World Journal of Information Systems 2(4) 40-54
DOI: https://doi.org/10.17013/wjis.v2i4.50

Article

Increasing Contributions to Accessibility Mapping Through Gamified Mechanics: A Case Study of the Visibility App

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(Article history: Received August 14, 2025; Received in revised form September 10, 2025; Accepted October 20, 2025; Available online December 15, 2025)

Abstract: In recent years, the need to guarantee access to people with limited mobility has made identifying accessible places to facilitate displacement and avoid possible barriers a critical task. In this sense, through an application based on maps and crowdsourcing, collaborative marking of locations is a viable alternative to maximize the identification of establishments and roads endowed with architectural resources that favor access. That is the premise of the Visibility application, which uses a map system to mark accessible locations and parking spaces for people in wheelchairs. This work aims to report the process of introducing gamification techniques to improve the engagement and motivation of the Visibility users to collaborate in marking places. Here we present the gamification techniques incorporated into the app, implementation choices, and results obtained so far.

Keywords: gamification; crowdsourcing; accessibility; reputation system

1. Introduction

Several people face mobility problems when moving from one place to another, such as potholes or uneven sidewalks, which often do not have ramps, making locomotion difficult. Mobility barriers represent a problem that affects many people, from parents with children in strollers, older adults with walkers or canes, and people with special needs, such as wheelchair users, who need more support to get around.

Some initiatives seek to use technology to provide systems that help mobility, using resources such as the Global Positioning System (GPS) and integrated map systems to allow users to locate themselves in cities, neighborhoods, and streets. One of these projects is the Visibility app, developed to improve the mobility of people with physical disabilities, more specifically, physical-motor disabilities.

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This article presents the process of selecting and implementing gamification techniques in the Visibility application, a system based on crowdsourcing and maps for marking accessibility levels of places and parking spaces for wheelchair users. The intention is to improve user engagement and thus increase the number of contributions to the application so that more people can benefit from its information.

The rest of this paper is organized as follows: Section 2 introduces the concepts of gamification and the different mechanisms that systems can use in its implementation; Section 3 presents similar projects and the techniques they use to engage users; the Visibility application, object of this work, is described in Section 4; Section 5 relates the method used in carrying out the project; in Section 6, we discuss the selected gamification techniques and the results of the implementation; finally, Section 7 presents the final considerations and future work.

2. Gamification

The boost of interest in digital games as entertainment has stimulated research on their effects in other areas, giving rise to gamification. However, this term has different definitions proposed by various authors, meaning there is no widely accepted definition [1].

Gamification is a strategy that incorporates game elements into interactive systems without the final product necessarily being a game [2]. This strategy has been used in several systems to motivate users to engage in different purposes, like education, healthcare, and others [3, 4, 5, 6].

Zicherman and Linder examine gamification from a psychological point of view and present another definition, dividing it into two types of motivation, intrinsic and extrinsic. They describe intrinsic motivation as the behavior or activity performed due to its alignment with a person's internal values. In contrast, extrinsic motivation occurs through external rewards, such as money offered to engage or motivate [7].

Intrinsic motivation is variable, as each user has his/hers inner stimuli, thus making it challenging to establish a standard and becoming less reliable [7]. However, the authors mention that it may not be necessary to supply this motivation and that it is essential to create extrinsic motivators so that people perceive them as intrinsic motivators.

Commonly, gamification techniques use cash rewards as motivating factors. However, this type of reward can decrease motivation over time. Ideally, gamification should grant monetary and non-monetary rewards to stimulate intrinsic and extrinsic motivation [7].

A well-known framework for gamification is MDA (Mechanics, Dynamics, and Aesthetics), which describes the interaction between these elements in games, thus allowing their application in non-game contexts [8].

Mechanics are the functional components, the tools used to create games. Dynamics determines the behavior of mechanics when executed by the player. Finally, aesthetics results from a combination of mechanics and dynamics, that is, the emotional response when

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interacting with the system. The most used game mechanics have been identified and are discussed below.

2.1 Point Systems

Points can be used in different ways, such as to reward users and drive behavior or even as status indicators, allowing the acquisition of items, gifts, and content, among other things. Point systems are also used to provide feedback to users [9, 10]. In gamification, point systems can serve a wide range of functions and are generally divided into five different types [8, 9]:

- Experience points, which track the experience over time, are not redeemable and may or may not expire;
- Redeemable points, which can be earned and redeemed and are usually the basis of a virtual economy;
- Skill points related to a specific area, such as completing alternative subgoals in an activity. They are tangential for both experience points and redeemable points;
- Karma points, acquired by helping other users, encouraging altruism. Karma points are not redeemable.
- Reputation points, generally present in more complex systems, must incorporate a wide range of activities where the points contribute to establishing the user's reputation.

2.2 Levels

Levels, or phases, are structured hierarchies of progress, usually represented by ascending numbers or values. The role of the levels is to provide users with a sense of progress and accomplishment [9].

Levels have point limits so users can advance according to their actions. They usually indicate the status or control access to content released according to the user's progress [10]. In games, the difficulty is not linear; the phases do not have the same amount of points and, in most cases, increase the obstacles exponentially and decrease with time. People are currently interested in more extended and longer-lasting games, starting with simple levels and progressing to more complex ones [8].

Progress bars work with levels, serving as guides that tell the user the score or percentage needed to complete a certain phase.

2.3 Leaderboards

The leaderboard highlights the best contributors according to desired actions, indicating how a user scores compared to others and thus stimulating competition [10].

They display an ordered list of users from highest to lowest score. Leaderboards can serve as a powerful incentive; however, they can have the opposite effect if too few players

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are listed. In addition, beginning players may feel demotivated by the lack of mobility. As a result, the current rankings have become relative rather than absolute, allowing even new players to compete and ascend the hierarchy [9].

2.4 Achievements and Badges

Achievements, also known as badges, challenges, or trophies, result from completing missions or tasks proposed for users to fulfill [10]. Since these tasks represent goals, users feel like contributing something and receiving recognition in return.

Badges are also present in scout and military organizations. They allow users to feel successful and encourage the desire to collect them [9]. One way to further improve engagement is by allowing users to share their accomplishments with others.

Achievements can still be used as a source of amusement when hidden until some unknown objective is accomplished. However, hiding both the achievement and the task may frustrate players due to the lack of transparency [8].

2.5 Virtual Goods

Virtual goods are non-physical and intangible objects that users can acquire in games, such as gifts, avatar clothing, stickers, and personalized items [10]. They allow users to spend their credits on things, motivating users to contribute more, engaging them, and encouraging creativity.

Still, item sharing stimulates competition when allowed in the community, as users may want items from other users and even acquire rare items.

2.6 Gifting and Charity

Gifts are acquisition and retention mechanics. Acquisition happens when users are encouraged to send gifts to their friends, and retention occurs when a gift is received. It is necessary to log into the system to redeem, therefore perpetuating the cycle of sending and receiving gifts [10].

The gifts may have different characteristics: free or paid, with time to purchase or in-app credits, and even personalized ones.

3. Related Work

One can find several works for conjugating systems based on maps with the collaborative marking of places for different purposes. Specifically for areas with accessibility, some projects are presented below, highlighting their main characteristics.

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3.1 WheelMap

Wheelmap is a map system specifically aimed at providing information about places seeking to serve wheelchair users and people with mobility difficulties. It has been available globally since 2010 for Android, IOS, and Web platforms. The system interface consists of a map, where it is possible to insert different markings of available places.
The system uses different icon colors to organize locations (Figure 1):

- green - indicates that the location is accessible, with all the necessary resources.
- yellow - defines the place as partially accessible, with some features to provide accessibility, but not all the necessary ones.
- red - represents that the location has no accessible resources.
- gray – areas not yet rated.

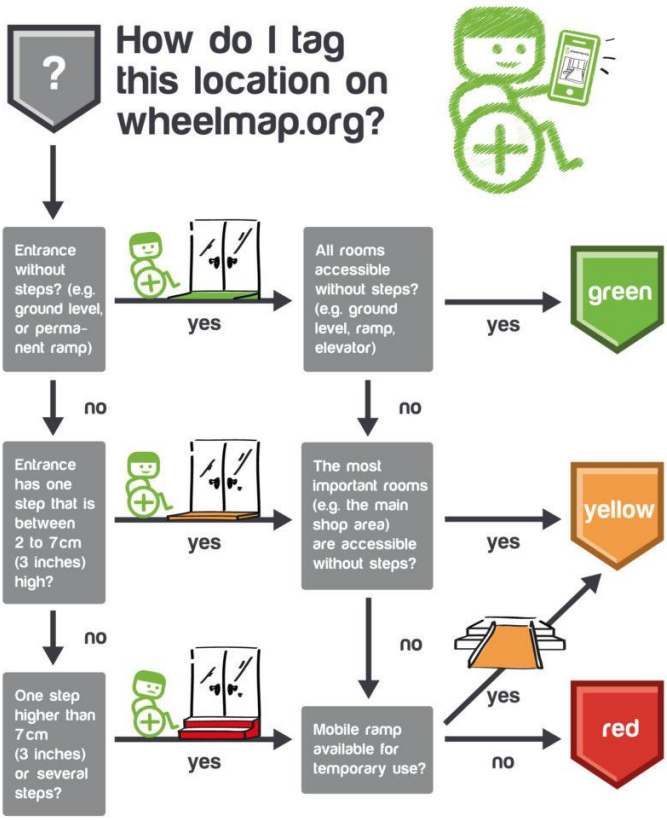

Figure 1. WheelMap Colors Flowchart

The application has different filter possibilities. Users can view from fully accessible places to those that do not have any accessibility, among other forms of classification.
Users of the system help provide evaluations by adding information from different categories and characteristics of the locations, such as the presence of ramps, steps, and bathrooms. According to the official page, it has more than 2 million reviews. From these, over 580,000 reviews, about 29% of all, come from users in Germany, where the app is quite popular.

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3.2 Google Maps

Google Maps is a system created in 2005 and a well-established application in the market of maps, with more than 5 billion downloads for the Android operating system alone. It is also available for IOS and Web platforms. However, especially in accessibility for wheelchair users, resources started to be implemented in 2017. The general functions include adding accessibility features to the places, such as entrances, seats, bathrooms, and adapted parking lots. Figure 2 shows the application's interface showing the presence of an accessible entrance. The accessibility markup-related functionalities are only available for some locales, such as Japan, Australia, the United Kingdom, and the United States. A noteworthy feature is Google Local Guides, which aims to motivate users to contribute information.

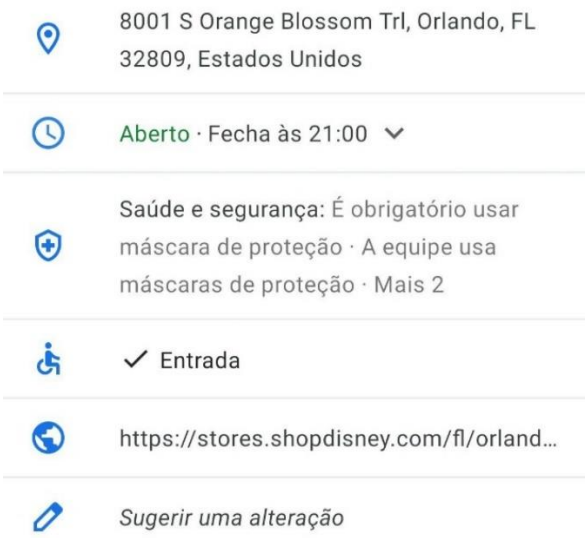

Figure 2. Google Maps Interface showing accessibility information

This gamified system consists of three factors:

- points awarded when a user contributes.
- levels defined according to the number of points given by users.
- badges awarded according to level.

One can contribute differently by adding or editing places, ratings, photos, videos, and comments. Each one corresponds to some points added to the user's profile. The more the users contribute, the more they earn points and advance to higher levels. Ten different levels and badges are assigned to users who reach specific goals.

3.3 AXS Map

AXS Map is a map system aimed at people with limited mobility, such as wheelchair users, the elderly, and people who need the help of canes and walkers, as well as parents who use strollers to travel with their children. The system divides places into three categories and uses a color system to classify them. The three categories and some of their respective features are:

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- entrance – steps, ramp, entrance width, reserved parking.
- interior – accessible elevator, table height.
- restroom – door opening, grab bars, lowered sinks.

According to the level of accessibility, each location receives a color, indicating the place is accessible, requires attention, or is not appropriate, as seen in Figure 4.

Concerning user engagement, AXS Map has the Mapathon, which allows the creation of events to portray and classify places and can be carried out individually or with other participants. Each Mapathon can last from a few hours to a few weeks and has its own points system to reward users according to their contributions.

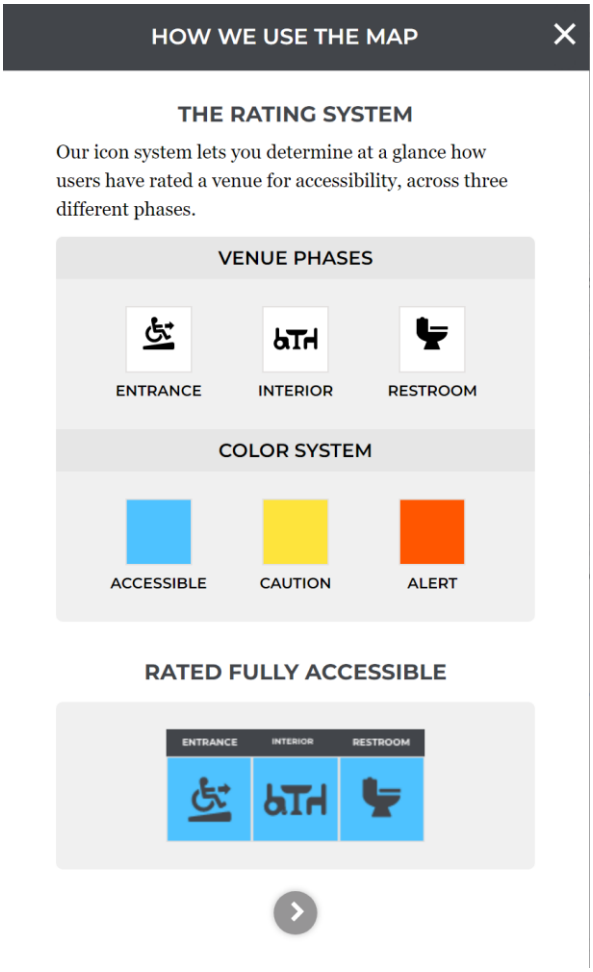

Figure 3. AXS Map Interface

All systems presented have similar solutions and characteristics. Wheelmap is intended for people with mobility difficulties and provides functionalities for classifying places but lacks information in Brazil and Latin America.

Google Maps has a gamification system intended for the general public, but it does not allow you to classify places according to accessibility. Instead, it exposes the resources that help people with limited mobility and is restricted to some countries, excluding Brazil. Finally, AXS Map is aimed at people with mobility difficulties and provides resources for their

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evaluation, besides having user engagement via Mapathon. As a disadvantage, it seems to be discontinued, currently available only on the website.

4. Visibility App

Visibility is an open-source Android app intended to help people with mobility difficulties and disabilities classify places according to specific accessibility characteristics. The main features of the application are:

- authenticated access of users through login and password.
- the possibility of marking places, informing the type of location, and the level of accessibility.
- filtering of places by accessibility level.

Before assigning any markup to a location, every system user must create an account and inform their data. Authenticated access prevents incorrect markups from being inserted by malicious users. In addition, it allows the inclusion of functionalities based on the performance of each user. At this point, only the system administrator can verify the individual contributions of users through the records in the database. Marking a new place in the app is done based on the GPS data of the user's position or via manual input on the map. Each unique marking represents a parking spot intended for wheelchair users or an assessment of the accessibility level of a particular place. Figure 4 shows the interface for entering data about a new location.

Figure 4. Interface for Adding a new Entry in the Map

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In this interface, at the top, the user can select whether to use the current position (GPS) or manually inform the new location on the map. The only information the user must provide when marking a parking spot is the location; therefore, it is quite simple. Differently, to indicate a specific place accessibility, the user must provide some information:

- an identifier for the location.
- a brief description.
- the perceived accessibility level (accessible, partially accessible, or not accessible).
- a category (transport, supermarket, services, leisure, education, food, hospital, accommodation, or finance).
- information on whether the place is private or public. One can view all the marked locations near the current position. Alternatively, it is possible to filter sites according to type and accessibility level.

5. Method

The method adopted in the development of this project is depicted in Figure 5 and described next.

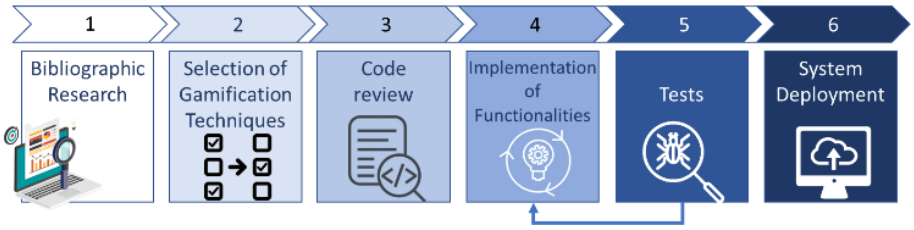

Figure 5. Development Phases of the Project.

First, comprehensive bibliographic research investigated the main themes addressed in the project. Although it focused mainly on gamification, this study also included topics addressed in the project, such as crowdsourcing, accessibility, and usability of interactive systems. We also identified related works to perceive solutions proposed by other researchers at this stage. Then, given the motivational and engagement aspects desired for the application, some gamification techniques were selected to be included in the project: points, levels, achievements, and ranking. These techniques were associated with the functional and non-functional requirements of the application. Thus, system requirements include the capabilities of:

- assigning achievements to the users according to their actions.
- assigning points to the users according to their actions.
- classifying users into levels according to points.
- distributing users along with a ranking.
- displaying statistics of gamification.
- adding and displaying comments.

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- displaying and validating the number of characters in the description of location evaluations.
- providing an accessible user interface for people with limited mobility and people with special needs.
- providing a color-based taxonomy to identify accessibility levels.

Then, it was necessary to review and understand the source code of the Visibility application to identify what modifications would be required, in addition to establishing a priority of actions taken to incorporate all the selected techniques and adapt the interface accordingly.
The developers introduced new features gradually, accomplished with functional tests in a continuous approach that suggests, if necessary, immediately providing minor bug fixes and adaptations. The tests aimed to discover problems such as incorrect or missing functionality, interface errors, behavior or performance errors, errors in the adopted data structure, and start or end inconsistencies.
Finally, the application was deployed in the cloud, and the source code is available to interested users in an online repository[1].

6. Results

The following sections describe the gamification techniques and new functionalities added to the Visibility Application.

6.1 Points, Levels and Statistics

We selected the points mechanic due to its popularity and users' familiarity with it. According to their relevance, specific behaviors may provide different amounts of points. In the case of Visibility, the immediate action is to assess the accessibility level of the places, so the number of points assigned to this action is higher than the others.
The choice was to award not redeemable experience points, which track user experience over time. In this system, points may or may not be expired. The decision was to adopt two scoring systems: points that expire weekly but accumulate over time.
The original version of the application allowed three types of interaction: evaluating places, marking parking spots for wheelchair users, and updating any existing evaluation. Inspired by Google's Local Guides system, the developers created new actions to increase the range of interactions possible and improve user engagement.
The first functionality is to count the number of characters used to describe a place (Figure 6). The description is one of the most critical parts of the evaluation; it explains what accessibility features are available. Supposedly, the more text, the more information there will be, so we decided to value longer descriptions with more than 200 characters.

[1] https://github.com/alanrps/visibility_mobile

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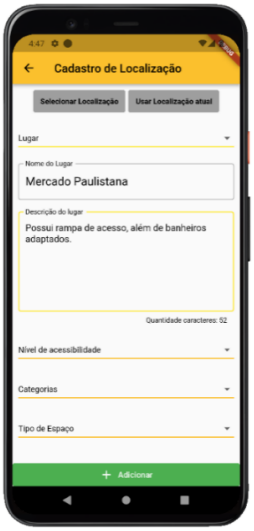

Figure 6. New location Markup

The second one is the addition of comments inspired by the Google Local Guides, which allows other users to submit questions, answers, and comments, thus contributing to the markup (Figure 7).

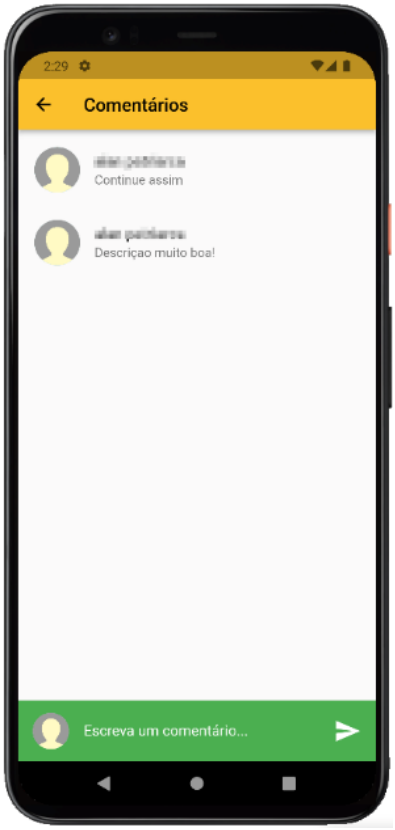

Figure 7. Comments, Questions and Answers

Next, it was necessary to establish the number of associated points, considering each action's frequency, difficulty, and importance. Table 1 shows the points assigned to each activity.

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Table 1. Actions and points associated

Action	Points	Description
New place evaluation	15	Inserting a place evaluation with up to 200 characters
New place evaluation with 200+ characters	25	Inserting a place evaluation with more than 200 characters
New accessible parking spot	10	Marking a parking spot for wheelchair users
Comment	5	Adding a comment on a location (question or answer)
Edit Evaluation	10	Editing an existing evaluation

In association with the mechanics of points, Levels induce a sense of progress and indicate the users' status. Levels are generally represented by ascending numerical values. In the case of the Visibility application, we decided to adopt ten levels, each associated with a certain number of points and corresponding to different materials that also increase in value in an ascending way, such as iron, bronze, silver, gold, platinum, and diamond.

The number of points needed to evolve is non-linear; the higher the level, the greater the number of points to reach the next one, challenging the user to perform better. This decision is inspired by the model used by Google Local Guides. Albeit some researchers state that the difficulty of the levels usually tends to increase exponentially and then decrease again with time [8], due to the small number of levels adopted in this project, it was not necessary to apply this approach. The levels, number of points, and description are presented in Table 2.

In the Visibility application, an area specific to gamification was created. The area is divided into three interfaces: a report of points, levels, and contributions statistics; a ranking; and a list of achievements for each user.

Table 2. Levels and points

Level	Points	Description
1	0	Contributor Junior
2	15	Contributor Iron
3	75	Contributor Bronze
4	250	Contributor Silver
5	500	Contributor Gold
6	1500	Contributor Platinum
7	5000	Contributor Diamond 1
8	15000	Contributor Diamond 2
9	50000	Contributor Diamond 3
10	100000	Contributor Master

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The report interface allows viewing two gamification mechanics: points and levels. This interface displays the following information: the level in which the user is, a progress bar that shows the evolution of the user's non-expirable points; the current score; the number of points needed to advance to the next level; the weekly points (expirable), used to establish the ranking of the users; and a description of the user's level (Figure 8). In the case of the user displayed in the Figure, the category is "Silver", corresponding to level 4.

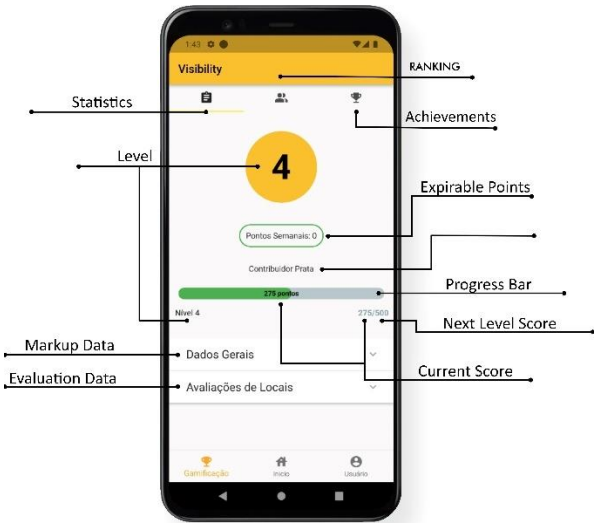

Figure 8. Report Interface

This interface area also includes two tabs that, when selected, display total statistics regarding the markups and the distribution of user evaluations. Originally, the Visibility app allowed marking both accessible parking spots and accessibility levels of the locations. Viewing the total contributions is an included functionality that enables users to view all the information they have provided over time, grouped into:

- accessibility level, that is, the perceived accessibility level (fully accessible, partially accessible, non-accessible);
- types of spaces (public or private);
- categories (travel, transport, supermarket, services, leisure, education, food, hospital, accommodation, or finance).

6.2 Achievements

In this area of the interface (Figure 9), it is possible to visualize all the user's achievements and the elements that make up each one. For each achievement, three pieces of information are displayed: the category, the description, and a circular progress bar showing the completed activity percentage.

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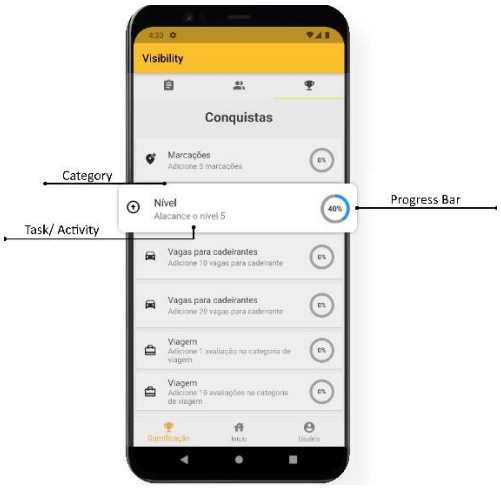

Figure 9. Achievements

6.3 LeaderBoard

A weekly Leaderboard ranks contributors according to points awarded to markups that expire weekly. Using expirable points is the solution adopted to provide mobility to the ranking, thus encouraging both new users and older ones to remain motivated. Figure 10 presents the ranking interface.

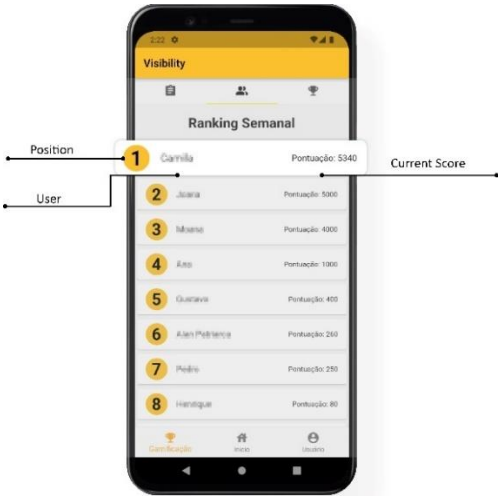

Figure 10. LeaderBoard

It is possible to identify the contributors associated with their scores in descending order of points.

CONCLUSION AND FUTURE WORK

The present work presents the selection and introduction of gamification techniques into the Visibility application. This application is based on crowdsourcing to report the perceived

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level of accessibility in different locations. All the enhancements introduced follow the interface patterns already existing.

In the case of this application, it is essential that users feel motivated to contribute more, given its social importance and aspect of inclusion.

In future work, it will be necessary to ensure that the enhancements comply with usability guidelines by conducting interface and acceptance evaluations with final users. It will also be essential to evaluate the effects of gamification on engagement by analyzing the number of contributions before and after its implementation. Additionally, it would be interesting to implement a graphical user interface for system administration.

Finally, it is possible to introduce new gamification mechanics and, eventually, resources such as a virtual goods store that uses the conversion of non-redeemable points.

Acknowledgments: This work was carried out with the support of the Universidade Tecnológica Federal do Paraná – UTFPR.

Conflicts of Interest: The authors declare no conflict of interest.

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