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BEHIND THE SCENES OF A CROWDMAPPING TOOL DESIGN AND IMPLEMENTATION: GUIDELINES FOR PARTICIPATORY MAPPING PRACTICES IN A MULTICULTURAL ENVIRONMENT

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Abstract

This study addresses the gap in knowledge regarding effective design practices for crowdmapping in participatory mapping, considering the diverse agendas, expectations, and needs of stakeholders. Through interviews and analysis of a crowdmapping project, we developed a roadmap and guidelines to inform the design process of a web-based crowdmapping tool. Unlike traditional approaches that focus on end-user evaluation, our paper explores the perspectives of facilitators and developers involved in the participatory process. By understanding their motivations and perceptions, we can plan and design user-friendly tools that meet the requirements of all stakeholders in participatory mapping.

Key words

participatory mapping • PPGIS • web-mapping • participatory design • in-depth interviews

Introduction

To provide a good platform for participation and crowdmapping, online maps must provide users with accessibility and usability from the perspective of human-computer interaction paradigms (Newman et al., 2010). There have been several studies conducted on developing usability guidelines for web

mapping interfaces in participatory mapping (PM), and testing various interface designs with users (Haklay & Tobón, 2003; Haklay, 2006; Nivala et al., 2008; Skarlatidou et al., 2011; Rzeszewski & Kotus, 2019; Bartling et al., 2021). However, larger spatial and social scales of PM implementations frequently include several stakeholders with their own agendas, expectations, and needs. Therefore,

it then ceases to be a simple relation between facilitators of the web mapping and a group of users, and becomes a complex set of interrelations mediated through technological solutions. In this paper, we posit that there is a gap in the applied knowledge on the good practices of crowdmapping design in such circumstances, a gap encountered while developing the TeRRIFICA project. We provide an insight into the process of participatory development of a web-based crowdmapping tool that would hopefully mitigate this situation, using a set of methods employed to monitor and evaluate all the development stages.

The primary objective of this paper is to develop and present a comprehensive set of detailed guidelines specifically tailored for the participatory design and effective implementation of a web-based crowdmapping tool. Our aim is to bridge the gap between technological capabilities and user needs in PM, thereby enhancing the overall efficacy and impact of crowdmapping initiatives in diverse contexts. The proposed design roadmap is constructed from first-hand experiences and the analysis of the lessons learned during the TeRRIFICA project. The project is a large-scale, multiregional endeavor that provides local communities with knowledge on climate change adaptation and mitigation activities. The paper looks into the process of designing web crowdmapping tool from the perspective of its facilitators and developers, and adds to the current PPGIS and PM body of knowledge. This is a seldom discussed view in the broader academic and practical discourse, which is often focused on the users' experience, participatory potential, and the quality of the data. While this is a crucial issue, other important motivations for running PM schemes are the perceptions of its potential capabilities and inherent biases in its implementation for the stakeholders and heavy impact on the final results. The individual experiences of the people creating the PM tool helped identify their motivations and knowledge about their perception and value in the project. This could lead to a better understanding of the popularity, advantages,

and shortcomings of the PPGIS methods. This project provides a unique view on the matter due to the stakeholders involved come from a wide range of backgrounds and data cultures. The partners in the project brought various expectations and agendas into the process of crowdmapping tool development. The final result was, therefore, a product of negotiation and a participatory endeavour in its own right.

In the following sections, we begin by literature review, followed by offering a concise overview of the TeRRIFICA project, delving into the methodologies employed for both the development of the application and the documentation of its process. This is followed by an in-depth analysis of the findings gathered from user feedback questionnaires and structured interviews with project partners, providing valuable insights into their experiences and perspectives. The subsequent discussion section is dedicated to presenting a meticulously crafted roadmap for a crowdmapping tool. This roadmap is designed to serve as a comprehensive guide for the development and implementation of similar tools in various contexts. The paper culminates with a critical reflection on the study's limitations, acknowledging areas for future research and improvement.

Literature review

Participatory mapping (PM) is the process of creating maps by local communities using the help of governmental and nongovernmental organizations, engaging in land development and planning (Corbett, 2009). PM encompasses a plethora of approaches, technological solutions, practical implementations, and social activities. However, it can also simply be described as a process of communicating spatial knowledge (Brown & Kyttä, 2018), since its popularity in various fields has increased in recent years (Brown et al., 2020). The use-case scenarios of PM include a variety of topics, such as urban green spaces (Heikinheimo et al., 2020), social landscape services (Fagerholm & Käyhkö, 2009), ecosystem services

(Jones et al., 2020), sense of place (Perez-Ramirez et al., 2019), facilitating participation in urban design (Müller, 2021), environmental protection (Muñoz et al., 2020), and detecting land-use changes (Brown & Weber, 2012). Landscape and urban planning studies are also increasingly using PM approach to map landscape values (Kivinen et al., 2018; Morse et al., 2020, Stahl Olafsson et al., 2022), landscape usage (Lehto et al., 2022), planning green and neighbourhood infrastructures (Rall et al., 2019), and placemaking (Aditya, 2010; Cilliers & Timmermans, 2014).

Several researchers and practitioners aim to improve it in a manner that is ethical and beneficial worldwide (International Society for Participatory Mapping, 2020). PM can be used as a tool to conduct research on the citizen science concept, which brings the public and science closer together by involving the public in the dialogue and decision-making processes (Irwin, 1995; Bonney et al., 2015; Vohland et al., 2021). Furthermore, PM allows citizens to provide valuable data of the spatial and qualitative character that describes local problems, and to expand their participation in developing planning documents at the local level, as long as the tools that are used are inclusive and people-centred (Kahila-Tani et al., 2019).

Public participation geographic information systems (PPGIS) and participatory geographic information systems (PGIS) are closely connected to PM. Both PPGIS and PGIS encompass a variety of approaches, without creating a distinction between them, which strive to make spatial decision-making systems more accessible to society (Schroeder, 1996), empowering the less privileged groups and allowing a wider participation (Brown et al., 2014; Sieber, 2006). Recently, "geoparticipation" has emerged as an umbrella term for all participatory approaches that utilize geographic information systems (GIS) (Pánek, 2016). The crowdmapping applications discussed in this paper belong to the transactional and consultative geoparticipation categories, according to the categorization proposed by Zhang (2019). However, since the lines

between the terms are blurred at best (See et al., 2016, Brown & Kyttä, 2014), the experiences, research, and guidelines presented in this paper are less connected to geographical information systems. Crowdmapping and its participation transcends widely into other scientific disciplines, and more importantly, into several activist practices, carried out by nonprofessional users (See et al., 2016). Therefore, this paper uses the term "participatory mapping" to denote all activities that involve participatory mapping practices. These activities utilize crowdmapping as a process of mapping spatial phenomena by using one of the many forms of web mapping and a wide range of stakeholders.

We focus on web mapping as it is one of the most popular technological solutions implemented widely within participatory mapping (Brown & Kyttä, 2014; Kingston et al., 2000), especially in urban planning (Nuojua & Kuutti, 2008; Bugs et al. 2010, Brown et al., 2018). Internet geoportals, geoquestionnaires, and crowdmapping platforms provide flexible and convenient solutions to the problems of providing a suitable participatory environment. These platforms assure a larger audience (Czepkiewicz et al., 2016; Jankowski et al., 2019), attractive interfaces, the possibility of sharing results with a wide range of stakeholders, ease in data gathering, and integration with geographical information systems. Different fields employ these platforms, despite some of their limitations, such as the possibility of introducing bias in data due to digital exclusion and divide (Brabham, 2009; Denwood et al., 2022), map literacy problems (Rzeszewski & Kotus, 2019), data sampling (Brown, 2016), and data quality (Brown et al., 2015). Some of the fields that utilize crowdmapping include urban planning (Babelon et al., 2017, Bąkowska-Waldmann 2023), climate change and environmental monitoring (Haworth et al., 2016; Pietrzyk-Kaszyńska et al., 2017), heritage public space protection (Elgobashi & Sernary, 2021), and research on sense of place (Hawthorne et al., 2022). The work by Babelon et al. (2021) provides an extensive review of the use of web maps

in urban planning, focusing on how these digital tools are applied and the motivations behind their usage.

Methods

The guidelines proposed in this paper come from the analysis and evaluation of the TeRRIFICA project crowdmapping tool design process. All the stages were documented and their usefulness and importance to the final results were critically evaluated, which supplemented the conclusions with empirical data from the evaluation stage. The data comes from three distinct sources: the design process documentation, user feedback forms, and the project partners' interviews.

The TeRRIFICA project

The TeRRIFICA project emerges from a work program in the EU's Horizon 2020 call in the theme Supporting the Development of Territorial Responsible Research and Innovation within the Science with and for Society (SwafS). The project partners represent a transdisciplinary community, since the consortium includes several universities and civil society organizations from six European countries: Belarus, France, Germany, Poland, Serbia, and Spain (TGA, 2018). TeRRIFICA seeks out the best practices to identify the approaches to adapt to climate change effects, and develop solutions – in a cocreation process that involves civil society, science, local administrations, policymakers, and businesses. Developing action plans for six pilot regions in the aforementioned countries to implement climate change adaptation and mitigation measures with stakeholders involvement are the goals of the project. Additionally, the findings can be transferred to other areas and broaden the experience with various collaboration formats that seek to awaken an interest in climate change adaptation and mitigation within different target groups (TGA, 2018; Fagiewicz et al., 2021; Rieckman et al., 2021; Steinhaus et al., 2021).

The milestone to achieving these goals was to design and implement a crowdmapping tool for preliminary identification of the effects and solutions for climate change proposed by the tool users. Data collected successively from 2020 to the present support the work in the living labs (Liedtke et al., 2012) established in each pilot region that integrates the active participation of different stakeholders. The results of the data collected from crowdmapping were an essential element of the prepared plan of intervention activities, including their territorialization, which follows the current recommendations for programming the public development intervention (European Commission, 2022). This provides more effective and tailored actions to address the current challenges in the regions. The driving factors in the dialogues on these actions are supporting climate change adaptation and mitigation, and hence give way to cooperation between the different participants, such as the inhabitants, decision-makers, infrastructure managers, social organizations, and entrepreneurs (Churski et al., 2021).

The crowdmapping tool design process and implementation

The design of the crowdmapping tool took six months, and it consisted of several stages. Firstly, the general ideas of the design were distilled into actionable goals, which involved several meetings between the project's partners (consortium members) and developers who were directly responsible for creating the tool. These discussions resulted in common conceptions of the aims, deliverables, and limitations. The development would involve three separate stages – the alpha, beta, and final version, and there will be a usability evaluation with partners and users at all the stages, according to the principles of the user-centered design (Abrás et al., 2004). The partners conducted the tests with users from their respective regions to accommodate the needs and specific geographical, organizational, and sociocultural conditions.

There were several changes during the developmental process due to the technical and usability requirements and data gathering needs. The crucial factor in the development was to maintain all the legal obligations for the data gathering and safety, including anonymizing personal information.

The final version was distributed separately through the web pages for each region, with an additional page in English to accommodate non-native speakers (Fig. 1). The recruitment procedures varied depending on the region and included social media, press releases, events, and small-scale workshops. A detailed design process is not described in this paper. However, all the stages are thoroughly documented, and the conclusions and lessons learned by analyzing the interviews with the project's partners and user feedback are presented here. The users could mark positive and negative spots within the five climate-change-related areas like air temperature (places where users feel comfortable or uncomfortable during heatwaves), air quality (sites where users rate good or poor air quality), water (places where users experienced high or low

risk related to water issues, e.g., floods, droughts), wind (places of a high or low risk associated to extreme wind), and soil (places with proper or inappropriate soil management). The positive marks indicate places that enhance the adaptation to climate change (good practices & solutions), and the negative ones are places that lower resilience to climate change and reveal local climate change challenges.

During the mapping action, i.e., from January 2020 to the end of May 2022, were 909 users registered from 18 countries (6% of unknown nationality). They marked 2,186 points on the map, of which 27% were in Poland (with 16% of users), 25% in the Balkans (Serbia, Montenegro, and Bosnia and Herzegovina – with 27% of users), 8% in Spain (10% of users), < 7% both in France (10% of users) and Germany (7% of users), and < 2% in other countries (<2% of users). The most frequently mapped climate change-related challenges were heat impact, water issues (droughts and floods), and poor air quality. For more information about mapping results, see Steinhaus et al. (2021) and Lupa and Fagiewicz (2022).

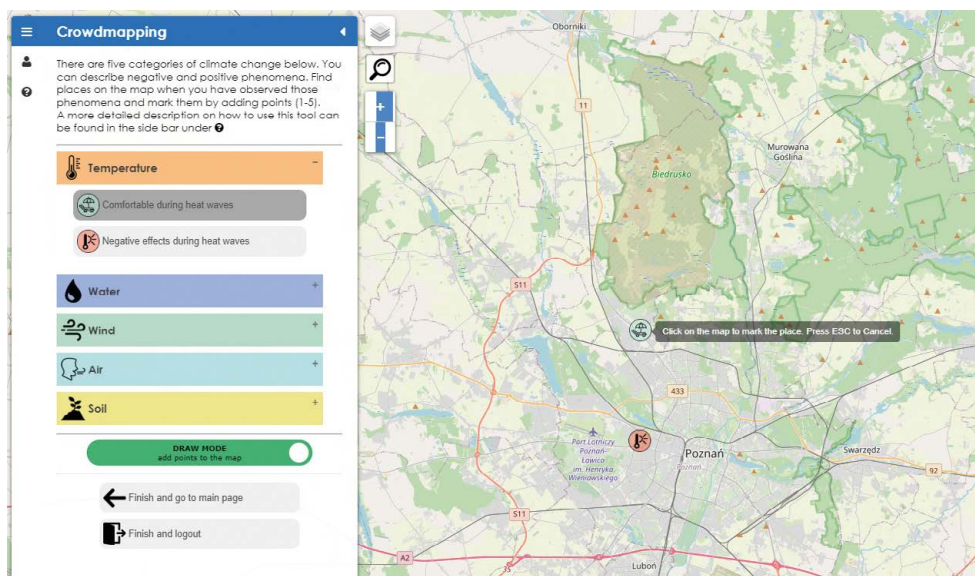


Figure 1. Crowdmapping tool main page

Documentation of the design process

We have included in the analysis meeting minutes at every stage, e-mail communication between the developers and partners and the usability test results for each version of the tool. We have identified misunderstandings between stakeholders, different perspectives on the usefulness and role of crowdmapping in the main project, major difficulties reported, and partner's feedback. This analysis helped in pointing out unnecessary steps of the process and proposing missing steps. We have also gained an insight into the importance of each stage for the final version of the software development.

User feedback

While the usability testing was conducted at the alpha and beta stages of the development, users could also provide feedback using a short online feedback form accessible through the mapping interface at the final version. While the questions do not directly relate to the design process, they can still be used to gauge whether the usability testing was thorough enough and if feedback is sufficient.

Interviews with the project partners

All the project partners (n=8) were interviewed to gauge the value of the participatory approach used to design the crowdmapping tool. From each organization directly engaged in every phase of the crowdmapping tool's design, one representative who was actively involved throughout the entire duration of the project as a stakeholder volunteered to participate in the interviews. Semistructured in-depth interviews (IDIs) were used, which took 30-60 minutes. The questions included in the interviews related to the following themes: use of the crowdmapping tool, cooperation with others, problems in the design and implementation phases, the perceived value of the gathered data, the effect on the engaged communities, missing features, the future evolution of the tool, value of the crowdmapping,

and the needs and expectations of the partners. The interviews were conducted in English, and were recorded, transcribed, and analyzed using the CAQDAS software, following the grounded theory approach (Glaser and Strauss, 2017). Two authors conducted the analysis separately using an open-coding analysis, followed by a discussion on the emerging themes. Core-related concepts were generated (Holton, 2007), which represented consistent and common ideas and thoughts among the partners (Brinkmann and Kvale, 2018). As per the guidelines of the authors' parent institution, ethical committee approval for non-interventional studies, such as interviews with people, not-at-risk was not necessary.

Results

Users feedback

Feedback from the map users is a useful tool in the evaluation process, and it is crucial at every stage of the development to unveil usability problems and software glitches. Analysis of the feedback, especially open answers, can also be performed to evaluate the design process and as a proxy of its quality. The feedback form was prepared using the descriptive Likert scale to allow for a quick quantitative evaluation of the user experience and to gather open answers about the main difficulties and improvements ideas. There were 138 completed feedback forms in the database in June 2022. According to the results of the feedback, 60.9% of the respondents perceived the crowdmapping tool as very easy to use, 15.9% as easy, 2.9% as difficult, and only 0.7% as very difficult. Among the respondents, 12.3% did not evaluate the tool quantitatively, and only used the open fields in the form to describe their problems and possible improvements. The open-text descriptions were analyzed to check for dominant themes or categories of problems. According to 24% of the respondents, including those that evaluated the tool as very easy to use, the main difficulty was that the categories of phenomena on the map were too concrete, tough to understand,

or hardly relatable to the lived experiences of the participants. This was mirrored by the proposed improvements, which almost exclusively consisted of things missing from the map categories, and expressions of the need for at least one open category. The other difficulties the participants faced were connected to technical issues – browser and account errors and the inability to use certain functions.

The main takeaway from the user feedback analysis was the efficient and successful design process to prepare the crowdmapping tool from the usability and ease of use perspectives. However, for some of the users, the descriptions and categories of the phenomena of the crowdmapping process were vague and hard to grasp. This may indicate that parts of the design process that deal with the needs of the facilitators related to the capabilities and knowledge of other participants need to be further analyzed.

Partners feedback

Through interviews with the project partners, the needs and expectations toward the crowdmapping tool from the perspective of active facilitators and users of the final results were gathered. Though some of the prevalent themes presented below are not directly related to the design process, these provide a unique perspective and information on future implementations. The themes described below and commented on by the authors were identified and present in all the interviews. Quotations by interviewees are differentiated by anonymized identifier (P1-P8).

Theme 1: *Crowdmapping data – quality and possible uses*

Not surprisingly, the issues related to data and the ways it can be used were given much consideration in the interviews. Spatial data was an entirely new form of material for several partners, and their participation in the project regarding this was “a journey of exploration.” The partners had to confront a set of expectations they had at the beginning with the results achieved. The expectations

mainly differed in two aspects – the quality and quantity of inputs. The quality issues important to the partners were related to the demographic and spatial bias, which is common in the crowdmapping data (Quattrone et al., 2015). At the end of the project, the participants were aware that the practical value of the results is limited due to this bias. As one interviewee described:

It’s very biased and very spread, and it’s a good example but it’s not a way of explaining what is happening in the Metropolitan area. It’s too personal and not systematic. It’s useful for doing a community work but not a systematic analysis of the situation. (P1)

The quantity of the data points was perceived lower than expected almost universally, and there has been much effort directed toward getting more people to contribute (discussed in the second theme presented below). There was also an important distinction found between the two types of data collection approach in the interviews. The first type of stakeholders perceive crowdmapping as a tool to gather data that can be stored and used either within the project itself or by other participants in the future. They value data analysis, and are therefore more concerned with the presence of various biases, sampling strategies, and quantity. The second type of stakeholders considers the data and its quantity is unimportant, and in a few selected cases, they focus on the collaborative process of mapping and engaging participating communities. This approach is adopted specifically in cases where the participation is either too small or distributed over a large region, and where the identification of hot spots is impractical. Rural regions are a good example for this approach.

Because even us, we don’t use all the data we have gathered. We just use the ones when we know we put it and the ones that were put with people that wanted to work on it. (P2)

The interface flexibility, specifically the openness of the questionnaires and the ease of use, is crucial for representatives of this type. The presence of the aforementioned types of approach must be taken into account in the crowdmapping tool design, since they bring different sets of expectations both for map interfaces and the database design. Importantly, inexperienced facilitators of the crowdmapping process lack the knowledge on their preferred approach. However, it must also be noted that the positions are not mutually exclusive.

Theme 2: *Engaging people and promotion of the tool*

The collection of a low number of points was one of the main problems with the tool. Partners devised various solutions to mitigate this, which ranged from social media campaigns to physical meetings and workshops. However, the level of initial engagement was a surprise for almost all of them, which is hard to gauge without experience. The general character of the crowdmapping tool and the individual topics and questions being unrelated to particular communities were partially blamed for the situation. It was suggested that this could be changed during the design process by introducing more region-specific characteristics. As one of the partners expressed:

But if you would like to reach more people now, each country would have to really think of the target group and how to attract this target group. I feel like if I reach out now, I would have to make a good strategy to reach the people in my area, but the tool itself would need to change. Because it's not the tool. It's the people I need to engage. (P4)

Theme 3: *General feedback and usefulness of the crowdmapping tool*

All partners perceive the mapping tool as relatively easy for their users, although this was based on anecdotal evidence since there was no formal feedback in most cases. Though

there were technical difficulties and several required functions were not implemented, the main attitude toward the tool was positive, and several partners declared that they want to use this tool in the future. It is interesting that the range of the uses declared is wide and goes beyond the current implementation, both in terms of function and geography:

I think it's a great tool, even we used the tool in the summer school. In fact we use it with people from different parts of the Mediterranean area, even from the African – And it was very interesting because people from Morocco, Italy, France, Algeria, different places, use the crowdmapping tool, and then, they use the crowdmapping to explain the rest of the people in the meeting about their situation. (P6)

It can be assumed that the first-hand experience with crowdmapping allowed partners to develop a focused view on its capabilities. From the perspective of the design process, there is a need for some kind of practical exercise for stakeholders to make the process as efficient as possible.

Theme 4: *Missing functions and input types*

The stakeholders were able to understand the possibilities of implementing the crowdmapping tool only after using it for some time, despite being engaged in a participatory design process from the beginning. The suggested changes range from minimal changes, to the overall look and feel of the tool and to significant alterations that would require additional database capabilities. The most common requests connected to the data gathering process – were whether it could include more specific questions focused on a given region or, contrarily, more general and open questions.

I introduce this point and now I do not call it according to these imposed categories, but name it myself, that

there is, for example, some drought or something else. (P3)

Maybe it's not implementable, but still, for example, for the city to add some more criteria, yeah, which are familiar to people and which they can recognize in their everyday life. (P1)

These seemingly conflicting requests are due to the general discussion on whether a given project is more focused on gathering quantitative or qualitative data or if data gathering should even be the main focus of the process. It must be noted that though not all

the functions of the crowdmapping tool were adequate for a specific aim of the partner, they could still adopt the tool by devising various strategies based on how and for whom the data was gathered, and what was done after that. However, a necessary consequence of this is that the final database includes data with varying quality and provenance. Therefore, the task of merging it into a coherent global picture can be a daunting task.

Discussion

Based on the results we have constructed and present below a design roadmap (Fig. 2), that

Crowdmapping tool - design roadmap

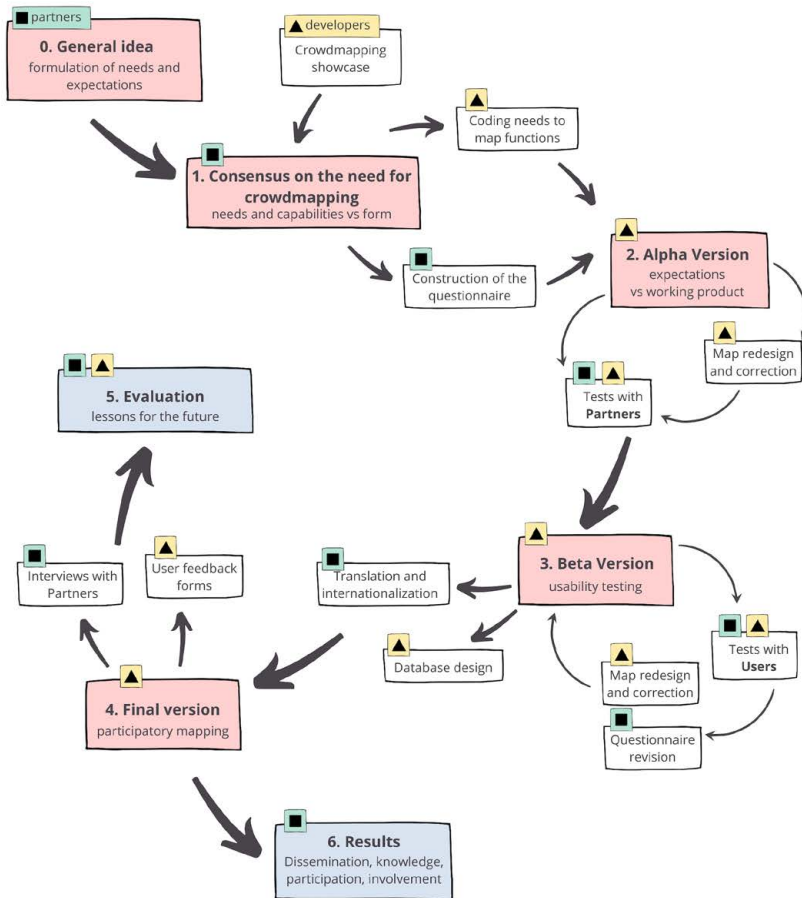


Figure 2. Crowdmapping tool - design roadmap

can guide the development of a crowdmapping tool. We are aware that an argument could be made against using such guidelines. This is because PM is a flexible approach at its core, and it is not often seen as a requirement to adhere to specific set rules – whether organizational and institutional in nature or related to the principles of cartographic representation. After all, PM is closely connected to the PPGIS ideals of countermapping, and imposing strict guidelines could encase the final product within a set of possible outcomes while also excluding alternatives that could prove to be better. While this is true to a certain extent, it is also true that the proposed roadmap can quickly be adopted and tweaked and, in its essence, does not guide the process into predesigned result. Instead, this paper focuses on the presence of particular processes that, when acknowledged, result in a more inclusive tool.

Crowdmapping tool roadmap

The design roadmap (Fig. 2) presents a rough guide for the design process, which takes into account both the experiences from this project and the result of a follow-up research. This is an idealized model of the process. In a participatory environment, every situation can be drastically different. Yet, the roadmap provided in this paper can be modified according to most of the needs. The main takeaway is that the path to the final result must include iterative loops at some of the stages. These stages must incorporate separate substages to solve the usability issues of the tool as well as the discrepancies between the needs of the stakeholders and the facilitators and the final results achieved within the implemented technological framework. Below, each main stage of the process is described, together with the reasons that are necessary, possible implementation variants, required participants, expected results, and the transition to the next phase.

General idea. This step is displayed as number '0' in the Figure 2 since it is located before the process starts and can take

an indefinite amount of time. Triggers are often related to administrative factors or funding availability. However, at this stage, there is a formulation of needs and expectations, which should be clearly stated generally. They will go through and gain further details in the next steps. However, this description will have a significant influence over the final product of the process.

Consensus on the need for crowdmapping. Though this is often an overlooked stage in the design process, it is crucial. As the experience and interviews show, stakeholders often decide on the use of a crowdmapping tool before they have sufficient expertise and knowledge on the technical limitations. In this stage, developers or people with sufficient expertise can step in to offer a critical overview of the method for all the parties present. Stakeholders, with no prior experience in crowdmapping, can benefit from a practical exercise or demonstration, leading to an informed decision on whether to proceed or to choose another participatory method instead. Not all projects require PM, and not all PM projects will benefit from crowdmapping tools that utilize web solutions. If the stakeholders reach a consensus to proceed, the next step is to describe the needs in a format the developers can code to map functions. Simultaneously, the questionnaire needs to be constructed. The term "questionnaire" is used rather loosely here, which denotes all kinds of internet forms that are used to gather information from participants.

Alpha version. This is the first version of a working web application. It should have all the functions desired by the stakeholders within the software limitations imposed by the developers. Next, the Alpha version must be tested in an iterative loop, where each test result is transformed into the redesign and correction of the crowdmapping tool. It should be noted that the test is recommended to be limited to the project's most direct stakeholders and facilitators in this stage. While usability will be improved during the tests, the main goal is to confront

the stakeholders' expectations with a working demo version of the tool. Therefore, they can see what and how their needs are fulfilled, and what technological compromises have been made. Separating the perspective of the end-users during the alpha testing is designed to help with fulfilling all the needs of stakeholders, without prematurely sacrificing their needs for usability improvements. The test will have a limited sample size, and standard usability tests were used in this paper, with clearly described tasks for the participants, and talk-aloud protocols (Krahmer & Ummelen, 2004) were encouraged during the testing. However, depending on the number of possible participants, other testing methods are also viable. Tests are necessary even with a simple one-to-one relationship between facilitators and developers. At this stage, significant reworking of the web application is to be expected and welcomed. Only after tests no longer show discrepancy between the needs and expectations, should the tool be promoted to a Beta version.

Beta version. This is the first stage in which real end-users are introduced to the process. This means that if a crowdmapping tool is planned to be accessible in a multi-language environment and in several geographical regions, it needs to be translated before the users can test it. While it may be tempting to use for the simplicity of testing, for example, only in an English version, it is strongly advised against. At the Beta stage, two things are tested simultaneously – the usability of the interface and the comprehension of the tasks required from the participants. The latter is directly connected to the language being used to describe the project. Consequently, the iterative redesign loop role is to improve both the usability and readability of the questionnaires. Methods for the usability tests are dependent on specific cases and the preferred design approaches (Skarlatidou & Haklay, 2021). Translation should also be done in the loop as users may report errors and typos. Further, the stakeholders at this stage are able to confront the database design as the first outputs will become

available. If needed, the structure could be changed to suit future dissemination needs. Beta version should lead to gradual and evolutionary changes in the crowdmapping tool, since the Alpha stage is responsible for getting the design to an acceptable state in its form and function. However, depending on the number of stakeholders involved, this could be one of the longest stages. When the tests no longer lead to meaningful changes, the final database design can be constructed and the crowdmapping tool can enter the final stage

Final version. In this stage, the crowdmapping tool can be distributed to a broader audience. The design choices made in the earlier stages will influence its performance, data-gathering capabilities, ease of use, and participatory potential. It must be noted, however, that even with a long process of adjustment and compromise-seeking, the resulting platform can be used in several possible ways in practice. When the expectations for the number of users are not met, partners are forced to devise contingency plans to attract a reasonable number of participants. Consequently, people were using this crowdmapping tool in unforeseen ways, not related to data gathering. An example of this was rebranding it into a purely educational exercise. These kinds of adaptations are, of course, good from the perspective of PM paradigms, as it promotes the goals of the local communities rather than adhering to the top-down aims and goals. Nevertheless, this possibility should be discussed at earlier stages of the design process to avoid potential conflicts.

It is also essential to set a reasonably adamant design boundary at the final stage of the process, which prevents further changes and tweaks. The only alterations that should be allowed are security issues. This boundary should be placed since it is not possible to change the crowdmapping tool for all the participants, as the mapping will already be in progress. Setting such a substantial limitation is beneficial because if all the stakeholders are aware of these limitations early

enough, it will motivate their participation in the design process.

The Results and Evaluation phases occur after the four stages. The former is not discussed here as it is highly dependent on the aims of a given project, and can include material results, such as spatial datasets and discursive results, developing an increased will to participate in the stakeholder's community. The evaluation phase is understood as the evaluation that takes place once the projects is finished. This phase lies beyond the design process in this proposition, as it is mainly concerned with the lessons for the future. The evaluation phase of the TeRRIFICA project, for example, is described in this paper and resulted in the guidelines presented above. We strongly urge the facilitators of participatory endeavors to include this process and share the results for the good of the community.

Limitations

We are reasonably confident in resulting guidelines, since they come from the evaluation process and are based on empirical data. What we have striven to do in this paper is to translate our unique experience into a more general description that could be used to streamline any crowdmapping project in the future. However, it must be observed that the usefulness of our results is limited by the specific nature of the theme of the project and the sample characteristic of its participants and stakeholders. Therefore, there needs to be caution when applying the guidelines to domains beyond public participation and environmental problems. Firstly, the guidelines are directly applicable to only one of the many forms of PM – online crowdmapping platforms. While they can be transformed, the platforms would require modifications. Secondly, while TeRRIFICA covers a variety of stakeholders, the sample used in this study is small and not representative of all possible arrangements. Finally, this paper is not aimed at providing a guide to organize the participation process, but to help with the tool development process.

Conclusion

Our paper aimed to propose guidelines for the participatory design and implementation of a web-based crowdmapping tool in PM applications. The paper also presents a possible scenario of the design process and the implementation of a final tool, with the help of empirical evaluation. The approach used in this work combines PM techniques, facilitation, and hands-on support with relevant and available technology application. We hope that at the current state of the evolution of PM practices, such a guide will prove a valuable addition to the body of knowledge of the PM community. Guides like this can lead to fewer mistakes and issues in the diverse universe of public participation, which can result in a larger number of sustainable endeavours. The results and guidelines we provide here can be combined with works such as analysis of critical success factors by Haltofóvá (2020) to overcome challenges in truly participatory mapping practices.

This paper is a part of the search for practical tools to engage society in solving contemporary environmental problems, which are often catastrophic (Poblet et al., 2014; Hicks et al., 2019). This is particularly important for urban areas with a large population and high human economic activity. Building resilience and adaptability to crisis phenomena must be carried out in such areas with the full inclusion of the inhabitants (Gull et al., 2022). At the moment of writing this paper, there are only few examples of crowdmapping tools that could be applied in such scenarios universally (Piccolella, 2013; Prutzer, 2019; Ahmouda et al., 2018). People willing to start a new participatory process have at their disposal several examples from various fields, regions, and paradigms. All of them are valuable but they are also vastly different. It may be argued that frequently used and recommended platforms such as Crowdmap / Ushahidi (Hirata et al., 2018, Pánek et al., 2017) can be implemented in most cases, but we think that the advantage

of custom-made approach is the ability to better adapt the created tool to the nature of the problem under consideration, especially to its future users' needs and limitations. However, the main disadvantage of a custom tailored PM application is that there is often no established roadmap to achieve a desired effect. It is even more important to realize that a "desired effect" can be understood widely differently within a given community of stakeholders. In response to this dilemma, our proposed solution include not only guidelines for developing a PM software but also to gradually develop a mutual understanding among partners in a project. We are hoping that this guidelines highlight main problematic points that could interfere with a successful implementation of a crowdmapping platform and they will help in promoting such approach to tackling serious issued that require public participation.

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Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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