Evaluative Maps 2.0: a web map approach to capture people's perceptions of a city

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Certificate of Originality

This is to certify that I am responsible for the work submitted in this thesis, which contains my original work, except as specified in acknowledgments or footnotes. All the used references and sources are mentioned and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

____ (Signature)

____ (Date)

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I dedicate this work to my father, Arildo, who enlightens me from heaven; to my mother, Maria Dirce, who enlightens me here from the earth, and my brother, André, my godmother, Maria Helena and my grandmother, Leonides. People who have always supported me regardless of the situation.

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May all the collective efforts and energies that have nourished this research process bear positive fruits for as many beings as possible.

Abstract

An evaluative image of a city can significantly help urban planners to understand the way citizens perceived their cities. In 1990, Nasar started this concept, but the method proposed by him is already outdated regarding technology. This masters thesis proposed, implemented and evaluated an alternative way of creating an evaluative image of a city through an interactive web map platform, here called eImage. eImage is an open-source system developed exploring the concept of "SoftGIS," by developing a public participation geographic information system , as a method to explore local knowledge of the citizens about a city. A user study with sixty-eight participants was conducted in Lisbon (Portugal) to test eImage and to understand the usability and usefulness of this platform, for what it is intended to do. The results showed a good usability score and usefulness of this platform.

Keywords: Evaluative Image of the city, SoftGIS, Public participation geographic information system (PPGIS), Interactive maps

1 Introduction

1.1 Motivation

Cities are increasingly looking for ways to improve their image, encourage urban development and draw visitors and investors. Richards & Wilson (2004) link this phenomenon to the increase in competition between cities seeking for relevant stakeholders, including consumers, investors, and policy-makers, as a way to stand out in the spotlight of the global economy.

In the past, Lisbon has never been among the leading capitals of the European scene, and the situation was even worse about one decade ago when Portugal was facing an economic crisis. With that, urban managers put their efforts on marketing strategies combined with policies to encourage territorial rehabilitation, as an idea to draw the attention of tourists and investors in order to make the urban economy to be active again (Ribeiro, 2017).

Since then, many advances have been made to elevate the city on the global stage, and due to the city of Lisbon focusing on tourism and city marketing, it was recently considered by The Wall Street Journal (2017) as "one of Europe's hottest stars, with tech startups mushrooming and investment pouring in" (Forbes, 2018; Teixeira, 2017; Costa, 2015; Freire, 2011; Dos Santos & Da Costa, 1999; PwC & ULI, 2017). Furthermore, the city approved in 2012 a new Master Plan where the priorities are to "promote an innovative and creative city; affirm the identity of Lisbon in a globalized world; create a participatory governance model and rehabilitation and urban regeneration" (Municipality of Lisbon, 2012), giving the first steps towards a smart city. As stated by Schaffers, Komninos, & Pallot (2012) "Lisbon's ambitions as a smart city is to improve the city's liveliness and quality of life, namely through the active involvement of citizens in the city's governance model."

In this context of bringing the citizen involvement to city's decision making, this work is an attempt to help Lisbon's inhabitants to voice their opinions. This research offers a new way to collect citizens' perceptions about a city. Simultaneously, it attempts to depict a live evaluative image of the city, by creating an interactive map containing the evaluation of all the participants, every time a participant interacts with the platform.

1.2 Background

A variety of continuous processes and actions happens every day within a city, affecting many ordinary people in their everyday activities. The combination of all these processes and actions shapes the way people perceived the city and the urban environment (Lynch, 1960). Making a city more pleasant for their citizens is what urban planners have been trying to do, by making improvements in the visual quality of the city (Nasar, 1989). As stated by Llinares, Page, and Llinares (2013), improving city appearance is a key factor in citizens' well-being and quality of life.

In 1960, the American urban planner Kevin Lynch wrote The Image of the City (1960), an influential work on the perceptual form of urban environments. This book has become a classic in the urban planning discipline. It comprises an empirical study on how people perceive the urban landscape. As proposed by Lynch (1960), the environment image is composed of three elements: identity, structure, and meaning. The last one was not emphasized in his work, although Lynch recognized its importance. After 30 years, Jack L. Nasar an American architect retook Lynch's literature to make a reservation: "Although Lynch recognized the importance of meaning and evaluation, his research emphasizes identity and structure. He felt that people have more consistent perceptions of identity and structure that of meaning. (…) Confronted with possible measurement problems and individual differences, he judged meaning as impractical to study and concentrated on form-identity and structure- separate from meaning". Therefore, Nasar put his efforts to show that community appearance, evaluation, and meaning can also be taken into consideration in a scientific study. Nasar extended Lynch's work by focusing his studies on gathering information about people's perceptions what he refers to as *likability* – of places within a city (Nasar, The Evaluative Image of the City, 1990, p. 7). After many face-to-face and phone calls interviews, Nasar created a composite map considering all the responses, what he named as the "evaluative image of the city," writing so a book with the same name.

An evaluative image of the city represents the evoked emotions (fear, excitement, pleasure) and inferences that influence someone's opinions and experiences about a city (Nasar, The Evaluative Image of the City, 1990). It helps to understand and structure the different facets of human interaction with the environment. Social psychologists also consider the physical environment an essential source of sensory information (Wohlwill, 1966).

In order to collect information from people about places taking the advantages of geospatial technologies, Rantanen & Kahila (2009) created the concept of "softGIS," which has been in development since 2005 at Aalto University, Finland. It is an Internet-based GIS platform integrated with a public participation GIS (PPGIS), which is a method to explore local knowledge of the residents about a city. PPGIS initiatives use geospatial technologies for collecting and analyzing public, place-based knowledge (Schmidt-Thomé, Wallin, Laatikainen, Kangasoja, & Kyttä, 2014).

The term "soft" refers to the local knowledge which is often considered to be "opinion" or "belief" and thus dispensed since the planning system still relies mostly on "hard" technical knowledge and professional expertise. According to (Kyttä, Broberg, Tzoulas, & Snabb, 2013), the "soft" information layer available, created by the experiential knowledge of citizens, comprises an additional layer of contextually sensitive information for the planner. Since then, this approach has been used in cooperation with urban planners with the aim of improving the user-friendliness of physical settings.

As described in Kyttä (2011), among the advantages of the softGIS approach are the use of place-based experiential knowledge being more useful for planners than the traditional criteria-based evaluations. Furthermore, the internet-based softGIS tools are efficient methods to collect evaluative information from large numbers of citizens. Advantages of softGIS tools include the fact that the data gathered is readily available in digital form and reaching groups that are hard to reach otherwise (Brown & Kyttä, 2018).

The softGIS approach was replicated in many studies, for perceiving environmental quality of a city (Kyttä, 2011); evaluating perceived safety of a neighborhood and the evaluating the environmental child-friendliness of a city (Kyttä, Broberg, Tzoulas, & Snabb, 2013); mapping bicyclists' experiences (Snizek, Sick Nielsen, & Skov-Petersen, 2013); and most recently, Acedo, Painho, Casteleyn and Roche (2018) have replicated this approach to collect the spatial dimensions of citizens' sense of place and social capital.

However, the studies mentioned above involving softGIS methods did not offer the visualization of the all users' responses map within the same platform, neither, presents it dynamically and interactively, where respondents can see the live result after finishing the questionnaires.

This research aims to explore the use of interactive maps to support the generation of city evaluative images by offering a visualization method for the participants through the use of an interactive map which speeds up its creation process through the use of digital technologies.

As Ciolfi (2004, p. 39) says, "understanding the dynamics of interaction in space can help us design more effective systems in responding to behavior and changes in the environment."

1.3 Research Aspects

1.3.1 Research Question

How to support the creation of a city's evaluative image through a web map?

1.3.2 Methods

Step 1: Define the scope of the study, as well as the area of study, which comprises four neighborhoods: Misericórdia, Santo António, Arroios e Santa Maria Maior. The study will collect data based on two types of user interaction, denominated in this work as supervised and unsupervised interactions.

Step 2: Build a prototype that helps the users draw places they, both, like and dislike. The prototype will provide two key features:

- Help users to give feedback about why they like and dislikes the places based on the attributes defined by Nasar's work (naturalness, upkeep, openness, order, and historical significance);
- Visualize the "live" results through a web map.

Step 3: Collect data:

- Engage citizens to participate by sending the link of the app via social media
- Make face-to-face interactions with citizens on the street.

Step 4: Evaluation of the prototype: Collect feedback on the usability of the application through a questionnaire.

1.4 Work Structure

The rest of this work is organized as follows. Section 2 presents the related work based on PPGIS and Evaluative image of a city. Section 3 describes the implementation of the application to collect data and to visualize it for the public. Section 4 introduces the user study. The results will be shown in Section 5 and their discussion and future work, in Section 6. Finally, section 7 will be reserved for the conclusion and final remarks.

2 Related Work

2.1 Public Participation Geographic Information Systems (PPGIS)

Public participation geographic information systems (PPGIS) was the terminology used at the meeting of the National Center for Geographic Information and Analysis in the United States (NCGIA, 1996) to depict how applications involving GIS technologies could involve and increase public participation in many decision-making processes (Brown & Pullar, 2012). It was described by Obermeyer (1998) as a way to combine the practices of mapping and GIS making it more inclusive to nonofficial voices and more adaptable to extra-organizational input, acquiring it from regular citizens. In general, PPGIS relates to methods and technologies for getting and using spatial information in participatory planning processes (Rambaldi, Kyem, McCall, & Weiner, 2006).

Kyem (2000) covered different aspects in his study in order to compare GIS and PPGIS. He concluded that the focus of both is technology. However, the second one also includes the sphere of people to it. The goal of GIS is to facilitate official policy-making and has a rigid, hierarchical and bureaucratic organizational structure related in opposition to the PPGIS' primary goal of empowering communities and having a flexible and open organizational structure.

Public Participation GIS touches the field of Volunteered Geographic Information (VGI) proposed by Goodchild (2007) in the context of creating and disseminating geographic data provided voluntarily by individuals. However, as explained by Tulloch (2008) the differences consist mainly of the purpose or motivation for participation. PPGIS projects are usually developed to inform planning, policy issues, and decision-making processes while VGI applications may have no explicit purpose other than participant enjoyment.

As stated in Sieber (2006), PPGIS can enhance public participation in policymaking, empower community members to improve their lives and advance democratic principles, promoting the goals of nongovernmental organizations, grassroots groups, and community-based organizations, using as a GIS tool for capacity building and social change. Mostly, PPGIS is the act of mapping at local levels in order to produce place knowledge (Schuurman, 2008).

2.2 Evaluative Image of the city

The way the city is perceived varies importantly with personal and cultural differences. People often see and interpret the same scene differently (Nasar, 1990). In 1960, Lynch wrote *The Image of the City*, a book about his empirical studies on how people perceive the urban landscape (Lynch, 1960). This work had a great recognition among city planners and urban designers that have been used to plan many cities, including San Francisco, Cairo and Castro's Havana (Hospers, 2010).

Lynch was interested to know "how cities are framed in our heads?". Therefore, in order to depict "the city of the mind," he used the term "imageability," which he defined as "that quality in a physical object which gives it a high probability of evoking a strong image in any given observer" (Lynch, 1960; Hospers, 2010). Years later, in 1990, Nasar pointed out that in Lynch's research, the priority was on identity and structure of the urban environment. Even though "Lynch recognized the importance of meaning and evaluation," these facets were not taken into account in his research (Nasar, 1990, p. 9). Thence, Nasar wanted to take a step forward by bringing into focus the evaluative aspect of the people towards a city. For this, he introduced the term "likability," which he describes as "the probability that an environment will evoke a strong and favorable evaluative response among the groups or the public experiencing it."

In order to elucidate "likability," a whole new concept was created by Nasar, what he named as "The Evaluative Image of the city." This concept was inspired by early researchers who produced "mental maps" of touristic places in the form of "contours," where peaks represent places that are generally desired and traveled to, and the troughs indicate places thought of as unappealing and avoided (Gould & White, 1974). The evaluative image allowed residents and visitors of a city to depict its image via the stimuli aggregated by the cityscape and experience related to this city. City images are communicable and projectable that may imply affection, feelings, and emotions (Motamed & Farahani, 2018).

As stated by Insh and Florek (2008), in order to assess whether a city is meeting the demands of visitors and residents, persistent measures and reliable indicator must be provided. Nasar (1990, p. 15) mentioned that evaluative maps "provide a basis for a visual plan for guiding the future appearance of a city" exposing the identity, location, and likability of visual features. Furthermore, he tackled that likability of places is associated with five features: naturalness, upkeep, openness, order, and historical significance.

Evaluation and imageability are connected, Lynch (1960) mentioned people would remember places about which they have strong feelings or are attached to, and they are more likely to have feelings about the imageable parts of the city. Nasar (1990, p. 8) added to it: "Evaluative reactions heighten imageability, and imageability intensifies evaluations." To sum up, evaluative maps of cities could aid city planners to determine the "marketing" of the city, or city image, which is based on peculiarities and identities of the cities, and is fundamental for achieving the goals of their stakeholders – visitors, residents and business people (Gilboa, Jaffe, Vianelli, Pastore, & Herstein, 2015).

3 Implementation

As part of the data collection and the automatic generation of the evaluative image of Lisbon, a web platform was developed. Therefore, a name and logo were created to be used as a signature of this platform. It is called: eImage (Figure 1). A suffix "LX" (which stands to Lisbon) was added to it, which refers to the area of study.

Figure 1: eImage LX. An app to create the evaluative image of Lisbon.

This app is open-source; hence, it can be replicable and reusable. Also, a GitHub repository was created to host the code and to have better control over the versions of the app, which can be found in the following link (Frame 1):

```
https://github.com/matheussiba/eimg_lx
```

Frame 1: GitHub repository for eImage-LX.

The next subsections will brief about the major components of the application.

3.1 eImage Architecture

A wide range of technologies was used to develop eImage. Altogether, this web-platform was built from scratch, both back-end (server-side) and front-end (client-side). The reason for that is the fact of having more flexibility to the tool, giving more autonomy regarding development, once the tool could be shaped more easily, and adapted to different environments and stakeholders.

In order to reduce the complexity of the system, eImage, consist of two main components: The Canvas and the Viewer (See Chapter 4). In the architectural point of view, those two components are mere, two web pages, each one performing different tasks.

The first one, the Canvas (Figure 2 - top), is where users have the first contact with eImage. It is the webpage where the user's city evaluation is collected, in other words, this is the place where each user will draw the polygons of areas they like and dislike, for the study area.

The second one, the Viewer (Figure 2 - bottom), is where each user is redirected when they are finished with the input part. This webpage contains the "evaluative image of the city," which is automatically generated all the time a user completes the drawing part (the Canvas). When it happens, a new evaluation is inserted in the database, and an updated evaluative image map is generated, being displayed by the Viewer.

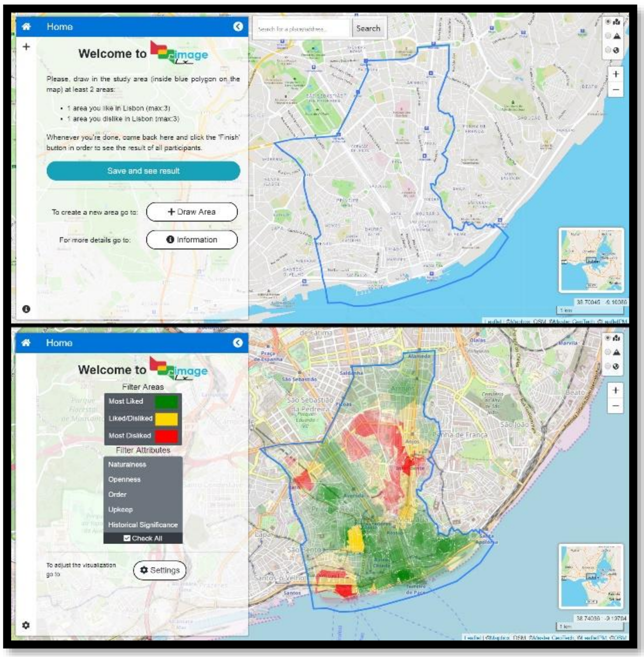

Figure 2: The two components of eImage, the Canvas (top), the Viewer (bottom).

A more detailed diagram of the whole architecture of eImage can be seen in Diagram 1. Additionally, an accurate description of the technologies and structure used for the server-side and client-side are found below.

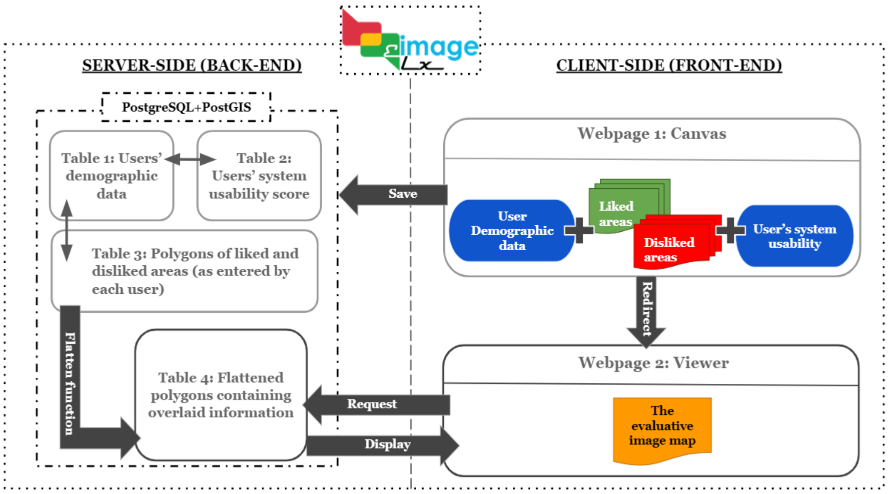

Diagram 1: eImage Architecture.

3.1.1 Server-side

The server-side processing refers to operations that happen behind the scene. The details are unknown and unimportant to the client. For dealing with that, PHP was chosen as a programming language. As described in PHP documentation (2019), it is a "widely-used open source general-purpose scripting language," being "extremely simple for a newcomer" and offering "many advanced features for a professional programmer."

For the database system, PostgreSQL was used. It is considered the “most advanced open source relational database” (postgresql.org, 2019). Furthermore, it also has many extensions that could be added to it in order to extend its capabilities. One of them is PostGIS, an open source, standards-based tool, which enables support for geographic objects. It is used in eImage, once it comes with a wide range of spatial functions, allowing location queries to be run in PostgreSQL.

Regarding the organizational structure inside PostgreSQL, four main tables were used in eImage (Diagram 1 – Server-side). Thus, three of them stores the user’s data created on the Canvas webpage, which are: user demographic data, system usability score, and the polygons drawn by the user.

Then, after each user interaction, a function that was implemented using PostGIS (see Annex 1) is triggered in the database creating a fourth table that contains the data to be displayed in the Viewer webpage. The role of this function is to deal with the intersection that occurs in eImage. To explain it, Figure 3-left shows three polygons that are drawn by different users. In the same area, there’re two persons liked it and one person does not like it. Figure 3-right shows what this function does. It splits the polygons by their intersections and sums the number of intersections. The way these intersections are displayed with eImage is described in Section 3.2.2.2.

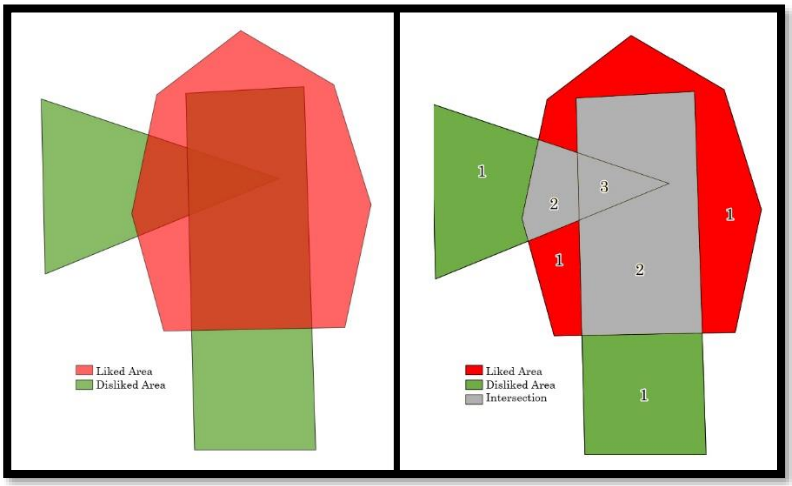

Figure 3: Dealing with intersections in eImage. (*left*: 2 liked areas and one disliked area is drawn, each one by three different users. Opacity is applied for better visualizing the intersection.; *right*: eImage interpretation, the polygons are split based on the intersection between them. The number inside each polygon represents the number of intersections they have.)

3.1.2 Client-side

The client-side processing refers to operations that are performed in the web browser. These are the activities noticed by the users. Hence this needs special attention regarding user experience, to maximize interactivity with the users, with the aim to implement an easy and pleasing system for them to use.

As shown in Diagram 1 – client-side, eImage comprises two main web pages. One denominated Canvas, where the primary objective is to capture the opinion of the participants about a city, that is, areas where they like and areas where they dislike in the study area. As a secondary data, but also essential to compute statistics of all participants, demographic data is also collected and the system usability score, or the evaluation of all users regarding the usability of the system. The second webpage is the Viewer; it has no other function except to display the Image of the city.

Both web pages were essentially a web map, the first one to collect data and the second to display data. In this way, eImage was built using Leaflet.js, the number one open-source JavaScript library for interactive web maps, which counts with many contributors all over the world (Leaflet, 2019). Besides that, it presents a ready-to-use capability for mobile-friendly applications and a wide range of plugins that could be combined with the library to extends its power and functions, as it will be described in the next section (see Section 3.2).

The communication for sending and retrieving data from the server is made using AJAX, which returns the response from the server in a JSON format, thus being parsed by eImage. AJAX is an asynchronous technique (which runs in the background) that sends queries to be executed in the server, allowing websites to save data or load content fetched from the server onto the screen without the need to refresh the page.

3.2 eImage Features

All features of eImage were developed considering mobile-friendly applications. It can be accessed from a desktop computer to tablets and smartphones; detailed information is described in the following sections.

3.2.1 Canvas

3.2.1.1 App Languages

By Lisbon is the area of study, eImage was implemented both in Portuguese, in order to reach the Lisbon citizens; and English, to reach visitors and even residents that, in turn, don't speak Portuguese.

3.2.1.2 Drawing features

The Canvas in eImage had its core components made for data collection of areas users like and disliked among a city. For that, participants should be able to complete the task of drawing these areas in the web platform. For this reason, it was invested a considered amount of time focusing solely, on the drawing part of the system, in order to guide the user through the whole process.

In order to create and edit the geometry layers in Leaflet, an open source plugin was used called, Leaflet.pm (2019); among its already implemented features, this plugin comes with the capabilities of removing the last node of a polygon that is being drawn, encouraging the user to backpedal, if any mistake is made during the drawing. In eImage, this tool was brought together among other tools, in a toolbar (Figure 4), and it is enabled when a new area is being drawn on the map. It contains a button that finishes the drawing, another to remove the last vertex (node of a polygon) and the last one to cancel the drawing of the polygon, if necessary. All of these buttons could be respectively accessed via keyboard shortcuts, by pressing Enter, Ctrl+z, and Esc.

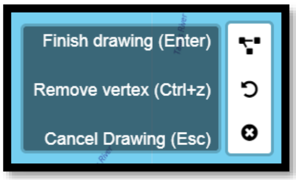

Figure 4: Toolbar for supporting the drawing process.

Another feature of eImage is the displaying of messages, while a participant is drawing an area. Some of these messages are shown in Figure 5, which are displayed in different moments during the drawing process.

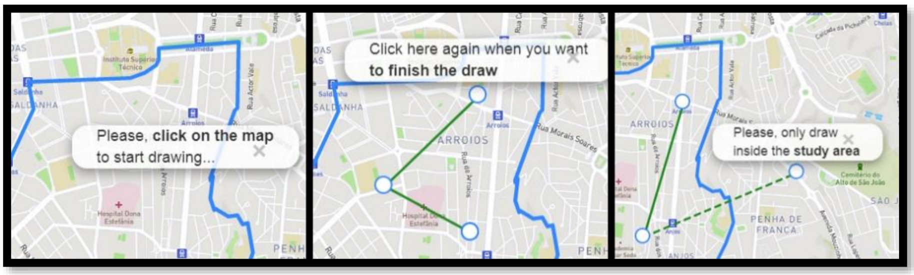

Figure 5: Messages to guide the user while drawing on eImage (*left*: appears when the user clicks in the button to draw an area; *center*: appears in the first node of the drawing; *right*: when the user tries to click creates a node outside the study area).

Any complex shapes (convex and concave) can be created by eImage, as long as they do not present self-intersections. When it happens, the dashed line that follows the user cursor gets yellow, alerting the user. Thus, not having polygons with self-intersection, guarantees robustness to data storage in the database, preventing eventual crashes in further calculations.

When an area is drawn in eImage, a sidebar window, correspondent to that area, is automatically opened, appearing the attributes to be marked by the user related to that area (Figure 6). Moreover, buttons for creating a new area or for saving or deleting (in case of any error) the recently created area is also added to this window. Similarly, the user can use the nodes of the polygons to adjust and edit its shape, if necessary.

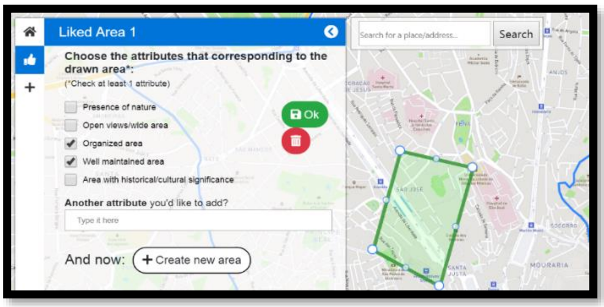

Figure 6: Polygon created by eImage.

3.2.1.3 Interface

As shown in Figure 7, the interface of eImage-Canvas tries to reduce as much as possible the number of elements presented to the user. The sidebar on the left contains the navigational elements to guide the user through the application, and it is based on the leaflet sidebar-v2 plugin (2019). Figure 7-A is the home button where the user has the basic instructions of eImage. Figure 7-B is the button to add a new area (liked or disliked place) by drawing on the map. Figure 7-C is the info menu, containing detailed information about eImage and the description of its features, as well, a 30 seconds video demonstrating the process of drawing on eImage (available in Portuguese and English).

As part of additional features, Figure 7-D brings to the user a geocoding tool, where an address can be searched to help the participant to find an area inside the study area. This tool uses Google Places API and works with a maximum of thousand requests per day, it only returns results inside the study area, giving an alerting message to the user otherwise. Figure 7-E is a feature to change the basemap, besides the standard one, terrain and imagery basemaps can be added, aiding users in determining better its polygons barriers based on geographic feature (top of the hill, end of a park, and others), if necessary. Figure 7-F is the zoom control (which also can be controlled by the use of a mouse, in laptops or desktops or the fingers in the case of mobile devices). Last but not least, Figure 7-G, shows the leaflet's overview map plugin (2019), which is a generalized view of the Canvas.

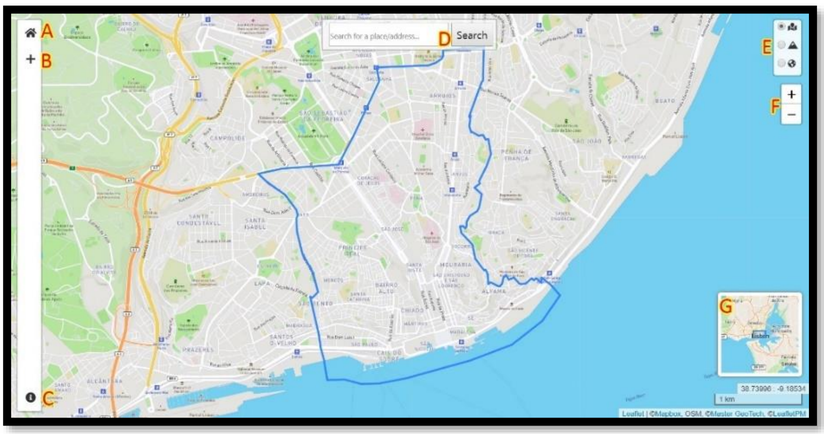

Figure 7: eImage Canvas interface.

Additionally, the user is forced by eImage to stay in the extent shown in Figure 7; this helps the user not to be distracted while panning over the map and it is made by controlling the panning extension of the map.

3.2.1.4 Liked and Disliked areas

A consistent color scheme was used in eImage to avoid the misleading of a user while using the system. For it, green was used to represent liked areas, and red was used to represent disliked areas (Figure 8).

As seen in Figure 8-bottom, a thumbs-up icon with a green background is added to the sidebar when a liked area is added to the map. On the other hand, a thumbs-down icon with the red background is added to the sidebar when a disliked area is added to the map.

Overall, the user is limited to draw three areas of each category (liked or disliked). When this limit is reached for one category, the button to add a new area (Figure 8-top) becomes disabled (for the same category).

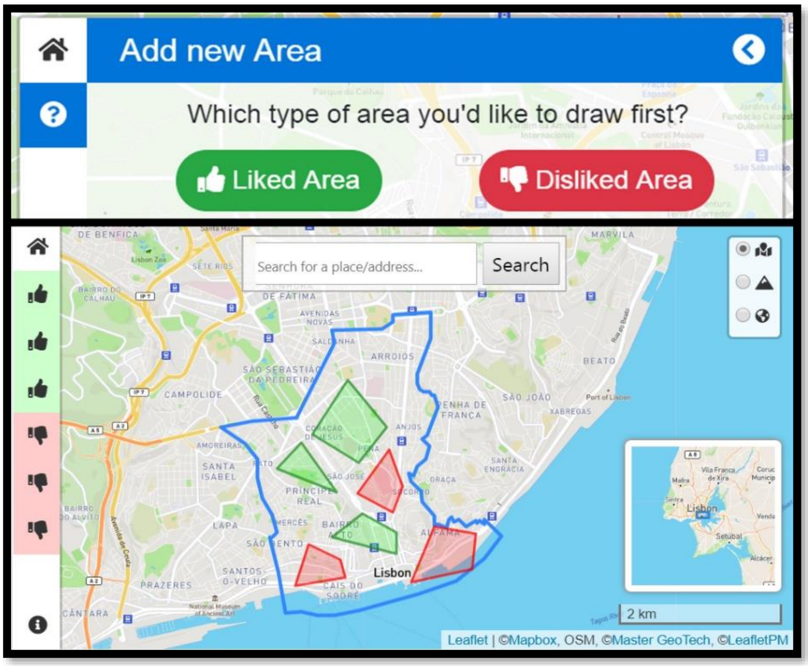

Figure 8: Liked and disliked areas in eImage. (*Top*: sidebar window when the user clicks to add a new area; *Bottom*: eImage-Canvas being accessed from a mobile device)

3.2.2 Viewer

3.2.2.1 Interface

The interface of eImage-Viewer is presented in Figure 9, which main intention is to display the "evaluative image of the city." Figure 9-A shows the legend of the map (in the example, three classes are displayed). Figure 9-B shows the option for filtering the data on the map. Figure 9-C is a button in the sidebar to access the settings of eImage-viewer. In the settings, the user can adjust the number of classes they want the eImage to be displayed (three or five), and the dataset (only face-to-face interviews or the whole dataset). Figure 9-D presents the "evaluative image" created by eImage for the area of study based on all participants options (further explanation. See Section 3.2.2.2). Moreover, Figure 9-E, F and G correspond to the same features described in the previous section, by Figure 7-E, F and G, respectively.

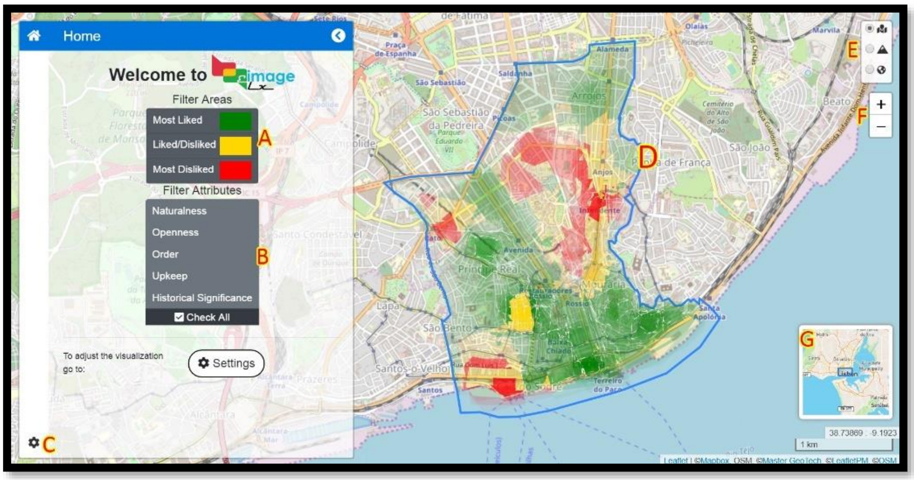

Figure 9: Interface of eImage-Viewer.

3.2.2.2 *The Evaluative Image of the City*

In order to display the evaluative Image of the city, eImage retrieves the polygons processed in the database (as described in Section 3.1.2). Then, for styling the polygons eImage colors, is based on the number of likes an area have, which is here called "Likeness rate" (Equation 1).

Equation 1: Math to style every single polygon in eImage-Viewer.

$$\text{Likeness rate} = \frac{N^{\underline{o}}\ likes}{N^{\underline{o}}\ likes + N^{\underline{o}}\ dislikes}$$

Below, Figure 10 shows the Likeness rate being used to color every single polygon in eImage-Viewer. When there's no disliked area intersecting with a liked area, the likeness rate is equal to 100%. The opposite is also true, no liked area intersecting a disliked area, the likeness rate is equal to 0%.

The classification method used by eImage is the Equal Interval Classification based on the likeness rate. Figure 10-right shows the example of styling polygons using three classes:

- Most Liked areas – Color: green, Likeness rate: from 66.67% to 100%;
- Liked/Disliked areas – Color: yellow, Likeness rate: from 33.33% to 66.66%;
- Most Disliked areas – Color: red, Likeness rate: from 0% to 33.32%.

The color yellow, in this case, means that, statically, the number of persons who disliked an area is about the same as the number of persons who liked it, and vice-versa. The color green means that most people liked that area, and the opposite is valid for the color red.

A 5 classes classification is also available for eImage; they are the following:

- Most Liked areas – Color: green, Likeness rate: from 80.01% to 100%;
- Liked areas – Color: Cyan, Likeness rate: from 60.01% to 80.00%;
- Liked/Disliked areas – Color: yellow, Likeness rate: from 40.01% to 60.00%;
- Disliked areas – Color: Magenta, Likeness rate: from 20.01% to 40.00%;
- Most Disliked areas – Color: red, Likeness rate: from 0% to 20.00%.

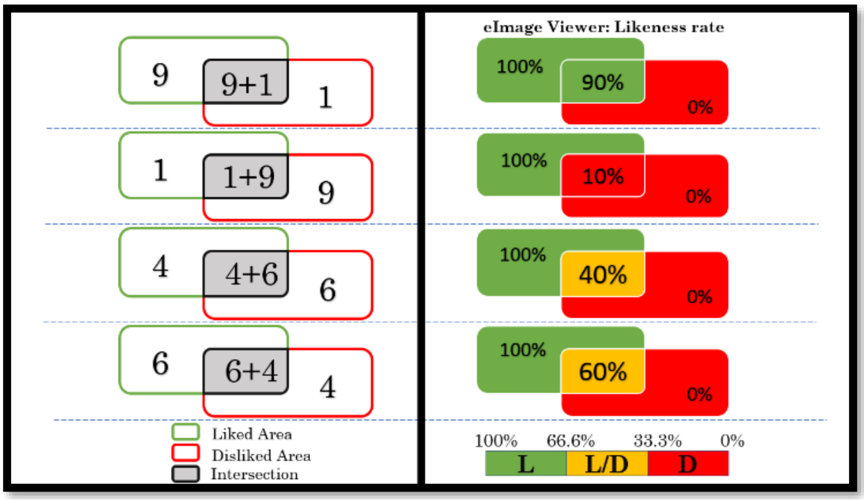

Figure 10: Styling polygons in eImage based on likeness rate. Three classes example: Liked, Liked/Disliked and Disliked. (*left*: Four examples of flattened polygon explained in Figure 3-right; *right*: The respective styling based on the likeness rate of the flattened polygons.)

The number of persons who evaluated an area is also taken into account by eImage-Viewer, using the opacity to identify it. Figure 11 shows the effect of opacity in eImage. For each class, the number of persons that evaluated an area is normalized by the highest number of this class receiving a stronger color (higher opacity), and the smallest number receiving a lighter color (smaller opacity).

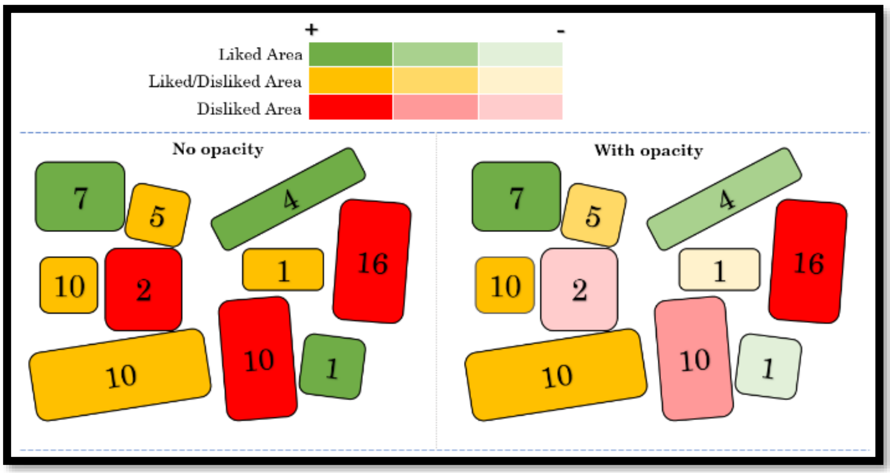

Figure 11: Opacity is representing the intensity of evaluation. Numbers inside polygons represent the number of persons that evaluated this area.
If an area was just liked by one person, it is not so relevant as an area liked by ten persons. In this case, the first one receives a darker color and the second a lighter.

Finally, all of this already mentioned features of eImage-Viewer is brought together in the real scenario by Figure 9-D.

4 User Study

4.1 Experiment Design

An experiment helps to answer a theoretical argument, which, in this case, is the research question stated in section 1.3.1. Thus, a user study was conducted between December 17th, 2018 until January 17th, 2019 in order to gather participants to test eImage interface, and then, give their feedback about this initial prototype.

This study has the components of both usability study and research. It proposes a method to digitalize and automatize the process of creating evaluative images, in the sense of Nasar, through interactive maps; and it also tests and evaluates this method by the participants of the study.

One independent variable is present in this study. It represents the way users interacted with the platform, which were divided into two. The first one is the supervised interaction, meaning the participants were recruited on public places via word of mouth communication. Furthermore, the conductor of the study was beside each participant in order to help them to use eImage, upon request. The second one is the unsupervised interaction, where the URL of eImage platform, was sent out to social media groups (Facebook and WhatsApp), which topic was about Lisbon. According to Lazar, Feng, & Hochheiser (2010) participants previous knowledge and number of participants may bias the results. The idea of both interactions is to compare the dependent variables later, using the supervised interaction as the "controlling" scenario (with a person assisting the user, if necessary) in contrast with the supervised one, where the users are by their own.

The dependent variables included in this study are *Usability*, *Efficiency*, *Dropout rate*, *Learnability*, *Usefulness,* and the *Technology influence*. These variables are measured by the logging system implemented in eImage-Canvas, in order to track user's interaction with the platform. For measuring usability, the System Usability Scale (SUS) was used. It comprises ten questions, whose final score can effectively differentiate between usable and unusable systems (Brooke, 1996). A direct Portuguese version of SUS validated in a study by Martins, Rosa, Queirós, Silva, & Rocha (2015) was used. Although SUS is a low-cost questionnaire that has been validated and it can help to distinguish between usable and unusable systems, it is used for generic assessements and it only measures perceived usability (i.e., subjective) and it doesn't identify anything further than that. Efficiency was measured by the average time people spent on drawing an area and giving the attributes related to it. The dropout rate shows the number of persons that quit the experiment before finishing it. Learnability was measured by analyzing whether the time to create an area decreases, while the number of drawn areas increases. Last but not least, the usefulness variable was measured by two questions added in the last step of eImage, whose responses have the same range as SUS (from Strongly Disagree to Agree Strongly). These two questions were the following:

- "This app helps me say what I like/dislike effectively."
- "This app could be an effective way to give feedback to my city council."

Between-group design (Lazar, Feng, & Hochheiser, 2010) was adopted for the user study, meaning one participant would do one type of task (either supervised or unsupervised interaction). It is a simpler design and avoids learning effects (Mosheiov, 2001). The demographic information of the participants is detailed in Table 1.

Table 1: Demographic information of the participants.

		Overall (n = 68)		*Supervised (n = 45)*		*Unsupervised (n = 23)*	
		Nº Part.	**%**	***Nº Part.***	***%***	***Nº Part.***	***%***
Gender	**Female**	29	42.65	18	40.00	11	47.83
	Male	39	57.35	27	60.00	12	52.17
Age	**18-24**	14	20.59	9	20.00	5	21.74
	25-34	36	52.94	25	55.56	11	47.83
	35-44	11	16.18	5	11.11	6	26.09
	45-54	3	4.41	2	4.44	1	4.35
	55-64	3	4.41	3	6.67	-	0.00
	>65	1	1.47	1	2.22	-	0.00
Education	**High school graduate**	2	2.94	1	2.22	1	4.35
	Professional degree	2	2.94	2	4.44	-	0.00
	Bachelor's degree	19	27.94	10	22.22	9	39.13
	Master's degree	39	57.35	28	62.22	11	47.83
	Doctorate degree	4	5.88	3	6.67	1	4.35
	No schooling completed	2	2.94	1	2.22	1	4.35
Income	**<1000**	20	29.41	8	17.78	12	52.17
	1000-1499	14	20.59	9	20.00	5	21.74
	1500-1999	5	7.35	5	11.11	-	0.00
	2000-2999	7	10.29	4	8.89	3	13.04
	3000-3999	-	0.00	-	0.00	-	0.00
	4000-4999	-	0.00	-	0.00	-	0.00
	>5000	1	1.47	1	2.22	-	0.00
	NA	21	30.88	18	40.00	3	13.04
Occupation	**Employed worker**	21	30.88	18	40.00	3	13.04
	Freelance	4	5.88	3	6.67	1	4.35
	Retired	1	1.47	1	2.22	-	0.00
	Student	34	50.00	20	44.44	14	60.87
	Other	6	8.82	2	4.44	4	17.39
	Unemployed	2	2.94	1	2.22	1	4.35
Type	**Resident**	67	98.53	45	100.00	22	95.65
	Visitor	1	1.47	0	0.00	1	4.35
Uses Mobile Device	**No**	28	41.18	14	31.11	14	60.87
	Yes	40	58.82	31	68.89	9	39.13

4.1.1 Tasks of the study

For each interaction in the platform, the participants needed to do the following tasks:

(1) Each participant should draw areas they like and areas they disliked within the study area. The minimum number of drawn polygons is two

(one liked and one disliked), and the maximum number is six (three liked and three disliked).

(2) Give an attribute for each drawn polygon. There're five available options for them to choose, presented in Table 2. At least one must be checked.

Table 2: Available attributes for users to choose referent to the drawn area.

Liked Area	***Disliked Area***
Presence of nature	Lack of nature
Open views/wide area	Restricted views/crowded area
Organized area	Disorganized area
Well maintained area	Poorly maintained area
Area with historical/cultural significance	Area with no historical/cultural significance

4.2 Procedure

The duration of each interaction is about 10 minutes. Firstly, the participant will receive the eImage web link, which can be accessed from a desktop computer, laptop, smartphone or tablet. The first page (Annex 2) contains a brief explanation of the objective of the study and a 30 seconds video explaining how to complete a task in the platform. In this page, it will be asked whether the person consents to participate or not in the study. After the agreement, it will be redirected to the second page, which contains the demographic questions about the participant (Annex 3). After answering those, the eImage-Canvas is finally accessed (Figure 2 - top), and the participant can start with the tasks (described in section 4.1.1), by drawing polygons of liked and disliked areas their like within the study area, in Lisbon. After each draw, the sidebar will open, asking the user to give an attribute to the drawn area (Figure 6). When the participant is finished, they need to click in the "Save and see result" button in the home tab of the sidebar (Figure 2 - top). It closes the eImage-Canvas the participant is redirected to the usability (SUS) and usefulness questionnaire (Annex 4). When the user is finished with it, the application will be redirected to the eImage-Viewer (Figure 2 - bottom). It is the webpage where the polygons from all collected answers are displayed.

4.3 Pilot Study

A pilot study was conducted before the data collection to take place. This preliminary study aimed to investigate whether the main components of eImage were understandable by a lay person. For that, two male participants of ages 28 and 35, were recruited. The first one is a resident of Lisbon, and the second one is a visitor, who, according to him, already visited Lisbon many times.

Thus, they were submitted to do the tasks described in section 4.2 (each of them was consulted individually). Although the conductor of the study was sat beside them to take notes of possible error or misleading the participants might face, no kind of help or support was provided, simulating an online interview. After each participant had completed the study, they were asked about the questions and issues they had while using eImage.

The main topics raised by them are described below:

- the lack of a searching tool for helping them to find the location they want (it was implemented, as seen in Figure 7-D);
- a beforehand description about the attributes to consider while drawing a liked/disliked area (it was implemented, as seen in Figure 12).

Similarly, other minor details were also made, such as the adjusting of the font-size in the application (it was considered too small), some typos corrections, as well the improvement of the explanatory text in the Home section of the sidebar.

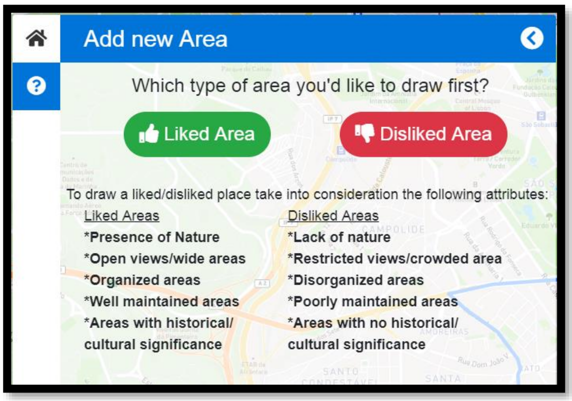

Figure 12: A beforehand description for the user to consider while drawing a liked/disliked area.

While observing the participants' actions and steps in eImage, all of them tried to draw outside the study area. To prevent this, the final version of the prototype controls the panned area of the map, and notifies the user when a node is clicked outside the study area (Figure 5-right). Likewise, an alert message is displayed when the user tries to search a location, in the geocoding tool (Figure 7-D), which falls outside of the study area. After all of these details were corrected and implemented, the study was conducted with the current functionalities of the application.

5 Results

Efficiency, Dropout rate, Learnability, Usability and Usefulness obtained from the study conducted with 45 participants in the supervised interaction and 23 participants in the unsupervised interaction is described in the next sections.

5.1 Efficiency

The time spent by the participants during the interaction with eImage-Canvas was recorded and presented in Table 3. Here, it was broken down into four categories. The first one is *Session*, it represents the time participants spent during the whole session of eImage-Canvas (process described in section 4.2), that is, since the time they accept to participate in the study until they submit the usability questionnaire. The second one is the time they spent while filling out the demographic questionnaire. The third one, *Drawing*, is the time participants spent doing the tasks in the platform. Moreover, the last one is the time spent answering the SUS and Useful questionnaire.

In general, participants spent less time in the supervised classification and more time in the unsupervised one, while drawing and when the whole time spent in the platform is considered. The reasons to it could be related to the fact that the supervised interaction the conductor of the study was beside the participant, which could fasten then to finish the application. The time spent in the questionnaire was about the same in both interactions.

Table 3: Time spent by participants during all the interaction using eImage-Canvas.

Time (Minutes)		Mean	Standard Deviation	Minimum	Maximum
Session	**Supervised**	7.68	1.70	6.35	10.62
	Unsupervised	11.08	5.52	3.64	18.84
Demographic questionnaire	**Supervised**	0.75	0.38	0.38	1.31
	Unsupervised	0.70	0.45	0.24	1.66
Drawing	**Supervised**	4.44	1.19	3.17	6.25
	Unsupervised	7.98	4.57	2.00	14.89
SUS and Usefulness questionnare	**Supervised**	1.55	0.61	0.97	2.22
	Unsupervised	1.48	0.60	0.67	2.62

Table 4, shows the average time users spent on completing one task. A smaller time was observed in the supervised interaction, and this could be explained that the participants were advised what to do by the conductor and they interacted with the platform in a straightforward way. While during the unsupervised interaction participants took more time to explore the platform, read the instructions, to better understand how to finish a task.

Table 4: Average time per task

Supervised	Unsupervised
1.40 min	2.71 min

5.2 Dropout Rate

The dropout rate represents the number of persons that quit the study without finishing it. It is presented in Table 5. There were no dropouts during the supervised interaction because they are counted when a participant quit the study after consenting to participate in it.

Table 5: eImage-Canvas dropout.

	Supervised (n = 45)	**Unsupervised (n = 23)**
Number of dropouts	0	9
Dropout rate	0 %	39.13 %

On the other hand, nine persons dropped out during the unsupervised interaction, having a dropout rate of 39%. Additional information about the participants who dropped the study is presented in Table 6.

When observing the demographic information of the participants (Table 1), it has verified only one participant who is visiting Lisbon; this person was probably in one of the social media groups, where there's no way to control this factor in those groups. This participant was one among the participants who dropped out the application before finishing the study.

Among the nine persons who accessed the application using a mobile device, more than a half (five in total) dropped the study out.

Table 6: Information about the 9 participants who dropped out during the unsupervised interaction.

		Nº Part.
Type	**Resident**	8
	Visitor	1
Uses Mobile Device	**No**	4
	Yes	5

5.3 Learnability

Chart 1 shows the average time spent by the participants based on the drawing order of each polygon. The idea is to see if this time decreases while the number of polygons is drawn increases. It would imply a learnability effect by the users, or, in other words, it would show that users quickly become familiar with the platform, making good use of all its features and capabilities. Although in this case, there's a little decay between the first one and the last ones, it is not possible to draw any conclusion about the learnability effect. One reason for this is that, during the supervised interaction, it was observed that participants didn't have the liked and disliked places already set in their minds before starting the application, so each time participants wanted to draw a new area, they spent relatively the same time to think about this new area, presenting in the end almost the same time, while drawing a new area.

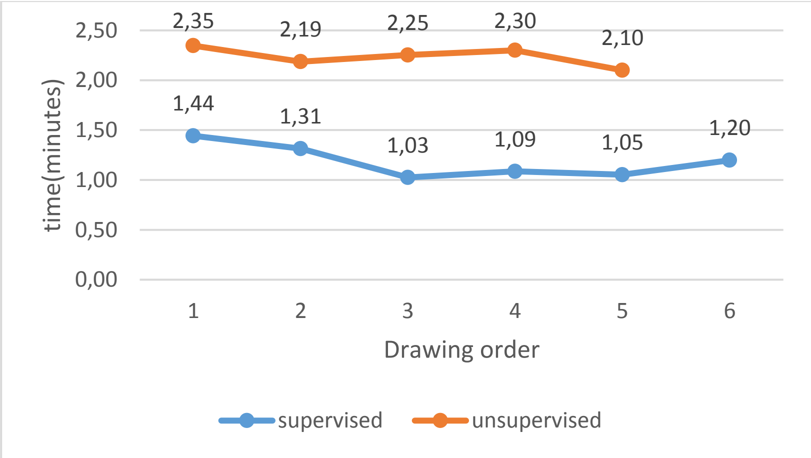

Chart 1: Average time spent per task per drawing order

5.4 Usability

Table 7 presents the SUS score calculated for both types of interaction, as well, the overall score of the application.

Table 7: eImage SUS score

	SUS score
Supervised	79.6
Unsupervised	77.1
Overall	**79.0**

The research did by Bangor, Kortum, & Miller (2008) aimed to give adjectives to the SUS score. According to it, eImage's usability is between "good" and "excellent" (Figure 13).

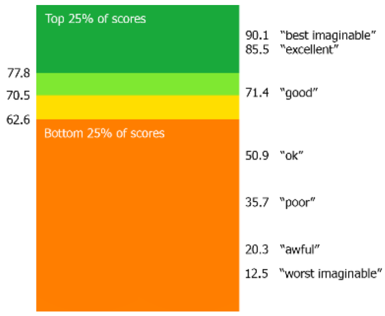

Figure 13: SUS score and its related adjective (Bangor, Kortum, & Miller, 2008)

The unsupervised interaction received a lower SUS score compared to the Supervised classification. This was already expected by the fact that users were by their own for the unsupervised interaction, what was not valid for the supervised one. However, the score difference between both interactions types was very similar (only two and a half points), classifying both with the same adjective (Figure 13), between good and excellent.

5.5 Usefulness

For calculating the usefulness score of the application, it was created two questions, to users to answer together with the SUS questionnaire (Annex 4):

- Question I: This app helps me say what I like/dislike effectively.
- Question II: This app could be an effective way to give feedback to my city council.

Participants were asked to answer these questions using the same response range used by SUS, from Strongly Disagree to Agree Strongly. It was divided into five steps, where the maximum score would receive the value 5 and the minimum the value of one, as seen in Figure 14.

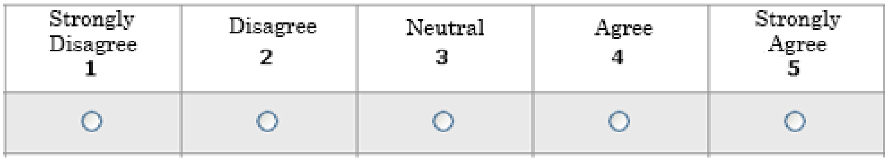

Figure 14: Response range for the usability and usefulness questionnaire.

In this way, Table 8 brings the usefulness score calculated for eImage.

Table 8: eImage Usefulness score

	Question I	Question II
Supervised	4.2	4.4
Unsupervised	3.1	4.4
Overall	**3.9**	**4.4**

Regarding Question I, the difference was very significative between both interaction types. For the unsupervised interaction, people were mostly neutral (3.1 points) that eImage can help them to say what they like/dislike in a city effectively; while in the supervised interaction, participants agreed with this statement (4.2 points). The main reason people complained during the supervised interaction is that they could not found the appropriate attribute to give to the area they had drawn.

For Question II, both interactions received the same score (4.4 points). It means that most of the people agree/strongly agree that eImage could be an effective way to give feedback to the city council.

5.6 Technology influence

The influence of technology was also considered during the eImage interactions. The participants were distinguished weather using a mobile device[1] (smartphones and tablets) or not (desktop computers and laptops). This was done to observe if there are any differences in a touchscreen interaction (mobile device)

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[1] For this study the term mobile device covers tablets and smartphones. However, From the perspective of human computer interaction, the perceived complexity of both are not the same.

or in a mouse cursor interaction (not mobile devices), which could influence user behaviors. Table 9 presents the influence of technology in eImage.

A hypothesis test, using p-value was used to verify if there're differences between the values. As seen in Table 10, the p-test for comparing mobile vs. non-mobile devices shows that in both interactions there's a significant difference between the size of the drawn areas (p-value < 0,05). This could be that users tend to zoom out the map to have a wider view about the area drawing while using a mobile device. Therefore, when drawing in a smaller scale, the precision of the boundaries is lower, hence, the area created for each polygons tends to be bigger when compared with non mobile devices.

The average time for drawing an area in the supervised interaction was about the same using both technologies. However, it has a significant difference in the unsupervised interaction.

The number of drawn polygons was about the same in the unsupervised interaction, but bigger for mobile devices in the supervised one.

Table 9: Technology influence in eImage.

	Supervised		***Unsupervised***	
	Not Mobile Device	**Mobile Device**	**Not Mobile Device**	**Mobile Device**
Average area for each polygon drawn (x1000sqm)	161.0	258.3	326.4	698.1
The average time for drawing an area (seconds)	44.68	47.16	54.71	38.83
Average number of polygons created per user	2.7	3.3	3.2	3.4

Table 10: P-value test for Table 9. (See Annex 5, Annex 6, Annex 7)

	Supervised vs. Unsupervised	**Supervised**: Mobile vs. non-mobile devices	**Unsupervised**: Mobile vs. non-mobile devices
Average area for each polygon drawn (x1000sqm)	0.096	8.756e-06	1.738e-11
The average time for drawing an area (seconds)	0.002	0.053	0.170
Average number of polygons created per user	0.928	0.115	0.849

5.7 Liked vs. dislike areas

While in the supervised interaction, people always were having trouble to choose areas they disliked in the study area. It is seen in Table 11 that most of the people start drawing the liked areas first.

Table 11: Count of drawn areas by type and order

	Supervised		***Unsupervised***	
Drawing order	**Liked Areas**	**Disliked Areas**	**Liked Areas**	**Disliked Areas**
1	44	1	13	1
2	18	27	9	5
3	12	10	5	4
4	3	12	1	5
5	3	4	-	3
6	-	2	-	-

The number of liked areas is relatively higher than the number of disliked areas in both studies as presented by Table 12.

Table 12: Total number of liked and disliked areas drawn in eImage.

	Supervised	**Unsupervised**
Liked	80	28
Disliked	56	18

Table 13 shows the average area of liked and disliked polygons drawn by the participants. It also shows that liked areas were relatively bigger than disliked areas.

Table 13: Average area of liked and dislike polygons drawn in eImage

(x1000sqm)	**Supervised**	**Unsupervised**
Liked	267.7	248.2
Disliked	151.0	205.7

6 Discussion and Future work.

It was a long time ago when Nasar published his study about the evaluative image of the city. Diagram 2 illustrated his methodology, where he interviewed visitors and residents of 2 cities, by either telephone or face-to-face interviews and asked them to draw or tell the areas the areas they liked or disliked and a city, then compiled an evaluative map for each answer and overlaid all maps together to create the evaluative image of the city.

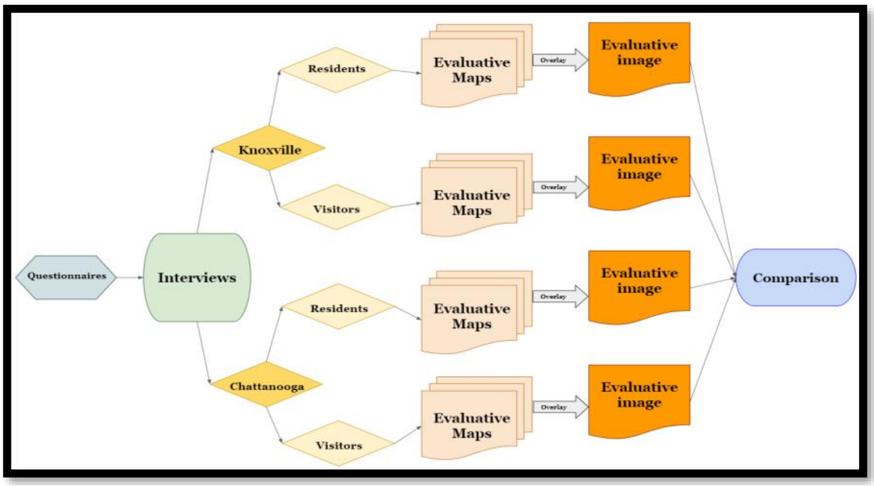


Diagram 2: Diagram of the Nasar's process for creating the evaluative image of the city.

With eImage this process is all automatized by the use of today's technology, dropping significantly the amount of time to process all the evaluative data given by each participant. Other public participation geographic information system (PPGIS) like Acedo, Painho, Casteleyn, and Roche (2018) and Kyttä (2011) doesn't include the process data processing and visualization instantly right after the participant used their application. The method of creating a evaluative map using eImage, showed a good Usability Score, which means that it's a usefull application.

Now comparing the final evaluative images, Nasar's approach showed a outstanding way of presenting the evaluative image of a city. In his work, three aspects could be seen in the final maps: Identity (the salient elements), location (where they are) and likability (the degree of likeness of each area). Also, the use of words in the map, refering to the adjectives that each area represents, conducts the person who sees the map to a clear understanding of the evaluative map of the city. In eImage, likability is protuberant, and a different approach for showing it was elected (red to green scale, and also making the use of opacity to exhibit intensity). However, identity and location was not entirely clear in the final map. In order to it to appear, an extra layer of point of interest could be added in the eImage-Viewer, conducting the person who sees the map to a notion of what are the salient places and where they are located.

Participants during the supervised interaction with eImage affirmed they felt confident using the platform and it that the functions in eImage were well integrated.

The main problem observed in the data collection with eImage was people complaining about the attributes could not express the exact reason for what they drew the area for. It was considered the most significant limitation in this study and should be revised for the next studies. What could be done instead is just to give a field to people to write the adjectives related to the drawn area and apply then, text mining techniques to aggregate these words in groups. This could also make the usefulness score higher for making people say what they like/dislike effectively.

Another substantial improvement that could be done is the intensity of the evaluation for each area. Here, in Image, all liked or disliked areas has the same weight, meaning that users liked or disliked all the areas they drew, in the same way. What could not be the case for some participants and it should be implemented to have a more precise evaluative map in the end.

About the both types of interactions, the supervised one, puts the participant in a control setting. The dropout rate is very low, but in the same time, it's hard to measure how reliable could be the drawn polygons, for example, of disliked places, once a conductor is together with the person during the whole interaction and the participants could not express themselves fully while dealing with "negative" factors.

For the next studies, the evaluation also should be done to the eImage-Viewer, presenting it to urban managers for them to report the usefulness of the created map.

Many people also had trouble to choose an area they dislike. The observed reaction in the supervised interaction was that they felt this name too strong. It could be considered to rename this name for something like "Not much liked" or other variations.

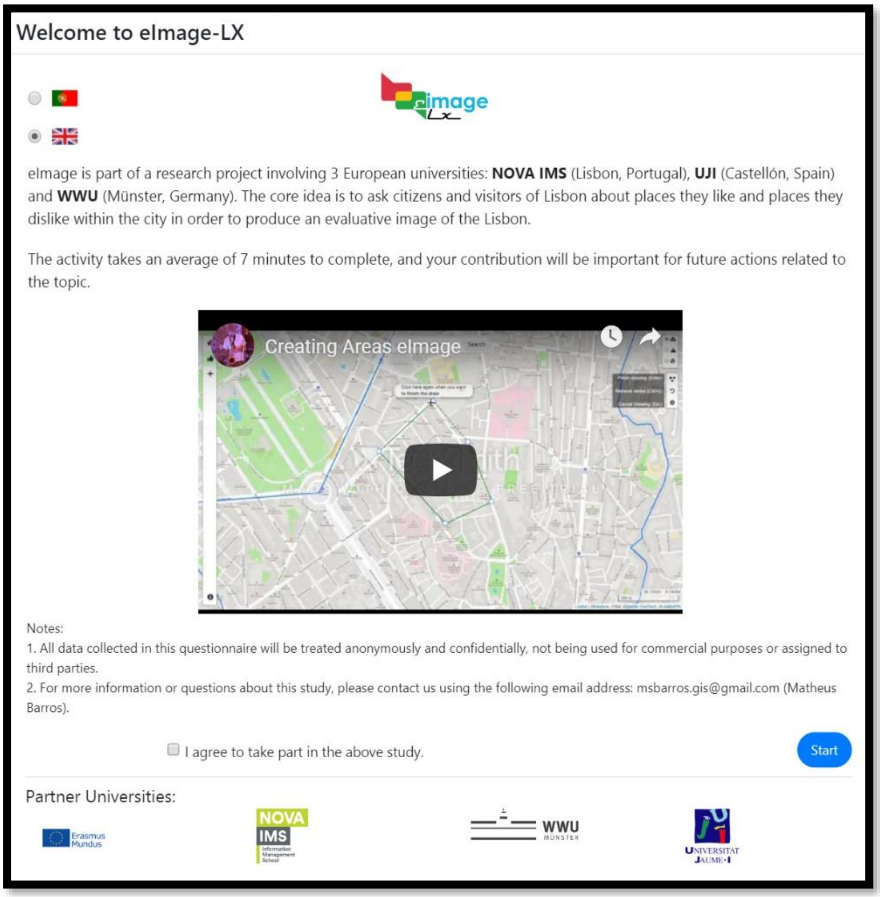
7 Conclusion

The results obtained from the user study answers our question that "the eImage can support indeed the creation of evaluative maps." More than that, eImage automatizes this process by creating the evaluative image of the city right after the user leaves their evaluation in the platform. In overall, eImage was well evaluated in the usability and usefulness score. Which means that the features presented in this Master Thesis were well integrated into the platform. Some improvements still should be made in order to revise the attributes for users to choose related to the drawn area. Finally, if city councils want to create an evaluation image of their city using eImage, this Master Thesis recommends that it should be analyzed the cost benefit of both methods. The supervised interaction would cost more to send people in the streets for asking citizens to participate in the study, but as an advantage, the whole study would be finished in a shorter time, with a very low dropout rate. The unsupervised interaction would be a low-cost alternative, but as a disadvantage, it would take a longer time to achieve the same number of participants as the supervised one, and, having a higher dropout rate compared with this other type of interaction.

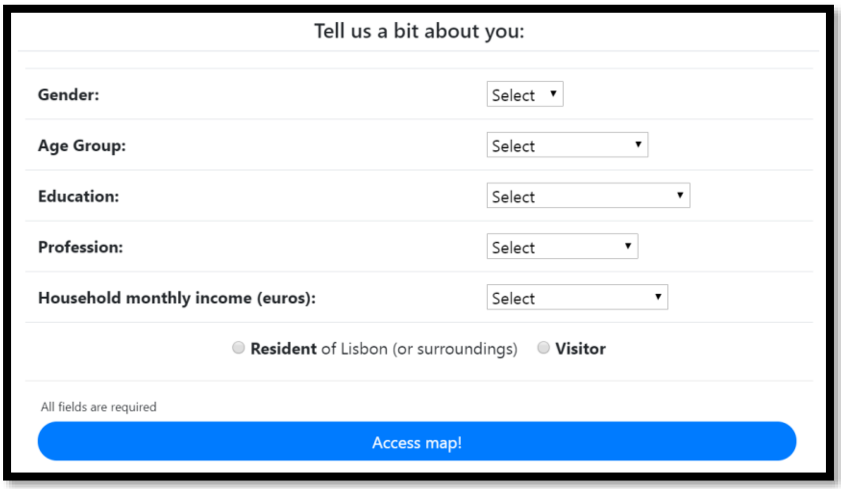
Annexes

```
DROP TABLE IF EXISTS eimg_raw_polys_online;
  --break each polygon in multiparts based on their intersections
  CREATE TABLE eimg_raw_polys_online AS
  SELECT e.*, d.type_interview
  FROM eimg_raw_polys e
  INNER JOIN data_demographics d ON e.user_id=d.user_id
  WHERE type_interview LIKE 'online';

  DROP TABLE IF EXISTS eimg_raw_polys_multi;
    --break each polygon in multiparts based on their intersections
    CREATE TABLE eimg_raw_polys_multi AS
      SELECT
        row_number() OVER () AS id,
        CASE WHEN a.eval_nr = 1 THEN 1 ELSE 0 END cat_liked,
        CASE WHEN a.eval_nr = 2 THEN 1 ELSE 0 END cat_disliked,
        unnest(ST_SplitAgg(a.geom_27493, b.geom_27493)) geom,
        ST_Area(unnest(ST_SplitAgg(a.geom_27493, b.geom_27493))) area,
        a.att_nat attNat, a.att_open attOpen,
        a.att_order attOrder, a.att_upkeep attUpkeep, a.att_hist attHist
      FROM eimg_raw_polys_online a,
         eimg_raw_polys_online b
      WHERE ST_Equals(a.geom_27493, b.geom_27493) OR
        ST_Contains(a.geom_27493, b.geom_27493) OR
        ST_Contains(b.geom_27493, a.geom_27493) OR
        ST_Overlaps(a.geom_27493, b.geom_27493) AND
        (ST_isValid(a.geom_27493) AND ST_isValid(b.geom_27493))
      GROUP BY a.id, a.eval_nr , ST_AsEWKB(a.geom_27493), attNat, attOpen,
attOrder, attUpkeep, attHist;

    DROP TABLE IF EXISTS eimg_raw_polys_single;

    --create single features
    CREATE TABLE eimg_raw_polys_single AS
      SELECT
          row_number() OVER () AS id,
          ST_SnapToGrid((ST_Dump(eimg_raw_polys_multi.geom)).geom ,
0.00001) geom,
          ST_Area(ST_Transform( (ST_Dump(eimg_raw_polys_multi.geom)).geom,
27493 )) area,
          id id_parent, cat_liked, cat_disliked, attNat, attOpen,
attOrder, attUpkeep, attHist
      FROM eimg_raw_polys_multi
      WHERE eimg_raw_polys_multi.area > 10;

    DROP TABLE IF EXISTS eimg_result_online;

    --create the final result
    CREATE TABLE eimg_result_online AS
      SELECT
        row_number() OVER () AS id,
        ST_SnapToGrid( ST_Transform( ST_Union(geom) ,4326), 0.000001)
geom,
        ST_AsText(ST_SnapToGrid( ST_Transform(ST_Centroid(geom),27493),
1)) centroid,
        CASE WHEN sum(cat_liked) = 0 THEN 'disliked'
          WHEN sum(cat_disliked) = 0 THEN 'liked'
          ELSE 'like/disliked'
        END category,
        CASE WHEN sum(cat_liked) = 0 THEN 2
          WHEN sum(cat_disliked) = 0 THEN 1
          ELSE 3
        END category_nr,
        sum(cat_liked) ct_liked, sum(cat_disliked) ct_disliked,
        sum(attNat) ct_nat, sum(attOpen) ct_ope, sum(attOrder) ct_ord,
        sum(attUpkeep) ct_upk , sum(attHist) ct_his
      FROM eimg_raw_polys_single
      GROUP BY ST_SnapToGrid( ST_Transform(ST_Centroid(geom),27493), 1);
```

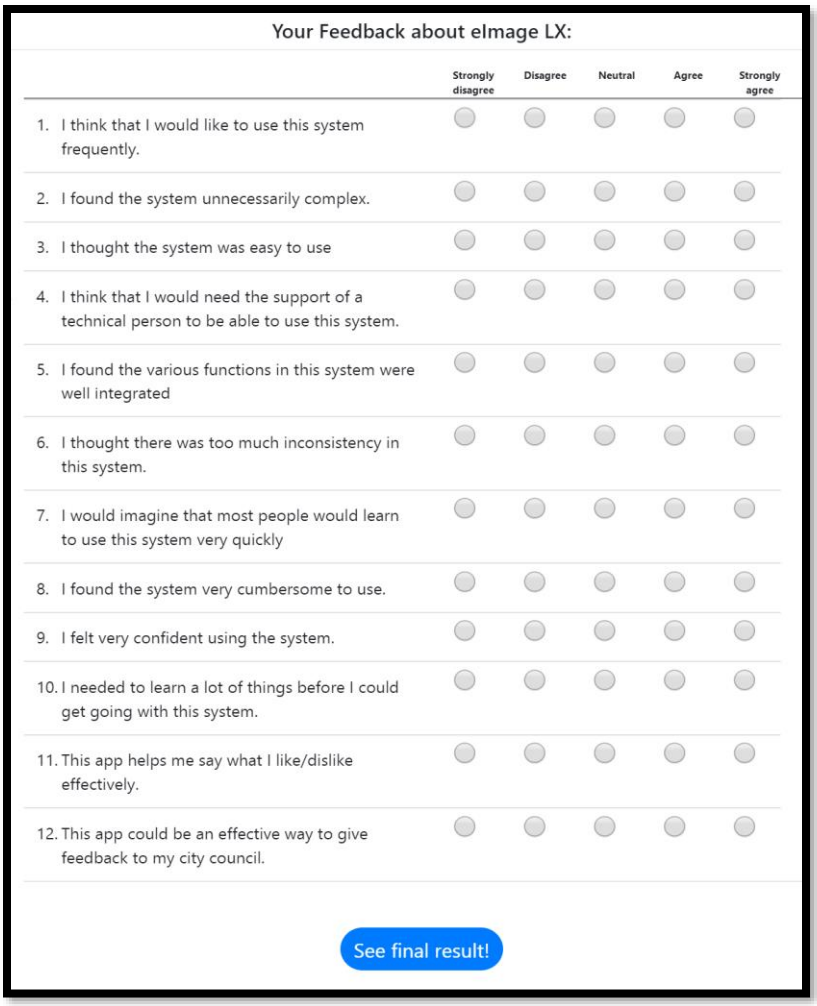
Annex 1: Snippet code for breaking polygons based on their intersection and preserving their attributes. An open-source PostGIS suite, developed by Racine (2017), is required for running this code in PostGIS.



Annex 2: Introdutory page of eImage.



Annex 3: Demographic questionnaire.

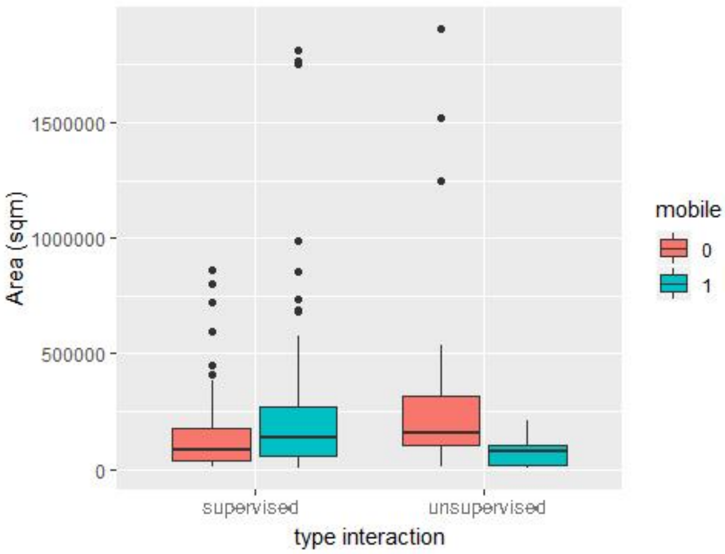


Your Feedback about eImage LX:

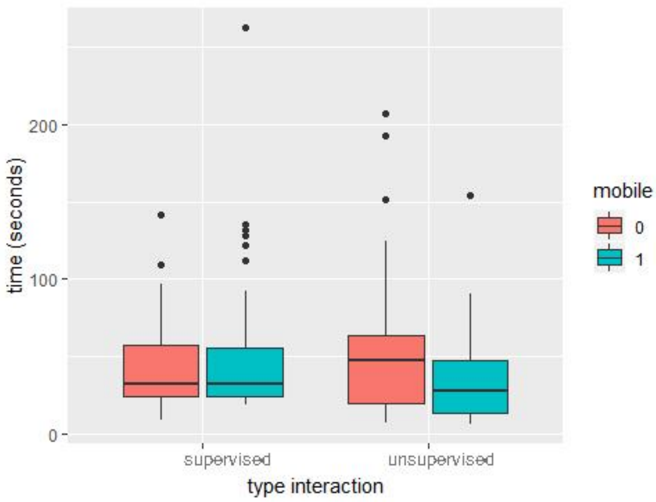
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. I think that I would like to use this system frequently.	○	○	○	○	○
2. I found the system unnecessarily complex.	○	○	○	○	○
3. I thought the system was easy to use	○	○	○	○	○
4. I think that I would need the support of a technical person to be able to use this system.	○	○	○	○	○
5. I found the various functions in this system were well integrated	○	○	○	○	○
6. I thought there was too much inconsistency in this system.	○	○	○	○	○
7. I would imagine that most people would learn to use this system very quickly	○	○	○	○	○
8. I found the system very cumbersome to use.	○	○	○	○	○
9. I felt very confident using the system.	○	○	○	○	○
10. I needed to learn a lot of things before I could get going with this system.	○	○	○	○	○
11. This app helps me say what I like/dislike effectively.	○	○	○	○	○
12. This app could be an effective way to give feedback to my city council.	○	○	○	○	○

See final result!

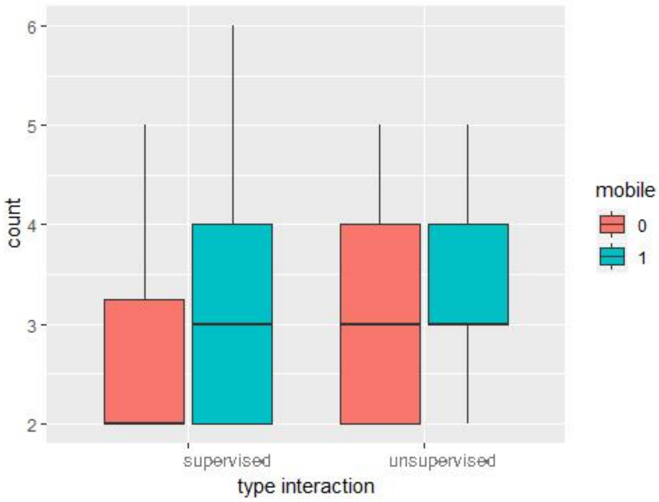
Annex 4: Usability (SUS) and usability questionnaire.



Annex 5: Box plot of size of the drawn area by the type of interaction



Annex 6: Box plot of time for drawing an area by the type of interaction



Annex 7: Box plot of polygon countings by the type of interaction

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