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Accessible Learning Management System (LMS) for Disabled People: Project Development Based on Accessibility Guidelines, Gamification, and Design Thinking Strategies

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Abstract

We live in a time of expansion and popularization of the processes of acquisition, retention, and sharing of knowledge in virtual media. Platforms geared towards digital learning now play a fundamental role in mediating knowledge processes. Many of them already use gamification with the use of game elements to increase engagement and stimulate the participants' immersion and flow status. But in addition to the development of dynamic platforms that enhance learning, it is essential that they are accessible to disabled people, allowing gamification resources and interactions between participants to be used by any audience, including people with visual and hearing disabilities. From this premise, this research problematizes the need to think from the initial project on the accessibility tools of an LMS following the recommendations prepared by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C), IMS GLC - Accessibility Guidelines (IMS GLC-ACC) and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA). In addition to studies for the development of accessible LMS, this research also presents the use of gamification strategies and design thinking in the development process, also using the method called Design Science Research to define the steps, thus seeking to promote engagement and immersion of the team, stimulating practical experiences with the gamification process. For the result, the proposal for the development of accessible LMS based on gamification and design thinking strategies is presented, with explicit use in the phases of empathy, definition, and ideation.

Keywords: Accessibility, Learning Management System (LMS), Gamification, ICT Awareness, Stakeholders Engagement

1. Introduction

Technological advances in the areas of computing, software development, internet, internet of things, cloud computing, and several other areas that encompass the New Information and Communication Technologies (ICT) brought changes in work routines, education, and even in social relationships. The ICT concept refers mainly to processes and products related to knowledge stemming from electronics, microelectronics, and telecommunications. These technologies are characterized by being evolutionary - that is to say, they are in permanent transformation. According to [1, 2], the Information Society or Knowledge Society is a phenomenon in which different instances (social, political, cultural, educational) are mediated by technological means. This new articulation allowed the consolidation of several remote activities such as virtual work, online classes, virtual communities for the development of activities of various kinds, providing new forms of the process of generating, acquiring, retaining, and sharing knowledge, with the emergence of platforms dedicated to formal and informal teaching-learning processes in digital media. Some researchers still believe that the maturity and excellence of remote work and education processes has not yet been reached. The processes of knowledge acquisition and sharing in digital environments still present several barriers. [2] emphasizes that access to technology is not what guarantees access to the digital world, as it is necessary "to be in a position to actively participate in the collective intelligence processes that represent the main interest of cyberspace".

The concepts of digital literacy and media literacy are also relevant, as they are defined in this work as elements linked to the use of ICT that enable the construction and sharing of knowledge. As defined by Livingstone [3], the concept of media literacy is a set of basic and advanced skills relating individual skills to social practices, crossing the border between formal and informal knowledge. For [4], the literacy is conditioned to the process of access to information, its critical understanding, and the production of new knowledge from this process, since they consider that "the critical dimension of literacy is the basis to ensure that participants can not only act in a practice and build a meaning within it, but can transform and actively produce it in various ways". Thus, digital literacy is related to different competencies that allow network users to access information on multiplatform, to critically and strategically evaluate it, and to use it for different purposes, from the acquisition process to sharing said knowledge, thus reaching the objectives sought.

Starting from the ICTs, the concepts of digital and media literacy, and the processes of knowledge sharing in LMS, we enter into the contemporary proposals of the use of gamification for the development and consumption of teaching-learning platforms and contents. From this introduction, the chapter structure presents the methodology used, the gamification relationships with accessible LMS, the use of Design Thinking as a model for building the gamification process, the importance of developing accessible LMS, strategies for the development of accessible platforms from gamification and design thinking, and the conclusions and proposals of future works.

2. Methodology

The research methodology adopted was qualitative, with an exploratory and descriptive study approach. According to [5, 6], through the qualitative method, one seeks in the process of collecting, analyzing, and interpreting data, paradigms that can validate the observations and considerations regarding the research. [5] also points out that during the process, the researcher immerses themselves in

the environment in which the research is being developed to relate their object of research to the study environment, drawing the conclusions in relation to the initial proposal.

The bibliographic review was carried out in books, articles, journals, dissertations, and theses, and with research also supported in scientific databases. The themes cut out for this first filter were the search for works that brought approaches related to objects of learning, gamification, design thinking, and accessibility on the web.

Then, we sought to filter the results of the first research with the scope of developing education platforms, accessibility, and possible gamified approaches. As an exploratory study, we sought to use the collection of information and studies from the bibliographic review, identifying the possibilities of applying gamification and design thinking in the development of accessible LMS, aiming to list steps to develop an accessible LMS with gamified resources for visually and hearing-impaired people, and the proposal to use design thinking and also gamification for organizing the flow of production and development of LMS, exploring gamification with a focus on accessibility tools, stimulating their implementation since the beginning of the project. Combined with the exploratory and descriptive study, Design Science Research - DSR precepts were adopted. The method is based on Design Science and was chosen for bringing an iterative construction proposal according to the prototyping, construction, and product evaluation processes.

The Design Science methodology seeks a scientific or technological gain from a raised problem. Technological research points to the design of an artifact to solve the problem and/or contribute to the area through gains in the field of research. But in addition to building a product, model, artifact, method, instance, it is essential to advance the theory and that the knowledge produced is disseminated in academic bodies and in the area in question, so that it can spread the dissemination of the knowledge produced to researchers, scientists, professionals and/or users in the research area, in order to guide them in solving problems. The choice of DSR is justified because, according to [7] the method "underlies and operationalizes the conduct of research when the objective to be achieved is an object or prescription".

Under the DSR's precepts, the path outlined in the research used the following DSR steps:

- Problem identification;

- Awareness of the problem,

- Literature review;

- Identification of artifacts and configuration of problem classes;

- Proposition of artifacts to solve the problem.

As mentioned, the DSR methodological scope was not applied in full, as the following steps (artifact design and artifact development); evaluation of the artifact; clarification of learning) will be applied in future steps, as we present in this chapter the scope of the research project and artifact proposal.

The initial steps of the research are presented here due to their relevance to the particular discussions regarding the artifact, which according to [8], is the organization of the components of the internal environment to achieve objectives in a given external environment.

Figure 1 shows how the design of an artifact should consider the different layers of the artifact's development process:
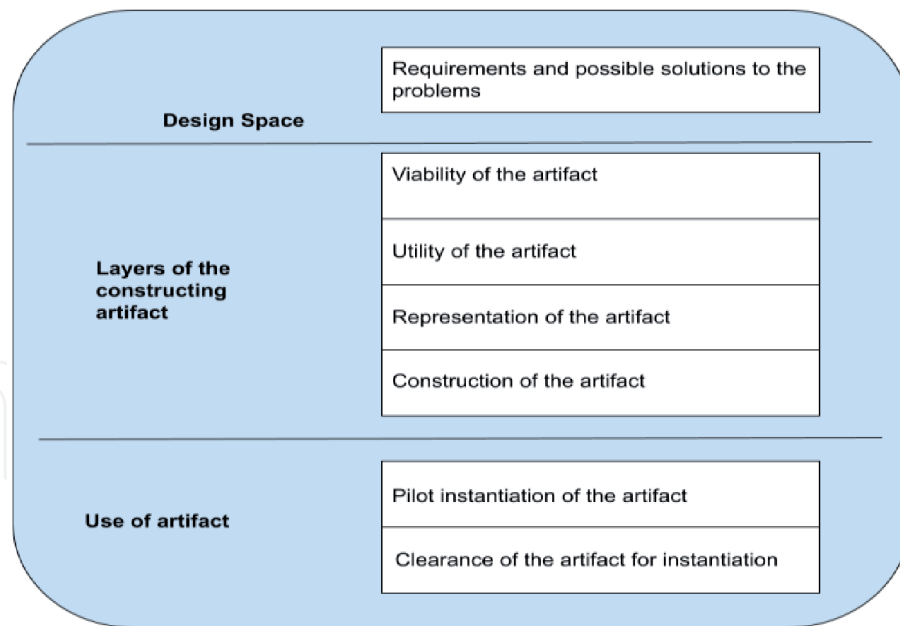
Figure 1.
Layers of the artifact development process: Adapted from [8].

Thus, artifacts are built to seek a solution in a given class of problems. According to [8], before starting the design or development of an artifact, it is necessary to consult what exists about this artifact in the scientific bases as well as its application in real environments. With this, it is possible to ensure greater assertiveness of the researcher when proposing the artifacts that can solve a given problem situation. Once a possible artifact solution is chosen, the researcher must take care of the development of the artifact itself. From the DSR, this research presents the DSR as a basis for the research, development and testing of the artifact, also associating the steps of design thinking with the method.

3. Gamification and accessible LMS

Gamification is presented in this research as a tool to enhance learning in accessible LMS, as well as to stimulate the development of accessibility tools by developers. For [9], the resource can help in the enrichment of educational experiences, as a way in which the student recognizes and responds through a differentiated use experience, very close to the experience he has in the simple act of playing. The term gamification was used for the first time in the early 2000s, but it was not noticed as something that deserved the attention of the industry. As of 2010, its use began to be observed in a series of conferences and events of great public in the world [10]. According to [9], the use of game design elements outside the context of games is called gamification. [11] see in gamification a possibility of creating "learning spaces mediated by challenge, pleasure, and entertainment". [12] defend the use of gamification in education, suggesting that the use of game mechanics in the learning process increases the commitment of users, making activities more attractive and captivating. Based on the authors, it is pointed out that in addition to the proven benefits to the target audience, also proposing that the development of software with game elements can bring benefits to the final product, as the developers are also experiencing the user experience process by following a gamified dynamic.

Gamification appears as a possibility of education in which the barriers of time and space can be broken with the use of appropriate technologies. However,

changes in the behavior of the subjects involved in the teaching and learning process are necessary so that demotivation does not occur and the main focus, which is education, is not lost. [13] present several characteristics and recommendations for the use of gamification in learning objects, among which we can mention the use of challenges, the possibility of teamwork, self-motivation, and the construction of social bonds. [14] bring other essential characteristics: the goal of the game, the well-defined rules, the feedback system, and voluntary participation.

For [15], gamification is formed by four principles - the basis, mechanics, esthetics, and thinking as in a game:

- the foundation of games is the creation of an environment or system in which people want to invest their cognition, time, and energy. Basically, it seeks to favor the engagement of individuals in abstract challenges defined by rules that have interactivity and feedbacks that result in quantifiable responses, culminating emotional reactions;

- mechanics are crucial blocks of rules used in the gamification process. Mechanics alone are not enough to transform a given experience into an engaged one, but they contribute to it;

- esthetics corresponds to the look and feel of experience, essential elements in the gamification process. It encompasses how the experience is esthetically perceived by the individual;

- thinking as in a game is the most important attribute in the gamification process - It corresponds to the idea and thought of converting a boring or monotonous task into a motivating activity, applying elements such as: competition, exploration, cooperation, and narrative. It becomes a virtual facts manager that promotes insights into real-world operations.

The development of platforms, LMS and other content flows related to knowledge has been increasingly developed through gamification. Among the justifications for its use, [16] points out that the challenges present in the games are invitations to the adventure of knowledge and to a dynamic learning experience within the work and education processes.

In relation to the learning mobilized in gamified LMS, for Piaget, errors mobilize learning because they allow reflection to solve problems. The immersion process of students within the LMS is enhanced by the gamification process and the experience can even articulate interactions and collective missions between students, providing the construction of knowledge shared through the Human Computer Interaction – HIC - process. This correlation indicates the associative potential of the gamification process with learning objects in classroom or distance education. The process uses an articulation of knowledge through an initial base, challenges to promote acquisition and sharing, missions that allow and enable learning from mistakes and the achievement of objectives, culminating in performance feedback and the advancement of levels, with benefits and prizes.

4. Design thinking as a model for building the gamification process

According to [17], "the evolution from *design* to *design thinking* is the story of the evolution of the creation of products to the analysis of the relationship between people and products and, finally, between people and people".

Analyzing the use of the Design Thinking approach to education and the gamification process, we can see the possibility of applying some of the concepts proposed by [18] such as empathy, prototyping, and design of experiences. In this perspective, the gamification process based on design thinking must work with the construction of a platform and its contents using steps like discovery, interpretation, ideation, experimentation, and evolution.

As [19] point out, this type of development must be collaborative and integrated, with group-oriented actions, collective participation in decision-making, self-regulating coordination, systemically organized thinking, and by building relationships through empathy.

Design thinking associated with gamification seeks to optimize products by matching human needs with available technical resources and considering the practical constraints of the projects. Thus, in the development of gamified platforms under the precepts of design thinking, the teacher and the team of developers carry out an intense investigation of how the platform and its contents meet the needs of students, as well as how to create added value for students who use it. To [20] the design thinking process is essentially centered on the human being who emphasizes observation, collaboration, rapid learning, visualization of ideas, rapid construction of prototypes, learning from failures, allowing a project to be validated more effectively and with public feedback.

This project model used in gamification in education contributes to the development of platforms closer to the needs of students, since, according to [21], agents are organized based on behaviors derived from mental models, focused on insights, observation and empathy, linked to other concepts of design thinking such as collaboration, creation, experimentation, and prototyping. From the initial ideas, one can use premises and hypotheses developed from the students' experiences, bringing to their content the insights; the "collaboration" process with the multidisciplinary team; the creation of prototypes in a simplistic and objective way, and experimentation of prototypes with students to collect feedback on inconsistencies and errors, redefining the product.

This process should always be guided by the student's needs, raised at the beginning of the project and the premises of knowledge construction through game strategies that, according to [22] mobilizes students to interact with the gamified environment receiving immediate feedback of their actions, being able to interpret their choices according to their goals. When they continuously repeat this cycle (action-feedback-interpretation) it allows players to gradually develop their cognitive abilities. Combined with design thinking, gamification allows developers and users to benefit from these processes, allowing LMS to be thought of since its development with triggers to stimulate immersion and the "Flow State", defined as "an activity carried out without the expectation of any future benefit, but simply because doing it is the reward itself" [22]. **Figure 2** shows the flow path:

The Theory of Flow by Csikszentmihalyi presents how some experiences can take its participant to a Flow state. Mihaly created the autotelic experience model, considered "a self-sufficient activity, carried out without the expectation of any future benefit, but simply because doing it is the reward itself" [22]. With the proposal to develop an accessible LMS with gamification we intend to promote this flow from A1 to A4, promoting students and developers of different profiles to rise from their challenges occurring according to their ability (A1). When starting the path, the Flow state is suggested, but this soon turns into boredom (A2), as the skills have already increased and no longer correspond to the initial challenge. But as soon as a new challenge is proposed, the feeling becomes anxiety (A3), since now the person intends to overcome this new challenge and reach the Flow state (A4) again.
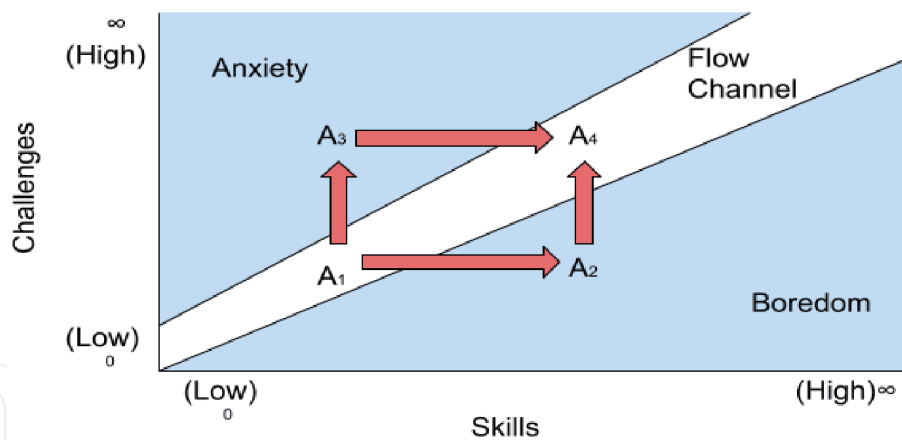
Figure 2.
Diagram showing the path for the flow state (source: Adapted from Csikszentmihalyi for authors, p. 74).

According to [23] the individual reaches their Flow state in two moments: A1 and A4, which are equally pleasant. What differs these times is the level of skill acquired, because upon reaching the full Flow state the individual realizes that his skill corresponds to the level of the challenge proposed, transforming motivation into stimulus.

In the article "Flow in games (and everything else)", [24] it is pointed out that Csikszentmihalyi's research and personal observations identified eight major components of Flow that can be associated with the gamification process: challenging activity requiring skill; a merging of action and awareness; clear goals; direct, immediate feedback; concentration on the task at hand; a sense of control; loss of self-consciousness; an altered sense of time. In addition to platforms that allow dynamic knowledge, that encourage and mobilize students to learn, exchange experiences, and share knowledge, it is also important to think about the experience of the different users who can use the platforms. In this context, in addition to the development of the platform and its contents and dynamics, the accessibility of disabled people must also be taken into account, following the accessibility guidelines from the beginning of the project to allow any user to have access to the available content.

5. The disabled person and accessibility feature in LMS

People with any type of disability have always lived on the margins of society for centuries. According to [23], the history of prejudice has always been present and many people have been placed on the margins of society because they have some type of disability. The search for inclusion begins to occur mainly in the post-1960s period, as a result of the struggle of organizations working to defend the rights of disabled people. Through innumerable guidelines, regulations and norms carried out, actions emerge that mobilize the path of social inclusion. In the search for rights, a very important motto for disabled people arises: "Nothing About Us Without Us". According to [25], the motto communicates the idea that no policy or decision regarding the rights of disabled people without the full and direct participation of the members of the group affected by this policy. The author also points out that in the words of the disabled person, there would be the understanding that "no matter how good the intentions of non-disabled people, public agencies, companies, social institutions or society in general, we no longer accept to receive results forged against us, even for our benefit."

Ref. [25] also points out that inclusion is necessary, as it cannot be seen as a utopia, but a possibility before the eyes against prejudices and masked forms of exclusion. It is not possible to think about inclusion without fighting the processes of exclusion inherent in life in society.

In this research, we propose the development of accessible environments based on the recommendations made by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C), IMS GLC - Accessibility Guidelines (IMS GLC-ACC) and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA) and [26] proposal, in which he proposed based on the web accessibility guidelines, on universal design and their possibilities to promote inclusion in Learning Objects accessible to people with visual impairments and people with hearing impairments. According to the researcher, to promote accessibility in digital content, varied media such as texts, audio, videos, animated images, static images, etc. should be used. The guidelines created provide recommendations for making media elements accessible by making alternative media available.

According to [26] alternative media are alternative content which function as an extension of equivalent content and are provided in different ways, but with the same ultimate learning objective. Alternative texts can be considered alternative texts; textual transcription of the video; extended audio description; audio description synchronized with the video; subtitles or captions for sounds; sign language interpretation for sounds. Equivalent media, on the other hand, are content identical to each other, but provided in a different mode, for example, a text available in the LMS and the same text associated with a file for printing in Braille.

But in addition to the recommendations of the W3C and GLC groups - categorization of menus and submenus and high-contrast, for example, the researcher also proposed as alternative media to ensure accessibility the use of resources that must be available to be activated in digital environments such as printing Braille text, audio description, sign language, subtitles for the deaf and people with hearing loss.

The general organization of the media and the alternatives required to ensure accessibility of the content must be thought of from the initial design of an LMS, promoting the native development of the environment to ensure accessibility. Using the proposed by [26], this research makes an initial cut for the development of accessibility in LMS for people with visual impairment and people with hearing impairment, presenting some peculiarities in the next items.

5.1 The person with sight loss

For educators, the concern with blindness focuses on the necessary and appropriate conditions for satisfactory development and learning. The moment in which blindness occurs is also important. For [27] "the person who is born blind, who establishes his object relations, structures his ego, and organizes all of his cognitive structure from hearing, touch, kinesthesia, smell, and taste, differs from someone who loses their vision after their development has already occurred". This distinction is made because the perceptions constructed by those who have had visual acuity are imagery.

The references of those who were born blind - or became blind until the age of 5 - are built and centered in other senses, having a different perception of the world in relation to those who have low vision or acquired blindness. Thus, this relationship with the imagery world is compromised but this does not mean the loss of their ability to understand. Researchers start to emphasize the disabled person as a social being in which, their marginalization in relation to the world deprives them of a development of the senses. [28] brought this reflection in relation to the

construction of identity, pointing out that blindness is not a defect, a lack, a weakness, but in some sense, it is also the origin of a new manifestation of skills, an additional, a strength - however strange and paradoxical that this idea may seem. The researcher starts to interpret the lack of a sense - the vision - as a means of linking a process of improvement of the other cognitions, in which they start to develop and refine the touch, smell, and hearing to compensate for the loss of vision. In relation to learning, [29] point out that the individuality of each person, in a more latent way for the visually impaired due to their lack or reduced vision, makes the learning processing mode also present specific characteristics, combining remaining sensory information for the mental construction of space. The researchers reinforce the value of language and the social experience it provides among people with sight loss and people with vision. Through language, the visually impaired individual is able to approach the culture and context of the person with vision.

Thus, it is essential that the materials available on the internet and in VLE have alternative media resources (such as text resources with larger sources or audio description, for example) to provide access and mediation to language and knowledge. As previously mentioned, the process of knowing and relating to the world goes through the process of language acquisition and mastery that can be of an oral, written, visual, and gestural nature, mediated by different cognitive senses.

5.2 The person with hearing loss

Hearing loss is expressed by the reduction or absence of the ability to perceive sounds. According to [30] it can be understood as a type of sensory deprivation whose common symptom is an abnormal reaction to the sound stimulus, expressing the hearing loss through deafness or low hearing. For [31], deafness is called the decrease in the capacity of normal perception of sounds, and is considered as being deaf the person whose hearing is not functional in ordinary life. Many people develop hearing problems throughout their lives, due to accidents or illness.

By having their capacity for sound perception reduced, the person with hearing loss has difficulty understanding the language used through orality - which has its expressive mark in the sound expression, in synchrony with the gestural. [32], define that it is through language that human beings establish communication with others around them, thus allowing the production of new knowledge. When sensory factors (such as hearing loss, for example) prevent oral language from being established, new forms of linguistic manifestation begin to emerge, such as visual and sign language, which allows the deaf person to have a new possibility of contact with the world, because the insertion of a deaf person in the digital environment faces the same challenges already experienced throughout their history. If, on the one hand, the standards established by WCAG 2.0 favor the accessibility of disabled people in the web environment, on the other hand, the question of language remains the obstacle that separates the deaf from their first language.

It can be seen that although there are different definitions and categorizations for hearing loss, it should be understood here that promoting accessibility on the web and VLE for people with any type of hearing loss, regardless of the language it expresses, is a step to reduce exclusion.

Another important point is the relationship of language built in these environments and their adaptations to promote accessibility. [33] point out that research related to didactic content for people with hearing loss in virtual environments points out the need to adapt short texts, reduce difficult vocabulary, use images to introduce a concept, use -when necessary- video with a Brazilian Sign Language interpreter, videos with sizes suitable for visualization of sign language and lip reading, adequate presentation speed, clear navigation.

When thinking about the precepts of web accessibility, we bring the concept of universal design, which, according to [34], is defined as a product, a physical environment or information, which must be accessed, understood, and used without the need for adaptation, modification or use of specialized solutions by anyone, regardless of their skills or disabilities. For an accessible LMS, the validation of the Universal Design concept only occurs when people with any type of disability or restrictions can have access to a product, physical environment or information.

Regarding the web, some sites are already looking to make adaptations for accessibility, but there is still much to be done. The WCAG guide and the W3C web "Accessibility Booklet" present the main idea contained in the Universal Design that the projected world should adapt as best as possible to all people, instead of requiring a great effort to adapt. However, most websites and LMS available on the Internet do not yet have accessible resources such as audio description, subtitles and sign language translation. Thus, the use of Universal Design means a big step towards an increasingly more inclusive world, which adapts to the different skills and needs of people, with less individual adaptive effort.

6. Strategies for developing accessible platforms from gamification and design thinking

For the development of accessible education and learning platforms, let us start with the theoretical framework related to the development of computer systems. According to [35], quality in Software Engineering must be directed taking into account three aspects: product quality, quality of the development process and quality of the development team. [35, 36] consider that the processes used to develop the software are directly linked to the quality of the product. Regarding development standards and quality, [37] considers that it is not uncommon for software development companies to deliver their products with features that were not requested by users, with delays in the schedule and low quality of the final product. Some processes are indicated by the authors, which show that many organizations that have adopted agile methodologies for software development has several benefits as result: more satisfied customers, better rates of return on investment, reduced development costs, faster results, among others.

Associated with agile methodologies, gamification and design thinking can be used to produce environments with accessibility.

For [38], one of the main objectives of agile software development is to develop the software more quickly and with quality through a series of iterations (short periods of time) that are feasible in terms of cost and time. Each iteration produces a version of the software bringing business value to the customer in a way that ensures that the defined requirements have been implemented.

Unlike traditional software development methods, agile methods are marked for being more collaborative and for encouraging team interaction through constant communication [39]. For [40], "We are discovering better ways to develop software by doing it ourselves and helping others to do it. Through this work, we started to value individuals and interaction between them more than processes and tools; Software in operation more than comprehensive documentation; Collaboration with the client more than contract negotiation; Responding to change rather than following a plan." The 'Agile Manifesto' does not reject processes and tools, documentation, contract negotiation, or planning, but it simply shows that they are of secondary importance when compared to individuals and interactions, with the software being executable, with customer collaboration and quick responses to changes and changes.

Based on what was proposed by [41], the use of design thinking for the process of developing accessible platforms is possible through the organization of multidisciplinary teams, with research teams from the design areas; programming; communication and accessibility specialist consultants. Starting from Theory of Flow, it was listed which premises could be followed in the stages of Empath, Definition, and Ideation, correlating to these processes the concepts of gamification and the accessibility guidelines in education platforms, as shown in **Figure 3**.

The figure presented in the research "Gamification in Education Through Design Thinking" presents the confluence and the different definitions of the theory of flow, design thinking, gamification, and accessibility in the phases of empathy/discovery; definition and ideation of design thinking.

Empath: in this phase, the process is user-centered, for the user to immerse, engage, and observe. The development teams use bibliographic research, the mapping of gamified LMS focused on mathematical concepts and accessible gamified LMS.

Definition: from the empathy studies presented above, a first definition about the project is sought, synthesizing the concepts raised and presenting the focus of the problem. Again, this step begins looking for definitions that can converge to solutions of the points presented in Theory of Flow.

Ideation: from the focus of the defined problem (making LMS platforms and their gamified tools accessible), solution possibilities are presented and ideation is carried out, taking into account how the design of the artifact.

In relation to the method, Design Thinking is associated with the Design Science Research method (see **Figure 1**), with confluent steps in which empathy, definition are associated with "Space of Design" of the DSR, listing requirements and possible solutions to problems and ideation, is associated with the layers of the artifact under construction, presenting the viability, utility and representation of the artifact. The prototype and testing steps are also related to the DSR with the construction of the artifact; and use of the artifact with pilot instantiation and clearance of the artifact.

This research does not include the Prototype and Tests phases, as they are subsequent steps for the construction of the prototype based on the concepts presented.

In software development, it is also possible to use gamification to promote the encouragement of fulfilling the stages in the processes of agile methodologies. It can be organized through groups of hierarchical and partially ordered challenges that must be overcome, with a developer or a team of developers who need to have various skills, different knowledge and organization of workflows. This concept is directly related to the steps of design thinking presented above; the game mechanics present in gamification and the different stages and sprints present in agile methodologies.
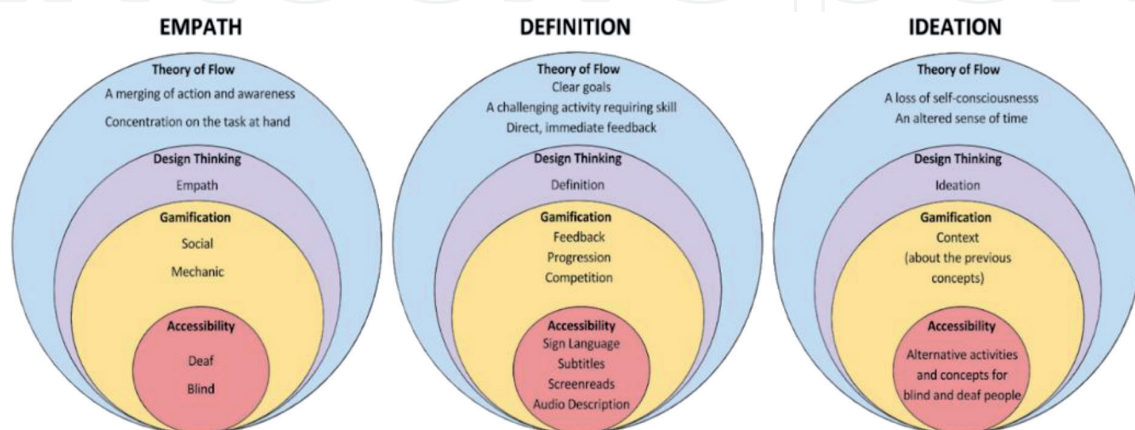
Figure 3.
Correlation between the theories presented and the empath, definition, and ideation steps. Source: from the authors.

This set of characteristics can be organized so that they can learn new skills and knowledge, combine them to overcome challenges during development and be rewarded with effective completion after each stage of the journey, whether they get rewards or not, depending on success or failure, respectively.

Flow State: The Flow State sought in this work is in the first instance to promote the engagement of developers with gamification strategies during development, and, from the development of web platforms with accessibility, to promote the Flow state in students as well.

The design thinking methodology applied to the project follows the definition of Bootcamp Bootleg by [42]. The approach proposed by [42] is divided into five phases: empathy (user-centered process, to immerse, engage and observe the problem); definition (makes a synthesis, presents a focus of the problem or point of view); ideation (generation of ideas, exploration of solutions); prototyping (producing ideas in a more real context, bringing material character); tests (to redefine solutions and put the prototype in contact with people).

Accessibility: As proposed by [43], the process of inserting gamified activities into a learning object must follow the precepts of game design and gamification. The authors [43, 44] use a taxonomy of user satisfaction metrics and intend to extend their studies to the area of Distance Education and to studies on 'Gamification'. [45], starting from [46], presents some characteristics and recommendations for the use of gamification in digital environments. Through this categorization it is possible to use the above precepts for the production of gamified and accessible OA. Thus, the concepts of gamification can also be inserted into the conceptual basis of an LMS.

Based on the categorization made by [44], associated with that proposed by [45, 46], we can list similarities between the two approaches. **Table 1** shows how the concepts can be related by these categories.

Based on the above, engagement is sought based on the application of the precepts of implementing accessibility for people with vision and hearing disabilities in the programming phases, based on accessibility guidelines, to ensure inclusive access for anyone in online environments through friendly and intuitive interfaces.

This step is already a first challenge, as there are still no recommendations or accessibility guidelines for LMS.

	Concepts of [44]	**Concepts of [45, 46]**
Feedback	Time that the user takes to dominate the game or perform a certain task	Pleasant productivity, the players see applied efforts and energies achieving the desired results
Social	Socialization- interaction between the system and users; and duty - the system's and the generated social relations' capacity of creating and accepting the user's emotional investment	Generation of the possibility of working cooperatively, in teams and groups in order to solve problems / Construction of stronger social relationships through emotional bonds
Competition	Self-competition and effort to overcome the results	Pursuit of self-motivation to remain in the activity (intrinsic motivation)
Progression	The system's capacity of providing persistence to the user	Activities created with challenges that can be overcome
Mechanics	Pleasure that the user finds in the game	Epic meaning of achieving something expected
Context	Context of the system's actions	_____

Table 1.
Relation between the concepts of [44–46].

Developers should follow the recommendations made by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C)[1], IMS GLC - Accessibility Guidelines (IMS GLC- ACC)[2] and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA)[3]), which are institutions that created parameters of accessibility in websites and virtual environments, of which they are the bases for the development for this research, because currently they are the ones that determine the guidelines of web accessibility, being the basis of the proposal for the recommendations presented for the proposal for the development of accessible LMS.

In relation to the visually impaired person, in order to browse the websites/ web systems, these people make use of assistive technologies, categorized as screen reader software, whose function is to interpret the page code and reproduce by audio through a speech synthesizer. However, the interaction of screen readers on websites will only work properly if certain coding standards are applied in the development, established in the International Web Accessibility Guidelines, which were developed by the Web Accessibility Initiative (WAI), an organ created by the W3C (World Wide Web Consortium). Among these initiatives, the WCAG (Web Content Accessibility Guidelines) and the WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications) guidelines will be highlighted, a standard created to make dynamic content and applications more accessible, which together with HTML, guarantee a navigation with accessibility for screen reader users.

When a website is not developed thinking about the access of people with vision disabilities, users of assistive technologies of screen readers not following the international standards mentioned may present several accessibility barriers that will hinder or even prevent access to the functionalities for a great number of people. Hearing impaired people, on the other hand, need resources such as the interpretation of texts in sign language and the use of subtitles for the deaf and people with hearing loss.

With the use of recommendations, WCAG (Web Content Accessibility Guidelines), and WAI-ARIA, and, with the production of audio description resources, self-contrast, subtitles for the deaf and people with hearing loss and sign language, it is sought that developers are encouraged to develop these steps with gamified strategies.

6.1 Gamification

From what was proposed, it is then presented what are the strategies for the development of an LMS based on gamification strategies. In the case of this study, the use of challenges is suggested, with the availability of a ranking of scores, as well as the use of badges as trophies, for example.

For the application of the elements of gamification in the design steps aligned with design thinking and accessibility, the steps follow the criteria of scoring and badges present in the gamification mechanics. The main strategy of gamification of the developed learning object occurs through the appropriation of the reward system of conventional games where the player earns points for each development task performed in the correct period and with proposals for solving the problems that arose during the execution.

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[1] Web Content Accessibility Guidelines. Available at https://www.w3.org/TR/wcag-3.0/

[2] IMS Guidelines for Developing Accessible Learning Applications. Available at https://www.imsglobal. org/accessibility/accessiblevers/index.html

[3] Accessible Rich Internet Applications (WAI-ARIA. Available at https://www.w3.org/TR/wai-aria

Activity	Points earned
Complete a step or sprint	100 points
Solve a problem	100 points + trophy
Post a reply on the forum	50 points

Table 2.
Scoring system for gamified development

Scoring rewards are awarded after the completion of each sprint or trouble-shooting presented. Also, a forum is proposed between the development teams so that doubts can be exposed to the teams and solutions proposals are sent.

6.2 Gamified development steps

It is therefore suggested that gamification from the rewards system be used for planning the development of the platform in all its phases, from presentation and training in the language chosen for the development to the identification of the system requirements, the test scenarios, prototyping, system modeling, implementation, testing and deployment, delimited by the phases of design thinking and Design Science Research.

The scoring system follows that specified in **Table 2**.

For [47] this type of strategy is known in the world of conventional games as badges and consists of an element that integrates reward at the same time. For the author, using badges is equivalent to a process of defining, seeking, and achieving goals and objectives, which increases performance in three ways: increasing the level of expectations regarding the result of the process, which leads the participant to increase his performance; defining clear goals which facilitates self-assessment during the process; and increasing satisfaction from meeting the target. Corroborating with this, in an experiment carried out with students through a virtual learning environment, [48] found an improvement in the results of practical activities through the adoption of gamification strategies with the use of badges.

With the adoption of this system of rewards, what is intended is to use gamification, as raised in the literature, to increase motivation and engagement in activities. In addition to these positive reinforcements materialized through points and trophies, the strategies developed also aim to mitigate negative reinforcements and frustration. In the case of scoring, it works as a personal motivation for development teams to seek to beat their records.

Likewise, winning trophies when correctly completing a step or solving problems generates a reward.

6.3 Score ranking

The score ranking serves to encourage developers to achieve leadership, as well as direct their efforts from their greatest qualities. The ranking itself is not just a query tool, but an agent that mobilizes engaged developers to seek to be in good positions on the table. In each of the steps, the following types of punctuation are defined:

- User score for each week

- Final user score for each sprint

- Scoring teams for each week

- Final team score for each sprint

- Punctuation for forum responses

6.4 Trophies

Trophies will be awarded for specific tasks and achievements, which are strategic for the progress of the project. In this project, they are similar to the reward systems of conventional games and are triggers for interaction, collective work and team engagement, and participation in problem solving. The trophies will be made available for:

- The team with the highest score in each step

- The developer who solves problems during the process

6.5 Accessible platform development steps

6.5.1 Step I—empathy

Presentation of the importance of accessibility in LMS - This process is user-centered to immerse, engage, and observe the problem. Regarding the gamification requirements, we have an emphasis on the social and mechanic requirements of the games, presenting the work of the multidisciplinary team being carried out through the concepts of Design Thinking, seeking a direct relationship with the issue of empathy for a product to be closely related to a social issue, in which users can, through the system, promote relationships of socialization and interaction, triggering the phases of competition and progression also in the product development process. Here, the work in cooperation is also directed, in teams and groups, to solve problems, mobilizing the construction of social bonds and stronger relationships through affective bonds. The mechanics, on the other hand, are directed towards the construction of the gamified LMS based on the generated relational situations.

The association with accessibility in this phase, however, occurs with studies directed to dynamics used in gamified LMS that, from the phases of a merging of action and awareness and concentration on the task at hand; Social and Mechanical, and Accessibility Strategies and Universal Design;

6.5.2 Step II—definition

Presentation of the concepts of accessibility, the accessibility guidelines, and case studies - This step makes a synthesis and presents a focus of the problem or point of view. For gamification requirements in this step, we have an emphasis on feedback from the empathy step, with a focus on different skills and a framework of prior knowledge. Thus, feedback related to the time when the user performs a certain task is essential, as well as the feedback regarding mistakes and successes. In the validation phase, this process must be mapped so that it continues and manages to feel the satisfaction of meeting the challenges. With this, the process of progression occurs;

Progression: In order for it to remain stimulated to develop accessibility in the LMS, its goals and actions must be clarified and what are the key points for it to be able to fulfill them. It is suggested to work in the team, with personalized progression according to the profile of the developer or the team, in which the goals are set according to the profile presented. Another possibility is for the developer or team to define their tracks and challenges, directing actions and goals according to their abilities and skills.

Competition: It was decided to seek in the definition step the possibility of, in addition to self-competition, also bringing collective challenges. This feature should be explored, but in a very reflective way in learning environments. Promoting competition in gamification is one of the engines that generates the process of immersion and resumption. As previously mentioned, the scores and trophies in the steps can increase engagement.

Accessibility: Emphasized points: sign language, subtitles, environment architecture for screen readers, and audio description. For accessibility, it is the moment, from the studies and the project proposal stimuli that came with gamification, to elaborate the framework of possibilities for the proposal of an LMS following the IMS-GLC and W3C-WCAG and WAI-ARIA guidelines with accessibility features such as sign language, subtitles, environment architecture for screen readers, and audio description.

6.5.3 Step III—ideation

In the ideation, all the information and data obtained during the immersion are gathered and it is time to sit down with everyone involved and devise the possible solutions. It is essential to take into account the point of view of each of the participants at this time, also realizing the various possibilities for the development of the accessible LMS. In this step, the ideas most voted by the team can be scored, with the score and trophies for developers and teams. It is worth remembering that the concepts presented must be articulated so that people with vision or hearing disabilities can explore them. Thus, it defines the importance of using what [4] defines as alternative media that, with studies for the execution of sign language resources and subtitles for people with hearing impairment, and organization of the Virtual Environment architecture according to with the guidelines of IMS-GLC and W3C-WCAG and WAI-ARIA, to be accessed by screen readers, in addition to the audio description feature of videos and images. It is the phase of generating ideas, exploring solutions to define teams and development steps.

As the proposal places LMS accessibility as the main element, in each step the scores must be articulated in relation to the development of accessibility requirements such as:

Organization of navigation elements on the website with the correct semantic structure of HTML provided by WCAG:

- Use of headers hierarchically

- Objective description in links

- Forms developed with labels, differentiated color, HTML fieldset and legend tags, description of the buttons,

- Accessible images

- Keyboard access

- Page titles

- Modal window

- Insertion of sign language window in the platform texts, videos, audios, podcasts and audiovisual resources.

- Inserting subtitles for deaf people and people with hearing loss in videos, podcasts and music

- Description of images, Audio description of videos;

- High contrast of images and platform.

It is also important to note that when developing a project that contemplates accessibility, it is worth noting the available options such as CMS, frameworks, and libraries. Many of the aforementioned options already have resources in their code to assist in development in compliance with international accessibility standards, providing guidance and information in the respective documentation. We can mention some as "Bootstrap", "React", "Angular", "Wordpress", "Moodle", among others. Based on what was discussed above, it is suggested that the entire production flow of an LMS and its tools have a gamified strategy for product development teams.

As previously presented, the next steps (Prototype and Tests) will not be presented, as they will be the scope for the development of accessible and gamified LMS, and will be described in future works.

7. Conclusion

The research develops the proposal for software development actions so that gamified LMS can be designed and programmed through design thinking, having gamified resources in the development process, encouraging the use of WCAG (Web Content Accessibility Guidelines) accessibility guidelines and WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications).

From the bibliographic survey and the steps described in Design Science Research and Design Thinking, and the search for accessible and gamified platforms, requirements were raised for a first gamified development experience of an accessible LMS. With the initial questions of this research, a proposal for prior planning is presented so that these platforms and their media - videos, texts, audios, and games contain accessibility resources and allow the disabled public to experience the same processes as those who do not have deficiency. As a way to streamline the workflow and incorporate game elements from the initial design, gamification and design thinking are used as part of the work methodology of the development teams.

The goal is to promote an immersive and gamified experience from the beginning of an LMS project, placing the development team itself in the midst of UXm stimulated by the theory of Flow for the production of the platform and its accessibility features. Gamified development inserts game elements into the various software engineering practices used by the team, and mainly the focus on project management to assist in the gamification of any software process. It is noteworthy that currently many development teams have used the agile methodologies and practices of software engineering expecting that, when applied during the development, the mechanics of the games allow a broad and analytical vision in the process of aligning the steps and sprints with challenges and exchanges between teams being crucial moments for the prototyping and testing phases - which must also be carried out with the disabled public. Thus, the proposal allows to follow the processes of [Lockwood], with the processes of observation, collaboration, rapid learning, visualization of ideas, rapid construction of prototypes, learning from failures, outlined by gamification strategies, allowing a validation of the project more effective.

Regarding the gamification of the steps of software development, it is expected that the teams will encourage increased dedication in carrying out tasks; the search to face the challenges of each step and to solve the problems autonomously; assisting other employees by stimulating punctuation and team satisfaction in seeking the best results from the gamification processes.

With the steps of empathy, definition, and ideation, and the proposal of gamification in the development of accessible LMS, we seek to initiate a path to stimulate new possibilities for software development, as well as the proposal to design LMS with accessibility since its initial draft. In addition to the use of gamification in the development process, this work seeks to bring reflection to researchers, educators, developers, and instructional designers about the need to advance in research that develop alternatives to foster the inclusion process and the active participation of disabled people in society.

8. Future steps

For future steps, it is suggested the development of an LMS with accessibility from the model proposals presented in this research;

To present the requirements of an accessible and gamified LMS for the end user, with tests carried out with disabled people;

It is important to emphasize that it is essential to present the execution and validation of a prototype, showing how the concepts of UX and accessibility applied since the development will benefit the accessibility and the gamification resources in the accessible LMS.

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