and then motivate her students to use it too and to carry out the task routine playfully without deviating. It was also designed to be a fun and affordable solution that she could use with her special education students.

3.1.1. Application Description

The solution was designed after a more in-depth understanding of the context and users.

Task Complete is a gamified solution located on a Web platform, that combines gamification and task management to boost productivity and the development of positive habits. Task Complete aims to transform daily management into a gaming experience through gamification, allowing users to control avatars that evolve by completing tasks, establishing habits, and achieving goals.

The platform has four main areas of functionality. In the **Tasks section**, users add their activities to be carried out eventually; in the **Daily section**, the player adds their daily tasks; in **Habits**, they are tasks that the player wants to continue completing in a certain sequence so that a habit is created; and finally **Bills** to manage players' monthly bills. By completing these tasks, the player earns money that can be spent on clothes for their avatar, thus customizing it and giving it the desired appearance. There is also a level system that increases as tasks are completed.

A set of screens was prototyped for the application using the Figma tool. Figure 5 illustrates some of these screens.

Figure 5 [a] illustrates the routine **Task** section (first secondary menu item), in which there will be specific tasks created based on the player's needs, and the player can add as many as he/she wants. Upon completing them, the task completion check will be marked, and the player will earn coins as a reward for completing the tasks stipulated for themselves. Next to it in the top menu are **Daily tasks**, verified daily. **Habits** (see Figure 5 [b]), also in the menu, have a save of the sequence that the player is completing, so they maintain their sequence number, and this number increases every time the player fulfills a certain habit. The sequence is reset if the player does not continue to follow the habit. Finally, **Bills** (last menu item - see Figure 5 [c]), is a section designed to assist with the player's monthly bills.

The inventory is primarily a customization section (see Figure 6), in which players can personalize their avatar in the application. It provides an overview of existing items within the platform.

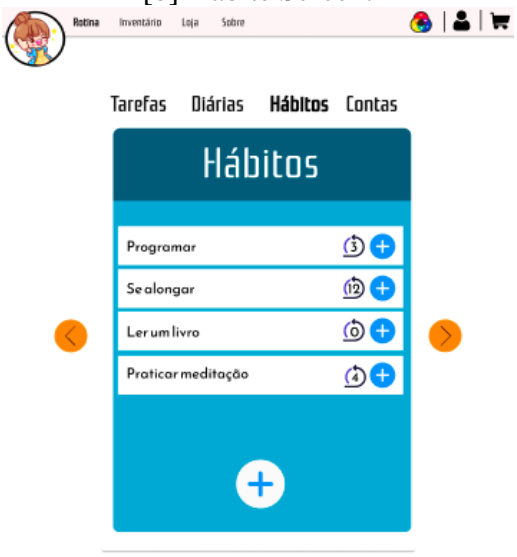
The player profile (see Figure 7) illustrates basic players' information such as name and email. It is also possible to view progress through the player avatar's level through the progress bar and the current level the avatar is at.

The feature of increasing and decreasing fonts was also designed, a requirement to provide a more accessible and personalized experience for users who cannot fully visualize the components and fonts (first icon on the main menu, on the right side - see Figure 5 [a]).

There is also a dark mode option in the top-right corner of the screen (second icon on the main menu, on the right side - see Figure 5 [a]). This is a display option that changes the color palette. Traditionally, light colors to a darker one. This functionality provides benefits for both user experience and accessibility, as it ends up increasing the contrast of the components viewed on the screen.

[a] Task Screen.

[b] Habits Screen.



[c] Bills Screen.

Figura 5. Some prototyped screens for the Task Complete application (in Portuguese) - secondary menu items.

Figura 6. Inventory screen (in Portuguese) - Main menu.

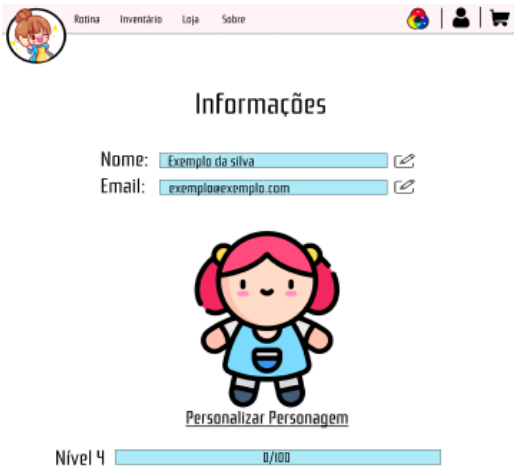


Figura 7. Profile screen (in Portuguese) - Main menu.

3.2. Development Stage

The application was developed using technologies in the context of Web development. The main tool adopted for programming and structuring the code was *Visual Studio Code*, an integrated development environment recognized for its efficiency and advanced features. It was chosen because it is an integrated development environment widely recognized for its efficiency and advanced features. One of the biggest advantages is the vast collection of extensions available, so developers can customize VS Code by adding extensions to support various programming languages, frameworks, and tools.

The programming language chosen for implementation was *JavaScript*, a versatile language widely used in Web development. The dynamic, object-oriented nature of JavaScript provided a solid foundation for creating an interactive and responsive application, ideally aligned with the project goals.

The *React.js* library was adopted as the Front-End framework, providing a declarative and efficient approach to developing complex user interfaces. This choice

was motivated by its component-based architecture that allows a modular and scalable organization of the code, promoting the maintainability and extensibility of the system. Using React.js not only facilitated the creation of an engaging user experience, but also contributed to an efficient and sustainable implementation of "Task Complete".

Tools integrated into VS Code, such as *Jest*, were used for testing. Unit tests were developed for each component, and the tests were executed directly in the editor.

The *RESTful* architecture was adopted for the Back-End, emphasizing *stateless* communication and resource manipulation through standard *HTTP* operations. *Spring Boot*, with its native support for *REST*, simplifies the creation of *endpoints*, handling requests and responses.

PostgreSQL was chosen for the database, for its reliability and robustness, and being fully integrated into the *Spring* ecosystem. Said integration is facilitated through *Spring Data JPA*, offering a layer of abstraction over data access and simplifying operations with the relational database.

Application security is guaranteed by *Spring Security*, allowing the implementation of authentication and authorization in a modular and customizable way. Furthermore, *Spring Boot* offers production-ready features, such as metrics and monitoring, contributing to effective application management in a real environment.

Figure 8 illustrates some screens implemented (e.g., Habits Screen, Name of inventory products, and Name of products in the store).

3.2.1. Project compliance with WCAG guidelines - Accessibility

During the project's development, some WCAG guidelines were adopted in code, to improve accessibility for players with different types of disabilities. WCAG guidelines define three levels of compliance: A, AA, and AAA. These levels indicate how accessible a website or application is by considering the guidelines. In the Task Complete solution, most of the guidelines implemented belong to Level A, complemented by some from Level AA and Level AAA. Some implemented guidelines are as follows:

- **Success Criterion 1.1.1 - Non-textual content [Level A]:** Any "non-textual" content that is relevant to understanding the information must contain an alternative description in the text (visible or not) to identify the content (including captcha, for example).
  In the code snippet represented in Figure 9, it is possible to see an example of *ALT* tag (alternative text) used to describe one of the images used in the solution;
- **Success Criterion 1.3.2 - Sequence with meaning [Level A]:** Whatever the method of interaction, the presentation of information on the screen must always have a logical sequence. For example, an error message on a form should have an alert icon, a message informing how to correct the error, and a color highlighting the information (not just the color change).
  In Figure 10, it is possible to see an example of an email entered incorrectly, and then an error message is displayed, which in turn alerts the user that the player needs to enter valid information to continue;

[a] Habits Screen.

[b] Name of inventory products.

[c] Name of products in the store.

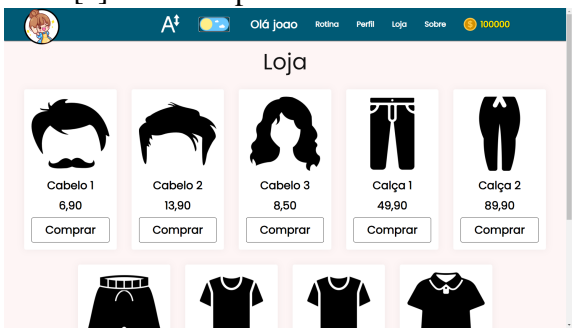


Figura 8. Some screens implemented for the Task Complete application (in Portuguese).

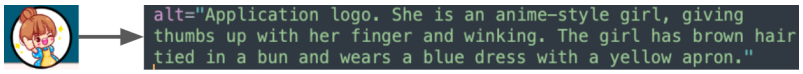


Figura 9. Code snippet using the ALT descriptive tag to inform the content of the logo image. This is a feature used by screen readers.

- **Success Criterion 1.4.1 - Use of colors [Level A]:** *Color is not used as the only visual means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.*
  Figure 11 illustrates how this strategy is used in the example of purchasing an item from the store, in which the color to convey purchase success is green, adding a label representative of the button's action;
- **Success Criterion 1.4.3 Contrast (Minimum) [Level AA] and Success Criterion 1.4.6 Contrast (Enhanced) [Level AAA]:** Texts must have a contrast ratio between foreground and background of at least 4.5:1. **Note**: if the text font size is at least "18pt" or "14pt bold" the contrast ratio can be 3:1.

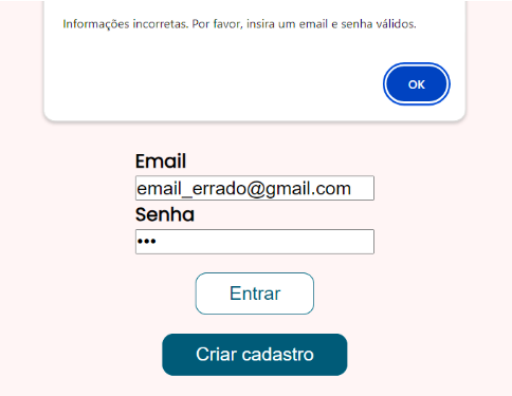


Figura 10. Filling error and clear message to the user (in Portuguese).

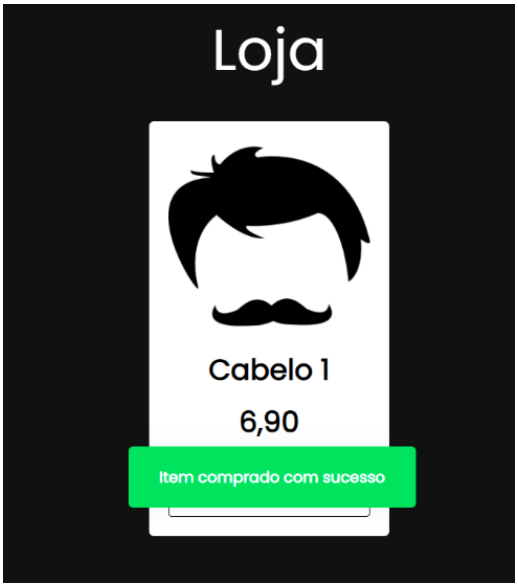


Figura 11. Example of an item purchase message in the store (in Portuguese).

Contrast-related illustrations referring to this guideline will be shown in the following (see Section 3.3.2), with the testing contrast application using the Color Contrast Analyzer[6] tool;

- **Success Criterion 1.4.11 Non-text Contrast [Level AA]:** Interface components (example: buttons) and images essential for understanding the content must have a contrast ratio between foreground and background of at least 3:1.
  Contrast-related illustrations referring to this guideline will be shown in the following (see Section 3.3.2), with the testing contrast application using the Color Contrast Analyzer tool;
- **Success Criterion 2.2.3 No Timing [Level AAA]:** No functionality on screen must have any execution upon completion within a certain period. **Note**: Real-time events are exceptions.
  In Task Complete there are no time-limited features;

[6]Available at: `https://chromewebstore.google.com/detail/color-contrast-analyzer/dagdlcijhfbmgkjokkjicnnfimlebcll?pli=1` or `https://dequeuniversity.com/color-contrast`

- **Success Criterion 2.4.2 Page Titled [Level A]:** All screens must have a main title that clearly describes their purpose.
  In Figure 8 [a], it is possible to see the habits screen with a clear content title.
- **Success Criterion 2.4.3 Focus Order [Level A]:** Interaction by focusable elements on the screen must always be sequential and logical according to the content presented;
  In Figure 12, it is possible to see the application menu with the logical sequence that the interaction between the elements follows, starting with general tasks, going through daily tasks, habits, and finally, the bills. All of them are elements related to the players' routine, thus maintaining a logical sequence of content.

Figura 12. Example of the logical sequence of the content (in Portuguese).

- **Success Criterion 3.2.1 On Focus [Level A]:** No contextual change that could disorient someone should occur when focusing on any element in the interface (e.g., opening a modal window) without direct confirmation (e.g., a confirmation button).
  One way to ensure this is that an image must have the same text on every page on which it is displayed. This happens in the Task Complete with the names of items, for example, that have the same name in the inventory and the store, as illustrated in Figure 8 [c].

The gamified application also does not violate other WCAG guidelines, such as 1.3.3 (Sensory Characteristics); 1.3.4 (Orientation); 2.4.11 (Focus Not Obscured (Minimum)); 2.4.12 (Focus Not Obscured (Enhanced)); 3.1.3 (Unusual Words) and 3.1.5 (Reading Level).

3.2.2. Project compliance with GAIA Recommendations

The project also follows GAIA recommendations [Pichiliani 2020]. GAIA is an open and collaborative set of 28 Web accessibility recommendations focused on aspects of autism, covering from content writing to programmable resources. We highlight that the GAIA recommendations were created in line with the WCAG guidelines.

Some recommendations used are listed: G01 about the **Color**, as it is not the only way to convey content and the contrast between background colors and foreground objects is adequate to distinguish items; G02 about the **Texts**, using a simple visual and textual language, avoiding jargon; G10 about the **Minimalist Interface**, as the interface is simple, with few elements and contains only the functionalities and content necessary for the current task; G22 about the **Consistency**, as similar elements and interactions have similar, consistent and predictable results; G25 about the **Simple Navigation**, as our interface has simplified and consistent navigation between pages, among other recommendations.

3.3. Evaluation Stage

Inspection and checklist evaluations were carried out in the Task Complete interface. The following sections describe these evaluations.

3.3.1. Player Experience of Need Satisfaction - PENS

This model was the first used to evaluate the gamified solution developed. The objective of the evaluation was to verify whether the solution could generate a positive experience in the player [Ryan et al. 2006].

To instantiate the PENS model, the solution was analyzed based on the concepts developed for gamification by Schell (2008), which is based on four dimensions: purpose, experience, narrative, and system. Below, each of them was analyzed for the Task Complete gamified solution.

- **Purpose:** The purpose of Task Complete is to help ID people achieve their daily tasks related to personal or well-being issues. The solution offers various gamification mechanics to help players motivate themselves and stay on track. For example, players can gain experience and level up by completing tasks, setting goals, and completing challenges. They can also receive rewards for their progress, such as coins to be spent in the store. These mechanics help players feel motivated and rewarded for their hard work, as illustrated in Figure 13 (areas outlined with red rectangles);

Figura 13. Level and money mechanics (in Portuguese).

- **Experience:** The solution uses various gamification mechanics to create an engaging experience. Task Complete uses, for example, a user interface that resembles a game, with a playful design that follows blue, orange, black, and white colors throughout the application. Players can customize their avatars' appearance and equip them with items. Finally, the solution also uses border styles with rounded elements and fonts. These elements are more accessible to process visually once the straight lines and sharp corners can be unsettling for people with autism, for example. In contrast, curved lines and rounded borders are softer

and less stimulating. Figure 14 demonstrates these characteristics adopted for the solution;

Figura 14. Player interface with rounded border (in Portuguese).

- **Narrative:** *Task Complete*'s narrative helps give meaning to the gamification experience. The solution occurs in a scenario where the player has an avatar that evolves as tasks are completed, thus gaining experience, levels, and new clothes that are personalized in the way the player wants.
  This narrative can help players connect with the application and feel more motivated. Users can feel like they are making a difference in their lives by seeing how much progress they make in completing their tasks and reaching goals. An example is the measurement of progress players can have through their inventory, viewing the items purchased due to their consistency in completing routine activities. This can be illustrated in Figure 15;

Figura 15. Inventory interface with player progress (in Portuguese).

- **System:** The Task Complete is a clear, fair, and consistent solution. The rules are easy to understand and apply. The system is designed to be easy to use and understand. There is no need for a tutorial to teach players how to play, as it is intuitive and straightforward to understand. The application is also fair, meaning all users have the same chance of success.

3.3.2. Contrast analysis

The digital accessibility criterion of minimum contrast (1.4.3 in WCAG) is crucial to serving people with low vision and color blindness. Applying these criteria not only benefits accessibility, but also visually improves the digital project for everyone.

The free tool *Color Contrast Analyzer*, developed from Deque University[7], makes it easier to comply with this criterion by allowing analysis of the contrast between background and foreground colors for large and small text. These principles can be extended to presentation slides, social media artwork, e-books, among others.

To carry out this test, it is necessary to have a success criterion to determine whether the contrast is sufficient for people with vision difficulties to see the message conveyed. Therefore, the following success criterion was adopted by Color Contrast Analyzer itself:

- **Success criterion:** Ensure color contrast of at least 4.5:1 for small text or 3:1 for large text, even if the text is part of an image. Large text was defined in the requirements as 18pt (24 CSS pixels) or 14pt bold (19 CSS pixels).

In tests with the tool, the colors of the interface elements were evaluated and verified to see if they passed the standards: 1.4.3: Minimum contrast (AA), 1.4.6: Improved contrast (AAA). These standards must be applied to small and large texts, UI components, and graphic objects.

To carry out the tests, the base colors of the prototyping made in the Figma graphic editor were used, these colors being: shades of white (#FEF5F5, #FFFFFF), shades of blue (#005A75, #1DA7CF, #BAE7F4), black (#000000) and orange (#FF8C00).

Figure 16 represents the software used to conduct the tests. In this example test carried out, the contrast test was approved in the WCAG AA and AAA levels, both for small text and large text, UI components (User Interface), and graphical purposes. The colors used in the test are the blue (#FEF5F5) on the menu, with the white (#FFFFFF) fonts on that same menu.

In conclusion, the tests carried out with the tool, covering the header with the menu, task topics, title of task items, arrow component, items in the footer, and text boxes, were all passed successfully. The base colors from the Figma prototype, implemented in Front-End, were used effectively. Thus, the results indicate that the project meets the accessibility criteria regarding color.

3.3.3. Test with Validator

The W3C Markup Validation Service, also known as W3C Validator or Validator, is an online service provided by the World Wide Web Consortium (W3C)[8]. This service allows you to validate the conformity of HTML documents with the specifications and standards established by W3C and WCAG.

[7]Available at: `https://dequeuniversity.com/`
[8]Available at: `https://validator.w3.org/`

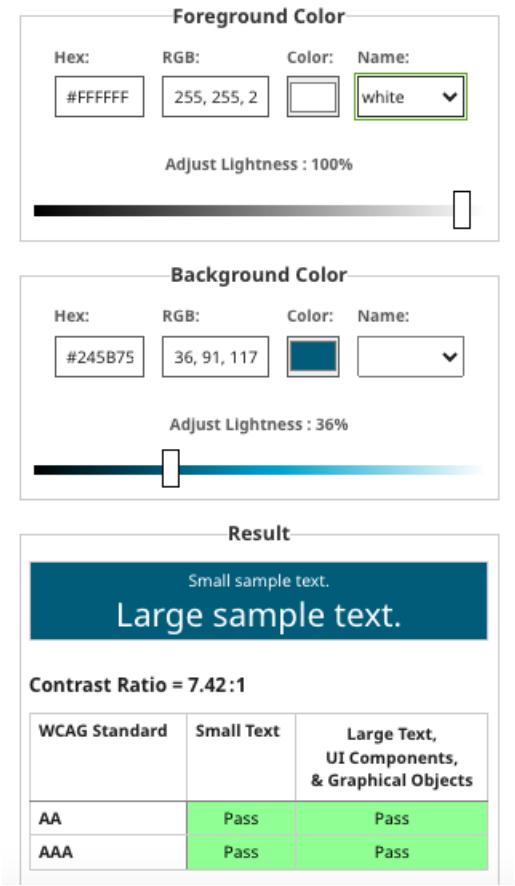


Figura 16. Use of the Color Contrast Analyzer - Approved menu color palettes.

Web developers can access the Validator through the service's official website, enter a page's URL (Uniform Resource Locator), or provide the code directly for verification. By following the Validator recommendations, developers contribute to creating a more standardized and accessible Web.

In this way, *Task Complete* also underwent a validation using the Validator. The errors returned are described below.

We received, for example, a warning "*Trailing slash on void elements has no effect and interacts badly with unquoted attribute values*", which generally occurs when using a slash (/) at the end of a void element tag, such as <img>,
, <hr>, or <input>. These elements have no content and do not need a closing tag or trailing slash.

This error was fixed in the code after inspecting whether there were more void element tags with a slash at the end and removing the unnecessary slash or closing tag.

We received the error "*Bad value image for attribute type on element link: Subtype missing*" generally occurs when there is a problem with the declaration of a link (<link>) in the <head> section of your HTML document, particularly in the type attribute. The type attribute indicates the media type of the linked resource.

Analyzing the HTML code where the error occurs verified that the ¡link¿ tag was being used correctly and that the type attribute's value was appropriate for the component

that was trying to be linked.

The errors found by the Validator tool were all handled, and none of them were accessibility-related; they were all bad coding errors.

The evaluations carried out at this stage were supported by tools and carried out by the development team itself. Now, with approval from the ethics committee (protocol number 76853723.3.0000.5504), empirical tests are being planned to be carried out with target users from the partner institution to evaluate the effectiveness of the solution and the emotions aroused by its use.

4. Accessibility Discussion

Creating and evaluating a gamified solution for people with intellectual disabilities represents a valuable contribution to society in several aspects. By incorporating accessibility features, the solution not only entertains but also promotes digital inclusion, providing equal opportunities for participation.

This project aimed not only to entertain but also to enable essential skills, such as organization, time management, and completion of tasks, fundamental for autonomy and active participation in society, to be exercised. People with intellectual disabilities often have difficulty adapting to routines, and this ends up having a detrimental effect on their lives. In this way, "Task Complete" allows these people to exercise consistent and structured routines once they can continue to be motivated by gamification.

By highlighting the importance of accessibility, the project promotes awareness of the needs of people with intellectual disabilities, cultivating a culture of empathy and inclusion in society.

The evaluations carried out in the project include a set of metrics highlighting the commitment to ensuring accessibility and usability for the project, with a particular focus on tests related to the WCAG guidelines.

These evaluations lead to compliance with specific standards and guidelines and promote a more inclusive user experience. By focusing on aspects such as contrast, font size, and readability, the project meets regulatory expectations and provides a digital experience that respects and accommodates the diversity of user needs. This approach benefits people with intellectual disabilities and contributes to creating a more inclusive and aware digital environment.

By providing details about methodological tests and accessibility practices, this work can be a reference for other developers seeking to create inclusive applications. Thus, the initiative can potentially not only positively impact the lives of people with intellectual disabilities but also contribute to a more accessible, egalitarian, and aware digital environment for society's diverse needs.

This is an especially important discussion in the context of games and gamified solutions, as this industry is still seeking alternatives to offer more accessible solutions.

5. Final Remarks

Throughout the development process of the accessible gamified solution, essential aspects were addressed that aim to provide an inclusive and engaging experience for

different users' profiles. Based on literature research, requirements collection guided the creation of representative personas. The prototyping carried out allowed us to visualize and improve the application's design, considering aspects such as colors, format, and arrangement of elements on the screen.

The implementation of Front-End, using technologies such as *React.js*, was guided by the search for efficiency, performance, and usability. The modular structure and coherent code organization in *Visual Studio Code* reflected the concern with the system's maintainability. Integrated into the development process, unit tests provided the quality and stability of the Front-End.

Concerning the Back-End, the choice of *RESTful* architecture, supported by *Spring Boot* and *PostgreSQL*, provided a robust solution for creating scalable Web services once the group aims to create new functionalities for this solution.

Regarding the evaluation stage, models were applied, including the PENS model, emphasizing competence, autonomy, relationships, and intuitive controls. These elements were integrated to optimize player satisfaction, balance challenges and skills, promote freedom of decision, foster emotional connections, and ensure an intuitive interface.

Additionally, the project adopted WCAG guidelines to improve accessibility, implementing alternative descriptions of non-textual content and guarantees of adequate contrast. Tests with the *Color Contrast Analyzer* tool confirmed compliance with WCAG AA and AAA levels, highlighting the project's commitment to accessibility and visual quality. The evaluation covered technical aspects and user experience, aiming to provide an engaging and accessible experience for different audiences.

In short, the accessible gamified solution "Task Complete" represents a joint effort to overcome barriers and offer entertainment and utility to an often neglected audience. The focus on accessibility, combined with the application of good technologies, provides the project with a significant contribution to promoting digital inclusion. Continuous development and seeking feedback from the community are essential to the constant evolution of this accessible application.

Ongoing activities include planning a longitudinal case study, which will be conducted together with education professionals from the partner institution. In this study, five people assisted by the institution will be monitored for a month, using Task Complete, to exercise activities of daily living and content from the mathematics discipline (treatment group). When the solution is used, professionals will monitor the performance of those assisted. In the end, players will answer the Game Experience Questionnaire [Poels et al. 2007, IJsselsteijn et al. 2013], and Game Engagement Questionnaire [Brockmyer et al. 2009].

In parallel, another group of five people assisted (control group) will have the same skills being worked on using methodologies already used by the institution's professionals. At the end of the observation time, the professionals will evaluate the performance of those assisted in both groups to compare methodologies and analyze the proposed solution's effectiveness.

With the observation of professionals, the collection of system interaction logs, and the evaluation of the experience and engagement using the questionnaires, the aim is

to empirically evaluate whether the gamified solution helped the group studied acquire skills related to daily routine and positive habits, as well as skills in the content of associated disciplines

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