OGITO, an Open Geospatial Interactive Tool to support collaborative spatial planning with a maptable

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ABSTRACT

Maptables are increasingly used to support collaborative spatial planning processes. Despite the proven benefits and claimed potential of using a maptable in such processes, software applications specifically designed for this device are still scarce. Moreover, often-used applications do not fully exploit the touch functionality of a maptable, or have low usability. To address this gap, we developed and evaluated the Open Geospatial Interactive Tool (OGITO), an open-source software application designed to support collaborative spatial planning processes with a maptable. To develop such tool, we combined human-centred design and Agile software development principles in a co-design effort with intended users and stakeholders. Through iterative development cycles and feedback from users, OGITO was evolved until it satisfied user expectations. In a case study on community mapping in Sumatra, Indonesia, a sample of users evaluated OGITO’s usability. Case study participants reported high satisfaction with this tool for the tasks and context given. Our research shows the added value of iterative development and user feedback for improving and further development of the tool’s usability and functionality.

1. Introduction

Maptables are increasingly used to support stakeholder participation in planning support system (PSS) workshops (Flacke, Shrestha, & Aguilar, 2020; Pelzer, Arciniegas, Geertman, & de Kroes, 2013). In these workshops, a maptable, i.e., a large horizontal surface that shows geographical content and enables user groups to interact with the displayed content via touch gestures, is the central digital instrument for supporting collaborative spatial planning tasks (Aguilar, Flacke, & Pfeffer, 2020). However, with a few exceptions such as Phoenix (Geodan, 2018), planning support software applications designed specifically for maptables are still scarce. Furthermore, frequently-used applications are poorly adapted to maptables (Eikelboom & Janssen, 2013) and have usability shortcomings: their single-user, desktop-oriented interfaces, with e.g., small icons and list-based menus, are designed for vertical screens and interaction with a mouse and keyboard. Hence, they do not function well in a touch-enabled device such as a maptable, where the display is usually bigger, and the interaction relies on touch gestures (Viard, Bailly, Lecolinet, & Fritsch, 2011; Zenghong, Yufen, & Jiaquan, 2012). Consequently, their usability remains low, limiting the support that they can provide to decision-making processes. Besides, the range of open source software for maptables is rather limited (Hewitt & Macleod, 2017).

The usability of PSS tools, such as maptables, has often been mentioned as a limiting factor of their adoption in planning practice (Russo, Lanziliotti, Costabile, & Pettit, 2018b; te Brömmelstroet & Schrijnen, 2010), as has been reported in various studies (Champlin, te Brömmelstroet, & Pelzer, 2018; Pelzer, 2017; te Brömmelstroet, 2013). However, the diversity of the PSS evaluation criteria, and specifically of usability criteria, makes comparison between PSS tools difficult (Pan & Deal, 2019; te Brömmelstroet, 2013). Also, evaluation criteria often exclude usability aspects as an outcome of the user-system interaction in terms of effectiveness, efficiency and satisfaction (Russo et al., 2018b).

A frequent recommendation to improve the usability of interactive systems, and, in particular, of planning support systems (PSS), is to involve intended users in developing them, e.g., by following a human-centred design (HCD) approach (Giacomin, 2014; Russo et al., 2018b). HCD is an interactive design workflow in which user expectations and user feedback are continuously considered throughout the design process. HCD can be combined with Agile software development principles...

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— these are practices for quickly delivering software that satisfies customer needs. The combination of HCD and Agile strives to incrementally produce timely, usable systems (Brhel, Meth, Maedche, & Werder, 2015). However, despite the growing interest in such a combination of methods in computer science research fields (Ardito, Baldassarre, Caivano, & Lanzilloti, 2017; Jurca, Hellmann, & Maurer, 2014), there remains a need for studies reporting on the benefits of applying HCD or its combination with Agile for developing PSS software for maptables (Flacke et al., 2020).

Therefore, the purpose of this study is to develop a software application, namely OGITO — an Open Geospatial Interactive Tool — and to test its usability in a maptable-based workshop setting. To do so, we applied a combination of HCD methods and Agile software development principles. OGITO’s initial conceptualization had already been generated with intended users (Aguilar et al., 2020), and served as an initial input to the further development process. A case study in community mapping in Sumatra, Indonesia – the participatory budgeting process Musrenbang (Akbar, Flacke, Martinez, Aguilar, & van Maarseveen, 2020) – provided the context for a formal usability evaluation of OGITO.

OGITO provides a map-based visualization platform to facilitate communication and interaction of stakeholders and supports knowledge elicitation, that is especially relevant at the early phase of a planning process. Elicited knowledge is used in planning for investigating and understanding the problem at hand; in our case study, it was the preparation of the village map necessary for the Musrenbang process (Akbar, Flacke, Martinez, Aguilar, & van Maarseveen, 2020).

The following section introduces the background concepts (PSS usability evaluation, HCD, Agile development). Section 3 elaborates on the methods, and Section 4 presents the results. Section 5 discusses those results and enumerates lessons learned. Finally, Section 6 provides a conclusion, outlining directions for future work.

2. Background

2.1. Usability evaluation in PSS

The usability of PSS tools is important because usability may influence the perception of users regarding the added value for planning of such tools and their potential to support participation of marginalized groups (Ballatore, McLintock, Goldberg, & Kuhn, 2020; Russo et al., 2018b; te Brömmelstroet, 2017). However, there is a lack of uniformity with respect to usability evaluation of PSS tools. For example, Trubka, Glackin, Lade, and Pettit (2016) evaluated usability by considering solely the level of expert knowledge or training required to use the PSS tool. Pelzer (2017), in contrast, adopted ten variables in his evaluation including data quality, transparency and calculation time, among others. Russo, Lanzillotti, Costabile, and Pettit (2018a); Russo et al. (2018b) construed usability as a system quality comprising learnability, efficiency, memorability, low error rate and user satisfaction. In contrast, Champlin et al. (2018) broadened the concept of usability across the context of actual use by including items related to the tools applied, and items related to the setup and facilitation of the PSS workshop where such tools were used. Examining Participatory GIS (PGIS), a form of PSS used for planning, Ballatore et al. (2020) decomposed usability into five dimensions: user interface, spatial interface, learnability, effectiveness, and communication. Meanwhile, specific studies reporting on usability evaluation of PSS tools from the human–system interaction perspective are still scarce (Russo et al., 2018a) or, in the case of maptables, non-existent. For these reasons, this study adopts the usability framework of the International Standard Organization (ISO, https://www.iso.org/). In the ISO framework, usability is defined as the extent to which users can achieve their tasks with effectiveness, efficiency and satisfaction in a specified context of use (European Committee for Standardization, 2018).

2.2. HCD

Human-centred design (HCD; European Committee for Standardization, 2019), in practice also referred to as user-centred design, is an iterative design approach where the intended user plays a pivotal role. User feedback guides iterative refinement of typical activities such as a) specification of the context of use, b) specification of user requirement, c) production of design solution, and d) validation of such designs.

HCD is widely seen as optional or as adding extra effort and cost. In consequence, HCD is rarely considered (Bednark & Krohns, 2015; Richter & Flückiger, 2014). However, a few studies in the literature confirmed that incorporating the user in the development of a system produces systems that users consider highly acceptable (Trubka et al., 2016; Vonk & Ligtengberg, 2010). Nevertheless, those studies did not explicitly use an HCD approach during the development of the software application, even though they reported close cooperation with intended users.

2.3. Agile methods

Agile methods for software development are highly collaborative, iterative and focused on delivering working software in short periods, ensuring that customer needs are satisfied (Jurca et al., 2014). Agile or “rapid” development techniques such as Scrum, eXtreme Programming (XP), and Dynamic System Development (DSD), share a number of principles such as a) development of incremental functionality, b) focus on the development of working code instead of documentation, e.g. exhaustive requirements specification, c) face-to-face communication among stakeholders and developers, d) short cycles or iterations in which feedback is collected and goals are adapted, and e) flexibility to allow the redefinition or reprioritization of requirements (Vijay Anand & Dinakaran, 2016). Agile methods have become widely adopted in the software industry but their focus on functionality and added value for the customer do not, strictly speaking, pursue usable software (Brhel et al., 2015).

2.4. Combining HCD and Agile methods

Recently, there has been an increasing interest in combining HCD and Agile development software methods in computer science research (Vijay Anand & Dinakaran, 2016). Both methods have commonalities, but also pursue rather different objectives. Specifically, both approaches involve intended users, and apply iterations, continuous testing and prototyping (Ardito et al., 2017). However, the aim of HCD is to produce highly usable interactive systems whereas Agile methods aim to meet customer requirements in a short time. Thus, combining both methods aims to deliver highly usable software in short time (Brhel et al., 2015), and can be done in different ways (Da Silva, Martin, Maurer, & Silveira, 2011). For example, development could involve a longer initial step to define the interaction design before starting the development phase, or could use working prototypes for usability inspection or evaluation, or could include usability elements in user stories (Ardito et al., 2017; Da Silva et al., 2011).

Our study builds on earlier work where users were involved in PSS software development such as reported by Trubka et al. (2016), who combined Agile methods for software development and user involvement in implementing the Envision Scenario Planner, a tool for precint geodesign.

3. Methods

We integrated Agile and HCD methods in the design and development workflow of OGITO (see Fig. 1). This integration implied an up-
front application platform selection and the consideration of previously generated user stories that this research builds on (Aguilar et al., 2020). The following subsections describe the development and evaluation of OGITO.

3.1. Selection of the application platform

The selection of OGITO’s application platform, i.e., the software components through which OGITO operates, was based on reported and verified user needs (Aguilar et al., 2020; Hewitt & Macleod, 2017; Levine & Prietula, 2014; Steiniger & Hunter, 2013). The four main needs were: a) support for gestures (e.g., pinch, pan, rotate), b) simple and mobile-oriented GUI, c) open-source, and d) integration with other tools in the geospatial ecosystem (Palomino, Muellerklein, & Kelly, 2017). Support for gestures was selected as primary factor as a maptable is a touch-operated device, and interaction becomes more natural when participants use gestures (Viard et al., 2011). A simple and mobile-oriented GUI entails minimal use of menus and dialogs, instead preferring icons and gestures for user–system interaction. This kind of GUI is desirable due to the increasing use of (map-based) mobile applications. Open-source access was chosen for its open collaboration opportunities, supplemented by a free usage license (Levine & Prietula, 2014). Integration within the geospatial software ecosystem is important because users require interoperability between different geospatial applications, for example, by using common formats (Palomino et al., 2017) and Open Geospatial Consortium (OGC) standards.

3.2. Iterative development and evaluation of OGITO

The workflow depicted in Fig. 1 illustrates the iterative development and evaluation of OGITO. This workflow distinguishes six principal activities: understanding and specifying the context of use, specifying user requirements, producing design solutions, evaluating design solutions, evaluating solution in controlled conditions, evaluating a solution in a PSS workshop. Various methods were applied (i.e., focus groups, high-fidelity prototyping, user stories, Agile software development and review meetings).

To understand and specify the context of use, we collected and analyzed information from two sources: available written documentation, and information from application stakeholders. The documentation analysis entailed reviewing available documents listing the goals of the intended users and describing the characteristics of the Musrenbang process. The Musrenbang is a participatory budgeting process in which villagers discuss and decide the allocation of a portion of municipal or public funds (Akbar, Flacke, Martinez, & van Maarseveen, 2020; Grillos, 2017). To gather stakeholder information, a series of face-to-face meetings were conducted with the application stakeholders who described the PSS workshop purpose, the planning process in which it was embedded, the environment where the application would be used, and the tasks that intended users were expected to complete during the workshop. Information collected from both of these sources was combined into a narrative detailing the context of use that fed into subsequent steps of the development workflow.

For specifying user requirements, a focus group was formed with representative application stakeholders and users (Paetsch, Eberlein, & Maurer, 2003). This focus group comprised three planning researchers,
one GIS researcher and one technical GIS expert. All participants had experience with maptables. The objective of this focus group was to provide comments and suggestions during the review meetings. Working software prototypes of OGITO, also called high-fidelity prototypes, were presented to the focus group. Using high-fidelity prototypes in review meetings is very common in HCD and Agile practices (Ardito et al., 2017; Da Silva et al., 2011), as they enable users to test the software functionality in addition to evaluating the user interface or interaction design. Feedback from the focus group was translated into user stories describing a) user needs (Brhel et al., 2015; Dimitrijevic, Jovanovic, & Devedzic, 2015), b) improvement proposals, and c) bugs or errors. User stories generated during the OGITO conceptualization phase (Aguilar et al., 2020) and related to community mapping were also included.

The production of design solutions followed Agile principles for software development. This entails close collaboration between two parties: representative stakeholders and users (i.e., the focus group) and the application developers (i.e., the researchers). In short development cycles (iterations), a subset of the software functionality was implemented as a high-fidelity prototype that the focus group tested. Several iterations of programming and feedback were performed until the prototype attained acceptance among the focus group participants. An initial step was required to produce a hi-fidelity prototype which required setting up development and application platforms. Then, iterations of programming and user feedback were conducted approximately every 2 weeks.

To create the working prototypes, a software development framework was chosen as it allows for rapid creation of applications by providing reusable code for generic tasks, and predefined architectures for applications and resource-testing. To select the framework, a number of factors were considered, specifically a) support for gesture, b) integration with map visualization libraries, c) open-source code, d) developer community size, and e) long-term support.

To evaluate the design solutions, participants of the focus group were given a list of tasks to perform with the application (OGITO prototype). The tasks concerned testing the functionality implemented based on feedback from prior review meetings. These meetings, conducted periodically, approximately every two weeks, can be comparable to the Sprint review meeting of the Scrum method for evaluating the software produced in a development iteration (Paetsch et al., 2003; Pathak & Saha, 2013; Vijay Anand & Dinakaran, 2016). In addition, we explored user perceptions of the working prototype, e.g., the number of clicks required to achieve a specific task. Feedback collected concerned errors or bugs in the application, or enhancement proposals related to usability aspects or to functionality itself. Errors or bugs were prioritized and addressed accordingly, whereas enhancement proposals were negotiated between the developer and application stakeholders considering the effort required for their implementation. Additionally, requirements were elicited or expanded upon through the group discussion during these review meetings (see above paragraph). Hence, feedback provided by the focus group helped to improve not only the functionality but also the visual appearance and operation mode of OGITO. In this way, the working prototype evolved until it reached acceptance among the focus group participants. Afterwards, the usability of the tool was comprehensively evaluated.

A formal evaluation of the usability of the design solution, in this case a fully functional prototype of OGITO, was conducted in a) controlled conditions, i.e., pilot PSS workshops and b) in an actual PSS workshop with the users of the case study. In both cases, the framework described in Section 3.3 was used, with the context and goals of the PSS workshops participants utilizing OGITO, and the usability measures applied to evaluate the outcome of the use. The evaluation involved field validation, for which users reported their perceptions about OGITO (Aguilar et al., 2020; Ballatore et al., 2020; Tullis & Albert, 2013a) by filling an anonymous questionnaire after finishing a community mapping workshop using OGITO (see Appendix A). The questionnaire aimed to assess usability as the extent to which these users could map the village in a participatory setting with effectiveness, efficiency and satisfaction in a given context of use (see usability framework in Section 3.3).

3.2.1. Evaluation in controlled conditions

Evaluating OGITO in controlled conditions began with two pilots of the designed planning workshop, with participants who shared similar characteristics with our intended users (Benyon, 2010). Two groups of approximately ten people participated in these pilots. The first group included Master degree students and PhD degree candidates. The second group was formed mainly of laypersons and a few professionals. In these pilots, the elements of the PSS workshop, tasks and questionnaire were tested so they could be adjusted if required. The workshop elements consisted of structure, order of tasks, instructions to be given by the moderator and the mapping workflow. The tasks and questionnaire were tested to determine whether the tasks were doable and the questions understandable. Both workshop pilots were conducted in the local language (Bahasa) to be used during the PSS workshop with the participants in the case study.

3.2.2. Evaluation in a PSS workshop with real users

After considering the feedback collected in the pilot meetings, the OGITO’s usability was evaluated in two PSS workshops held in Denai Lama and Kramat Gajah, both located in Sumatra, Indonesia. In both cases, the participants, who were village residents, were asked to produce a) a village map of the current situation including facilities, roads, borders and land use including conflicting areas if applicable (for example discrepant village borders or land use), and b) a proposed development map indicating community-suggested interventions. Such maps are required by current regulations in the country and can be used in the participatory budgeting process later on.

3.3. Usability framework

We contextualized the definition of usability of an interactive system (European Committee for Standardization, 2018) to our study. Hence, we defined the usability of OGITO as the extent to which a user group can produce a participatory map of their village in maptable-based PSS with effectiveness, efficiency and satisfaction. Fig. 2 illustrates the framework used to conduct the usability evaluation in a maptable-based planning workshop with end users. In the workshops, users were asked to complete community mapping tasks using OGITO in a maptable. Specifically, they were to produce two maps: a village map and a proposal development map. The first included existing facilities, roads, water bodies, land use and borders, including any conflict areas. The second map indicated interventions to be submitted for approval and funding in the Musrenbang. A very high resolution (VHR) satellite image (50 cm), acquired for the project, was inserted as a background layer, enabling participants to identify and draw map elements in each village. Each image, a natural color composition (pan-sharpened), covers the full study area, i.e., the village and its boundaries, and was captured between January and May, 2019 by the WorldView2 platform (https://worldview.earthdata.nasa.gov/).

The usability dimensions, namely effectiveness, efficiency and satisfaction (European Committee for Standardization, 2018; Russo et al., 2018), were evaluated using the indicators described below:

- Effectiveness: assessed by perceived completeness, meaning that the map is complete (sufficiently represents the current situation), and perceived participation, meaning that everyone is able to contribute in the discussion that produced the maps. To accomplish that, OGITO should enable participants to locate themselves spatially, i.e., to locate their village on a map, and to draw all the necessary elements of the community maps to be produced.
The above-listed dimensions and their indicators were selected while considering the nature of participatory processes in map table-based workshops that impose additional challenges to evaluating the usability of PSS tools (Ballatore et al., 2020). For example, a traditional usability evaluation based on the duration of executing tasks would not sufficiently reflect the usability of a PSS tool used in a maptable-based planning workshop (Pelzer, Goodspeed, & te Brømmelstroet, 2015) because other factors such as discussions among participants might take place between map-drawing events, which would affect the duration measures. Besides, qualitative self-reported indicators, e.g., perception of ease of use, considered as subjective have proven to be as valid as quantitative observations (Tullis & Albert, 2013b).

4. Results

This section presents the architectures and central components of OGITO, and reports the usability evaluation.

4.1. OGITO application platform

We explored current stable, mature, open-source desktop GIS software platforms to assess their suitability for OGITO, considering the criteria described in Section 2.1., namely a) intuitive gesture support, b) simple and mobile-oriented GUI, c) source openness, and d) integration with the geospatial ecosystem. Current open-source GIS desktop software, e.g., QGIS (www.qgis.org) or Ilwis (https://S2north.org/software/software-projects/ilwis/), did not adapt well to touch-screen interfaces. Specifically, these applications have a limited gesture support and the GUI (menus, dialogs) are designed for desktop screens. Although it was possible to customize some of their GUIs, the complex interfaces included many functionalities not required for our intended users to achieve their tasks. Keeping in mind the spatial limitations of accommodating people around a maptable, we selected a web platform given the flexibility that such implementation may offer regarding space and time for group collaboration. This means that the application could be used remotely, enabling a broader audience to participate. This characteristic has become especially relevant after restrictions were put in place to limit the spread of COVID-19. In many countries, face-to-face meetings were replaced by online communication.

Angular (https://angular.io) was chosen as the application development framework because it allows the reuse of open libraries for common tasks, integration of gesture support via hammer js (https://hammerjs.github.io/), and inclusion of open libraries for specific tasks. For example, OpenLayers (https://openlayers.org) for map visualization, and angular material (https://material.angular.io/) for GUI elements. Besides, Angular is open-source, and enables applications to be created using components suitable for short production times. It also benefits from the long-term support offered by Google and a large community of developers. As result, OGITO is built on widely accepted components already available in the current geospatial software ecosystem (Palomino et al., 2017). Fig. 3 shows the frontend and backend architectures of OGITO. The frontend uses Angular together with basic web technologies such as HTML, CSS and Javascript, and includes specific libraries, i.e., OpenLayers (https://openlayers.org/) and HammerJS for map visualization and touch-gesture support respectively. The backend components consist of QGIS server (https://qgis.org/) as a provider for geowebservices (OGC WMS and WFS-T) configured on top of Apache Web Server (https://httpd.apache.org/). Such geowebservices provide access to the database that could be, e.g., a set of structured shapefiles, geopackages, or a more complex structure implemented in a Spatial DBMS (Database Management System). OGITO thus uses well-tested software components and widely recommended geospatial formats and standards (Falco & Kleinhans, 2018).

4.2. Components of OGITO – layout

OGITO is implemented in several modules that provide an interactive map, layer management, data input and sketching. Fig. 4 shows the OGITO interface layout where the interactive map canvas is the central component. This map (1) responds to common gestures such as pinch (for zooming in), unpinch (for zooming out), pan (one or two fingers), and rotate (two fingers). In addition, a zoom control bar and buttons for zooming in and zoom out are provided at the left side of the map. A graphical scale bar is also provided, at the low left corner. The layer management (2) allows layers to be shown, hidden, and re-ordered. Data input and sketching tools are supplied on the main toolbar (3), an editing toolbar (4), and a symbol panel (5). All of these functions are available via touch, so no mouse or keyboard is required. OGITO’s minimalistic and simple design provides only the tools needed for the...
purpose at hand.

OGITO accommodates data input of a) simple geometry types (points, lines and polygons) and, b) composite geometries i.e., simple geometry types combined in the same layer. A tap gesture is used to draw points whereas lines and polygons can be digitized using free-hand drawing (one finger). The digitizing of polygons can be done through free-hand drawing of a closed polygons (https://openlayers.org) or a line. Such a line will be automatically closed within a certain configurable distance threshold to form a valid polygon. Points, lines and polygons can be deleted or moved.
By selecting a certain symbol from the symbol panel (see Fig. 4 – box 5), the element being drawn takes the category associated with that symbol. In this manner, intuitive data input is offered without using a mouse or keyboard. Map symbology, i.e., geometry styles, followed the technical specifications for the production of village maps in Indonesia (Akbar, Flacke, Martinez, Aguilar et al., 2020).

Focus group feedback, collected during the periodical meetings, helped to improve OGITO design and functionalities. Below we provide some examples of such feedback and the response provided by the developing part:

- The functionality provided to draw closed polygons using free-hand drawing did not fully satisfy user expectations because the polygon being drawn partially covered the area of digitization (https://openlayers.org/en/latest/examples/draw-freehand.html). Therefore, it was proposed to include free-hand lines that could be automatically closed within a configurable distance threshold. This enhancement was developed and tested, by users, in a subsequent meeting. Users considered this feature as relevant giving the flexibility that it brings when drawing in a surface such as a maptable.
- A preliminary design used red color to indicate the current tool in use; however, a user mentioned "I associate red color with stop as in the traffic light." As response, the design used green color instead (see Fig. 4).
- Users observed that sometimes, the map was flickering while points were drawn via tap gestures. This was solved in a subsequent development cycle and tested in the following focus group meeting.

Fig. 5a and b illustrate the current situation as mapped by the participants from Denai Lama village and the proposals map. Three main developments were proposed namely 1) a drainage system for the village to prevent damage to the road infrastructure and sanitation issues due to water accumulation; b) a paved road to link communities from neighbourhoods I and III as current access is only a dirt road, and 3) a bridge to connect the main road of the village with the main road of its neighbor - the Denai Sarang village.

4.3. Usability evaluation

We evaluated OGITO’s usability through post-workshop questionnaires (see Section 3). During the workshops, a moderator (professional planner) facilitated the discussion and guided the activities, the main researcher and developer of OGITO was available to provide technical support as needed, and workshop participants used the tool themselves (see Fig. 6).

Pilots of the workshop, i.e., evaluation in controlled conditions, provided useful inputs concerning the sequence of activities of the workshop and the mapping workflow. During the pilots, all participants were able to conduct the selected tasks (see Fig. 2). Nonetheless, during the first pilot, it was observed that drawing elements (points, lines and polygons) would be better understood gradually, for example, first drawing point elements, followed by lines and polygons. The sequence of these tasks was therefore adjusted accordingly. Also, first pilot participants suggested explaining a step-by-step mapping workflow for digitizing consisting of a) select type of element to draw, b) select symbol, and c) draw the desired element in the map (see boxes 4 and 5 in Fig. 4). In such a manner, lay persons that are not familiar with GIS can adhere to a defined sequence of steps to facilitate digitizing with OGITO. All participants from the controlled conditions workshops reported that they understood the questionnaire well (see Appendix A), hence no adjustments were needed for that.

Below, we provide an overview of workshop participants’ characteristics and analyze their questionnaire responses concerning OGITO’s usability. The number of participants attending the workshops is too small to derive significant statistical patterns; we only compute percentages to describe patterns in their responses.

4.3.1. Workshop participants

The workshops were attended by 16 participants in Denai Lama, and 10 participants in Kramat Gajah. All participants were males. More than two thirds of the participants in both villages were aged between 31 and 50 years, while the portion of participants aged 51–65 was 18.7% in Denai Lama and 40.0% in Kramat Gajah (see Table 1).

Regarding the level of education (Table 2), in both villages, a small
portion of the participants only finished primary school whereas 80% or more had completed a high-school level of education at junior or senior level. Very few participants were university graduates.

Concerning computer and digital maps use (Table 3), in both villages, half of the participants had never used a computer, but contrastingly, more than a quarter of participants reported using a computer every day. Also, low familiarity with digital maps was observed among participants in both villages. Almost half of the Kramat Gajah participants had never used a digital map, whereas in Denai Lama, although we see greater diversity in use frequencies, more than half of the participants had never used a digital map.

We also asked about our participants’ previous experience in community mapping activities (Table 4). In general, participants were aware of community mapping workshops. In both villages, 60% or more of the participants reported experience in at least one community mapping workshop. In comparison, the fractions of participants who had never participated in any participatory mapping activities in Kramat Gajah and Denai Lama were 30.0% and 18.7%, respectively.

4.3.2. Usability ratings
Concerning effectiveness, users responded “highly positive” about the functionality of OGITO (see Fig. 7) for a) identifying their village on the map and b) drawing all the elements identified by participants (see questionnaire in Appendix A). In Denai Lama, more than 90% could locate or identify their village in the map while in Kramat Gajah, all participants could perform this task. Concerning the capability of drawing all the elements in a map as identified by participants, the response was highly positive as well. In Denai Lama, most respondents agreed or strongly agreed while 6.3% gave a neutral response. In Kramat Gajah, a 100.0% agreed or strongly agreed to this question.

Participants also gave positive responses concerning the completeness of the map (i.e., reflecting the current situation of their village), and their participation (i.e., everyone could contribute). All respondents from Denai Lama agreed or strongly agreed that the produced map reflected the situation; respondents from Kramat Gajah provided similar positive responses. Concerning participation, more than 90% responded from Denai Lama agreed or strongly agreed that the produced map was the result of everyone’s contributions; 6.3% responded neutral. In Kramat Gajah participants also agreed or strongly agreed on the same statement whereas 10.0% disagreed on this statement.

Efficiency was measured by human effort, expressed as perceived

| Table 1 | Age group of participants per village (N = 16 and N = 10 respectively). |
|---------|-------------------------------------------------------------------------|
| Age group (years) | Village | Denai Lama (%) | Kramat Gajah (%) |
| 18-30 | 6.3 | 0.0 |
| 31-50 | 75.0 | 60.0 |
| 51-65 | 18.7 | 40.0 |

| Table 2 | Highest level of education of participants per village (N = 16 and N = 10 respectively). |
|---------|--------------------------------------------------------------------------------------|
| Level of education | Village | Denai Lama (%) | Kramat Gajah (%) |
| Primary school | 6.3 | 10.0 |
| Junior High School | 25.0 | 30.0 |
| Senior high school | 56.3 | 50.0 |
| Diploma | 6.2 | 0.0 |
| Bachelor | 6.2 | 0.0 |
| Not say | 0.0 | 10.0 |

| Table 3 | Frequency of use of computer and digital maps per village (N = 16 and N = 10 respectively). |
|---------|--------------------------------------------------------------------------------------|
| Frequency of use | Village | Denai Lama | Kramat Gajah |
| | Computer (%) | Digital Map (%) | Computer (%) | Digital Map (%) |
| Daily | 37.5 | 12.5 | 30.0 | 0.0 |
| Every week | 6.3 | 12.5 | 0.0 | 0.0 |
| Once per month | 0 | 6.3 | 0.0 | 0.0 |
| Few times per year | 6.2 | 12.5 | 20.0 | 60.0 |
| Never | 50.0 | 56.2 | 50.0 | 40.0 |

| Table 4 | Experience of workshop participants in collaborative mapping activities (N = 16 and N = 10 respectively). |
|---------|---------------------------------------------------------------------------------------------------|
| Participation in a group mapping activity (times) | Village | Denai Lama (%) | Kramat Gajah (%) |
| | | | |
| Never | 18.7 | 30.0 |
| 1-2 times | 68.7 | 60.0 |
| 3-5 times | 6.3 | 10.0 |
| More than 5 times | 6.3 | 0.0 |
ease of use and learning time. This means the effort that users have to make to achieve tasks such as map navigation and editing, i.e., drawing and deleting elements in a map; and how long it took participants to learn how to perform such tasks.

Participants reacted positively about effort and learning time (Table 5) to achieve tasks such as map navigation and editing (drawing and deleting elements in a map). In Denai Lama, participants rated OGITO very positively for ease of use; 87.5% rated the tool as easy or very easy to use, while 12.5% found OGITO neither easy nor difficult, to use. Rating for specific tasks, e.g., navigate, draw, and delete, were equal or higher.

In Kramat Gajah, participants responded moderately positively about ease of use. 50% rated OGITO as easy or very easy whereas 30% found OGITO difficult; the remaining 20% found OGITO neither easy nor difficult to use. Regarding the individual tasks, participants rated equal or higher. However, 20% found the tool difficult to navigate and to draw whereas 10% found it difficult to delete elements.

Regarding the learning time (Table 6), the majority of respondents, in both villages, perceived neither a short nor long learning time. In comparison, 18.7% of the participants in Denai Lama and 10% in Kramat Gajah responded that they needed a long time to learn how to use OGITO. In both villages less than a quarter of participants responded that they needed a short time. Only 6.3% of participants from Denai Lama found that a very short time was required to learn how to use OGITO.

Concerning satisfaction, respondents from both villages showed a positive attitude toward the use of OGITO during the mapping. Table 7 lists their responses in this regard. The majority of participants were satisfied or very satisfied; and participants from Denai Lama reported higher levels of satisfaction than participants from Kramat Gajah.

Table 5
Ease of use of OGITO per task, grouped by village (N = 16 and N = 10 respectively).

| Ease of use\Tasks | Village | | |
|-------------------|---------|---|---|
|                   | Denai Lama | Kramat Gajah |
|                   | Navigate | Draw | Delete | Overall | Navigate | Draw | Delete | Overall |
| Very difficult    | 0.0      | 0.0  | 0.0   | 0.0     | 0.0      | 0.0  | 0.0   | 0.0    |
| Difficult         | 0.0      | 0.0  | 0.0   | 0.0     | 20.0     | 20.0 | 10.0  | 30.0   |
| Neutral           | 6.3      | 0.0  | 6.3   | 12.5    | 10.0     | 10.0 | 10.0  | 20.0   |
| Easy              | 68.7     | 81.3 | 75    | 68.8    | 50.0     | 60.0 | 40.0  | 40.0   |
| Very easy         | 25.0     | 18.7 | 18.7  | 18.7    | 20.0     | 10.0 | 40.0  | 10.0   |

Table 6
Learning time as reported by participants in both villages (N = 16 and N = 10 respectively).

| Learning time | Village |
|---------------|---------|
|               | Denai Lama (%) | Kramat Gajah (%) |
| Too long      | 0.0     | 0.0      |
| Long          | 18.7    | 10.0     |
| Neutral       | 56.3    | 80.0     |
| Short         | 18.7    | 10.0     |
| Very short    | 6.3     | 0.0      |

Table 7
Satisfaction of participants concerning OGITO (N = 16 and N = 10 respectively).

| Satisfaction | Village |
|--------------|---------|
|              | Denai Lama (%) | Kramat Gajah (%) |
| Very satisfied | 43.8    | 30.0      |
| Satisfied     | 56.2    | 70.0      |
| Unsure        | 0.0     | 0.0       |
| Dissatisfied  | 0.0     | 0.0       |
| Very dissatisfied | 0.0    | 0.0       |
5. Discussion

This study applied a combination of HCD and Agile methods to develop a maptable software application for planning support named OGITO, tested with users in PSS workshops. Overall, participants reacted positively toward the tool. On all three usability dimensions, users gave the tool generally positive scores. We surmise that this result was obtained by involving users in the iterative development process of the tool, as it was also found in similar studies (Vonk & Ligtengen, 2010), and that our findings provide evidence of the benefits of the user involvement during PSS tool development (Russo et al., 2018b). In Kramat Gajah, a few users found it difficult to use OGITO. This response can be explained by the low digital map literacy reported in this community (see Table 3) as such users might experience difficulties when managing web maps (Gottwald, Laatikainen, & Kyttä, 2016). In consequence, to overcome these difficulties we could extend the time for the tool exploration prior to the tasks execution and provide incremental guidance (Barnard, Bradley, Hodgson, & Lloyd, 2013).

By combining HCD and Agile methods, we addressed both functionality and usability via close cooperation among stakeholders of the application, users and development parties in frequent review meetings. These frequent review meetings and feedback collected from the focus group shaped OGITO into a lightweight application with a simple interface that provides the required functionality that satisfied both the application stakeholders and the users. Testing the application periodically was useful, allowing timely detection of pitfalls and discussion of improvements.

While previous studies such as te Brömmelstroet (2017), Trubka et al. (2016) or Pelzer (2017) measured usability as the ease of use or user-friendliness of PSS tools, our study explicitly provided insights into the effectiveness, efficiency and satisfaction from the user–system interaction perspective. These insights corroborate the importance of the usability in PSS evaluation studies that recently focused on the usefulness of PSS tools (Flacke et al., 2020; Pelzer, 2017). Nevertheless, the understanding of both usefulness and usability remains important, as particularly does their interplay (te Brömmelstroet, 2017).

This study is limited in offering insights related to an often-mentioned challenge of the integration of HCD and Agile that concerns the combination of the workflows of two different teams: design, and development (Ardito, Buono, Caivano, Costabile, & Lanzilotti, 2014). The first author, with expert support, both designed and developed the tool, and designed and conducted the usability evaluation. For this reason, there was no friction or challenge to address or report. This is not, however, the case for most software development projects.

Our workshops were only attended by males. This concern has been previously reported (Beard, 2005). We cannot draw conclusions about the reasons for the low participation of females. In future studies, separate workshops for females can be organized to provide a more open environment for their participation and hence achieve a more inclusive evaluation. We also observed that some participants disagreed with the statement that the map produced was the result of everyone’s ideas. This might be explained by the self-organization of the groups that delegated most of the drawing to one of the participants who was a village officer. However, a deeper analysis and different kind of data documenting the participation and conversation dynamics are required, which is beyond the scope of this research.

6. Conclusions and future work

This study aimed to develop a software application, namely OGITO — an Open Geospatial Interactive Tool, and to test its usability in a maptable-based workshop setting. The tool developed was well-received by workshop participants who had never used a maptable before. They could use OGITO without assistance during a community mapping workshop, found it easy to use, and reported high overall satisfaction. Despite of the discussed limitations of our study, this result confirmed that including the intended users in the development of the tool, i.e. of OGITO, led to a usable tool that just provides the required functionality (an Agile principle). Besides, our study contributes to the broader literature by reporting a usability framework for the development of PSS applications considering human–computer interactions. This framework, following established criteria from the ISO and the European Committee for Standardization, addresses the inconsistency of usability criteria when comparing different PSS. Future work involves a) the evaluation of memorability, i.e., the sufficiency of recalling the handling of OGITO when participants attend multiple workshops, b) improvement to the current version of OGITO considering the feedback collected during the usability evaluation, c) the current version does not accommodate calculation functions and queries since they were not demanded by the users, the development of the next version of OGITO will include analytical functionalities, and d) exploration of bias in participation due to usability.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Questionnaire

This survey is part of the mapping activity in Village:______. Your participation will be a great help to us. The responses will be kept anonymous. They will be used to better understand your perception about the usability of the tool (interactive map in the horizontal surface) used in the activity. In addition, summarized data will be used in scientific articles to be published. Please complete this survey before you leave.

Thank you for your participation!

| About the digital tool (interactive map on a touch table) | Very difficult | Difficult | Neutral | Easy | Very easy |
|---------------------------------------------------------|----------------|-----------|---------|------|----------|
| Please answer the following questions by selecting an option on the right. |                |           |         |      |          |
| 1. How was it to navigate the interactive map (e.g., zoom in, zoom out, pan)? | 1 | 2 | 3 | 4 | 5 |
| 2. How was it to draw an element in the interactive map, e.g., areas, facilities? | 1 | 2 | 3 | 4 | 5 |

(continued on next page)
About the digital tool (interactive map on a touch table)
Please answer the following questions by selecting an option on the right.

3. How was it to delete an element in the interactive map, e.g., areas, facilities?

4. In general, how will you rate the ease of use of the interactive map?

About the map.
Please agree or disagree with the following statements

5. I could locate or identify my community/village

6. The tool allows to draw all the elements identified by participants

7. I feel that the produced village map represents the current situation

8. I feel that the produced village map is the result of everyone’s ideas and inputs

9. How long did it takes you to learn how to use the digital tool?

10. How satisfied are you with the digital tool used in the mapping activity?

Part 3. About you

This part aims to know about your personal background and experience with maps and participatory mapping activities. Please fill the questions below by selecting one of the given options.

11. Fill in your gender:

12. Age group:

13. Select your highest completed educational level

14. What role do you hold in the community organization?

15. How often do you use a digital map (e.g, in a phone)?

16. How often do you use a map in paper?

17. How often do you use a digital map (e.g, in a phone)?

18. Have you participated in a group mapping activity?

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