Theoretical model and playful practice: a pathway to digital accessibility

Modelo teórico e prática lúdica: um caminho para a acessibilidade digital

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gamification, inclusive design, education

Digital accessibility has often been reduced to merely larger buttons or high-contrast texts; however, it must be approached as a complex cycle involving perceptions, emotions, and values. In this context, technology should serve as a bridge to digital inclusion rather than a barrier. This article examines how a theoretical model for inclusion and digital accessibility can be transformed into an interactive game experience, while also exploring how theory can be gamified to promote inclusive education. Based on a multidimensional theoretical model – which integrates accessibility, usability, functionality, emotion, and value – we discuss the creation of the analog game *Jornada da Acessibilidade* (Accessibility Journey). Beyond its pedagogical function, the game symbolizes the continuous efforts toward building inclusive digital environments by encouraging user participation in simulations that mirror practical challenges. Preliminary results reveal the potential of gamification in fostering empathy and highlight the necessity to address disabilities beyond the visual and auditory realms. This work serves as an invitation to reconceptualize accessibility as a commitment to human diversity rather than merely a technical requirement.

gamificação, design inclusivo, educação

A acessibilidade digital tem sido frequentemente reduzida a botões maiores ou textos em alto contraste; no entanto, deve ser compreendida como um ciclo complexo que envolve percepções, emoções e valores. Nesse contexto, a tecnologia deve atuar como uma ponte para a inclusão digital, e não como uma barreira. Este artigo examina como um modelo teórico de inclusão e acessibilidade digital pode ser transformado em uma experiência de jogo interativo, explorando também como a teoria pode ser gamificada para promover a educação inclusiva. Com base em um modelo teórico multidimensional – que integra acessibilidade, usabilidade, funcionalidade, emoção e valor –, discute-se a criação do jogo analógico Jornada da Acessibilidade. Além de sua função pedagógica, o jogo simboliza os esforços contínuos para a construção de ambientes digitais inclusivos, ao incentivar a participação dos usuários em simulações que refletem desafios práticos. Resultados preliminares revelam o potencial da gamificação na promoção da empatia e destacam a necessidade de abordar as deficiências para além dos âmbitos visual e auditivo. Este trabalho se apresenta como um convite para reconceituar a acessibilidade como um compromisso com a diversidade humana, e não apenas como um requisito técnico.

1 Introduction

In a scenario where the digitization of education emerges as the great promise for equitable access to knowledge, challenges persist that extend far beyond mere technical shortcomings of digital interfaces. Millions of people – especially those with visual, auditory, and other disabilities – continue to face barriers that compromise their fundamental right to education. Videos without subtitles, websites incompatible with screen readers, and interfaces that disregard the human experience are not simply design flaws; they are obstacles that reveal systemic exclusion and a disregard for diversity, a phenomenon termed "digital ableism" (Goggin & Newell, 2003).

The issue is exacerbated by the fact that, although normative advancements such as the Web Content Accessibility Guidelines (WCAG) exist, their practical implementation is often reduced to a series of technical checks. This focus, by prioritizing the measurable aspects of accessibility, ignores the experiential, emotional, and human dimensions of interacting with the digital environment. It is as if the true meaning of inclusion is overshadowed by an approach that treats accessibility merely as a checklist, at the expense of its real impact on users' lives.

In light of this panorama, this article presents an integrative approach that seeks to convert the theoretical principles of digital accessibility into concrete, transformative actions through gamification. Inspired by a perspective that unites inclusive design, knowledge management, and playful practices, this study introduces the Accessibility Journey – an analog game conceived to transcend traditional technical instruction and promote emotional and reflective engagement. By simulating digital barriers, the game invites participants to symbolically experience the challenges faced by people with disabilities, thereby fostering empathy and encouraging the proposal of inclusive solutions.

The theoretical foundation underlying this proposal rests on a multidimensional model that integrates the dimensions of accessibility, usability, functionality, emotion, and value (Binda, 2023). This approach posits that digital inclusion is not limited to adherence to technical standards but requires a holistic understanding of the user experience. Drawing inspiration from both classical and contemporary studies – from reflections on human-centered design (Norman, 2013) to Nonaka and Takeuchi's knowledge creation spiral – the model advocates for the integration of explicit knowledge (such as formal guidelines) with tacit knowledge derived from users' experiences and perceptions.

In this context, gamification emerges as a pedagogical strategy. By transforming abstract concepts into playful and interactive challenges, the Accessibility Journey enables students, professionals, and interested individuals to engage practically with the dilemmas of digital accessibility. This experience facilitates the understanding of existing barriers, stimulates creativity, and promotes collaboration in developing solutions that consider the diversity of human experiences.

Furthermore, the article emphasizes the importance of knowledge management beyond the mere collection and dissemination of technical

data. The creation of inclusive digital environments demands a continuous process of socialization, externalization, combination, and internalization of knowledge (Nonaka & Takeuchi, 1995), allowing for the constant updating of practices and the incorporation of new perspectives. It is through this dynamic that a foundation for innovation is built, where the interplay between theory and practice becomes a driving force for transforming educational and technological spaces.

This work, therefore, invites critical reflection on the role of design and technology in promoting an inclusive society. By placing the user at the center of the creative process and valuing both technical standards and subjective experiences, the proposal presented here reaffirms that digital accessibility is, above all, a social issue. The Accessibility Journey symbolizes this commitment, demonstrating that gamification can be the bridge that unites academic rigor with human sensitivity, making digital inclusion a tangible and transformative reality.

2 The digital inclusion model: a spiral of transformation

Human-computer interaction (HCI) does not emerge from a technological vacuum but from an anthropocentric imperative: the social demand for access to digital products and services. As Norman (2013) posits in The Design of Everyday Things, usability is a dialectical construction between human desire and systemic response. In this scenario, designing interfaces transcends mere functionality; it requires encoding experiences that harmonize technical efficiency with psychosocial well-being.

Interactivity, far from being a neutral phenomenon, operates as a cultural mediator. Its core lies in observing behavioral affordances (Gibson, 1979) – gestures, clicks, touches – that translate into computational instructions. However, reducing this dynamic to a mechanical input-output process ignores its affective dimension. Successful interfaces, as demonstrated by Saffer (2005) and the principles of emotional design, orchestrate sensory elements (colors, micro interactions, tactile feedback) to engage users in cycles of motivational feedback.

Accessibility, in turn, is an ethical barometer for HCI. Data from the World Wide Web Consortium (W3C, 2023) reveal that 98% of global websites fail to meet WCAG 2.1 standards, perpetuating what Goggin and Newell (2003) refer to as digital ableism – the systemic exclusion of users with accessibility needs. The inclusion of subtitles, Brazilian Sign Language interpreters, or compatibility with screen readers is not mere "good practice" but a historical redress within an ecosystem marked by the dominance of abled design.

The standardization of interfaces, although useful for scalability, often succumbs to the tyranny of the statistical average. As Hamraie (2017) warns in Building Access, the fetishization of the "average user" renders dissonant bodies invisible. Inclusive designs require radical epistemologies: replacing accessibility checklists with co-design involving marginalized communities, as advocated by disability studies.

Ergonomic criteria, heirs to Card et al.'s (1983) cognitivist tradition, remain pillars, yet their application demands critical updating. Choosing a color palette is not merely about legibility; it is a political act that resonates with issues of neurodiversity (e.g., autistic visual sensitivity). Similarly, multimodality (voice, gestures, gaze tracking) must avoid technological determinism, prioritizing situated ecologies of use (Suchman, 1987).

Thus, 21st-century HCI faces a dual challenge: overcoming the utilitarian reductionism that dominates interface design and embracing digital activism as a design methodology. After all, as evidenced by 20 years of stagnation in inclusion metrics (United Nations Development Programme, 2022), without cognitive reparation there is no active innovation – only replicas of the same exclusionary code, creating products exclusively for certain user profiles while excluding others.

It is in this context that Binda's (2023) digital inclusion and accessibility model seeks to offer alternatives for creating and evaluating accessible digital resources, as illustrated in Figure 1. Unlike technical approaches, this model considers the user experience in a holistic manner, including the emotional and psychological aspects that impact interaction with digital resources. The model is structured as a spiral, symbolizing the interconnection among its dimensions and the continuous evolution of digital accessibility.

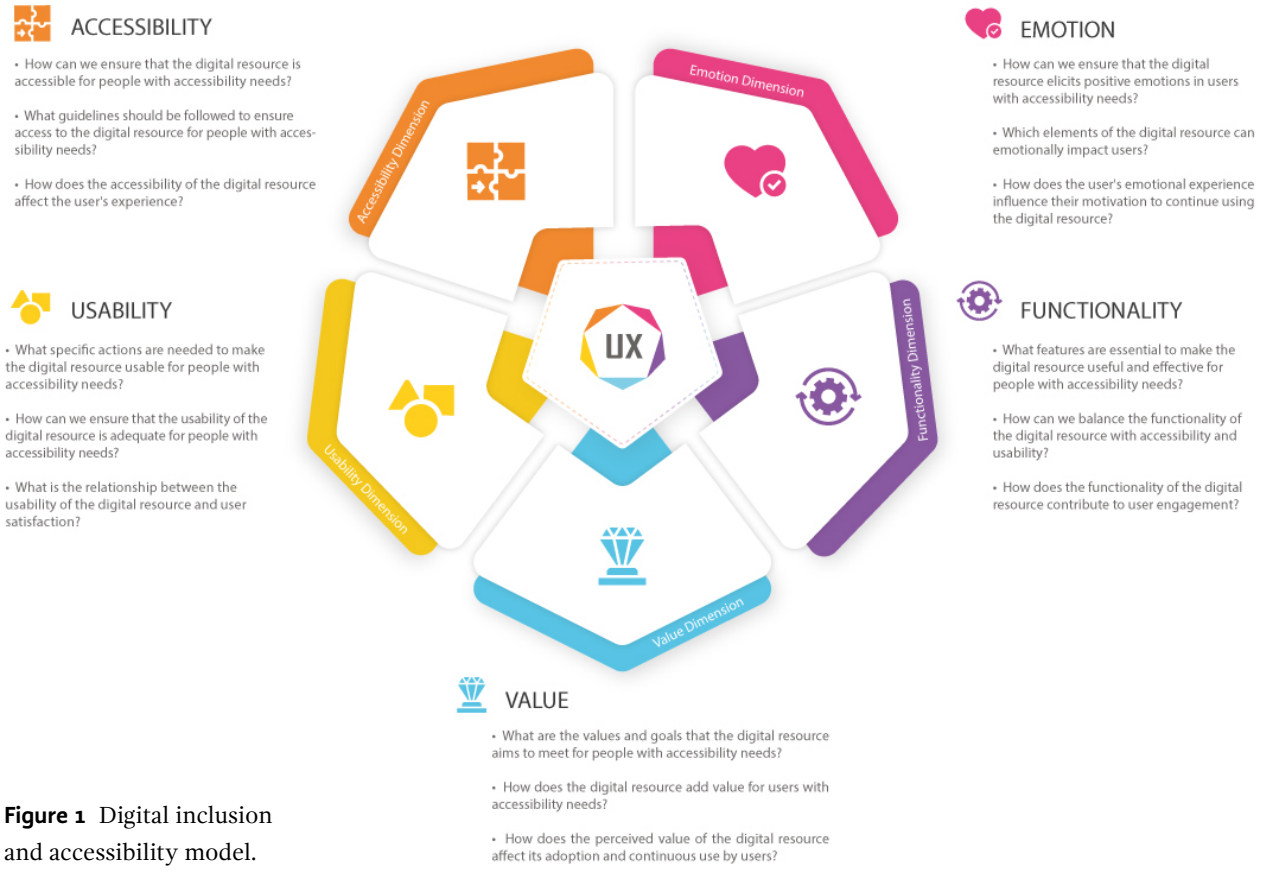

Figure 1 Digital inclusion and accessibility model.

2.1 Dimensions of the conceptual model

The Binda (2023) model is composed of five dimensions, as shown in Table 1, and has three main characteristics. The first is its multidimensionality: it is not limited to technical accessibility but also encompasses usability, functionality, emotion, and value to ensure that the user experience is complete and satisfactory. The second is its focus on the user experience, incorporating emotional and psychological factors to understand how the interface affects users' perception, motivation, and engagement – differentiating it from models that treat accessibility merely as a technical requirement. The third characteristic is its cyclical and iterative structure, designed as an ascending spiral to symbolize that each interaction with technology is an opportunity for evolution. This approach allows for continuous improvements and ensures that the accessibility guidelines within the model evolve as new technologies and user needs are identified.

Table 1 Dimensions of the conceptual model.

Dimension	Description	Essence
Accessibility	Refers to ensuring that digital resources are perceivable, operable, understandable, and robust. This includes aspects such as compatibility with assistive technologies, alternative descriptions for visual content, and captions for videos.	"Can I perceive and operate this resource?"
Usability	Relates to the ease of use and efficiency of the interface. It encompasses aspects such as intuitive navigation, clear organization of information, and adaptability for different devices and user profiles.	"Can I navigate without getting lost?"
Functionality	Examines whether digital resources provide the necessary tools to meet the specific needs of users with disabilities, offering engagement and autonomy in their use.	"Can I accomplish this task?"
Emotion	Considers the emotional response of users when interacting with the digital resource, highlighting the importance of design in generating positive and satisfactory experiences while avoiding unnecessary frustration and difficulties.	"How do I feel using this?"
Value	Pertains to the perceived relevance and meaning that users attribute to the digital resource. Accessible resources should be seen as elements that add value and promote inclusion.	"Does this make a difference in my life?"

2.2 Spiral structure and knowledge management

The structure of the model is represented by a spiral, as illustrated in Figure 2, symbolizing the interconnection among these dimensions as well as the continuous evolution of digital accessibility. The spiral reflects the dynamic nature of the user experience, where each interaction with a digital resource can influence the perception and improvement of accessibility. This representation helps to understand the complexity of the user experience and demonstrates that the various aspects of accessibility are not isolated but rather interdependent.

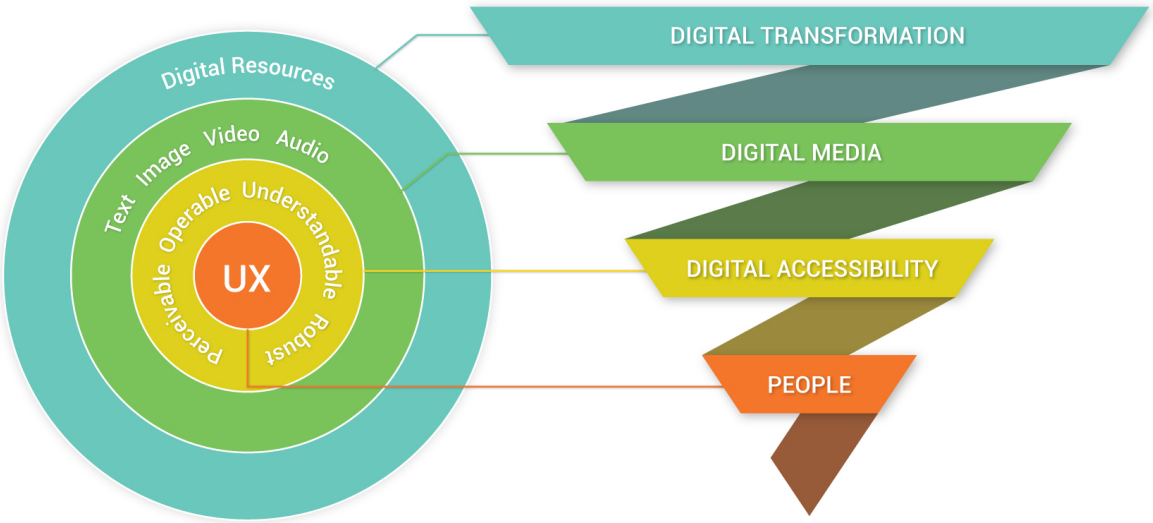

Figure 2 Spiral structure of the digital inclusion and accessibility model.

Furthermore, the model emphasizes the importance of knowledge management in digital accessibility to promote a continuous cycle of improvement and updating of adopted practices. The knowledge spiral integrates and continuously updates digital inclusion practices for people with visual or auditory impairments by combining tacit knowledge (individual experiences and skills) with explicit knowledge (formal guidelines and directives). This process involves four key stages (Nonaka & Takeuchi, 1995):

- **Socialization**: interaction and observation, where tacit knowledge is shared through direct experience.
- **Externalization**: detailed documentation of practices, converting tacit knowledge into explicit forms.
- **Combination**: integration with other fields such as design and user experience, systematizing explicit knowledge.
- **Internalization**: practical application and professional training, converting explicit knowledge back into tacit understanding.

This spiral foster constant evolution and adaptation of solutions to meet user needs. For instance, in the context of digital accessibility, socialization occurs when designers observe users with disabilities interacting with prototypes; externalization happens when these observations are documented as guidelines; combination takes place when these guidelines are integrated with design principles; and internalization occurs when designers apply these principles in new projects.

This model has been evaluated by experts, who highlighted its applicability in the creation and assessment of accessible digital resources. Based on this structure, the Accessibility Journey game was designed to allow players to explore each of these dimensions in practice, identify challenges, and propose inclusive solutions for different usage scenarios.

3 From theory to practice: the journey begins on the board

The development of the Accessibility Journey game followed a structured process based on the Design Science Research (DSR) approach (Dresch et al., 2015), aimed at constructing an artifact to solve a specific problem within a given context. DSR is particularly suited for this study as it focuses on creating and evaluating innovative artifacts intended to solve identified problems. The process was divided into three main phases: problematization, construction, and evaluation.

3.1 Problematization phase

The first step involved identifying the problem: the limitation of digital accessibility practices to technical compliance, neglecting human and emotional dimensions. This phase included a literature review on digital accessibility, inclusive design, and gamification, as well as an analysis of existing tools and methods for accessibility education. The problem was framed as: "How can a theoretical model of digital accessibility be transformed into an engaging, practical experience that promotes empathy and inclusive solutions?"

3.2 Construction phase

The construction phase involved translating the dimensions of the theoretical model into game mechanics. Each dimension was represented by cards containing challenges, instructions, and criteria related to accessibility for an inclusive experience. The process included:

- **Translation of dimensions**: accessibility, usability, functionality, emotion, and value were converted into game elements (the guidelines and directives for accessibility were transformed into cards, the guiding questions of the dimensions into challenge cards, and spaces on the board).
- **Board design**: the game board was designed around the user journey when interacting with an digital resource. Key stages – discovery, access, navigation, usage, and feedback – were identified and became central elements of the game.
- **Prototype development**: an initial prototype was developed, incorporating the mechanics and components.

3.3 Evaluation phase

The evaluation phase involved iterative testing with participants to refine the game. This phase included:

1. **Participants**: 15 graduate students from the Engineering and Knowledge Management program at UFSC, aged between 25 and 40, with varying levels of familiarity with digital accessibility, as shown in Figure 3. Additionally, 5 digital accessibility experts were consulted.

Figure 3 Graduate students testing the game's dynamics.

2. **Instruments**:

- Observation protocols to record player interactions and difficulties.
- Post-game questionnaires with open-ended and Likert-scale questions to assess learning outcomes and engagement.
- Focus group sessions to gather qualitative feedback.

3. **Procedure**:

- Participants were introduced to the theoretical model.
- They played the game in groups of 3–4.
- After the game, they completed questionnaires and participated in focus groups.

4. **Iterative refinement**: feedback from each test cycle was used to adjust rules, improve clarity of instructions, and enhance the overall player experience.

The game also participated in the SINOVA UFSC Game Factory Program (SINOVA, 2024) where contributions from game designers and educators further refined its gameplay. These enhancements aimed to make the game more engaging and effective as an educational tool, as shown in Figure 4.

Figure 4 Accessibility journey analog game.

4 Development: gamification of the model

The gamification of the theoretical model's dimensions was achieved by translating abstract concepts into interactive and playful elements within the **Accessibility** Journey game. The process began with the Accessibility dimension, represented by cards that incorporate practical guidelines – such as including subtitles in videos or ensuring appropriate color contrast. These cards are used in challenges that simulate real-life situations, like adapting a digital resource for a persona with visual impairment, while a special die directs players toward specific actions related to this dimension, reinforcing the application of technical standards like the WCAG (see Figure 5).

Figure 5 Guidance cards.

Regarding **Usability**, the game simulates a user's journey in a digital environment through a modular board that includes stages such as "Access" and "Navigation." Usability errors – like confusing interfaces – result in penalties, whereas correct decisions, such as simplifying navigation, are rewarded with points. Complementary guidance cards offer recommendations on ensuring compatibility with assistive technologies, among other aspects, thereby reinforcing the importance of efficiency and clarity in interacting with digital resources (see Figure 6).

Figure 6 User journey.

Functionality was gamified using challenge cards that require creative solutions, (see Figure 7), such as developing multimodal resources or adapting content for users with accessibility needs. This approach highlights the need for digital resources to be flexible and adaptable to the specific requirements of users.

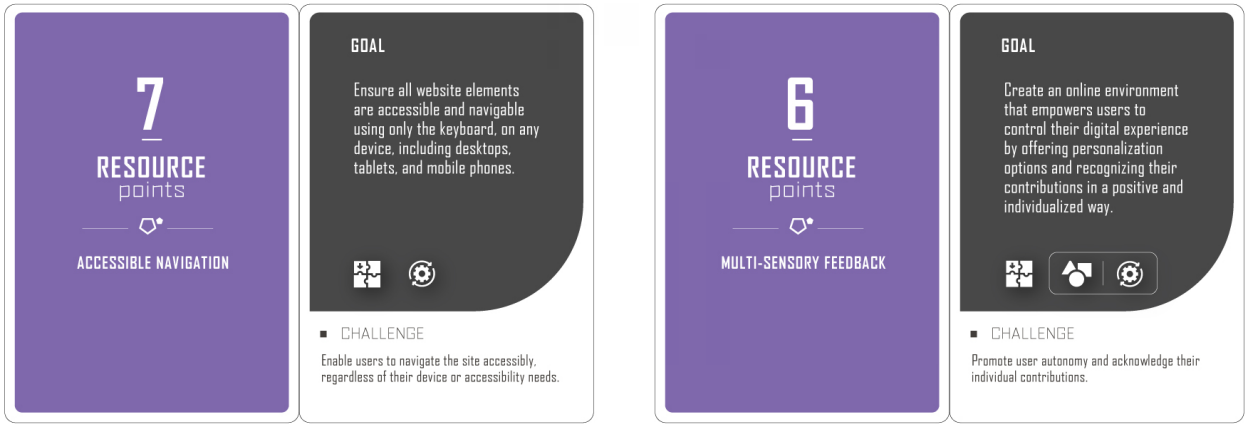

Figure 7 Challenge cards.

The **Emotion** dimension is represented by personas based on real cases, such as "Lucas, a blind user who relies on a screen reader" (see Figure 8). These personas contextualize the challenges and foster empathy by simulating emotional situations, like the frustration experienced when facing access barriers. A reward system values decision that promote satisfaction and inclusion, effectively linking technical aspects with the users' emotional responses.

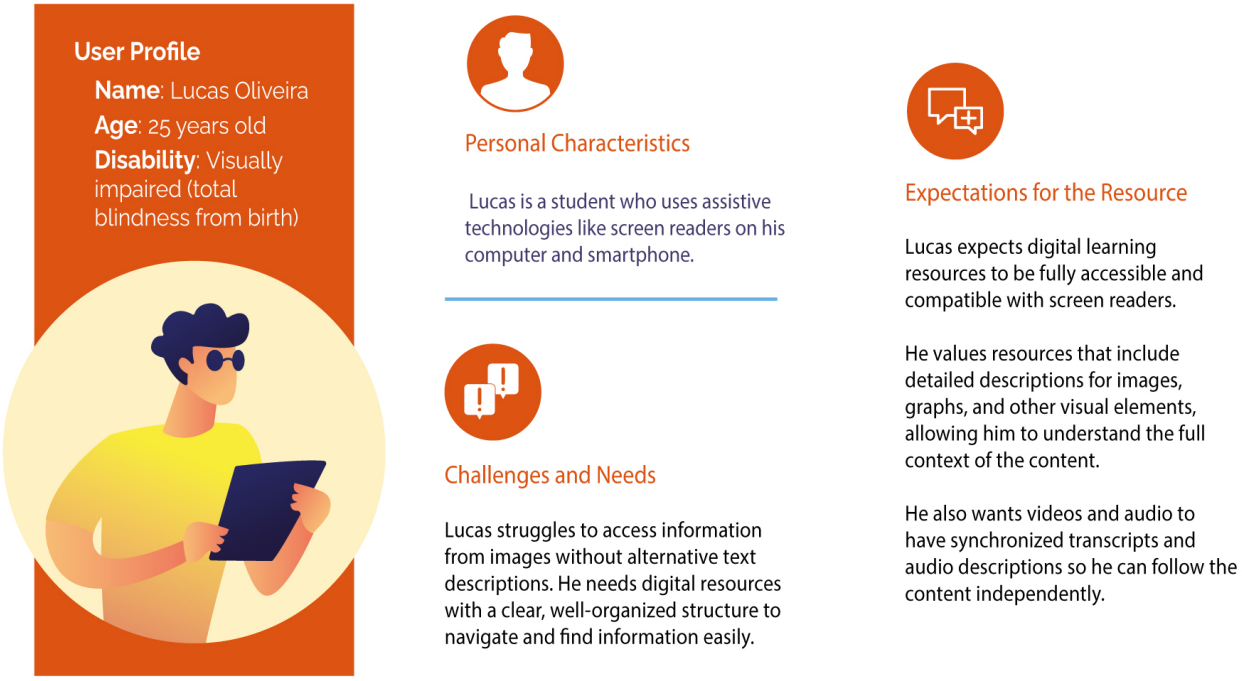

Figure 8 Personas.

Finally, **Value** is incorporated into the strategic scoring system, which reflects the social impact of the players' actions. For instance, solutions that benefit a larger number of users earn more points, while collective objectives – such as democratizing access to a resource – require collaboration among participants. Cards with messages like "Promote equal opportunities" reinforce the role of accessibility in building an inclusive digital environment.

Additional elements, such as the board that maps the user journey and the multidimensional dice – whose faces direct focus to different dimensions – ensure that the experience remains balanced and educational (see Figure 9). Participation in workshops organized by the SINOVA UFSC Game Factory Program (SINOVA, 2024) allowed for iterative refinements and ensured that the mechanics were intuitive and aligned with the educational objectives.

By transforming theory into practice, the game facilitates the learning of complex concepts and engages participants through both competition and collaboration. The humanization of personas and the immersive narrative generate empathy, while the implementation of solutions in simulated contexts prepares players to apply accessibility in real projects. This approach demonstrates how gamification can bridge academic rigor and social transformation, making digital inclusion a tangible and engaging experience.

Figure 9 Board and multidimensional dice.

5 Results and discussion

5.1 Results

Initial tests conducted with graduate students (n = 15) and experts (n = 5) indicated that the game was effective in raising awareness about digital barriers, encouraging collaboration to find inclusive solutions, and transforming technical concepts into practical actions. The results are summarized in Table 2, below:

Table 2 Test observations.

Observation	Description
Increased awareness	Players reported a heightened sensitivity to previously invisible barriers.
Creative collaboration	The need to solve challenges as a team mirrored the multidisciplinary reality of inclusive design.
Revealing limitations	The focus on visual/auditory disabilities highlighted the necessity to include other conditions, such as motor or cognitive.
An interesting finding	The complexity of the rules, initially seen as an obstacle, became a metaphor for accessibility itself – a system that requires patience and continuous adjustments.

However, some limitations and challenges were observed:

- **Scope limitation**: the game primarily focused on visual and auditory impairments, not comprehensively addressing other disabilities such as motor or cognitive challenges.
- **Validation gap**: the empirical validation of the game still requires testing with diverse audiences to measure its long-term effectiveness.
- **Complexity issues**: some players reported difficulties in balancing strategy with the learning process, suggesting the need for adjustments to make the experience more accessible and fluid.

5.2 Discussion

The results demonstrate the potential of gamification as a tool for promoting digital accessibility education. The game successfully translated the model's principles into interactive experiences. For example, the **Accessibility** dimension was reflected in cards that required solutions to perceptual and operational barriers in digital interfaces. **Usability** was explored when players had to choose between different approaches to make a digital resource more intuitive. **Functionality** was addressed by considering how resources can meet the needs of users with disabilities. **Emotion** was represented through players' interactions with personas based on real experiences, while the **Value** dimension emerged from the perceived relevance of the proposed solutions.

The qualitative feedback from participants highlights the game's ability to foster empathy and collaboration. For instance, one student stated: "Playing as Joana made me understand the emotional impact of inaccessible design." This aligns with the model's emphasis on the emotional dimension of accessibility.

However, the identified limitations reveal areas for improvement. The focus on visual and auditory impairments reflects a common gap in accessibility practices, which often prioritize these disabilities over others (e.g., cognitive or motor). Future iterations of the game should expand

to include a broader range of disabilities to truly embody the model's holistic approach.

The complexity issues reported by some players point to a design challenge: balancing educational content with engaging gameplay. This mirrors the broader challenge in accessibility design – balancing technical requirements with user experience. As one participant noted, "The game itself needs to be accessible to teach accessibility."

These findings suggest that gamification, when aligned with theoretical frameworks, can serve as an epistemological tool, catalyzing paradigm shifts in how accessibility is perceived and taught. The game does more than simply transmit knowledge; it actively deconstructs exclusionary practices and replaces them with co-creative processes. In this sense, the Accessibility Journey transcends its playful function, becoming an instrument for institutional change – a space where inclusion transforms from a normative requirement into a collective ethical commitment.

6 Conclusion

The integration of Inclusive Design and Knowledge Management, based on Binda's (2023) model, has proven effective in translating theoretical principles into practical interventions through gamification. The Accessibility Journey game has established itself as a pedagogical artifact capable of operationalizing technical guidelines – such as the WCAG (W3C, 2024) – while humanizing the discussion around digital inclusion. Anchored in challenges derived from real-life situations experienced by people with visual or auditory impairments, the game demonstrates that accessibility goes beyond technical checklists; it requires critical empathy and an understanding of the nuances in human-technology interactions.

Inclusive Design, as the structural backbone, ensures that the game embraces the diversity of experiences as a driving force for innovation – moving beyond mere replication of norms. This alignment reflects the Inclusive Design principle of "solving for one, extending to many," wherein solutions crafted for specific needs reveal scalable potential. For instance, the collaborative challenge mechanics, which demand the integration of technical and subjective perspectives, illustrate how inclusion is built at the intersection of functionality and human sensitivity.

In parallel, Knowledge Management – drawing inspiration from the knowledge creation spiral (Nonaka & Takeuchi, 1995) – structures continuous learning cycles. During gameplay, explicit knowledge (such as accessibility protocols) is challenged by tacit insights – like the spatial expertise of users with visual impairments or the interpretation of non-verbal cues by deaf individuals. This dynamic not only validates existing guidelines but also subjects them to the test of lived experience, generating hybrid solutions that defy conventional boundaries.

Preliminary tests with students, experts, and professionals confirmed the dual impact of the approach: (1) an enhancement of technical competence, with a deep understanding of standards like the WCAG; and (2) critical

awareness, evidenced by participants' recognition of the inadequacy of supposedly "accessible" resources when viewed from non-hegemonic perspectives. These results reinforce the premise that digital exclusion is as much a technical problem as it is a sociocultural phenomenon, rooted in design biases.

The identified gap – the need to incorporate challenges related to motor and cognitive disabilities – underscores the urgency of broadening the game's scope to ensure that the representation of human diversity is comprehensive rather than fragmented. This limitation reflects a broader challenge in the field of accessibility, where certain disabilities are often prioritized over others.

The experience demonstrates that gamification, when aligned with theoretical frameworks, can serve as an epistemological tool, catalyzing paradigm shifts in how accessibility is taught and practiced. The game does more than simply transmit knowledge; it actively deconstructs exclusionary practices and replaces them with co-creative processes. In this sense, the Accessibility Journey transcends its playful function, becoming an instrument for institutional change – a space where inclusion transforms from a normative requirement into a collective ethical commitment.

This study, by synthesizing Inclusive Design, Knowledge Management, and gamification, validates a model applicable in both educational and corporate settings and outlines a methodological path for future research: the creation of educational technologies that integrate technical rigor, dynamic knowledge management, and active listening to marginalized communities. Ultimately, achieving inclusion – as a goal to be reached – demands a continuous process of learning, revision, and action, a challenge that calls for both precise tools and the courage to confront the invisible hierarchies that perpetuate exclusion.

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