Promoting community-based networks through digital media

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Abstract

Digital media can provide an essential contribution to the development of local communities by creating digital environments that facilitate the sharing of information, dissemination of knowledge, and construction of organizational learning. Digital media can also promote interaction and collaboration processes among different regional agents, fostering a continuous flow of territorial-based innovation. The study reported in this paper was carried out within the research activities of the CeNTER project, aiming to deepen the knowledge about the conditions that influence the dynamics of community-led territorial-based innovation in the Centro Region of Portugal, focusing on the areas of Tourism, Health, and Wellbeing. As part of this project, a mobile application is being designed, aiming to strengthen the relationship among agents of local communities/entities and to promote mediation mechanisms among all stakeholders in the process of territorial-based innovation. This paper presents the main concepts underlying the development of the CeNTER application and the outcomes from a usability evaluation of the mobile app prototype. The first section discusses the most relevant topics that this paper covers. In the second section, an overview of the theoretical background in digital media used to promote territory-based innovation is presented. The third section describes the concept of the CeNTER application and the main features of the prototype/mobile app. The fourth section addresses the methodology adopted for evaluating the prototype and the fifth presents the main outcomes of this process. Finally, the sixth and final section presents the main conclusions about the potential of the CeNTER application, and current and future research activities.

Keywords: Territorial innovation, Hypermediation, User Experience, Usability, Community-led initiatives.

Introduction

Community-led initiatives have great potential in developing cultural, tourism, and environmental projects, making it possible to value endogenous resources and promote innovation in the territory. Digital technologies can be especially useful in community-led initiatives, allowing them to establish a "virtual proximity" between the different actors involved in the territory's development process (Saint-Onge & Wallace, 2012).

To create a digital solution for the promotion of community-led innovation in the Centro Region of Portugal, a research was carried out which included several steps: a systematic literature review (Silva et al. 2020) of the Centro Region's innovative initiatives; a benchmarking of websites and social networks (Tymoshchuk et al. 2019a; Martínez-Rolán et al. 2019); interviews with leaders of community initiatives (Renó et al., 2019; Silva et al. 2018; Tymoshchuk et al. 2019b), as well as two focus groups attended by representatives of initiatives that stand out from their dynamism in the Centro Region (Silva et al. 2019).

Based on these surveys, a reference framework for digital mediation strategies was developed, presenting a modular structure based on local development agents and innovation-promoting initiatives, interconnected by hypermediation dynamics (Tymoshchuk et al. 2019c). The synthesis of all the information obtained in this process allowed us to define three main topics that hypermediation can assume in the process of promoting territorial based innovation: i) information distribution, which facilitates the recording and sharing of data between participants, partners, and the general public, enabling the visibility of initiatives and activities to be enhanced and the building of their "brand"; ii) communication, which promotes processes of interaction and collaboration, allowing each initiative to guide its activities towards the execution of its objectives and the growth of the entities/initiatives itself; iii) hypermediation of the innovation processes, which encourages the creation, evolution, and implementation of innovative ideas and the promotion of networks that benefit the civic involvement of populations in processes of territorial development (Tymoshchuk et al. 2019c, p.1014).

The concept of the CeNTER mobile application was also defined, which consists in bridging communication and feeding interaction gaps identified by the agents of the communities, to make the initiatives more open and to stimulate the citizen's involvement and participation in the activities that promote the territory development (Renó et al. 2019a).

Considering the preceding information, the main objectives of the CeNTER application under development are defined as follows: i) to promote mutual knowledge among territorial agents (initiatives, entities, citizens, etc.); ii) to foster interaction and collaboration between initiatives/volunteers/entities/local populations; iii) to facilitate the sharing of information among users; iv) to favor the articulation and hypermediation of activities of the different initiatives; vi) to encourage capacity-building actions in the context of community-based initiatives (Renó et al. 2019a). Further, the CeNTER mobile application aims to promote new planning and management mechanisms for a sustainable future of the territory, based on the potential of the local community and the enhancement of local resources (Renó et al. 2019a).

This paper aims to present the main concepts underlying the CeNTER digital application, and the main outcomes from a usability evaluation of the mobile app prototype made by invited experts. The results encompass qualitative and quantitative data, which helped refine the prototype under evaluation and gather relevant suggestions concerning usability and design issues.

Conceptual background

According to Oliveira & Campolargo (2015), regarding the use of digital platforms, the citizens can co-create solutions for their wishes, interests, and needs. Digital technologies are a key piece of the innovation

ecosystem in which user-driven innovation, participation, collaboration, co-design of services, and gamified processes are expected to lead to sustainable and scalable solutions for a city and community.

Community-led initiatives can benefit from digital solutions, being essential to understand the community for the design process. Van Zuthem (2014) defines a community as "a group of two or more mutually connected people, having a common characteristic and collective purpose that requires collective action" (p.2). The basic principles for a group of people to be recognized as a community are related to the number of members, a mutual structure, and a collective purpose. For the CeNTER project, a glossary was prepared, being community defined as "(...) a group of people who share affinities and, voluntarily, develop joint actions, in a physical and/or virtual environment, in the context of a territory and produce, repurpose and share information relevant to the development of that territory" (Renó et al., 2019a, p.1).

An approach that maximizes the success of a digital solution is the "User-Centered Design" (UCD) method, since it is wholly centered on peoples' needs and desires (Hartson & Pyla, 2012). In this sense, as the UCD defines the process necessary to develop products that better fulfill the objectives related to usability (Fonseca et al., 2012). Therefore, UCD is highly recommended for the designing processes in the community since it seeks to understand the citizens' needs and feelings.

Also, Rosenzweig (2015) affirms that a participatory design constitutes a benefit to the community, since it provides hints and the understanding of the common problems to be solved. One of the biggest challenges of participatory design and the development of new technologies is the understanding of user participation in the design process. According to Markel et al. (2004), the participatory design includes "partnering with community groups as they pursue their goals and, in some cases, suggesting ways that a group might redirect their efforts to achieve more favorable outcomes." (p. 8). Through participatory design it is possible to support sustainability in community organizations, since the participation of the citizens occurs throughout the design process (Markel et al., 2004). According to Wanick (2020), the involvement of all stakeholders in developing new technologies is crucial for participatory activities to occur. The techniques used in the design process should be aligned with the stakeholder's perspective, for example, through establishing a shared vocabulary and recognizing the stakeholder as a specialist of the community's environment.

Mirafshar (2019) points out the existence of two major principles in design thinking, which are achieving an empathetic connection with the audience and applying an iterative mindset (test solutions, gather evidence, and iterate). The author highlights that using these principles can enrich an understanding of the user's needs, as well as better disclose what factors influence the success of a mobile application.

According to Hartson & Pyla (2012), the user experience is composed of usability, usefulness, and emotional impact, generating memory after the interaction. Usability is the practical component of user experience, being constituted by "[...] effectiveness, efficiency, productivity, ease-of-use, learnability, retainability, and the pragmatic aspects of user satisfaction" (p.163). Usefulness focuses on the use of a system as a means to achieve objectives. Emotional impact is the affective component of the user experience, focusing on the user's feelings.

Nielsen's (1994b) heuristics is a systematic evaluation method based on a set of usability principles that allows identifying problems in user interface design and involves interface analysis. This method is based on a 10 "heuristic" checklist, which can be used in interface specifications, prototypes, or complete systems. Nielsen's ten heuristics include the following guidelines: i) visibility of system status, ii) match between

system and the real world, iii) user control and freedom, iv) consistency and standards, v) error prevention, vi) recognition rather than recall, vii) flexibility and efficiency of use, viii) aesthetic and minimalist design, ix) help users recognize, diagnose, and recover from errors, and x) help and documentation (Nielsen, 1994b).

In accordance with Nielsen & Landauer (1993), three to five evaluators are recommended to perform a heuristic evaluation, which can identify around 75% to 95% of the problems. Originally, Nielsen's heuristics were designed for desktop environments, therefore it didn't consider specific features and limitations of mobile devices, such as the small screen, storage capacity, and power consumption. In 2020, the Nielsen heuristics were updated to add current features and examples, keeping the core intact, as ten heuristics have been an essential tool in developing user interfaces since 1994 (Nielsen, 2020).

Evaluating the usability of a mobile application is of great importance to ensure its good usability and acceptance. Mobile applications must meet several essential requirements, such as being easy to use, flexible, simple and intuitive to the interface, and allowing the user to easily adapt to the environment of use (Feijó et al., 2013). In this context, several studies have been developed aiming to adapt heuristics to the specific characteristics and limitations of mobile devices, establishing a set of heuristics for smartphones (D'Carlo et al., 2017; Feijó et al., 2013; Krone, 2013; Silva Junior et al., 2019, Wangenheim et al., 2017).

The MATCH scale was developed to address this issue aiming to use heuristics to evaluate a smartphone system's usability. This scale was based on Nielsen's generic heuristics with the addition of three mobile device heuristics (Lacerda et al., 2016; Salazar et al., 2012): i) minimize human-computer interaction - considering that typing on mobile touchscreen keyboards is more error-prone than on conventional keyboards, it is important to minimize user interaction with the app; ii) physical interaction and ergonomics - given the limited screen size, it is considered necessary that the action controls are adequately sized and at a distance from each other so that the user does not press the button by mistake; iii) readability and quick view - considering that the mobile app user is generally interacting with the app in dynamic contexts, it is important to ensure that the user can get crucial system information quickly (e.g. at a glance) (Machado, 2017). The scale features a checklist that serves as a reference for evaluating the usability of mobile apps (Von Wangenheim et al., 2017).

Methodology

The CeNTER Prototype development

The development of the application prototype used the co-creation approach and had the involvement of ten local community initiatives. In this context, the organization of two focus groups comprising various local stakeholders allowed the definition of the main functionalities of the application under development CeNTER. Furthermore, a brainstorming technique, which involved the entire project team, was employed to identify the main features that should exist in the prototype and the more suitable device to be used, being the smartphone the chosen one.

The choice of the mobile format took into account the success of smartphones in terms of widespread use in all social strata, demonstrating the significant democratization in the use of these digital devices

worldwide. A user flow was created, allowing to identify the main interactions and the necessary screens for the elaboration of the prototype. Subsequently, low-fidelity mockups were created, tested, and discussed among the team members.

The prototype's sketches were converted to wireframes on the "Sketch" application. At this stage, improvements were also made with the team and later applied to the wireframes and screens that resemble the look and feel of the mobile application, being later used to create a medium-fidelity prototype. The project used the "Principle" software[1], which allows the development of a prototype capable of realizing complex interactions, such as dragging on a map, swiping on a carousel menu, or tapping to collapse visible content.

Evaluation methodology

The user evaluation process of the CeNTER app relies on a spiral model of iterative design, including early testing of the low fidelity mockups with the team members, medium-fidelity prototype evaluation by experts, and laboratory tests with end-users.

Two evaluation panels, each one constituted by five experts, were organized according to the evaluators' expertise to validate the CeNTER application prototype. As previously said, three to five evaluators are able to identify between 75 to 90% of the usability problems, making the chosen sample (10 experts in total) suitable for the test's purpose (Nielsen & Landauer, 1993).

In this sense, the first panel consisted of five experts in the digital technology's field, who have the knowledge and experience in developing interfaces. The second panel consisted of three experts in the field of Tourism, and two in the field of Health and Wellbeing, who have knowledge of the domain and are involved in different community projects. The two panels did not test the same app, since the main improvements were made before the evaluation by the second panel. Therefore, the methodology consists of two different stages, considering the iteration made, being the first stage the tests with digital technologies experts, and the second, the evaluation by Tourism, Health and Wellbeing specialists.

Since the tests with experts were essentially aimed at analysing the main functions of the prototype's screens, guiding the next phases of the development, the goals of the experts' evaluation were: i) validate the CeNTER prototype concept; ii) verify the acceptance of the interactions within the prototype (Drag and drop interaction mode, for example); iii) evaluate the user interfaces' aesthetic; iv) evaluate the usability of the prototype; v) collect technical and fundamental issues for further on improvements; vi) collect suggestions for improvements and prototyping errors.

In order to achieve the goals of the test and maximize the identification of usability problems, two techniques were used: i) the inspection technique (Heuristic Evaluation), based on checklist and verification items, which allow the evaluators to identify usability problems; and ii) the observation technique, in which an exploratory overview of the prototype using a think-aloud protocol was encouraged (Cho et al., 2019). Additionally, the interactions and comments of the evaluators while performing the test were recorded in video.

[1] https://principleformac.com

The heuristic evaluation process took place in three stages, according to the proposal of Nielsen (1994a): i) Preparation phase in which the prototype screens for evaluation and the list of heuristics to be used were defined and organized; ii) Evaluation phase, to collect evaluation data from each evaluator, individually, that tested the prototype by identifying the guidelines that were not followed and the degree of severity of the problems iii) Results consolidation phase and results report at the end of the tests, during which the data collected from the two panels of evaluators was analyzed and compared. During this process, the evaluations were made in person and under equal conditions. Assessment data were collected using the same heuristic checklist and observation record.

For this study, a heuristic checklist was adapted from the ten Nielsen heuristics (1994b); three heuristics were added from the MATCH scale (Salazar et al., 2012). A total of 44 items were present in the checklist to evaluate the prototype usability.

The tests took place at the facilities of the University of Aveiro, with the first panel on October 28-31 and with the second panel on November 11-29, 2019. The evaluation was organized in two phases. The first phase included the expert's free exploration of the prototype, their comments, and the answering of their doubts. The second phase included filling in a table of design-oriented heuristics for mobile phone applications by the experts.

Results

The results will be presented in two parts. The first will present the prototype after the modifications made subsequently to the two stages of evaluation. The second part presents the test results with the expert panels.

The CeNTER Prototype

This study intends to develop the CeNTER mobile application (Carvalho et al., 2020) with an interface that allows both a pleasant user experience and intuitive and fast navigation. A consistent layout was delineated transversely to the screens, with coherent and easily identifiable graphical elements that allow effective interaction on any page. In this sense, the application's first screen consists of the main menu with an interface for communities (see the second image from the left of Figure 1. The user has access to tabs that collapse or expand when the respective button is tapped. In each of those tabs, a carousel with cards of different initiatives, events, entities, volunteers, resources and highlights is presented. It is possible to drag and drop the card vertically to save it to the favorites list in each tab. This drag and drop function is also used to remove cards from favorites.

Figure 1: Sample of screens from the CeNTER application (from left to right): Tutorial, main menu, map and details of an event selected by the user.

The map (see the third image from the left of Figure 1), despite having a carousel, similar to the main screen, also has a layout and interactions similar to the Google Maps mobile application. From this screen, the user can drag his finger on the screen to explore the map, pinch with two fingers to zoom in and zoom out and tap on a pinpoint to see more details about it, which will appear at the bottom of the screen. The content on the cards allows the user to view brief information on the small card which, after being tapped, expands to show more details (see first image from the right of Figure 1).

The prototypes' header presents, in addition to the project name and the CeNTER logo, calendar features, general search across the application, and access to settings. The footer is made up of other functionality options, such as accessing the profile and ideas, visiting saved items, viewing notifications and general exploration on the map. The user has access to features, like: i) the calendar of events shared by the communities; ii) tools for searching initiatives, events, entities, volunteers, resources and highlights; iii) the map that allows locating its contents; iv) access to ideas shared by the community; v) access to notifications to understand any news or changes to existing content in the application; vi) proactive actions such as creating and sharing ideas and other content; vii) save content the user likes in a list; viii) access to settings to customize the users content viewing preferences. The interaction is made from the input of hand gestures on a touch screen, and the interface consists of tangible graphic elements. In most tangible content, interaction is performed via tap.

In conjunction with the main screens presented above, a tutorial was also developed (first image from the left of Figure 1). It is shown to the user for the first time he opens the application. The tutorial consists on an animation, explaining the different contents organized/hierarchized in the application, which are: i) the creation and sharing of ideas, initiatives and events; ii) the demand of resources, volunteers and

partnerships; iii) explanation of possible interactions within the application, such as creating a favorite list of content or even exploring the location of specific content on a map.

After presenting the developmental phases of the CeNTER mobile application prototype, the following sections will present the most relevant results achieved by the evaluations from experts.

Results Obtained Through the Think-aloud Protocol

Considering the main goals of the performed tests, the expert's recommendations proved that an application to promote territorial based innovation is a sustainable and timely proposal, although there are still some issues to be reviewed. The following results are presented according to the assessment technique used, i.e., observation & report, and heuristic evaluation. By reporting the interactions and comments of the experts through the think-aloud protocol, it was possible to extract both qualitative and quantitative outcomes, while the heuristic evaluation provided valuable quantitative data. To define the main improvements to be accomplished at the prototype, the registered inputs were separated into two tables, according to the corresponding panel of the test. Subsequently, each input was measured according to the level of modification priority of the item, and to the level of effort that the task requires. The results are described below.

One hundred and twenty-one (121) inputs were reported during the free exploration by the digital technology experts, 83 of which were considered as suggestions for application improvements, 30 as prototyping errors and eight were interpreted as suggestions for improvement and prototyping errors. Prototyping errors correspond to inconsistencies in the use of the prototype and the user interface, such as different icons representing the same function or lack of an icon that should be present by default (e.g., the absence of the return icon on some screens, with consequent impossibility to perform this action through the mode considered as standard in the prototype). An example of a suggestion that enabled the identification of a prototyping error is: "*Standardize the 'save' icons on the right side of the ideas screen with the rest of the application."* (Panel 1 – Expert 1). An example of a suggestion for improvement is: "*In 'Ideas', add year information and not just day and time*." (Panel 2 – Expert 2).

Regarding the inputs collected from the Tourism, Health and Wellbeing specialists' assessment, a total of 53 inputs were obtained during the free exploration of the prototype by the experts, 41 considered by the CeNTER team as suggestions for application improvements, 11 as prototyping errors and one as improvement suggestion and prototyping error. In this case, the prototyping errors were considered screens with too much information, interactions that conveyed a sense of lack of control of the prototype contents, and inconsistency in icons. Lexical inaccuracies mainly represented improvements suggestions, due to lack of expertise in the specific areas of expert knowledge. An example of a prototyping error is: "*A person can get lost while switching between tabs, and not be sure on how to go back when opening one tab and how to minimize another.*". (Panel 2 – Expert 3). An example of suggestions for improvement is: "*Change 'sport' by 'physical and sport activity'. Sport is interpreted as a competitive action".* (Panel 2 – Expert 4). Table 1 shows the number of inputs registered by the CeNTER team on both set evaluations.

It is important to note the considerable difference in the numbers of inputs registered between the two panels. Panel 1 (P1) consisted of digital technology specialists who, in addition to personal considerations about the concept, functionality, innovation and other principles, closely observed the technical aspects of

the prototype. In contrast, specialists of Panel 2 (P2) mainly commented about the concept of the CeNTER prototype, functionality and effectiveness for the end-user, while technical factors were not so mentioned. One example is that only the experts of the digital technology area were able to explore the Drag and Drop interaction without help from the CeNTER team.

Table 1: Expert's inputs

Inputs	P1	P2	Total
Total of inputs	121	53	174
Suggestions for improvement	83	41	124
Prototyping errors	30	11	41
Errors and suggestions	8	1	9

The data extracted in the evaluations were also analyzed according to the priority of each item to correct. In the first Panel of testing, 22 inputs were considered as high priority by the team, since they were problems that affected the usability of the prototype, influencing the high quality of the user experience. Forty-one were considered as medium priority, or issues that altered the usability of the system but did not impair the quality of the user experience, and 58 were considered as low priority, as they did not affect the quality of the user experience. Of the specialists' inputs, 14 were considered as high priority by the team; 12 were considered as a medium priority, and 27 were considered as low correction priority (Table 2).

Table 2: Level of priority for the correction of the prototype

Level of priority	No. of inputs P1	No. of inputs P2
High priority	22	14
Medium priority	41	12
Low priority	58	27

In addition, the effort level for the improvement of the prototype was evaluated (Table 3). Thus, in the first Panel of testing, 57 inputs present a low level of effort as they require a short time to solve the error/problem. Forty-two data were considered as holding an average effort level since they required some time for error/problem resolution, and 22 were considered as a high effort level, i.e., they required a long time for error/problem resolution. In the specialists' case (Panel 2), the number of items that represent a low level of effort is nine, while 13 were interpreted as being average effort level, and 31 were considered as a high effort level.

Table 3: Level of effort for the improvement of the prototype

Level of effort	No. of inputs P1	No. of inputs P2
Low level of effort	57	9
Medium level of effort	42	13
High level of effort	22	31

Lastly, the inputs were divided according to each correspondent screen. Table 4 shows the number of inputs related to the main screens tested.

As previously said, aiming to determine the main modifications for the prototype's improvement, all the above information was separated into two different tables, according to the corresponding panel of the test. To choose the modifications to be made at the prototype by the CeNTER team, the key factors taken into account were the level of priority of each item registered and the level of effort for the improvement at the prototype. Thus, the expert's inputs were measured by the level of priority and level of effort of the respective modification outlined. The items with a high level of priority and low level of effort had the most chance to be taken for adjustment. Thus, although all results are shown together in this paper, this is done for comparison purposes only, as they were analyzed separately. Each phase gave rise to modifications that reflect the inputs of each expert set.

After analyzing the tables, the first panel of tests gave rise to fourteen items to be modified at the prototype, all demanding a low level of effort to be made. Six items presented a high level of priority, seven had a medium level of priority, and one presented a low level of priority. From the table of the second panel of tests, 20 items were selected to be modified at the application prototype. Thirteen items had a high level of priority, six had a medium level of priority, and one got a low level of priority. Regarding the required effort, seven demand a low level of effort, while 7 and 6 demand an average and high level of effort, respectively. Examples of the selected improvements from the first panel of tests were: "*It should be able to return to a previous screen in the tutorial*." (Panel 1 – Expert 1), "*The search function on the screen 'ideas' should be consistent with the rest of the app.*" (Panel 1 – Expert 3 and 4), "*The 'search' and 'settings' icons have the order changed on the 'notifications' screen, taking into account what you see on the home screen or map."* (Panel 1 – Expert 5) and "*Standardize the 'saved' icons, on the right side of the screed ideas, with the rest of the app*." (Panel 1 – Expert 5).

Examples of the selected improvements from the second panel of tests were: "*Should be better hierarchized / explained to understand the contents present in the platform (initiatives, activities, volunteers, resources, etc)*." (Panel 2 – Expert 4), "*It is suggested to find another nomenclature for initiatives, as they are confused with activities*" (Panel 2 – Expert 1, 2, 3 and 4), "*Drag and drop gesture is very fast. It seems to have no control over the interaction elements*" (Panel 2 – Expert 1 and 4) and "*On the 'share' screen: what is the difference between SMS and Phone icons?*" (Panel 2 – Expert 1, 2, 3 and 4).

Although the contrast in the number of inputs described between the two panels (with panel 1 presenting a significantly larger amount), some inputs are worth highlighting since both panels pointed them out. Overall, it was a consensus that the Drag and Drop interaction system is a challenge regarding usability.

Only the experts of the digital technology area were able to explore this interaction mode without any clue from the CeNTER team. However, considering that this kind of interaction is not common and has been successfully used by other applications, such as Tinder, the users may become familiar with this interaction after the first use. In terms of interaction, the swipe between the cards had good acceptability among the evaluators. Still, according to most of them, it won't be possible to use the carrousel with a high amount of information in the application's database. According to some experts, an alternative could be using a list format instead of cards.

Table 4: Inputs according to the prototype interface

Interfaces	**No. of inputs P1**	**No. of inputs P2**
Tutorial	11	2
Main screen	21	19
Profile	10	3
Register of an initiative or activity	16	4
Ideas	16	2
Maps	7	3
Agenda	8	1
Saved	5	1
Notifications	6	2
Details of an activity / initiative / entity	16	9
Others	5	7
Total	121	53

Another significant input is concerned with the blurring between "Activity" and "Initiative" definitions. For the majority of the experts, those two titles are equal and correspond to the same idea. The team agreed to change the name "Activity" to "Event" since, in the context of the CeNTER application prototype, the activity is related to any action or event which happens in a specific place and date, or period. Additionally, overall, the interface was well evaluated and received a lot of praise, mainly the color palette used on the idealization and development of the prototype. The size and font used were also appreciated by the experts of both panels.

Finally, it is important to emphasize that the concept of the CeNTER application prototype has been well evaluated among the experts of both panels. In this aspect, the "Resources" and "Volunteer" components were highlighted as being the most innovative features of the application: "Resources and volunteers are the differentiating elements of the platform." (Panel 2 – Expert 5). Since the specialists of the second panel are more familiarized with the existing available territorial innovation services, this panel of evaluators

proved to be a valuable choice for the prototype assessment, as they were able to provide significant contributions for the success of the application: "*It is suggested to convert the app into a website to be accessible to more people in Portugal. Make it a more universal alternative because it is an innovative tool, and it can be complex and demanding for the average user*." (Panel 2 – Experts 1, 5).
In contrast, Panel 1 provides essential technical inputs, which directly impact the prototype usability: "*Drag and drop visual feedback is required: card absorption animation on save / delete balls. Swipe diagonally can lead to the mistake of dragging the recommendation*." (Panel 1 – Experts 2, 3, 4).

Heuristic Evaluation

After performing the heuristic evaluation and completing the checklist, the general opinion about the prototype was characterized as quite positive. Overall the prototype was considered to have a simple interface: the page layout was appropriate, easy to use, and did not require much effort on the part of the user; no incongruities were detected in the form of presentation, although some errors were indicated in the passage of links and in the use of some specific terminology in the area of Health and Welfare.
The heuristic evaluation of the prototype was performed through a comparative analysis between the evaluation results of two expert panels. A grid was created that gathered all the results to consolidate the heuristic validation results performed by both panels. Next, the grids were analyzed and compared. Table 5 shows the number of problems identified by each panel of evaluators, the severity of problems, and the average of severity.

Table 5: Number of Problems and Average Severities identified by each panel of evaluators

Panel	**Experts**	**Total problems**	**Severity of problems**				**Severity Average**
			1	2	3	4	
1	Technology Experts	109	46	39	21	2	1,78
2	Tourism, Health and Wellbeing Experts	46	14	26	6	0	1,53

As we can see in Table 1, the panel of technology experts identified a higher number of usability problems (109) than the other panel (46). Regarding the severity of problems, it is essential to note that Panel 1 identified: 46 problems with score 1 (visual problem only), 39 problems with score 2 (small usability problem), 21 problems with score 3 (main usability problem) and two problems with score 4 (usability catastrophe). Two problems with score 4 were identified by the same evaluator from Panel 1. These problems refer to the heuristic "*Correspondence between the system and the real world*" and are related to the items "*The proposed interactions in the application are similar to real actions*" and "*Information appears in a logical and natural order*". No violations with score 4 were reported per the second panel.
With the highest Mean Severity, panel 1 identified the heuristics: Help and Documentation (2.75), Recognition rather than Reminder (2.5), and Interaction between person and application (2.33). Panel 2 reported the highest Mean of Heuristic Severities: Flexibility and Efficiency (2.25), Help and Documentation

(2.2) Recognition rather than Reminder (2) and Interaction between person and application (2). Therefore, both panels were quite consistent in assessing the severity of the heuristic violation. The Mean Severity in the two panels was low, with a score close to 1.78 (P1) and 1.53 (P2).

The difference in results between panels also occurred in the type of problems identified. The problems identified by Panel 1 were more focused on prototype design, robustness, and accessibility (Table 6). The problems identified by Panel 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 6: Type of violated heuristics and Average Severities identified by each panel of evaluators

Nº	**Heuristic**	**P1- Technology Experts**		**P2 - Tourism, Health and Wellbeing Experts**	
		Number of Problems	Average of Severities	Number of Problems	Average of Severities
1	Visibility of system status	11	2.18	1	1
2	Match between system and the real world	11	2.27	6	1.5
3	User control and freedom	13	1.54	11	1.45
4	Consistency and standards	7	1,57	3	1,66
5	Error prevention	5	1,6	7	1.86
6	Recognition rather than recall	4	2,5	1	2
7	Flexibility and efficiency of use	7	1,85	4	2.25
8	Aesthetic and minimalist design	12	1.66	1	1
9	Help users recognize, diagnose, and recover from errors	10	1,1	4	1,9
10	Help and documentation	4	2,75	5	2.2
11	Interaction between person and application	3	2.33	1	2
12	Physical interaction and ergonomics	8	1,75	0	0
13	Readability and layout	14	1,5	2	1
	Total	109	1,78	46	1,53

As it is possible to see in Table 2, the maximum number of heuristic non-observations, identified by Panel 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). Panel 2 identified

the maximum number of heuristics non observations: 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 non-observations will make it easier to identify and prioritize issues that need urgent attention before the final deployment of the application.

Discussion and Conclusion

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 issues and identify important improvements to be made. Through the techniques used at the presented evaluation, it was possible to collect valuable data, inquiring experts from different areas of knowledge. In this regard, the nature of the experts' area oriented the character of suggestions (Almeida et al., 2017), with the most technical issues naturally being pointed out by the professionals of the technologic area.

Usability tests proved to be an effective way to acquire information that contributes to significantly improving the interface of a future mobile application, favoring the user experience, as evidenced by other studies (Lacerda et al., 2016; Salazar et al., 2012). The user-centered design approach, used in all stages of the CeNTER prototype development, contributed strongly to the understanding of the users' needs.

Moreover, the methods and techniques of production of the application were supported by methodologies oriented to the needs and requirements of users, while being anchored in a continuous spiral of evaluation-correction of the prototype, resulting in improved versions of the pilot application. Such developmental characteristics make it possible to build highly usable applications. At the same time, the spiral evaluation-correction model will make it possible to listen to users' opinions and, consequently, to develop an application with a more attractive look & feel.

In this context, it is important to highlight the aggregation of the participatory component in the CeNTER mobile application. The platform intends to promote new ideas, which aim to leverage regional potential built through discourses arising from personal interests in social spaces. This characteristic consolidates the participatory culture, which raises the articulation between community members while elevating the user to the role of creator and producer of texts and artefacts, which are shared or distributed in social environments (Ritzer & Jurgenson, 2010).

Through the conducted tests, the development of a community-based territorial innovation application proved to be a sustainable and timely proposal, as the " CeNTER" prototype concept was properly approved. Additionally, the prototype seems to be a remarkable novelty, since it brings up new features, such as the "Resources" and "Volunteers" and comes up with unconventional interaction paradigms. The results also provide the means to verify the decrease in the heuristic values concerning usability issues between the two panels, giving a stamp of approval that the changes made after the first round of tests improved the prototype.

Regarding sustainability, the CeNTER mobile application is expected to be self-powered by local initiatives, which share events, ideas, resources, and volunteers with the community. Additionally, it will be a tool that can be adapted and supported by public entities in the Centro Region of Portugal, as it can provide relevant data about innovative projects that arise in the community. As Srnicek (2017) states, the more people interact, the more information can be collected and used. Digital platforms produce and depend on "network

effects", that is, the greater the number of users the more valuable a platform becomes. Therefore, the implementation and sustainability of the CeNTER platform will involve the elaboration of strategies to attract a significant number of users.

This collaborative process turned possible to learn many lessons that can be useful for other researchers developing digital solutions in the same subject area, like including community initiatives in the entire design process to better tailor the solution to their needs; being flexible to meet the preferences of the community and stakeholders; incorporating mixed methods in design and assessment tests that provide valuable information to produce an acceptable and well-designed solution.

Future work includes performing laboratory tests with end-users. Before further tests, the final experts' suggestions for improvements need to be considered. The CeNTER team believes that the intrinsic conceptual idea of the project can make an essential contribution to the future of territorial innovation, showing the potential of digital media to improve community engagement in their territorial matters.

Finally, through the current and future evolutions of the CeNTER prototype, mainly after the changes made from the user tests, it is hoped that it makes a difference in the everyday life of the territory agents since it becomes possible to contribute actively using a hypermediated application for their engagement. The platform will make it possible to create content and disseminate information, facilitating communication between the respective agents in the territory, and citizens' access to a set of initiatives. The prototype app intends to encourage their involvement. Such involvement can generate proactive behaviors, contributing to the promotion of activities and the development of the territory, so the citizens become actors-agents that consolidate networks of cooperation in the territory

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Bibliographical references

Almeida P, Abreu J, Oliveira ER, Velhinho A. (2017). Expert evaluation of a user interface for the unification of TV contents. In: *Proceedings of the 6th Ibero-American Conference on Usability and Interactive TV Applications - jAUTI'2017.* 2017. (59-70).

Carvalho, D., Oliveira, E., Tymoshchuk, O., Antunes, M. J., Pedro, L., Almeida, M., Carvalho, D. & Ramos, F. (2020). Prototipagem de uma Plataforma Digital para a Promoção da Inovação Territorial de Base Comunitária. Journal of Digital Media & Interaction, Vol. 3, No. 6, (2020), 53-71 https://doi.org/10.34624/jdmi.v3i6.15517

Cho, H., Powell, D., Pichon, A., Kuhns, L. M., Garofalo, R., Schnall, R. (2019). Eye-tracking retrospective think-aloud as a novel approach for a usability evaluation, *International Journal of Medical Informatics*, *129*, 366-373.

D'Carlo, D., Barbosa, R. G. A., & Oliveira, E. R. (2017). Proposta de um Conjunto de Heurísticas para Avaliação da Usabilidade de Aplicativos Móveis Educacionais. *Abakós*, *5*(2), 16-28. Retrieved from https://doi.org/10.5752/p.2316-9451.2017v5n2p16.

Feijó, V. C., Gonçalves, B. S., & Gomez, L. S. R. (2013). Heurística para avaliação de usabilidade em interfaces de aplicativos smartphones: Utilidade, produtividade e imersão. *Design e Tecnologia*, *3*(06), 33-42.

Fonseca, M. J., Campos, P., & Gonçalves, D. (2012). *Introdução ao Design de Interfaces* (2a Edição). Lisboa, Portugal: FCA. Retrieved from https://www.fca.pt/pt/catalogo/informatica/design-multimedia/introducao-ao-design-de-interfaces/

Hartson, R., & Pyla, P. (2012). *The UX Book: Process and Guidelines for Ensuring a Quality User Experience.* Elsevier. Retrieved from https://www.sciencedirect.com/book/9780123852410/the-ux-book

Krone, C. (2013). *Validação de Heurísticas de Usabilidade para Celulares Touchscreen*. Grupo de Qualidade de Software (GQS). Florianópolis (SC): Universidade Federal de Santa Catarina. Retrieved from http://www.gqs.ufsc.br/wp-content/uploads/2013/07/WorkingPaper_WP_GQS_01-2013_v10.pdf

Lacerda, T. C, Nunes, J. V, von Wangenheim, C. G. (2016). Usability heuristics for mobile phone applications: a literature review. In: *Emerging Perspectives on the Design, Use and Evaluation of Mobile and Handheld Devices.* IGI Global. (143-157).

Machado, E. C. (2017). *Melhoria de um conjunto de heurísticas de usabilidade para sistemas mHealth em smartphones*. Retrieved from https://repositorio.ufsc.br/handle/123456789/177694

Martínez-Rolán, X., Tymoshchuk, O., Piñero-Otero, T., & Renó, D. (2019). Instagram como red de promoción e hipermediación del turismo rural: el caso de Aldeias Históricas. *Revista Latina de Comunicación Social, 74,* 1610-1632.

Mirafshar, B. (2019). *Design thinking vs. design sprint demystified - UX Planet*. Retrieved from https://uxplanet.org/design-thinking-vs-design-sprint-demystified-fed300b3ecad

Nielsen, J. (1994a). Enhancing the explanatory power of usability heuristics. *Conference on Human Factors in Computing Systems - Proceedings*, 152–158. https://doi.org/10.1145/259963.260333

Nielsen, J. (1994b). *10 Usability Heuristics for User Interface Design.* Retrieved from http://www.nngroup.com/articles/ten-usability-heuristics

Nielsen, J. (15 de Novembro de 2020). *10 Usability Heuristics for User Interface Design*. Retrieved from https://www.nngroup.com/articles/ten-usability-heuristics/

Nielsen, J., & Landauer, T. K. (1993, May). A mathematical model of the finding of usability problems. In *Proceedings of the INTERACT'93 and CHI'93 conference on Human factors in computing systems* (206-213). ACM.

Oliveira, Á., & Campolargo, M. (2015). *From smart cities to human smart cities. Proceedings of the Annual Hawaii International Conference on System Sciences, 2336–2344. https://doi.org/10.1109/HICSS.2015.281*

Oliveira, E., Tymoshchuk, O., Branco, A., Carvalho, D., Sacramento, E., Antunes, M. J., Pedro, L., Almeida, A. M., & Ramos, F. (2021). End-user evaluation of a mobile application prototype for territorial innovation, In *Proceedings of International Conference on Enterprise Information Systems (ICEIS)2021*, p.495-504. DOI:10.5220/0010479104950504

Renó, D., Tymoshchuk, O., Silva, P. A. (2019). Redes, comunidades e cultura digital: a inovação pela desconexão. *CHASQUI - Revista Latinoamericana de Comunicación.137(1),* 191-207. https://revistachasqui.org/index.php/chasqui/article/view/3562

Renó, D., Silva, P. A., Almeida, A. M., Ramos, F., Pedro, L., Antunes, M.J., Tymoshchuk, O. (2019a). Conceção de uma plataforma de mediação digital para a Região Centro. In *proceeding de conferência APDR 2019*, 1194-1199. http://apdr.pt/data/documents/ATAS_APDRcongress2019.pdf

Ritzer, G., & Jurgenson, N. (2010). Production, Consumption, Prosumption: The nature of capitalism in the age of the digital 'prosumer.' *Journal of Consumer Culture, 10*(1), 13-36. DOI:10.1177/1469540509354673

Rosenzweig, E. (2015). UX Thinking. In *Successful User Experience: Strategies and Roadmaps*. Ed. Elizabeth Rosenzweig & Morgan Kaufmann. (41-67). https://doi.org/10.1016/B978-0-12-800985-7.00003-X.

Saint-Onge, H., & Wallace, D. (2012). *Leveraging communities of practice for strategic advantage*. Routledge.

Salazar, L. H. A., Lacerda, T., von Wangenheim, C. G., & Barbalho, R. A. (2012, November). Customizando heurísticas de usabilidade para celulares. In *IHC Companion,* (37-38).

Silva Junior, S. D. P., Oliveira, C. M., Galvão, L. F. O., Rodrigues, J. S., & Puska, A. A. (2018, October). Investigando Heurísticas de Usabilidade no Contexto Móvel de um App de Saúde. In *Extended Proceedings of XVII Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*. SBC. https://doi.org/10.5753/ihc.2018.4206

Silva, P. A., Antunes, M. J., Tymoshchuk, O., Pedro, L., Almeida, M., Renó, D. & Ramos, F. (2019). Involving communities in shaping digital solutions for innovation in societies and territories. In *ICGI'2019 – International Conference on Graphics and Interaction.* Faro, Portugal, November 21-22, 2019. 145-152 DOI: 10.1109 / ICGI47575.2019.8955087

Silva, P. A., Antunes, M. J., Tymoshchuk, O., Pedro, L., Almeida, M. & Ramos, F. (2020). Understanding the role of communication and mediation strategies in community-led territorial innovation: a systematic review. *Interaction Design and Architecture(s) Journal (IxD&A), 44,* 7-28. http://doi.org/10.1007/978-3-319-92022-1_5

Srnicek, N. (2017). The challenges of platform capitalism: Understanding the logic of a new business model. *Juncture*, *23*(4), 254-257.

Tymoshchuk, O., Renó, D., Silva, P. A., Almeida, A. M., Pedro, L., & Ramos, F. (2019 a). Mediação digital para a inovação territorial: um estudo de caso múltiplo em redes sociais digitais. *OBS* Observatorio*, 13(4). p.70-88. https://doi.org/10.15847/obsOBS13420191435

Tymoshchuk, O., Reno, D., Silva, P.A., Almeida, A. M., Pedro L. & Ramos, F (2019 b). O papel das tecnologias digitais no desenvolvimento das comunidades rurais: o estudo de caso múltiplo de "BioLiving" e "Bons Sons". *Revista Portuguesa de Estudos Regionais (RPER)* *3*(52), 131-144. http://www.apdr.pt/siterper/numeros/RPER52/52.8.pdf

Tymoshchuk, O., Renó, D., Silva, P. A., Almeida, A.M., Antunes, M. J., Pedro, L. & Ramos, F. (2019c). Construção de um quadro de referência para a conceção de estratégias de mediação digital em Inovação de base territorial. In *Proceeding de conferência APDR 2019*, 1007-1016. http://apdr.pt/data/documents/ATAS_APDRcongress2019.pdf

Van Zuthem, H.M. (2014). *Design for community well-being*. Unpublished Master Thesis. Delft, NL: Delft University of Technology.

Von Wangenheim, C. G., Von Wangenheim, A., Machado, E., Lacerda, T. & Azevedo, L. F. (2017). MATCH-MED: Heurísticas e Checklist para Avaliação da Usabilidade de Aplicativos mHealth em Smartphones. *Relatório Técnico do Instituto Nacional para Convergência Digital/ Departamento de Informática e Estatística*, Centro Tecnológico, Universidade Federal de Santa Catarina. Florianópolis: INE, UFSC.

Wanick, V., & Bitelo, C. (2020). Exploring the use of participatory design in game design: a Brazilian perspective. *International Journal of Serious Games*, *7*(3), 3-20.