Usability Evaluation of a Community-led Innovation Mobile App

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Keywords: Mobile Application, Usability, Heuristic Evaluation, Community-led Innovation.

Abstract: Digital media can facilitate collaborative processes among local agents, value endogenous resources, and promote assets associated with territory. This article presents the results of a study concerning the development and validation of a mobile app for promoting the relationship among agents of the Portuguese Centro region's communities/entities. This paper focuses on the results of a heuristic evaluation of the mobile app carried out with two groups of experts in Digital Technologies, Tourism, Health, and Well-Being, besides providing an overview of the mobile app that was developed and a theoretical background regarding community-led innovation, usability, and heuristics. For the CeNTER app prototype evaluation itself, the use of Nielsen's heuristics, a MATCH-MED scale, together with a Think-Aloud Protocol allowed us to improve its usability. This article contributes to a reflection about the evaluation of mobile apps in the scope of territorial-based innovation initiatives, engaging its stakeholders in the process.

1 INTRODUCTION

Community-led initiatives have great potential in the development of cultural, tourism, and environmental projects, enabling valuing endogenous resources and promoting innovation in the territory. Digital technologies can be particularly useful in community-led initiatives, allowing to recreate a "virtual proximity" between the different actors involved in the territory's development process (Martínez-Rolán et al., 2019). They can offer several advantages to community-led initiatives, as, for example, facilitating innovation, because of access to information and experiences; sharing practices, leading to knowledge co-creation and the emergence of new ideas; and enabling their members to improve their practices through a continuous engagement in a meaningful participatory environment (Saint-Onge & Wallace, 2012; Snyder & Wenger, 2010).

However, several studies indicate that community-led initiatives face several challenges, especially in rural areas (Brown & Nylander, 2009; Marré & Weber, 2010). These challenges are related to the fact that local participants, namely elderly people, have difficulties accessing the Internet, present limited digital skills, and lack access to technological equipment. To overcome these challenges, new political measures are required to empower local communities to the social, cultural, and economic valorisation of territories.

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Branco, A., Sacramento, E., Oliveira, E., Tymoshchuk, O., Antunes, M., Almeida, M., Pedro, L., Ramos, F. and Carvalho, D.
Usability Evaluation of a Community-led Innovation Mobile App.
DOI: 10.5220/0011263000003323
In *Proceedings of the 6th International Conference on Computer-Human Interaction Research and Applications (CHIRA 2022)*, pages 81-88
ISBN: 978-989-758-609-5; ISSN: 2184-3244

This study was developed under the CeNTER Program, which has as one of its objectives to understand the active role those digital technologies can play in the process of territorial innovation (Silva et al., 2021). In this context, a digital platform (mobile app) is being designed, whose primary focus is to promote collaboration between the various agents involved in territorial-based innovation processes. The CeNTER mobile app intends to be a tool that encourages internal and external interactions and facilitates communication and collaboration processes, to strengthen existing mediation strategies and stimulate the creation of new ones, as well as new ideas/activities (Tymoshchuk et al., 2019). However, the design of a mobile app for community mediation is still a great challenge due to the variety of initiatives and the diversity of stakeholders (public institutions, companies, and communities) involved in territorial-based innovation processes.

This paper presents the results of a heuristic evaluation of the CeNTER app prototype, which will provide the development cycle with crucial usability data, required to converge to a final solution that will offer a coherent and effective experience about the distinguishing features of this app to its users. The study is supported by a User-Centered Design approach, which focuses on satisfying the user desires and needs (Hartson & Pyla, 2012). Also, it is framed by the User Experience (UX) theoretical basis, guiding the prototype evaluation in the CeNTER Program scope, which will crucial the development of the CeNTER mobile app.

2 BACKGROUND

2.1 Territorial Innovation

Innovation can be translated as the systematization of knowledge shared between actors in the spaces in new products and services. Systematized knowledge, when interacting with the social, historical, and cultural constructs for which they are intended, change the behaviour of social groups in a systemic way, enabling the development by promoting territorial innovation (Ferreira, 2020). In geographically close groups, these historical-socio-cultural constructs are perceived in a systemic way, which characterizes the territories (Keating, 2020).
Territorial innovation is a complex process that results from an intentional collective action promoted by a set of actors and organizations (companies, universities, local government bodies, communities) that interact to develop innovation (Morgan, 1997). So, the initiatives led by groups coordinated from the bottom up respond to the development needs of territories, as they address ecological, social, economic, and political problems of global resonance (Seyfang & Smith, 2007, p. 585).

Furthermore, the sharing of information to solve local problems has become more effective as a result of the integration provided by the dissemination of information and telecommunication technologies, especially mobile apps (Diniz et al., 2019), further enhancing the importance of mobile apps in the territorial-based innovation domain. These digital solutions must meet the community's needs to foster the local economy. To ensure that a product meets users' needs, such mobile digital solutions must be developed under the User Experience (UX) theoretical basis, which is crucial to gather relevant information regarding the interaction with the product.

2.2 User Experience

An experience is a complex event, which is created in the mind of the user and is influenced by many factors, being a completely personal issue (Knight, 2019). Therefore, User experience is subjective and is related to how the user feels regarding a created product. Further, the current concept of UX is strictly related to emotional results that emerged from the user when interacting with a product, such as pride, joy, and fun (Bernhaupt & Pirker, 2013). Therefore, creating an experience is not just about how the product is designed, which structures were implemented or whether state-of-the-art technology is used (Knight, 2019). It is also about how the specific product can help the user to accomplish their tasks successfully and how the user feels when getting involved with the product.

UX is composed of three factors: usability, usefulness, and emotional impact, and generates a memory related to the product interaction. Emotional impact is the affective component of the user experience, focusing on the system as a means that affects the user's feelings. Usefulness focuses on the use of a system to achieve goals and accomplish specific tasks. Usability is constituted by effectiveness, efficiency, ease-of-use, learnability, and the user satisfaction, being the practical component of user experience (Hartson & Pyla, 2012).

The usability factor contributes to the elaboration of a product that is easy to use and is pivotal in creating digital products since it provides products with a low level of difficulty, reducing the platform's

disuse (Partridge, 2017). Since ensuring high usability for a mobile app is of great importance, as a predictor of its acceptance and of its success, is crucial in all phases of app testing (Muchagata & Ferreira, 2019), including early testing with experts.

2.3 Usability

Usability is an essential concept in developing digital interfaces, focusing on users and contexts of use, and ensuring they can achieve their goals with efficiency, effectiveness, and satisfaction. The usability concept was defined by Nielsen (2012) as an attribute with qualitative nature that assesses the ease of use of user interfaces. Usability directly relates to methods for enhancing this attribute during the design process phase that includes the following five main components: (1) the ability to learn - the ease with which users complete basic tasks during the primary interaction with the interface; (2) efficiency - the speed with which users reach their goals after they have learned to interact with the platform; (3) memory - the easiness with which users interact with the interface after a period without using it; (4) errors - the number of errors that are made by the user and the ease with which it is possible to correct them; (5) satisfaction - a component related to the desire and pleasure expressed by the user during and after the interaction with a specific product (Nielsen, 2012).

Due to several specificities related to the small screen, storage capacity, and energy consumption of mobile phones, it is essential that these apps meet a set of basic requirements, such as: being easy to use, being flexible, having a simple and intuitive interface, allowing the user to easily adapt to different contexts of usage, etc. (Feijó et al., 2013; Kumar & Mohite, 2018).

In this sense, usability evaluation of mobile apps is a mandatory process to ensure that such apps are practical, effective, and easy to use (Kumar & Mohite, 2018). Usability evaluation is the generic designation for a set of methods aiming at interface inspection. The final objective is to identify usability issues, through the indication of the severities' level of each issue (Nielsen, 1994). These methods include heuristic evaluation, cognitive pathway, consistency, pattern inspection, among others. One of the commonly available and employed methods for assessing and improving interfaces is heuristic evaluation (Nielsen, 1994).

2.4 Heuristic Evaluation

Nielsen's heuristics (1994) is a systematic evaluation method allowing the identification of problems in user interface design that involves interface analysis. As the author states, heuristic evaluation requires fewer resources than other methods to detect usability issues. As Nielsen (1994) states, "basically, a set of evaluators inspects the interface with respect to a small set of fairly broad principles, which are referred to as the 'heuristics" (p. 152).

This specific method is based on a 10 "heuristic" items checklist, which can be used in interface specifications, prototypes, or complete systems. Nielsen's 10 heuristics include the following guidelines (Nielsen, 1994): (1) Visibility of the system; (2) Match between system and real-world; (3) User control and freedom; (4) Consistency and standards; (5) Error prevention; (6) Minimise the user's memory load; (7) Efficiency of use and performance; (8) Aesthetic and minimalist design; (9) Help and documentation; (10) Help users identify, analyse, and improve from errors.

According to Nielsen and Landauer (1993), between three to five evaluators are recommended to perform a heuristic evaluation, which can identify around 75% to 95% of the problems, considering that an individual evaluator usually finds around 35% of them.

2.4.1 MATCH-MED Scale

Testing the usability of mobile apps can be done using several sets of checklists and protocols available to carry out heuristic evaluations. However, the vast majority of these scales are geared towards generic systems, demanding adaptations to fulfil specific requirements of mobile apps (Hashim & Isse, 2019; Inostroza et al., 2016). Considering that the CeNTER application is aimed at Tourism, Health, and Well-being clusters, a set of MATCH-MED usability heuristics was used.

The MATCH-MED scale aims to evaluate the usability of mHealth systems on smartphones and was developed based on Nielsen's generic heuristics, with the addition of three heuristics specifical for mobile devices (Lacerda et al., 2015; Salazar et al., 2012), which consist of: (1) Minimization of human-computer interaction: Considering that typing on mobile touch screen keyboards is more error-prone than on conventional keyboards, it is essential to minimise user interaction with the mobile app; (2) Physical interaction and ergonomics: Given the limited screen size of a mobile device, the action

controls must present suitable sizes and minimal distance from each other, ensuring the user does not press a button by mistake; (3) Readability and Quick View: Considering that mobile apps are generally used in dynamic contexts, it is essential to ensure quick access to system information by the user (e.g., at a glance).

According to Zhang and Adipat (2005), a comprehensive usability study for a mobile application should assess a variety of issues such as interface design, ease of use, and perceived attitude by the user and measures related to the application's performance.

3 THE CENTER PROTOTYPE

The team researchers developed a CeNTER mobile application prototype based on an in-depth study under this project. That research included a systematic review of the literature, a benchmarking of the communities' digital platforms, a series of interviews with local stakeholders, and two focus groups with representatives of community-led initiatives (Oliveira et al., 2021). The results of these methodological procedures made it possible to identify the main difficulties found on community-led initiatives and led to the proposed digital solution that aimed to fill these gaps.

The researchers chose a card-based user interface design that is both simple and innovative in appearance. This type of interface design tries to provide information in a readable format, easy to navigate, allowing an overview of the application's content and quick access to all categories (Seifi, 2015). Considering the requirements and functionalities defined as important in the proposed digital solution, the medium-fidelity prototype was developed with the support of “Principle” software, an interactive user interface, and animation design software.

The prototype’s content evaluated by experts was organised according to the categories defined by the team as being essential in the mobile application: Initiatives; Events; Entities; Volunteers; Resources and Highlights. These categories were defined during the Focus Group sessions with the local initiatives, through a User-Centered Design approach. In the CeNTER app context, these categories are called "Tabs" and represent the main relevant elements in the community dynamics. Such “Tabs” are organised in horizontal lines on the screen and have secondary content that is modified according to the preferences defined by the user in the app settings (Branco et al., 2021).

By touching each one of the Tabs, a vertical opening occurs on the screen, where it is possible to view suggestions (of local Initiatives, for example) through cards displayed on the screen. Each card presents a single content and appears ordered in a carousel layout.

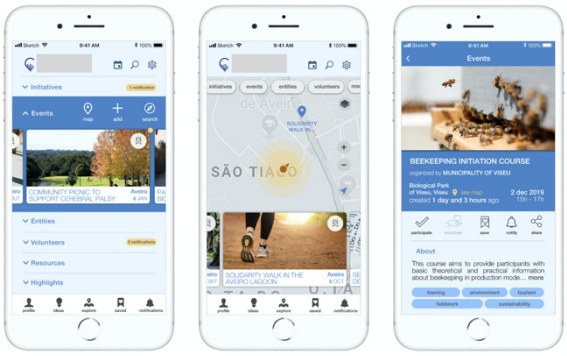

Figure 1: Home screen of the version of the medium-fidelity prototype “CeNTER” evaluated by experts.

4 METHODOLOGY

The evaluation process for the CeNTER mobile application prototype is outlined according to an iterative design methodology (Lorenz et.al., 2010). It provides for the initial testing of app mockups with team members, evaluating medium-fidelity prototypes by experts and laboratory tests with end-users. This article presents the second stage of evaluation of the prototype, which consisted of heuristic evaluation by experts to detect and correct issues related to the prototype's usability.

Through dissemination seminars, organized by the CeNTER team, it was possible to recruit local stakeholders to actively participate in the project as experts. To accomplish the assessment, two panels of experts were organized according to the evaluators’ expertise. In this sense, the first group consisted of five experts in the field of digital technologies, having deep knowledge and experience in developing interfaces. The second group consisted of five experts in the fields of Tourism, Health, and Well-being, who have knowledge of their specific domain and involvement in local community projects.

To determine the severity of usability issues for this study, a heuristic checklist was developed to evaluate the application prototype, based mainly on Nielsen's 10 heuristics (1994). Besides that, three heuristics of MATCH-MED scale (Salgado et al.,

2019) were added to allow the evaluation of mobile apps in health and well-being areas. It is important to note that the researchers chose to add these items on the MATCH-MED scale since Nielson's heuristics do not consider specific characteristics and limitations of mobile devices (Hashim & Isse, 2019), as it was pointed out before.

A total of 44 items were identified in this checklist, which was employed to evaluate the prototype usability. The heuristic evaluation process took place in three stages, according to the proposal of Nielsen (1994): (i) preparation phase, in which the prototype screens for evaluation and the list of heuristics were defined and organised; (ii) evaluation phase, which consisted of collecting data from each expert, individually. The evaluators tested the prototype by identifying the guidelines that were violated and the degree of severity of the problem.

In addition, the Think-Aloud Protocol (Jaspers, 2009) was also employed to obtain immediate feedback from experts about their experience of interacting with the prototype. The application of this method allowed the qualitative evaluation of the prototype based on the experts' verbal comments.

The tests took place at the facilities of the University of Aveiro, with the first group on October 28-31, 2019, and the second group on November 11-29, 2019. In total, 78 screens of the developed application prototype were evaluated. This evaluation consisted of two phases: in the first phase, the experts freely explored the prototype and commented on their doubts about the CeNTER program, and in the second, the experts filled a table of design-oriented heuristics for mobile phone interfaces and apps. A User-Centered Design approach was used as an interactive design process to get users feedbacks and their needs in each phase of design evaluation process.

5 RESULTS AND DISCUSSION

This section presents the results obtained from the usability test, through a heuristic evaluation, of the CeNTER application prototype with the two groups of experts (five users in each group). To consolidate the heuristic validation results performed by both groups, a grid was created for each group to gather all of the obtained results.

A total of 174 usability problems were identified. After eliminating the duplicate issues, 155 unique usability problems remained. Table 1 shows the number of problems identified by each group of evaluators, the severity of such problems and their average severity.

Regarding the severity of problems, it is important to refer that Group 1 (G1) identified 46 (42,2%) cosmetic problems, 39 (35,8%) small usability problems, 21 (19,3%) main usability problems and 2 (1,8%) usability "catastrophes". The group of digital technologies experts identified two problems with score level four. These problems referred to the second heuristic: "Correspondence between the system and the real world" and were related to the following items: "The proposed interactions in the application are similar to real actions"; and "Information appears in a logical and natural order". Those are relevant feedback because the prototype is applied to promoting community-led initiatives and those participants may present different levels of digital literacies. In this sense, a simple and intuitive interface, easily adaptable to different contexts of usage (Feijó et al., 2013; Kumar & Mohite, 2018) is important to make sure individuals use the application properly, which in this case is represented by different territorial agents (communities, entities, networks and citizens).

Table 1: Number of Problems and Average Severities identified by each group of evaluators.

Group	Experts	Total problems	Average severity
G1	Digital Technologies Experts	109	1,78
G2	Tourism, Health and Well-being Experts	46	1,53

Regarding the severity of the found problems, it is important to note that Group 2 identified 14 (30,4%) cosmetic problems, 26 (56,5%) small usability problems, and 6 (13%) main usability problems. It should be noted that no problems with a score of level 4 (usability catastrophes) were reported by the second group.

Tables 2 and 3 show the type of usability problems and average severities identified by each group of evaluators. With the highest Average Severity, Group 1 identified the heuristics: Help and Documentation (2.75), Recognition rather than Reminder (2.5), and Interaction between person and application (2.33). Group 2 reported the following Heuristic Severities Averages: Flexibility and Efficiency (2.25), Help and Documentation (2.2) Recognition rather than Reminder (2), and Interaction between person and application (2). Therefore, both

groups consistently assessed the severity of the heuristic violation. The Mean Average Severity in these two groups was low, with a score close to 1.78 (G1) and 1.53 (G2).

The difference in results among both groups also occurred in the type of the identified problems. The problems identified by Group 2 were more related to the suitability of the prototype for each application domain, as well as the efficiency and type of functionality available to users (Table 3). For example, experts of Group 2 did not observe inconsistencies rectified after the first round of tests, such as different icons representing the same function, or the absence of the return icon on some screens.

Table 2: Type of usability problems and average severities identified by Group 1 of evaluators.

Heuristic	G 1 - Digital Technologies Experts	
	Frequency N=109	Average of Severities
Visibility of system status	11	2.18
Match between system and the real world	11	2.27
User control and freedom	13	1.54
Consistency and standards	7	1.57
Error prevention	5	1.6
Recognition rather than recall	4	2.5
Flexibility and efficiency of use	7	1.85
Aesthetic and minimalist design	12	1.66
Help users recognize, diagnose, and recover from errors	10	1.1
Help and documentation	4	2.75
Interaction between person and application	3	2.33
Physical interaction and ergonomics	8	1.75
Readability and layout	14	1.5

As it is possible to see in Table 2, the maximum number of usability problems, identified by Group 1, included: Readability and layout (14, mean severity 1.5), followed by User controls and free will (13, mean severity 1, 54) and Aesthetics and minimalist design (12, medium severity 1.66). In Table 3, Group 2 identified the following number of heuristic violations: User controls and exercises free will (11, mean severity 1.45), Avoid errors (7, mean severity 1.86), and Matching the system to the real world (6, mean severity 1.5). Identifying these heuristic violations will make it easier to identify and prioritise issues that need urgent attention before the final deployment of the application.

The application of the three heuristics proposed by the MATCH-MED scale allowed the identification of 28 usability problems related to the different specificities of mobile devices, namely "Readability and layout" (16) and "Physical interaction and ergonomics" (8).

Table 3: Type of usability problems and average severities identified by Group 2 of evaluators.

Heuristic	G 2 - Tourism, Health, and Well-being Experts	
	Frequency N=46	Average of Severities
Visibility of system status	1	1
Match between system and the real world	6	1.5
User control and freedom	11	1.45
Consistency and standards	3	1.66
Error prevention	7	1.86
Recognition rather than recall	1	2
Flexibility and efficiency of use	4	2.25
Aesthetic and minimalist design	1	1
Help users recognize, diagnose, and recover from errors	4	1.9
Help and documentation	5	2.2
Interaction between person and application	1	2
Physical interaction and ergonomics	0	0
Readability and layout	2	1

The Think-Aloud Protocol application allowed the collection of 124 suggestions for improving the prototype under evaluation, which will be considered in the following stages of the mobile application development. The first group of experts made 83 suggestions for improvement, which were very focused on technical aspects and improving interactions. For example, “standardise the ‘save’ icons on the right side of the ideas screen with the rest of the application” (G1E1) and “Drag and drop visual feedback is required” (G1E2), respectively, for the evaluators E1 and E2 of Group 1.

In contrast, the second group of experts mainly commented on the concept of the CeNTER application, functionalities, and effectiveness and did not mention technical aspects. This group made several suggestions regarding the lexical inaccuracies

used in the application. It is important to note that both experts' groups highlighted the "Resources" and "Volunteer" components as being the most innovative features of this application: "Resources and volunteers are the differentiating elements of the platform" (G2E5). Overall, the prototype was described as having a simple interface, with an appropriate layout, easy to use and not requiring much effort from the user.

The study's results demonstrate that usability testing is an effective way to significantly improve the interface of a future mobile app, favouring the user experience, as mentioned by other authors (Lacerda et al., 2016; Salazar et al., 2012). The methods and techniques of application production were supported by methodologies oriented to the user's requirements and were anchored in a spiral of evaluation of the prototype, resulting in improved versions of the pilot app, attending to users' statements, and developing an application with a more attractive look & feel.

6 CONCLUSIONS

As the development of the CeNTER prototype requires an iterative design process, performing early tests is a crucial part of the system design to detect usability problems and make essential improvements. Through the techniques used for the presented evaluation, it was possible to achieve value data, as the experts are from different areas of knowledge.

Therefore, according to the current study findings, the identification of usability problems facilitated the identification and prioritisation of problems that need urgent attention before the final implementation of the application. In this case, the heuristic "control and freedom" deserves special attention, since it received the major severity score by both groups. Furthermore, a decrease in the heuristic values between the two groups was verified, which leads to the conclusion that the changes made after the first round of tests helped for the improvement of the prototype.

This study also showed the importance of developing heuristic usability evaluation scales. As already mentioned, the researchers applied three items proposed by the MATCH-MED scale, which allowed us to identify usability problems related to the specificities of mobile devices. The evaluation of the prototype, not only by professionals in the field of digital technologies but also by professionals in areas related to the application, such as tourism, health, and well-being is also important. It is essential to mention that the professionals in the areas of tourism, health, and well-being, who participated in this study, have a strong connection with different community initiatives and deeply know the local associative dynamics, which was very advantageous for evaluating the prototype.

Future work includes performing laboratory tests with end-users, which are of most importance in this project, requiring accommodation of the experts' suggestions for improvements. Some limitations of this work include the fact that Principle software does not allow to test some features and interactions of the prototype, such as writing on the interface and changing the letters' size for accessibility. Besides, the Principle software only works with iPhone, which limits the evaluation using Android devices.

Specifically, it is hoped that this app can make a difference in everyday life, promoting community-led initiatives, towards adding value to local resources and, therefore, the increment of the region's social, cultural, and economic levels.

ACKNOWLEDGEMENTS

This work is financially supported by national funds through FCT – Foundation for Science and Technology, I.P., under the project UIDB/05460/ 2020

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