Improving Accessibility with Gamification Strategies: Development of a Prototype App

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Abstract: Objective: The study aimed to demonstrate the development of a mobile app prototype, BarrierBeGone, a system that identifies potential barriers for individuals with mobility disabilities and promotes accessibility using gamification strategies. The main goal is to raise awareness about mobility and accessibility difficulties, especially for wheelchair users, and to promote more responsible behaviours. Method: The User-Centred Design methodology was employed, going through three phases: requirements gathering, design and development, and evaluation. Additionally, interviews with five individuals with mobility disabilities helped define the initial system requirements. The development of the barrier identification system was followed by usability tests with nine representative users. Results: The results of the usability tests of the "BarrierBeGone" barrier identification system were extremely positive. Stakeholders recognized the utility and simplicity of the platform, considering it a motivating factor for future use. Conclusion: The results support the effectiveness of the proposed educational tool in increasing awareness about accessibility and social inclusion in smart cities. This study makes a significant contribution to the field of urban planning and inclusive design.

1 INTRODUCTION

Successful inclusion addresses the issue of how well a society can prevent discrimination and ensure access to information, products, services, and spaces for everyone (Rebernik, Favero, & Bahillo, 2020; Reinhardt, et al., 2020). Accessibility is a key component of smart cities, impacting the quality of life of its residents and should reduce the gap between those with unrestricted movement and those who have movement restrictions due to disabilities (Palazzi & Bujari, 2016). The topic of accessibility for people with motor disabilities is important and timely (Lee, et al., 2020).

Mobility impairments can significantly affect an individual's ability to move and participate in society, and it is essential that our cities and communities are designed and built to be inclusive (European Parliament and Council of the European Union, 2019). Disability does not necessarily lead to exclusion unless society fails to meet the needs of people, regardless of their disability (Rebernik, Favero, & Bahillo, 2020). A significant number of environmental barriers are reported, most of which are modifiable (Reinhardt, et al., 2020).

Environmental barriers are mainly reported in relation to insufficient resources and accessibility, and participation restrictions occurred primarily in the use of public transport, in caring for others, and in traveling to places (Yang, et al., 2023).

As cities become more digitally connected and data-driven, there is an opportunity to leverage these advancements to promote accessibility for all individuals, including those with disabilities. Smart

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city initiatives can integrate assistive technologies, accessible infrastructure, and inclusive design principles to create an environment that meets the diverse needs of its inhabitants (Ponciano, et al., 2021). Technological solutions are increasingly being used to address a variety of challenges faced by people with motor disabilities, including technologies around navigation and transportation, often mobile applications, including GPS or crowd-sourced systems, which provide real-time information on accessible routes and transportation options with tips and ratings (Lima, et al., 2018).

There are accessibility information apps that provide information on the accessibility of buildings and streets more focused on the fastest way to a specific destination, not focusing on the accessibility of the city or on identifying barriers, and thus negatively affects people with disabilities (Lima, et al., 2018; Mora, et al., 2016). The lack of solutions to identify barriers affecting people with disabilities is a significant problem in our society (Akter et al., 2020). People with disabilities face numerous challenges in their daily lives that can limit their ability to access their destinations (Ponciano, et al., 2021). Despite some efforts to address these issues, there is still a significant gap in identifying and resolving the barriers that affect people with disabilities (Yang et al, 2023). This means that many people with disabilities face barriers that prevent them from fully participating in society and achieving their full potential (Lee, Kim & Hwan Yun, 2023). It is crucial to raise awareness about the barriers in the population that affect people with disabilities and create and practice effective ways to remove them to help cities become more socially inclusive and accessible (Santoso, 2023). The problem at hand is the lack of effective solutions to identify and address the barriers that prevent the full participation and inclusion of people with motor disabilities in society, especially within cities. Solutions must go beyond simple navigation and provide real-time accessibility information, route planning, and collaborative data to create more socially inclusive and accessible urban environments. Another important aspect is the possibility of including gamification strategies in these resources, such as the case of serious games. Serious games are games specifically designed for education or training, rather than just for entertainment (Toukiloglou & Xinogalos, 2023). They can be video games, board games, virtual reality experiences, among others, and played on various platforms. A key advantage is that they provide an immersive and interactive learning experience, more engaging and effective (Van Zyl-Cillié, 2023).

To address the defined problem in this article, the development of a mobile app prototype, BarrierBeGone, is presented. This system not only identifies potential barriers for people with mobility disabilities using gamification tools but also actively promotes accessibility improvements by engaging users in the process.

2 METHOD

To address the problem outlined in this topic, a mobile application named BarrierBeGone is introduced, a system that identifies potential barriers for people with mobility disabilities. Using a User Centred Design, it is an iterative design process that characterized by establishing the needs, objectives, and general satisfaction of the users as the driving force behind product design and development. The steps include, based on existing research on the relevant topics, first understanding the specific challenges faced by people with limited mobility, then creating and developing a barrier identifier focused on improving accessibility and social inclusion, and finally evaluating the developed prototype by involving its potential users. (figure 1).

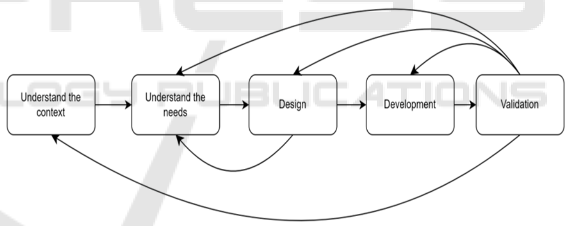

Figure 1: Methodology Diagram.

2.1 Understand the Needs

A crucial component of the design of this project is the identification and comprehension of parameters that affect mobility experiences when users are doing their routes. So, we conducted a set of Interviews sessions with people with limited mobility to supplement all the information gathered. Each interview was expected to have a duration of fifteen to twenty minutes. In total, five participants were interviewed.

A semi-structured interview was conducted, addressing the following topics: perceptions of the citizen's role in identifying accessibility and social inclusion, opinions on the use of apps to identify barriers for people with reduced mobility, availability of these tools for such identification, the relevance of developing such apps, identifying actions to take in case barriers are detected, the utility of gamification in these resources, and suggestions for improving accessibility and social inclusion in cities.

For the purposes of this project, the selection of participants as a research method was based on the convenience of collecting data in the field of study within a broad social context and within a short period of time temporal.

After the recruitment stage, all participants were informed about the study's objectives, the rules and guidelines for participation, and the limits of confidentiality regarding their involvement. They were required to verbally consent, indicating their understanding and agreement to participate in the study.

In addition to the empirical data gathered from the sessions, a preliminary questionnaire was also administered to gather sociodemographic information about the study sample. This questionnaire served as a complementary tool to further characterize the participants.

The interviews were recorded, transcribed, and subsequently subjected to content analysis. Quantitative data were analyzed using statistical methods.

2.2 Design and Development

In this phase its was developed a high-fidelity prototype that is completely functional and inter-active and closely resembles the actual expected accurate depiction of the mobile application's user interface was created during this prototyping stage. Following a usability assessment, the prototype was improved based on user input, and for the application development, it used Android Studio using Kotlin as the programming language.

2.3 Validation

Another crucial component of the design of this solution is the creation of usability tests. The interactive user experience that comes with a user interface, such as a website or software program, is measured by its usability.

For an overall view of the subjective usability evaluation of the designed technological product, the first sub phase used a sociodemographic survey to get information about their users, using a set of questions including their names, literary qualification, age, if they have any disability, and their comfort level using mobile phones using a Likert scale.

The second sub phase involves a set of tasks that illustrates the functionalities of the application. The third sub phase of the system evaluation stages utilized an adaptation of the System Usability Scale (SUS).

To develop the described process, authorization was requested and obtained. Regarding the participants in the requirements assessment and the feature testing, both groups signed informed consent forms. Anonymity was ensured through participant coding, where participant names were replaced with codes.

3 RESULTS

3.1 Requirements Definition

In this stage, the interviews were realized with 5 participants. Based on findings from interviews, individuals with limited mobility face six primary obstacles in their daily lives: barriers, steep ramps, large stairs, blocked access, improperly occupied parking lots, and the absence of necessary ramps.

The most reported issue was the misuse of parking spaces. This was followed by issues related to the lack of ramps, blocked access, and steep ramps, while large stairs and barriers were less frequently mentioned. These insights are crucial for understanding the challenges faced by this demographic, enabling the development of targeted interventions to enhance accessibility and inclusivity in urban environments.

3.2 Application BarrierBeGone

The BarrierBeGone app is an accessibility-focused innovation developed from a comprehensive theoretical review. It leverages advanced mobile technologies, including GPS, network triangulation, and wireless communications like 3G, 4G, and Wi-Fi, enabling users to identify and classify barriers in real-time. This collaborative system not only allows users to report obstacles encountered in their daily lives but also actively involves them as contributors and advocates for creating a more accessible world. Through BarrierBeGone, user-generated data forms a comprehensive database on accessibility challenges, providing valuable insights for individuals with disabilities, policymakers, and businesses.

To ensure the reliability of information, BarrierBeGone implements a voting system that automatically qualifies information as untrustworthy if it receives three or more negative votes, in addition to utilizing location-based services to provide relevant data to users. The app also promotes spatial data validation and disseminates information in real-time, enhancing the organization and transmission of data through user participation.

Furthermore, BarrierBeGone encourages user participation through a scoring and rewards system, including a leaderboard that gamifies the user experience. This leaderboard highlights the contributions and successes of users, fostering a spirit of healthy competition and recognition. The app also offers incentives, such as virtual rewards, exclusive access to new features, or tangible benefits to motivate users to actively contribute information about barriers.

The app's architecture consists of a user-facing frontend and a backend that includes a server and a database managed by the Firebase SDK for Android. This database stores detailed information about users and the locations of identified barriers, using unique identifiers to ensure accuracy and security of data. The barrier detection system's interface is designed to be intuitive and user-friendly, with an emphasis on usability and inclusion, offering features like barrier marking and interaction with an integrated map to facilitate navigation and barrier identification by the user (figure 2).

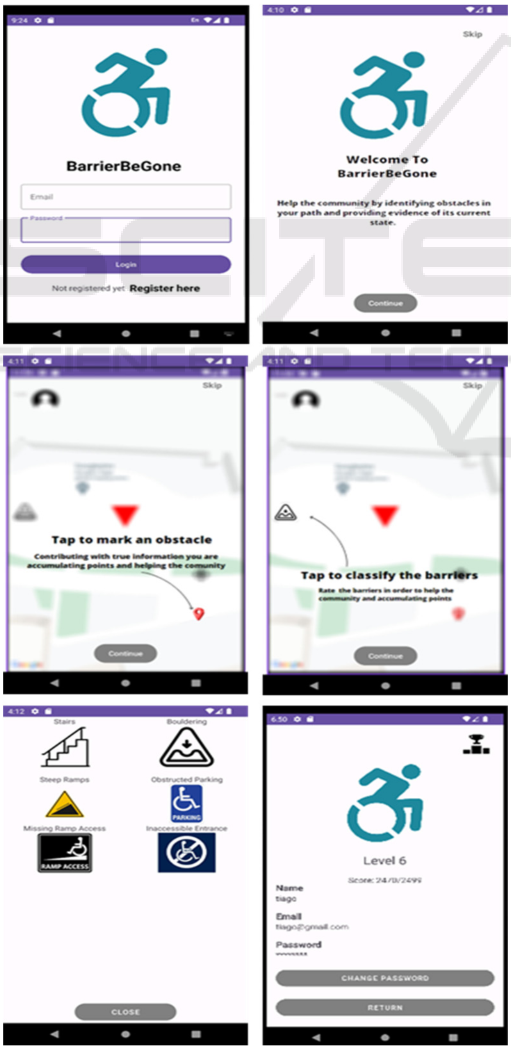

Figure 2: App Barrier BeGone.

3.3 Usability

The usability test session was broken up into three sub-phases to measure the Barrier- BeGone application's usability and usefulness both numerically and qualitatively:

- Pre-test survey - designed to assess participants' levels of digital literacy, determine their mobility limitations, and characterise the sample's sociodemographic features.
- Testing phase - Participants were required to execute a predetermined set of tasks that matched steps needed to be taken in the application mobile prototype. The participants were urged to explain your thinking while carrying out the tasks during its performance.
- Post-test survey - using the System Usability Scale (SUS).

During the testing phase, 9 participants, who had not participated in the previous phase, were utilized. These potential users, involved in the assessment of the barrier identification system, ranged in age from 18 to 52, with a majority being male.

During the testing phase, participants interacted with the BarrierBeGone prototype through seven tasks designed to assess their understanding and usability of the system, with the tasks being completed with high execution efficiency, reflected in an average score of 4.57 out of 5. However, identifying barriers within a 50m radius was found to be more challenging, indicating areas for improvement in system design or user instruction. Despite this, the authentication process was highly rated for ease of use. Feedback from the testing phase led to suggestions for improving the onboarding mechanism, such as increasing text size for better readability and allowing users to bypass or revisit onboarding steps via their profiles. Post-test surveys revealed positive impacts of real-time data on users' mobility and security, emphasizing the system's potential to enhance urban navigation and promote inclusivity.

In a global perspective, the usability evaluation results of the BarrierBeGone barrier identification system are undeniably positive, reinforcing its simplicity, speed, and consistency in promoting accessibility and social inclusion in smart cities, as proposed in this dissertation. The quantitative analysis revealed high levels of ease of execution in most interaction tasks performed by potential users in the mobile application prototype, with average scores exceeding four points on a five-point Likert scale (4.57), as shown in the usability evaluation stage of BarrierBeGone. The average execution time for participants who used the game was approximately 146 seconds, equating to 2 minutes and 26 seconds.

These auspicious results reaffirm the perceived ease of interaction and validate the underlying concept of the barrier identification system.

3.4 Limitation

To enhance the value of the barrier identification system and provide better experiences for its users, another future work is the creation of a route planner that allows users to proactively identify the types of issues they may encounter during their journeys. Although the usability evaluation of the barrier identification system, conducted with representative users, yielded undeniably positive results, there were areas for improvement identified that could enhance the quality and subsequent value of the barrier identification system within the community. These improvements should be considered in a subsequent iteration of BarrierBeGone. Additionally, it is recommended that BarrierBeGone be evaluated in a real mobility environment in urban areas. It is advisable to consider larger samples in future phases.

4 CONCLUSIONS

The initial phase of this project is dedicated to identifying and understanding the challenges faced by individuals with limited mobility. Discussion groups were held with people who have mobility limitations, capturing a wide range of perspectives on the barriers that hinder accessibility in urban environments. These barriers include bouldering, steep ramps, large stairs, obstructed access, improperly occupied parking spaces, and the lack or absence of ramps.

Subsequently, the project shifted focus to the design and development of a prototype for a barrier identification system. This system aims to meet the accessibility and social inclusion requirements outlined in the dissertation's primary objectives. By leveraging the widespread use of mobile and ubiquitous computing in everyday life, BarrierBeGone was conceived as a platform for identifying obstacles. Implemented as a mobile application, it enables users to identify and validate potential physical barriers in real-time that might be encountered by wheelchair users. To ensure the information provided is relevant and delivers a user-centric service, BarrierBeGone incorporates information from its users through a collaborative model, offering contextual data of interest.

The usability of the BarrierBeGone barrier identification system was evaluated to fulfill the final objective of this dissertation. This evaluation aimed to measure both quantitatively and qualitatively the usability and usefulness of the obstacle identification platform. Usability tests were conducted with representative users to facilitate the refinement of the final product.

The evaluation results were overwhelmingly positive. The system's usefulness and the users' intention to frequently use the BarrierBeGone application received widespread acclaim, particularly among participants with mobility impairments, though it was less unanimous among those without mobility impairments. Its simplicity and user-friendliness stood out as disruptive features of the platform, driving the primary motivation for future use intentions and distinguishing it from other accessible solutions available on the market.

Given these successes, enhancing user experiences in the face of various obstacles, and improving accessibility and social inclusion in smart cities are deemed entirely feasible.

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