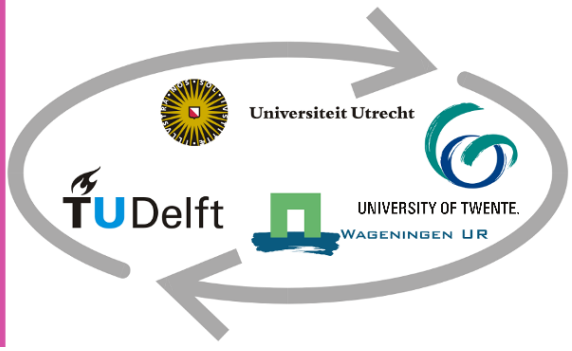
GIMA

Geographical Information Management and Applications

Measuring the perceived usability of geoportals on their communication and visualization of land use plans. The case RO-Online



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Summary

This research investigates the quality of communication of land-use information to citizens. It elaborates on its parallel with the technical evolutions and changing perceptions on the communication of geographical information in general in the last couple of decades. Resulting in that current land use information is communicated via geoportals. Those portals are in general extremely technical and not easy to use. They are due to its current users more focused on exploration and synthesis rather than presentation of information. Because of changing regulations and new technologies the government is looking for new ways to also involve ordinary citizens in a better way. This research is focused on the Dutch geoportal, *ruimtelijkeplannen.nl* (hereafter: RO-Online). Previous studies revealed that citizens are negative on its usability, especially in case of navigation and the cartographic readability. According these previous studies there should be more emphasis on the use of alternative user interfaces and a better presentation of the information. These conclusions are made based on perceived opinions of visitors of the website. This study test the actual usability of the current design, and see whether these opinions are based on their actual performances on the platform. What and how to test: The developed usability test is a combination of performed tasks, a questionnaire and activity recordings. The outcomes of the analysis of the usability test have revealed that:

1. There is a clear difference in perceived opinion about usability of the website between users with and without a dedicated geographical training/education. Respondents without seem to evaluate the platform more negative.
2. There is a clear difference in performance between the two respondent groups. Respondents without geographical knowledge are under performing in finding the needed information on the website.
3. There is a strong correlation noticeable between opinion and performance of the two respondent groups.

Therefore, based on the platforms target to involve citizens without professional experience in geography, it could be said that the usability of communication of this kind of information is not up to standard. Perceived opportunities to enhance this communication and confirm previously defined advices to enhance the general visualization and used legends, since a significant part of the respondents is not aware of its functionality. It should be interesting to explore the added value of a three-dimensional view and different types of perspectives for different users. Also, there is an urge to modify the way of navigation, since respondents struggle with the current used document system.

Preface

This master thesis is the final product of my Masters in Geographical Information Management & Application. This study gave me insight in the possibilities and added value of geographical information in our current society. I started the study in 2014, with the idea to learn more about ways to apply geographical information in the real world. During my second year, I had the chance to do my internship for the Dutch documentary program "Onzichtbaar Nederland", and incorporate understandable data visualizations for people without geographical knowledge. I want to thank Frederik Ruysch, Tim Tensen and Geert Rozinga for this opportunity.

During this internship, I became more aware of the possibilities of geographical information and its future importance to citizens. Therefore, I focused my Master Thesis on the usability of a platform that should focus on clarify geographical information, especially about land use plans, to citizens. Thanks to my supervisor Ron van Lammeren for the opportunity to work on this project. I want to thank him for all the help and advice during this period. Also, my thanks go to the participants that gave up their time to help me during this research. Without their help this research wouldn't be possible.

Finally, I want to thank family, especially my mother, Margreet, and my girlfriend, Ismay, for supporting me during this period. But special thanks go to my sister, Ted, simply for being the best sister I could ever imagine. It reminds me of the many extra late night hours that I spend with my father, on subjects as chemistry and foreign languages, during my high school. It wasn't really my favorite, but he always knew how to make it more exiting. You are a more than worthwhile successor. It reassures me that you always there for me, in case of advice.
He would be proud.

November 24, 2017

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1. Introduction

In the year 2019 the Dutch government will introduce a new legal instrument in the Netherlands, the 'Omgevingswet'. By developing the 'Omgevingswet', the Dutch government aims to combine different types of information about current land use regulations based on their spatial location, in a more simplified manner. In the most ideal scenario, citizens are able to summon information about rules concerning their property in one centralized digital environment, instead of contacting several authorities individually. According to its slogan: "eenvoudig beter: minder regels, meer verantwoordelijkheid bij burgers, met behoud van beschermingsniveau en met voordeel voor iedereen", it is for the Dutch government one of their top priorities to involve and inform ordinary citizens in a better way about the overall land-use regulations and zoning plans, and in an earlier stage of the development process (Steenbekkers, Houwelingen, & Putters, 2016). However, these intentions are being questioned by the Sociaal en Cultureel Planbureau (SCP). According their research report, 'Niet buiten de burger rekenen!', the Omgevingswet makes great demands in the role and participation of ordinary citizens in future planning, while it lacks a proper reflection how and by what means this participation should take place. Therefore, the SCP calls for a more thorough evaluation with respect to the Omgevingswet, with emphasis on the overall quality of the communication via decision support tools (Steenbekkers et al., 2016). Therefore, in response to this call, the government is also currently experimenting with several prototypes of decision support tools that should enhance the communication with and participation of ordinary citizens regarding the 'Omgevingswet'. Both on national scale (http://watmagwaar.nl) as well as municipal scale (http://arcg.is/1funu8).

In earlier days, the Dutch government already made increasingly use of online possibilities to make information accessible for the ordinary citizen thereby encourage the participation of ordinary citizens in the spatial planning process, for example when it comes to the latest zonal plans that potentially impact their own location and surrounding neighborhood. A well-known example of such an online platform is the geoportal *ruimtelijkeplannen.nl* (hereafter: RO-Online). RO-Online has the legal obligation to provide private companies, the government itself, and ordinary citizens with the most recent spatial information about land use plans in a transparent and centralized manner, thereby encouraging more mutual participation (Steenbekkers et al., 2016).

Nevertheless, the Dutch government has not found yet the most optimal way to present information via these online channels to citizens, to enable more engagement and decision support (Steenbekkers et al., 2016). Earlier self-performed usability studies looking at the functionalities of RO-Online revealed that citizens are not able to find the right information on the website of RO-Online, let alone finding the website at all. Issues that are however not unique and occur also on other platforms (Wolters, 2015). The lack of interest of citizens for such platforms, or the misperceived usability of these platforms, can be explained usually by a number of common limitations in design (Isaacs, Gilmour, Blackwood, & Falconer, 2011): (1) Such platforms are often dominated by the perceptions of the "expert" decision makers (e.g. planners, architects, and design engineers) and focus mainly on the technical design of a project; (2) Such platforms are typically two-dimensional, while the problems

they are required to address are three-dimensional (volumetric) and four-dimensional (temporal); (3) Such platforms lack effective means of communication to a range of stakeholders, including the ordinary public; (4) Such platforms often do not adequately consider the complex and interconnected domains that affect the sustainability of urban areas, and have limited predictions.

Therefore, the problem statement for this research is: The current used geoportals to communicate the land use plans do not meet the needs of its intended users.

1.1 Research objectives and research questions

Given the known limitations in design of online decision support platforms and the government's aim to improve RO-Online as part of the Omgevingswet, there is a need to further enhance the accessibility and communication of spatial information to include citizen-participation in the spatial planning process. The objectives of this research are therefore twofold: (a) analyzing the currently perceived usability of RO-Online, and limitations therein, regarding the representation and communication of land use regulations to ordinary citizens, focusing on the role of (multi-dimensional) visualization and usability design; (b) And to investigating future possibilities to enhance the perceived usability of RO-Online for ordinary citizens, focusing on the added value of three-dimensional visualizations. To meet these objectives the following research question has been formulated as focal point for this research:

> *What is the currently perceived usability of RO-Online regarding the representation and communication of land use regulations to ordinary citizens? And what are future possibilities to enhance this usability?*

Subsequently, four sub-questions have been designed to help formulating an answer to the main research question:

1. What is the current role of (multi-dimensional) visualization within the communication and representation of future zoning schemes and land use regulations via geoportals to citizens?
2. What are ways to measure and test the (perceived) usability of online platforms currently in use presenting such information (i.e. future zoning schemes and land use regulations)?
3. What is the (perceived) usability of RO-Online by citizens?
4. What are, according the users, future possibilities to enhance the usability of RO-Online, improving the communication of future land use regulations?

1.2 Structure of this thesis

The remainder of this thesis consists of five chapters. Chapter 2 ('theoretical framework') discusses the current theories behind communication and visualization of environmental legal issues (i.e. land use plans, future zoning schemes, land use regulations) to citizens within the Netherlands, the quality of doing so in an offline and online manner, and ways to measure it via usability studies. In doing so this chapter provides an answer to research question 1 and research question 2. Chapter 2 starts with an overview of the general concepts behind geographical visualizations - their function and the way they are applied in the presentation of land use plans, and discusses theories behind usability design. Subsequently chapter 2 gives a brief overview of the current Dutch situation regarding the regulations on zonal plans, focusing on the role of visualization and communications. Chapter 2 ends with summarizing the results of an earlier performed usability study regarding RO-Online, performed by the Kadaster.

Chapter 3 ('methodology') deals with the methods of performing a usability test, more specifically with a focus on RO-Online and this research. In doing so, chapter 3 elaborates further on research question 2, specifically focusing on the case of RO-Online. First, an overview is presented of the complete usability design study, after which the subsequent paragraphs elaborate further on the methods and steps needed to be taken in order to evaluate individual aspects of usability design in the case of RO-Online. Chapter 3 includes a step-by-step overview on how to evaluate the current usability design of RO-Online, how to specify the context of use and its requirements, and eventual steps that need to be taken to find usability solutions for a new design.

Chapter 4 ('results') discusses the outcomes of the usability study regarding RO-Online and thereby provides an answer to research question 3 and 4. In doing so, chapter 4 compares the characteristics of individual respondents ('the users') with their perceived usability of RO-Online, as measured by means of a questionnaire, and with their performance (success/failure) in executing specific tasks while navigating through the RO-Online portal.

Chapter 5 ('conclusion, discussions & recommendations') elaborates further on the results of this research, discussing their implications and consequences, and putting them in context, comparing them with previous studies and with the theoretical framework. Moreover, chapter 5 discusses the limitations of the research performed and concludes with a number of policy recommendations based on the perceived opportunities for future development.

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2. Theoretical framework

This chapter discusses the current theories regarding the role of (multi-dimensional) visualization within the communication and representation of future zoning schemes and land use regulations via geoportals to ordinary citizens in the Netherlands. Paragraph 2.1 starts with a discussion about what is understood by geographical information, and its recent developments regarding visualization and communication (see figure 1). Subsequently, paragraph 2.2, focuses on the tools or modes of communication, for example geoportals. After this, paragraph 2.3 discusses methods to test these systems on their usability. Paragraph 2.4, finally, gives a brief introduction to the current Dutch urban planning system and what role geographical information and communication of geographical information plays therein. Figure 2.1 visualizes the theoretical framework that highlights the aspects of communication and geo-visualization.

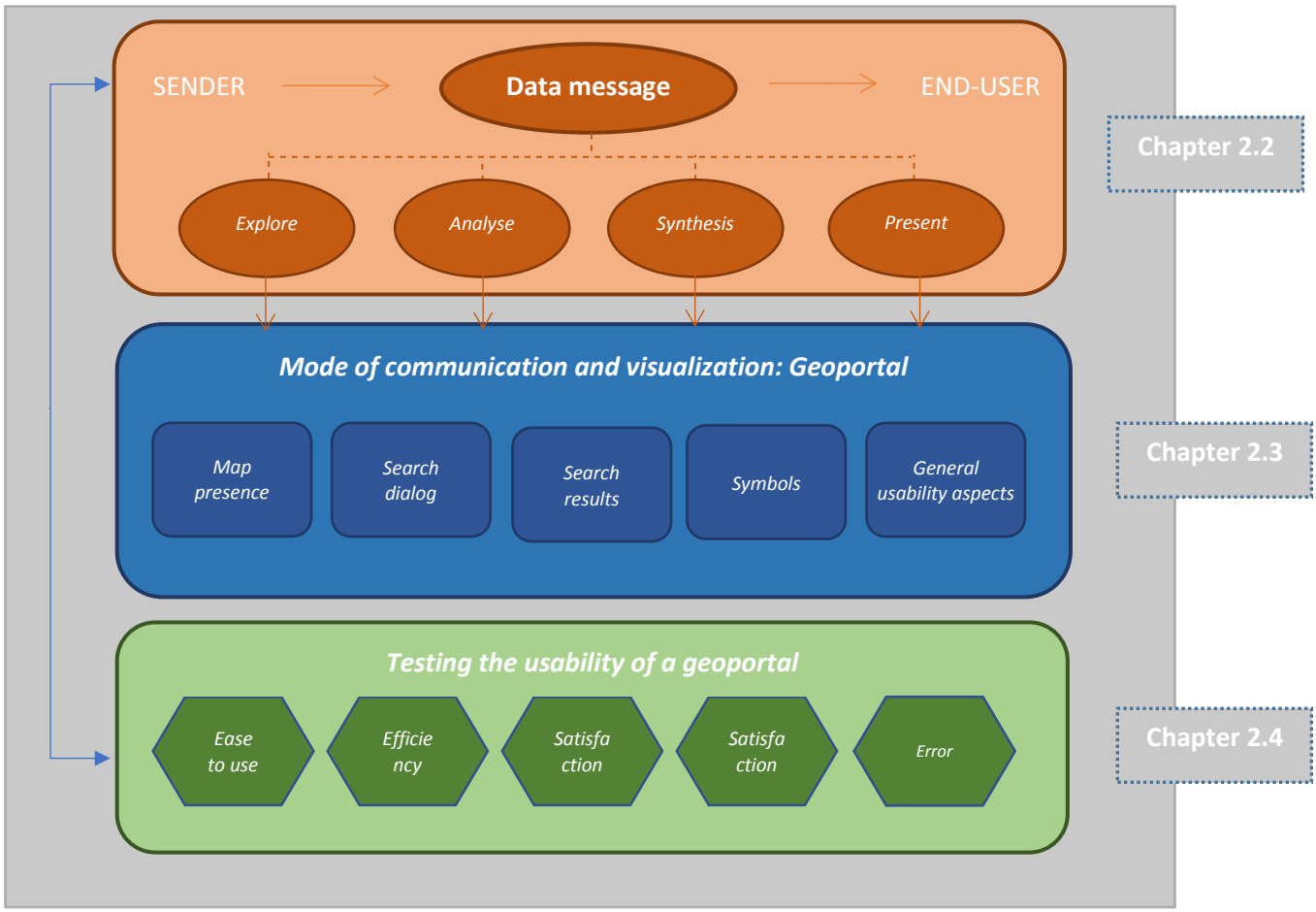


Figure 1: Theoretical framework of this research.

2.1 Geographical information: data

Geographical information is different from other types of information in that the data contains information about the specific location in space of certain objects (Kriz, 2013), enabling the visualization of this type of information on cartographic maps (Kriz, 2013). Geographical information is usually stored in databases containing

information with respect to: (1) locational data, referring to the geometrical aspects; (2) attribute data, referring to the non-geometrical characteristics; and usually (3) temporal data, referring to the moment in time for which the locational and attribute data are valid (Shekhar, Coyle, Goyal, Liu, & Sarkar, 1997).

2.2 Geographical information: sending the message by means of visualization

The communication of geographical information does not only deal with the way of visualization as well as with the used tools for communication. The visualization of geographical information could be explained as a data message (containing geographical information) that is transferred from the sender towards the user (Whyte, 2002), see figure 2. Paragraph 2.2.1. focuses on the technical evolution of this data message (i.e. way of visualization) over the last couple of decades, transforming from two-dimensional maps towards three-dimensional visualizations. Paragraph 2.2.2 deals with the changing general goal and function of the visualization regarding the communication of geographical information between the sender and end-user.

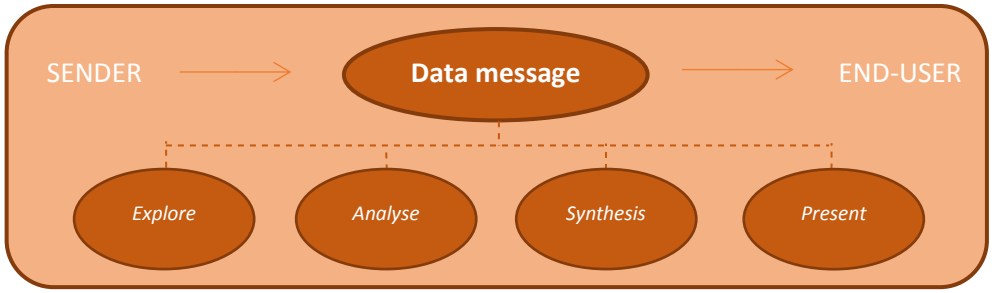


Figure 2: Sending the message by means of visualization.

2.2.1 Technical evolutions in the visualization of geographical information

The visualization of geographic information is the modern synonym to cartography, and arose with the advent of computer mapping via Geographic Information Systems (GIS) in the early 1960s (Whyte, 2002). In pre-computer times, geographical information was visualized via presentational maps, only able to represent static information (Whyte, 2002). In recent decades, the nature of the map has undergone drastic changes (Whyte, 2002). The need for further spatial analysis and the rise of advanced computer systems changed the scenery, opened the path for advanced geographic information applications that could create dynamic data visualizations (Whyte, 2002). Current geographic information systems are increasingly transforming the way in which information about our environment is stored, managed and accessed (Whyte, 2002).

Through the years many types of (multi-dimensional) representations were applied to visualize geographical data, including paper plans, wooden Marquette's, animations, photos and computer-based models (Whyte, 2002). Still today, differing representations all have their own strengths and weaknesses. The most preferable dimensional representation is highly dependent on the intentions associated (Whyte, 2002). Using a map could be preferred instead of using a satellite mage based top down view in planning the best route between two points. In other occasions a three-dimensional approach might be more appropriate, for example when

evaluating the visual impacts of the construction of a building on its environment (Whyte, 2002). Generally, three levels of multi-dimensional representations can be distinguished in the visualization of geographical data, going in parallel with the evolution of computational (visualization) possibilities. These are respectively: (1) a two-dimensional representation; (2) a two-and-a-half-dimensional representation; and (3) a three-dimensional representation (Whyte, 2002).

Two-dimensional representations such as paper plans and maps are extremely suitable in giving a direct overview of large and complex plans from a higher perspective (MacEachren, 1995; Whyte, 2002). This can supply the audience of an enormous amount of information about the environment in a quick and efficient way. As Whyte (2002) describes it: "*In 2D representations, a whole environment can be simultaneously understood from a single vantage point. The ability to look at the world at different scales, such as 1:500, 1:200, 1:100. 1:50, 1:20 and 1:10, allows structures that are most apparent at these different scales to be considered, and moving between scales shifts the focus of attention*." (Whyte 2002, p.36). The two-dimensional (i.e. orthogonal) representation is currently the most regular used interface in GIS (Verbree et al., 1999). It is possible for the user, via this 'plan orientated view' to create and manipulate two-dimensional vector and raster files through the use of graphical interaction and by performing certain queries (Verbree et al., 1999).

Before going further in detail about the three-dimensional perspective, it is worthwhile to touch upon the area in between those two perspectives, also known as parallel perspective (or two-and-a-half dimension). According to Marr (1982) a *two-and-a-half dimensional* representation could be interpreted as a 3D representation projected onto a 2D screen (Marr & Vaina, 1982; Whyte, 2002). This form of representation, also called the model-view provides a bird-eye's view on a partly symbolic and simplified 3D representation of the data (Verbree et al., 1999). The two-and-a-half dimensional representation is very suitable for manipulating the individual objects such as is needed for positioning and orientation (Verbree et al., 1999). Geometric constraints could be defined to align roads and bridges and guarantee continuity in connections under transformations (Verbree et al., 1999).

In contrast to two- and two-and-a-half, a *three-dimensional perspective* (I.e. perspective projection) enables the evaluation of spatial aspects of the existing and proposed built environment. Many authors (Whyte, 2002; Lawrence, 1987; Wotton, 1624) argue that the physical models of buildings are often more important than paper drawings in case of a building plan. When using three dimensions, the representation of the 'virtual world' becomes more and more immersive (Verbree et al., 1999). When using this three-dimensional world-view perspective, the user sees the projected reality from a certain position within the model. Using a three-dimensional perspective is especially useful to give a realistic impression of the plan (Verbree et al., 1999).

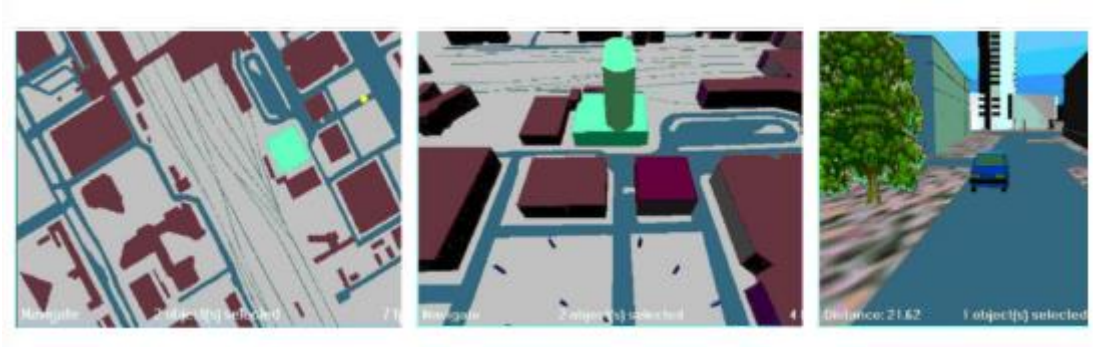


Figure 3: From left to right: Two-, Two-and-a-half- and Three-dimensional representations (Verbree, 1999).

2.2.2 The function of visualization

In parallel to the technical evolutions in the visualization of geographical information, also the overall function of visualization developed over the last couple of decades, and therefore its communication framework (Treinish, 1999). In general, it changed from a visual thinking perspective for personal use to a visual communication perspective for public use (van den Brink *et al.*, 2007). According MacEachren (1994), visualization is the complement of communication. All map-use involves both visualization and communication, but the map in which one of these activities is emphasized can differ significantly from each other. The balance between those two aspects is ultimately based on the eventual goal of the map, which could be: (1) to explore, (2) to analyze, (3) to synthesize, (4) to present, or (5) a combination of each of the preceding (figure 4), and are based upon the questions: Who is the targeted audience? (public – private), What is the data-relation of the audience? (revealing the unknowns - presenting the knowns); and, What is the expected level of map-interactions? (high – low) (figure 4).

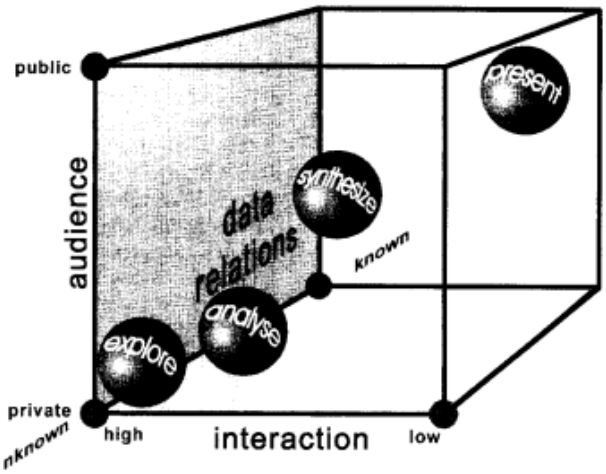


Figure 4: The location of the spheres in the diagram below represents current typical applications of visualization methods to each goal (Maceachren & Kraak, 1997).

A visualization to explore is the dominant strategy at the private-high interaction-exploration of unknown corner of the map use cube (Maceachren & Kraak, 1997). In applications that handle lots of temporal and abundant data focus lies on the ability to explore the data visually, to identify relationships among different variables, and to be

able to analyze the data from multiple perspectives (Maceachren & Kraak, 1997). In most of the cases the user is unfamiliar with the exact nature of the data, which calls for a flexible way of visualization. A visualization that is applied to analysis generally involves manipulation of known data in a search for unknown relationships and answers to questions (MacEachren & Taylor, 1994). Similar to the visualizations to explore this strategy also emphasize relatively private use facilitated in interactive systems (MacEachren & Taylor, 1994). It is ideal to discover relationships between already understood data sets. An overlay could give new outcomes (MacEachren & Taylor, 1994). Within the visualization to synthesize, it is not anymore about revealing the unknowns by single investigators, but rather about presenting the knowns towards bigger groups. However, within the synthesis category, there still is a considerable space for new insights (MacEachren & Taylor, 1994). The final category is the presentation phase (MacEachren & Taylor, 1994). The presentation phase can include both transfer of some predetermined "message" and the prompting of new insight on the part of the person who experiences or accesses the presentation (MacEachren & Taylor, 1994). This type of data communication is emphasizes the data message its focus for public use and therefore the real data Is in most cases only known to the information designer, and not to the user of the presentation (MacEachren & Taylor, 1994).

As the design of current geographic visualization has been predominantly driven by the growing potential of human-map interaction of computer tools, rather than by the objective or function of use, potential mismatches could occur between the type of used visualization and communication and its actual purpose (Isaacs et al., 2011). It is true that cartographic interaction adds value for exploratory geovisualizations, it does not mean that every map should be interactive (Roth, 2013). As described in chapter 2.2.1, ideally every type of visualization has its own functionality and is developed for its own type of end user. One of the most resent forms of communication of geographical information is the geoportal, which originated in the time that spatial data infrastructures play a prominent role in the society (Maguire & Longley, 2005).

2.3 Modes of communication and visualization: geoportals

Spatial Data Infrastructures (SDIs) give the broad public, via geoportals, access to a variety of spatial datasets to fulfill their needs in terms of spatial questions, and are means to visualize and communicate spatial information (Maguire & Longley, 2005). The most primitive forms stem from the 1980s in which the first maps where digitalized into datasets to enhance the efficiency of maintenance (Maguire & Longley, 2005). Since 2007 members of the states of the European Union (EU) had to provide, according the INSPIRE rules, their environmental geo-data in a defined standardized format. Since that moment, many countries legalized the value of a harmonized SDI (Resch & Zimmer, 2013). It turned out that those datasets were easy to combine and analyze (Maguire & Longley, 2005). Through the years, the SDIs became more advanced, layered and intertwined, and appeared in different shapes in different fields of work (Maguire & Longley, 2005).

A geoportal is the gateway that organizes the content of SDIs (Maguire & Longley, 2005). As such, geoportals could occur in many forms, like: directories, search tools, community information, support resources, data and applications (Maguire & Longley, 2005). Traditionally, geoportals are often web-based systems that allows users

to discover particular geo-datasets by looking into the associated metadata, to portray the data on a map, and to retrieve the data in adequate formats to further process them in a professional workflow (Resch & Zimmer, 2013). Important part in the design of the geoportal is the map. It constitutes itself as the central component of the geoportal's interface in that is helps with the geographic data discovery, for data display, and potentially for data retrieval (Resch & Zimmer, 2013). They are within geography one of the most recent forms of communicating data messages. It facilitates finding information in today's informational chaos and represent it in an understandable matter to its intended users. Therefore, the geoportal in its origin is the perfect example of an explorative design to communicate spatial information, since it asks for a high interaction, is presenting the unknowns, while has in most cases a proficiency specific (i.e. private) relation with its user (figure 4).

Throughout the years, however, the use of geographical information and subsequently SDIs limited itself no-longer only towards professionals and the government, and also ordinary citizens got involved (Stoter, 2014). New forms of geoportals occurred, such as the informational portal, which is designed to satisfy the information needs of specific groups in a community, based on their personal characteristics (Bećirspahić & Karabegović, 2015). Therefore, geoportals are perceived to be key in encouraging participation of both experts and non-experts in using and interacting with SDIs (Maguire & Longley, 2005). Despite the increasing trend of involving ordinary citizens in interacting with SDIs by means of geoportals, its actual uptake remains however limited. This could be partially explained by practical problems regarding the usability of geoportals. Whilst the geoportal's owners pay usually more attention to the functionality of the portal, rather than to the usability of its interface; it is the development of systems that allows a usable interaction that really fit to the users' tasks and requirements that can potentially enable better citizen participation (Aditya & Kraak, 2005).

Due to current complicated data structure (i.e. SDIs) it is not possible to go back to more simpler forms of data message structures. The current used geoportals are here to stay. However, it is interesting to see what possibilities there are to change the portal so that it also fulfills more presentational functionalities and thereby to connect better with the non-expert user. In doing so, it is crucial to evaluate the core mechanics of the current geoportal.

The five key components that determine the current design of a geoportal are (Resch & Zimmer, 2013): (1) presence of a map; (2) presence of search dialog; (3) presence of user's search results; (4) use of proper symbols and icons; and (5) more general usability aspects (i.e. loading times, legends, pop-up windows, etc.) (figure 5).

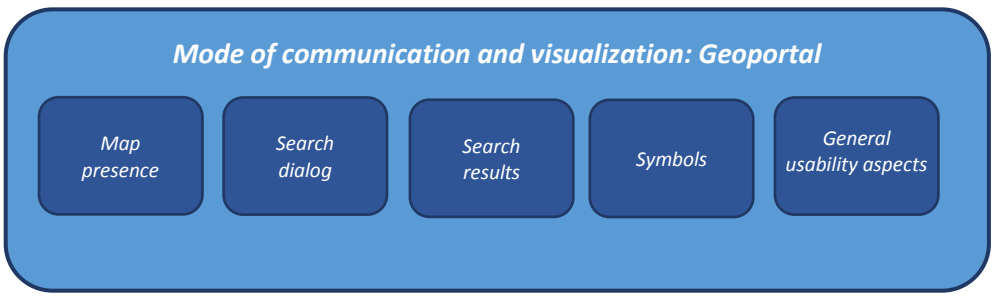


Figure 5: Key elements of a geoportal as mode of communication and visualization.

The presence of a map is a first essential component that determines the design of a geoportal since it is a crucial tool for users to navigate to the right spatial location when searching for the needed information. Moreover, a map enables the visualization of spatial information in an understandable manner. Important aspects of a map are its size, resolution, information density, interaction possibilities, functionality, customizability to the users' particular needs, and performance in loading spatial datasets (Resch & Zimmer, 2013). Map displays that are meant to give access to information about a particular theme, like physical planning maps, consist of a primary thematic information layer, for instance a layer with information about planned land uses, that is projected onto a topographic base (Resch & Zimmer, 2013). The use of a topographic base map allows the map user and the map producer to localize the thematic information (i.e. navigation), and helps explaining the geographic distribution of the thematic information (i.e. visualization) (Resch & Zimmer, 2013).

Search dialogues are a second critical component for the effective use of the data in a geoportal (Resch & Zimmer, 2013), varying in its application between free-text search using a text box, spatial search over a geographical area, or category-based search using a drop-down menu. The third essential functionality of a geoportal is the presentation of the results of a user's search (Resch & Zimmer, 2013). Here an adequate representation is crucial as a misleading presentation of the results can potentially cause misunderstandings in interpreting the given information. (Resch & Zimmer, 2013). The crucial aspects regarding the presentation are related to the display of metadata, the order of datasets, the use of multiple pages, and the font size (Resch & Zimmer, 2013). The fourth essential component is the use of proper symbols and icons for user interaction (Resch & Zimmer, 2013). Finally, some more general usability aspects play a role in the quality and usability of a geoportal, such as loading times, the presence of legends, pop-up windows, the use of advertising elements, linkages to individual pages, the use of frames and scrollbars, the availability of animated graphics, help options and inactive links (Resch & Zimmer, 2013).

2.4 Testing the usability of a geoportal

The potential users for current geoportals tend to have a diverse range of computer literacy, world view, cultural backgrounds and knowledge (Haklay & Tobón, 2003). Although the usability of GIS related products improved enormously in recent years, in order to operate them, still a considerable amount of technological knowledge is required (Haklay & Tobón, 2003; Traynor & Williams, 1997). The systems are often difficult to use for non-expert users. The support system uses different concepts of language, world view and general architecture than the common user usually navigates through (Haklay & Tobón, 2003; Traynor & Williams, 1995).

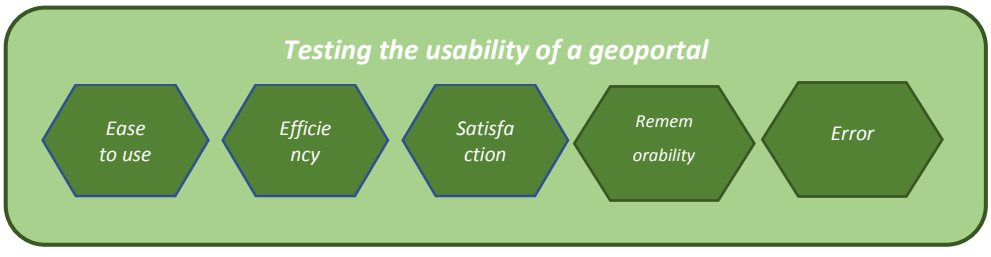


Figure 6: Key aspects in testing the usability of a geoportal.

In getting a better understanding of how people exactly use these kinds of computer systems, it is necessary to perform a usability study (Resch & Zimmer, 2013). Usability refers to the effectiveness of the interaction between humans and computer systems (Resch & Zimmer, 2013). In which effectiveness, can be specified in terms of how well potential users can perform and master tasks on the system (Butler & A., 1996; Haklay & Tobón, 2003). Usability testing focuses on measuring a product's capacity to meet its intended purpose (Haklay & Tobón, 2003). The system's usability can be measured empirically in terms of its: (1) learnability, (2) efficiency, (3) memorability, (4) error rate, and (5) user satisfaction (Nielsen 1993b; Haklay & Tobón, 2003), see figure 6. The ease of learning a product (learnability) is measured as the time it takes a person to reach a specified level of proficiency in using it, assuming the person is representative of the intended users (Haklay & Tobón, 2003). Efficiency refers to the level of productivity that the user must achieve once the system has been learned (Haklay & Tobón, 2003). Memorability measures how easily a system is remembered either after a period of not using it or by casual users (Haklay & Tobón, 2003). An error in the context of usability (error rate) is defined as "any action that does not accomplish the desired goal" (Haklay & Tobón, 2003). Counting such actions provides a measure of a system's error rate. Satisfaction, finally, refers to how pleasant the system is to use (Haklay & Tobón, 2003).

The usability of geoportals is commonly evaluated by means of the ISO 13407 method (Meng, 2003). This method provides guidance on achieving quality in use by incorporating user-centered design activities throughout the life cycle of interactive computer-based systems (Jokela, Iivari, Matero, & Karukka, 2003). A user-centered design consists of the following general phases (figure 7):

1. Evaluate the usability of the already existing application. The first step in a usability design of a product, according ISO 13407 (Meng, 2003), is to evaluate the usability of the already existing application via mixed methods. The following steps need to be set in order to perform a proper evaluation: (a) Planning a test; (b) Recruiting participants; (c) Moderating technique; (d) Pilot testing; (e) Usability test evaluation. See also Appendix B.
2. Specify context of use. After performing the usability test on the existing application, the context of use will be specified thanks to the outcomes of the user identity related questions in the survey. Clarifying the context of use will help in identifying the users, their reason for use and the conditions of use.
3. Specify requirements. Based on the outcomes of the questionnaire and additional literature it is possible to specify the requirements for a new design.
4. Design solution. Based on the outcomes regarding the context of use and the minimal requirements, it is possible to design new solutions for the application.

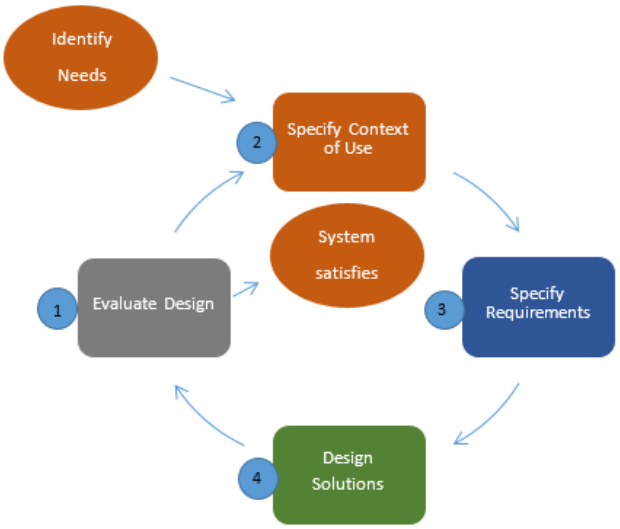


Figure 7: User-centered design process according the ISO 13407 method (Meng, 2003)

To be able to evaluate the current design of an application the usability test should take place under some preconditions (Goldberg et al., 2003). Those preconditions are:

- Users are selected from target market groups or customer organizations;
- Users interact systematically with the product or service;
- They use the product under controlled conditions;
- They perform a task to achieve a goal;
- There is an applied scenario;
- Quantitative behavioural data are collected.

Eventually usability is about the quality of the human/application interaction. The way in which this quantitative behavioural data is collected and analysed is essential for the overall quality of the usability study. Apart from the more frequently used moderating techniques to evaluate the usability within social science (Appendix B), the use of eye-tracking techniques increases tremendously in the last couple of decades (Masciocchi & Still, 2013). Eye-tracking generally is an excellent indicator for the visual clarity of an interface since it is suggest that eye-tracking movements have a direct and natural relationship with visual attention (Masciocchi & Still, 2013). There are advanced forms of eye-tracking techniques. But unfortunately, it has a number of recognized costs that can outweigh the benefits within a practical, usability testing phase of a product. Eye-tracking systems are often expensive, are not easily accessible, gradually lose calibration and are time consuming. To overcome these problems also easier-to-use and more basic variants are being developed (Masciocchi & Still, 2013). An interesting technique discussed by Masciocchi & Still (2013) is the interest point technique. This variant involves acquiring interest points by asking participants to highlight five of the most interesting locations in a web page screenshot (Masciocchi et al., 2009; Masciocchi & Still, 2013). Since, according to Masciocchi *et al*. (2009), there is a high correlation between human-defined points of interest and eye fixations, and therefore can be used to predict where users will fixate (Masciocchi & Still, 2013).

2.5 Dutch urban planning and the role of geo-information

The following paragraph will go further in detail about the current Dutch situation regarding the communication of land use plans. This is evident, since this research includes a Dutch case-study in answering the main question.

2.5.1 Dutch urban planning

Inherent to the construction of our modern cultivated society is the urge to plan urban and non-urban environments in a systematic manner (Dutt & Costa, 1985). This is especially the case in the Netherlands, often considered to be the 'most planned country' in Europe (Dutt & Costa, 1985), given the fact that it is one of the world's most densely populated countries with a highly urban nature, and that it has a history of organizing sea defenses (Dutt & Costa, 1985). Urban planning in the Netherlands is characterized by the continuous acquisition, selling, and leasing of land, from and to private developers or housing associations (Dutt & Costa, 1985). Amsterdam for example owns 75 percent of its territory (Dutt & Costa, 1985). This affects the relationship between the state and the developer, a relationship that is rarely just one of regulation but also involves partnership, negotiation, and the creation of opportunities (Dutt & Costa, 1985).

Given this background, the Dutch government prefers active ways of spatial planning to create towns, cities and the countryside, instead of leaving it to market forces (Keenleyside et al., 2014). Herewith a preference exists to organize and plan large areas all together, regardless of its land ownership, and with inclusion of the public shared spaces (Keenleyside et al., 2014). Being able to achieve such ambitions depends, however, on the citizens' agreement in what desirable land use should be for the broader public interest, as well as being prepared to accept limitations on their own actions (Keenleyside et al., 2014). The Dutch system therefore requires a high degree of coordination and consultation in order to achieve consensus for preferred planning solutions (*draagvlak*), often referred as the 'polder model' (Keenleyside et al., 2014). However, over the years, reality has shown that it becomes more and more challenging to find solutions that satisfies everyone, for example due to increasing congestion and high land values (Keenleyside et al., 2014).

Over the past 40 years the Dutch national government followed four major principles regarding its ambition for land use, although heavily depending on the extent to which the provinces and municipalities also shared them (Keenleyside et al., 2014). These principles are:

- A focus on concentration of urbanization, to sustain high-quality services, public transport and to preserve open countryside;
- A spatial cohesion between related land uses. Facilities as shops, schools, employment and recreation should be near housing;
- An explicit spatial hierarchy, expressed as a range of urban centers in which the highest-grade facilities are in the biggest centers;
- Spatial justice, so that people have access to good facilities and services wherever they live.

The eventual implementation of land use policies that are based on the above-mentioned principles are documented in municipal land use zoning plans, also known as "*bestemmingsplannen"*, that were introduced during the implementation of the new laws on urban planning called "*Wet op de Ruimtelijke Ordening"* (WRO) in 1965. Zoning plans are a juridical instrument for municipalities to influence the future construction of the urban environment (Keenleyside et al., 2014).

2.5.2 Zoning plans in the Netherlands

Zoning is the process of dividing land in a municipality into different zones in which certain land uses are allowed (Keenleyside et al., 2014). A zone could be used for residential, industrial, or other purposes. The type of zone determines whether certain constructions are allowed on a certain location (Keenleyside et al., 2014). The aspects of a zone are documented in a zoning plan, a document that functions as a backup for future planning. Zoning plans are used to translate the municipalities guidance for future apparatus for the local environment (Keenleyside., 2014). It offers clarity to local landowners and other stakeholders, about what is allowed in case of future constructions on their property (Keenleyside et al., 2014).

However, the overall purpose of zoning plans has not always been the same and changed drastically in the last couple of decades (Keenleyside et al., 2014). Since the midcentury, the nature of the zoning plan has shifted from an elitist, inspirational, long-range vision that was based on fiscally innocent implementation advice, to a framework for community consensus on future growth that is supported by fiscally grounded actions to manage change (Kaiser & Godschalk, 2014).Currently they are legally binding, and are leading in spatial legislation.(Georgiadou & Stoter, 2010). The format has shifted from simple policy statements and a single large-scale map of future land use, circulation, and community facilities, to a more complex combination of text, data, maps, and time tables (Kaiser & Godschalk, 2014) Currently, zoning plans consist of textual documents, alphanumerical tables, and graphical maps that help to manage the appropriate land uses in both urban and rural areas. Therefore, zone planning involves multiple fields, such as design art, engineering, and geographical science, since it handles information about physical spatial locations (Lin, 2015). The produced content of a zoning plan can therefore be perceived as geographical information (Lin, 2015).

The Dutch planning system consist of three different layers – the government, the province and the municipalities. The municipalities are the lowest level, but are the most influential in terms of what happens on the ground. Their actions have immediate impact on every citizen. Therefore, the zoning plans are regarded as a tool for municipalities to manipulate the spatial development through environmental legislation regarding the rules for urban (Keenleyside et al., 2014). Within the zoning plans different types of land use, such as shops, housing or agriculture, are assigned to different zones. But also, other aspects are specified, such as how the land may be used, where buildings can be build and their maximum height (Keenleyside et al., 2014).

The traditional zoning plans consist of a zoning map and additional written regulations. The most important function of the zoning map is the ability to designate the zones and highlight its boarders. It is a way to visualize

the scale of the plan. The difference between zones (Living, offices, agriculture, recreation, traffic, etc) are highlighted through the use of different colors while specific aspects are visualized through symbols (Figure 8). The additional writer regulations elaborate on the details of the plan, including definitions, measurements and interpretation of the appointed destination.

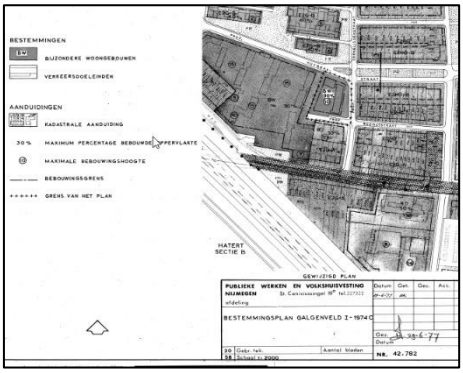


Figure 8: Example of a traditional zoning plan (Gemeente Nijmegen, 1980).

2.5.3 RO-Online: an effort to digitize the zoning plans

There is a striking resemblance between the recent development of the communication of land use plans in the Netherlands as described in paragraph 2.5.1, and MacEachern's theory (MacEachren & Taylor, 1994) about the evolutions that undergone regarding the visualization in terms of map use, as described in paragraph 2.2.2. Similar to MacEachern's theory, the communication of Dutch land use plans is shifting from *exploration of the unknowns for private use*, in which citizens individually had to find information about their own location via multiple documents looking for information that could potentially help them in their needs, towards a system of *presenting the knowns for public use*, by creating an environment sharing pre-processed outcomes in a map and made publicly available via the internet (Steenbekkers et al., 2016)

While, over the years, the government strived for a better and more efficient service to citizens and companies, it became too cost expensive to keep the traditional zoning plans up-to-date and at the same time understandable for the proposed users. As a result, this led to rigidity in revisions of plans for over 35 years in particular cases. To deal with this issue, major changes were introduced via a new law on digital exchange format for spatial regulations and plans (DURP) in 2010, in which municipalities, provinces and the government were obliged to share spatial information about their environment on the digital platform RO-Online (Ruimtelijke Ordening Online) and to continuously update their plans (Steenbekkers et al., 2016).

RO-Online (figure 9) is a governmental website (www.ruimtelijkeplannen.nl), maintained by Geonovum (GI consultancy agency) and Kadaster (the land registry and mapping agency), that operates at a national level as an information providing platform where citizens, companies, and governmental agencies can consult the latest zoning plans. To do so, also a set of agreements and rules called *"RO Standaarden 2008"* were introduced to harmonize the spatial information, and to smoothen the process of updating existing plans (Alterra et al., 2000).

Figure 9: Screenshot of RO-Online (RO-Online, 2017).

RO-Online makes spatial plans publicly available via a web services, and covers the entire country at all tiers of governmental organization: State, Province and Municipality. However, in contrast to the developments made regarding the presentation and communication of geographical information, the methods used to visualize the information are surprisingly congruous with the traditional zoning plans. The website presents digital zoning plans via a top-down web map viewer, that links users to the additional written regulations.

2.5.4 Current limitations of RO-Online

RO-Online, just as other web-portals, is currently struggling to find the most optimal way in reaching citizens involvement. Earlier performed internal evaluations about the quality of RO-Online (Commissioned by the Kadaster in 2015) have issued that there are a couple of shortcomings regarding the current used system (see appendix G for extended summary). Between the years 2012 and 2015 opinions of respondents about the quality of use of several segments of platform were mapped and analyzed, focusing on the usability of the search function and map viewer, the speed, and its overall clarity (Wolters, 2015). Over a period of three years, the usability was tested four times via a questionnaire on the website, with a participation ranging between 300 and 2000 respondents, in which a distinction was made between three types of users: the government, businesses and individuals (Wolters, 2015).

The following main conclusions were drawn from this previous usability assessment. In first, over time the overall frequency of use of the platform RO-Online increased drastically (Wolters, 2015). But mainly due to the increased intensity of use within governmental and business related groups since daily use of visitors with a governmental background has grown over the years from 21 to 53 percent, and in case of a business background from 16 to 43 percent (figure 10). On the opposite, in the same period no significant increase of use was noticed in the case of individuals (Wolters, 2015).

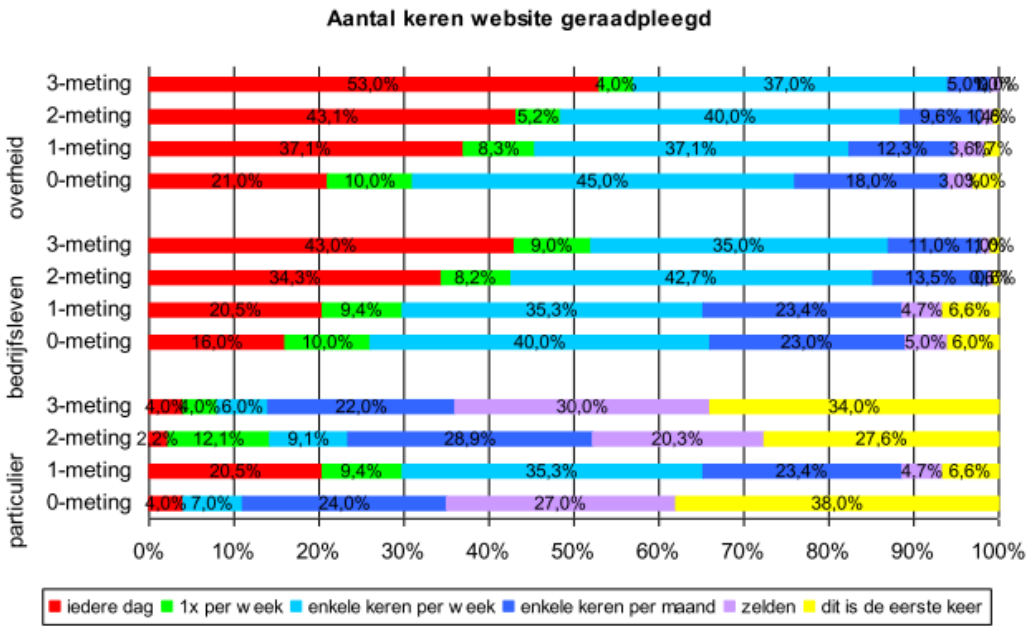


Figure 10: Overall usage of RO-Online per group (Wolters, 2015).

Secondly, when visiting the platform to search for information, the government and businesses are through the years, compared to individuals, double as productive in finding the right answers on their questions (Wolters, 2015). Under governmental organizations and businesses there is a slight increase of success, while in case of individuals there is a minor decrease (Wolters, 2015). Thirdly, the most frequently used segment of the platform for all groups is the map viewer (ranging per group between 88 and 97 percent), followed by the segment that gives information on general documentation (between 19 and 26 percent), and the page about the most frequently asked questions (between 7 and 22 percent) (Wolters, 2015). Fourthly, the introduction of the new map viewer satisfied the government (65 percent are satisfied to very satisfied) and businesses (63 percent satisfied to very satisfied) the most, while it satisfied individuals in a lesser extent (only 48 percent satisfied to very satisfied) (figure 11) (Wolters, 2015).

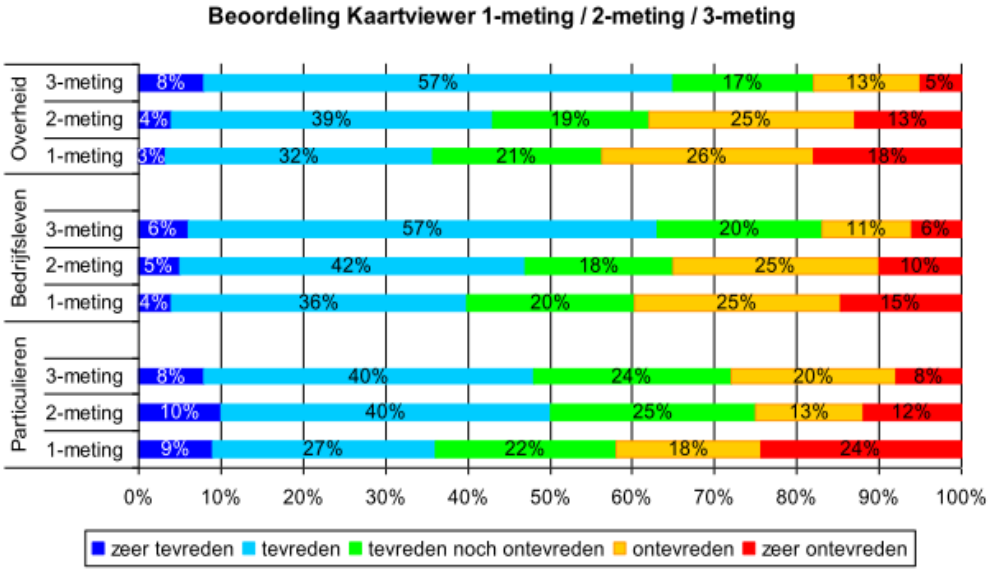


Figure 11: Evaluation map-viewer per group (Wolters, 2015).

The results of this previous assessment show that there is a difference in experience of RO-Online between users with an individual motive and users with a professional motive (Wolters, 2015). Through the years there is a positive tendency on the satisfaction of use under professionals, while there is a negative tendency in case of individual use (Wolters, 2015). Current problems for individuals are related to the following uncertainties:

1. In case of searching for information (i.e. navigation). There is much indistinctness in the way they can find information. Their main concern is the usability of working with the map-viewer and the overall structure of the website (Wolters, 2015). It is for citizens often confusing, devious and unclear. Therefore, the report advises to come up with alternative user-interfaces.

2. About the clarity of the map viewer (i.e. visualization) (Wolters, 2015). Especially, there are many problems with the clarity of the map-viewer and legend (Wolters, 2015).

These concerns are shared by prominent geographers and information designers (Boddaert, 2010). Edward Mac Gillavry, cartography and geo-ITC advisor is concerned about the platforms ability serve the ordinary citizens in their needs (Boddaert, 2010). According Mac Gillavry, it is currently unclear how to navigate through the map: *"Maar kent iedereen de logica achter de driedeling in Bestemmingsplannen, Structuurvisies en Algemene regels overheden? Hoe weet ik, dat ik een 'uitwerkingsplan' onder de tab 'bestemmingsplannen' kan vinden? Onder welke tab vind ik de 'reactieve aanwijzingen'? Door in de opzet uit te gaan van het vakjargon wekt de website de indruk, dat zij is gemaakt door professionals, voor professionals. Voordat burgers aan de hand van deze website zullen begrijpen wat er in hun buurt speelt, moet er dus nog veel gebeuren aan de gebruiksvriendelijkheid."* (Boddaert, 2010, p. 37).

In case of the visualization there are lots of comments about the used legend. As quoted by Mac Gillavry in Boddaert (2010): *"Toch kan hier meer ordening in de legenda-eenheden worden aangebracht en kan meer ruimte voor de legenda worden gereserveerd.* And by Tjeerd Nijeholt, advisor geo-information and auteur of the book Geo-visualisatie: "*De legenda is echter onduidelijk. Zij toont bijvoorbeeld legenda-eenheden uit (nog) zichtbare kaartlagen. De blauwe punten staan niet in de legenda en de verschillende kaartlagen hebben heel aparte, onderling afwijkende visualisaties mee gekregen."* (Boddaert, 2010, p. 37). While Frederik Ruys, information designer, quotes: "*Hoewel het duidelijk is, dat er bij het opzetten van de interface geen grafisch ontwerper aan te pas is gekomen, is de presentatie werkbaar"* (Boddaert, 2010, p. 37).

The conclusions of this this research and opinions of prominent geographers, form an interesting starting point to measure the actual usability of RO-Online, by making use of usability evaluation and design methods conform ISO 12407 as described in chapter 2.4. Within the usability study, there will be a special focus on the respondents' performance on navigation and visualization. In doing so, it is interesting to evaluate whether actual actions of users correlate with their opinions about the system. The following chapter will discuss how such a usability study in case of RO-Online should be designed.

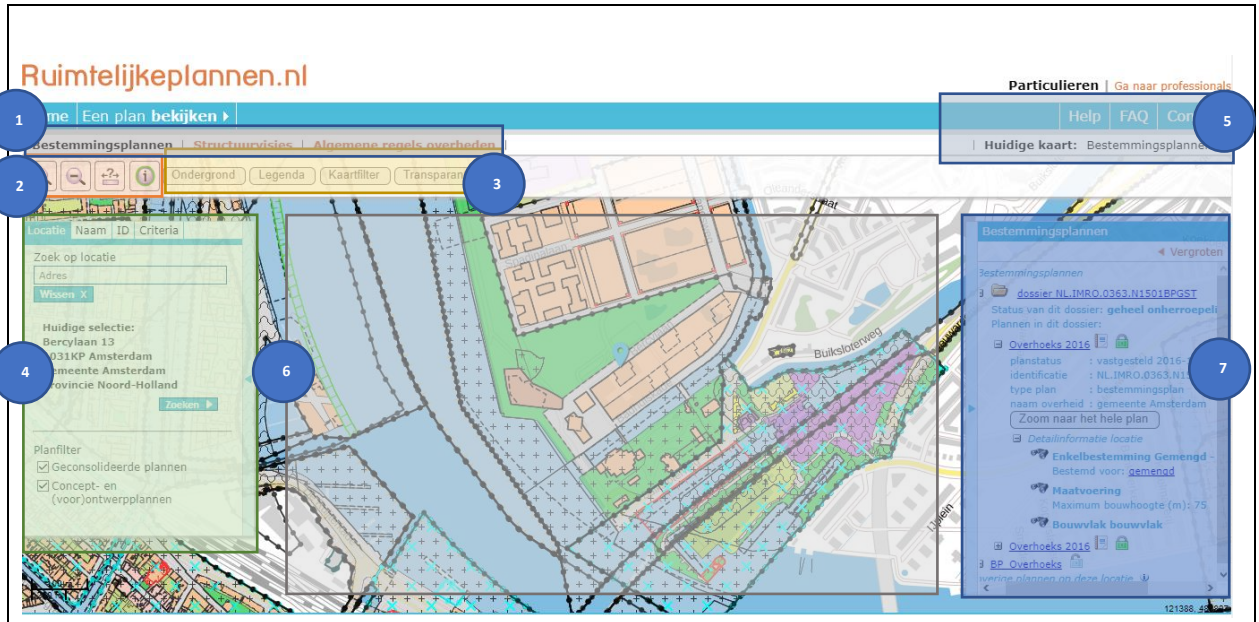
3. Methodology

This chapter elaborates further on the used data and methods in measuring the usability of the web-portal RO-Online for citizens. Keeping in mind the mismatch between the theoretically substantiated importance of the map in a geoportal and the outcomes of the earlier performed usability study on RO-Online, this study investigates by means of a case study in Amsterdam-Noord the usability of the web-map of RO-Online conform their supposed two important aspects: (1) its quality of communication and (2) its function in case of navigation (Wolters, 2015). These two functions have been tested on their usability, looking at: the ease of use, the efficiency, the memorability, user-satisfaction, the error rate conform ISO 12407. Paragraph 3.1 introduces the case study applied. Usability was tested empirically, not only by performing a survey among participants but also by monitoring their behavior in accomplishing specific tasks. Paragraph 3.2 discusses the methods for doing so. Paragraph 3.3 discusses finally the methods applied to process the test outcomes into useful and applicable means of information.

3.1 The case study: Amsterdam-Noord

As mentioned in earlier chapters, the Dutch urban planning system and its channels to communicate underwent major changes in the last couple of decades (Keenleyside et al., 2014). It transformed from paper plans with a limited public reach to a more open digital environment trying to enhance citizen's involvement and encouraging public participation even further, for example as part of the 'Omgevingswet' (Stoter, 2014). The online environment currently in use to communicate the land use plans to the citizens and the platform investigated in this study is RO-Online, a platform that contains most key elements of a geoportal as described in chapter 2.5.3.

At the moment, the RO-Online portal uses a map only to visualize basic information about the type of land use in a particular location, followed by planning contours, building surface and area indications. Next to visualization of geographical information, it is possible in RO-Online to select objects within the map thereby navigating to additional information. In figure 12 an overview is given of the main page of the platform (figure 12). The structure of the website is subdivided into three types of plans: (1) *Bestemmingsplannen*, (2) *Structuurvisies* and (3) *Algemene regels overheden* (figure 12-1). The main page makes use of a web-map layer that could be used to navigate to the potential location of interest (figure 12-6). Navigation within this web-map is possible via a search bar that allows a variety of queries (figure 12-4) or several tools (figure 12-2). The information on the web-map itself is interpretable via the legends (figure 12-3) or via the extended documents containing more specific information (figure 12-7).



1. Plan documents

- Bestemmingsplannen
- Structuurvisies
- Algemene regels overheden

2. Map activity tools

- Zoom +
- Zoom –
- Measure ?
- Information i

3. Layers and legends

- Ondergrond
- Legenda
- Kaartfilter
- Transparantie

4. Search tools

- Criteria
- ID
- Naam
- Locatie

5. Help options

- Help
- FAQ
- Contact

6. Map

- Functioneel
- Niet fucntioneel

7. Additional documents

- Plannen in dossier
- Zoom naar plan
- Detail informatie
- Detail Informatie
- Maatvoering

Extern

Figure 12: Most important components main page RO-Online

Within the case study set-up for this research, the research participants were asked to answer questions and to perform tasks around their hypothetical living environment, Amsterdam-Noord. An area of 1 by 1 km was selected to serve as hypothetical living area of the respondents, for which maps were represented and information was shared (See figure 13). This place was chosen for this case study since most respondents are familiar with the area, and this part of Amsterdam underwent big changes in last couple of years. It transformed from a desolated industrial area towards one of the new hot spots in Amsterdam for living, working and recreation. Up until this day the area is still under construction and in development.

Figure 13 - Case study area Amsterdam-Noord.

3.2 Testing the usability of RO-Online

In performing the usability study on RO-Online, a test setup is used conform the ISO 13407 standards, as described in chapter 2.4 and Appendix B. In short, the research makes use of mixed methods to test the (perceived) usability of RO-Online among 15 respondents, with an age between the 20 and 30 years old and living in Amsterdam. Respondents within this age group are regarded as people that are familiar with the use of digital applications in their daily live. This makes it more interpretable compared to people that are unfamiliar with digital applications in general. It is chosen only to use respondents that are currently living in Amsterdam for two reasons: (1) In first, for practical reasons. The test had to take place in in a 45 minutes long face-to-face session without any external distraction. To guarantee these conditions, it was chosen to perform the tests fixed location, in project rooms B2.02 and B2.06 at the Library of the University of Amsterdam (Singel 425). (2) In second, because the users should be familiar with the used case study in Amsterdam-Noord.

During the test the respondents were asked to fill out a questionnaire (See appendix D) and to perform several tasks while being monitored by making use of audio recordings, screen capture recordings (See appendix B) and eye tracking techniques that focusses on points of interest (appendix C).

The screen capture application Screencastify was used to record the respondents' actions and voice during the tasks. All respondents were aware and agreed in being recorded during these sessions. The recorded actions were subsequently then written down into steps, which will be discussed in chapter 3.2.2. and Appendix F.

The first part of the test was executed to characterize the respondent by means of ten introduction questions that reveal their personal characteristics, such as the current living situation and their familiarity to zoning plans. In the second part of the test, the respondents were introduced to the case study, consisting of several tasks they had to accomplish in a limited amount of time. The tasks were designed as such that they give a good insight in the quality of communication and navigation of the RO-Online geoportal for ordinary users. The focus of the tasks was on the usability of the web-map page of RO-Online, since this is the most used page on the website (Wolters, 2015). After the test case, the respondents were asked to fill out another set of ten questions to evaluate their experience with the performed tasks. The used monitoring methods: eye-tracking, test case tasks and the follow-up questions, that were designed to test the usability of communication and navigation, are discussed in detail in the following paragraphs.

3.2.1. Eye-tracking to measure usability

Before performing the tasks, the respondents were asked to perform an eye-tracking test conform the interest point method as described in paragraph 2.4. Further explanation about the preference for this technique in this research is explained in Appendix C. The respondents were asked to appoint five points of interest on a picture that corresponds with the main layout of RO-Online, also represented in figure 9. All appointed locations of interest off all respondents were then combined and transformed into a heatmap by making use of the basic heat map functions of the program QGIS. The heatmap highlights the most gazed locations on the main page of the platform.

Also, the individual points of interest have been plotted against the first performed actions of respondents during their first task. This reveals potential interesting correlations between points of interest and performed first actions (See figure 23). In other words, it highlights whether the users also make use of the locations they see at first sight. Moreover, it enables an evaluation on whether respondents who performed the tasks successfully, gaze at other locations and take other steps in comparison to the respondents that fail the tasks. It should be noted that this analysis focused only on the first performed action of each respondent, since the following actions are influenced by previous ones.

3.2.2. Tasks to measure usability

To measure the ease of use, the efficiency, error rate and memorability of the RO-Online geoportal, three simple tasks were designed to be performed by the respondents on the platform. Each task was designed to measure the systems function for navigation, visualization and/or memorability. The respondents were asked to perform each task within a 5-minute time-frame.

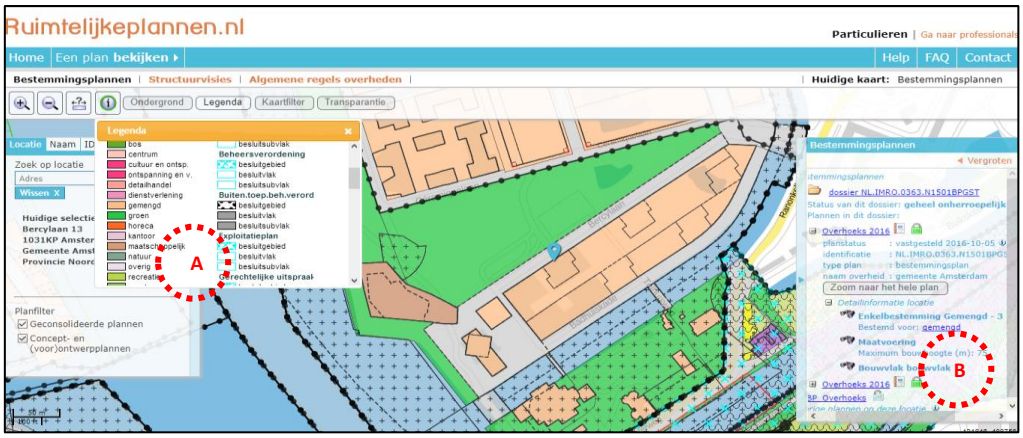


Figure 14: Approaches to find an answer on task 1; Via the legend (A); Via the extended documents (B).

As part of the first task, the respondents were asked to: "*Look-up the current zonal function of your location"*. This task forced the respondent to use and interpret the legend and choropleth map to find the right answer, which is in this case mixed zoning (figure 14). The speed, the steps taken to arrive at the answer, and the final answer itself were used to evaluate the quality and usability of the current visualization of RO-Online. An alternative but a less obvious approach in finding the right answer is the use of the extended documents on the right side of the web-map (figure 14).

The second task to be performed by the respondents focused on the maps' function for navigation. The task respondents had to perform was: "*Look-up the maximum building height of the building next to your own location?".* This task was formulated as such to force the respondent to use the map as a tool to interact with in order to navigate to the needed information. Respondents had to replace the cursor of the map to find the right answer in the extended documents on the right sight of the layout view (figure 15). The outcome of the task, as well as the speed of performance, and the steps taken to arrive at the outcome, indicate the quality of the *ease of use* and *efficiency*.

Figure 15: Approach to find an answer on task 2; Move cursor to other location (A) and go to extended documents (B).

For the third task, the respondents were asked to: “Look-up *what are, apart from its living functions, other possible functions for this location”.* This task included actions both related to navigation and visualization, and was applied to check the respondents’ memorability, as it asked for a repetition of actions compared to previous tasks in order to arrive at the right answer. While the subject of task 3 related heavily to the first performed task, the only way in finding the appropriate answer, was to navigate to the predefined location, and to go to the linked documents on the right side of the map-viewer. This task enabled thereby, with regards to the users’ memorability, an evaluation on whether the respondents decided to repeat the applied steps of their first or second performed task.

Figure 16: Approach to find an answer on task 3; Move cursor to other location (A) and go to extended documents and click on “gemengd” (B).

3.2.3 Questions to measure usability

To evaluate the (perceived) opinion among the respondents, the respondents were asked to answer 20 questions about the usability of the RO-Online environment for use in the case study Amsterdam-Noord (See appendix D). A total of 10 questions were included at the start of the survey to control for the variation in the respondent-group, e.g. age, living situation, interest in the topic, and to get insight in their level of proficiency with the use of geo-information (table 1). Apart from these questions also the respondents' current proficiency was registered, to check whether they are geographically skilled (Appendix E).

Table 1: Personal characteristics questions.

Q1: Experienced in using geo-information tools	Dichotomous
Q2: Living situation	Nominal
Q3: Interest in restrictions regarding your home	Ordinal
Q4: Future possibilities in the near environment	Ordinal
Q5: Current source for information for restrictions regarding own home	Nominal
Q6: Current source for information for changes in near environment	Nominal
Q7: Experience with land use plans	Nominal
Q8: Reason for use of land use plans	Nominal
Q9: Experience with online land use plans	Dichotomous
Q10: Awareness of the website www.ruimtelijkeplannen.nl	Dichotomous

The follow-up questions in the test were designed to enable the respondents to give a reflection on their satisfaction about the platform in general and the performed tasks, focusing on usability by means of visualization and navigation (table 2). The outcomes of the questions have been ranked and plotted against the performed tasks or characteristics of the respondents to identify any correlation (See appendix F). Question 11 asked the respondents directly whether they found it easy to navigate through the geoportal, whilst question 12 questioned whether the visualization was done in an appropriate manner. Thereafter, questions 13 and 14 were set-up as control questions, indirectly testing on the same matter but via questions about the performed tasks.

Table 2: Reflection questions regarding RO-Online.

Reflection questions		*Visualization*	*Navigation*
Q11: Navigating through RO-Online is user friendly	Ordinal		X
Q12: Is the information visualized in an appropriate way?	Ordinal	X	
Q13: It is easy to find information about the maximum building height	Ordinal		X
Q14: It is easy to find information about its zoning function	Ordinal	X	

The final questions, questions 15 – 20, are targeted on the perceived opportunities for further development of RO-Online. By asking these questions, a discussion was opened regarding the use of different types of (multi-dimensional) perspectives to visualize geographical information and their potential added value for RO-Online.

Table 3: Questions about perceived future.

Q15: The current two-dimensional presentation gives enough information	Ordinal
Q16: Visualizing land use plans in 3D has an added value to 2D	Ordinal
Q17: What perspective should be used with regards to your home	Nominal
Q18: For what reason?	Open Questions
Q19: What perspective should be used (bird-eye, top-down or first person) with regards to the environment	Nominal
Q20: For what reason?	Open Question

3.2.4 Processing the test outcomes

Based on the introductory questions in the questionnaire, it is possible to perform a stratification of the respondents group:

- Distinguished between different characteristics: (a) used RO-Online before; (b) are active in the geography working field; (c) show an Interest in current building restrictions; (d) are Interested in development in surrounding environment; (e) live in a specific type of residency.
- In the remainder of the study used geographical background as a pivotal variable as this is also the aspect RO-Online is struggling with. Being able to communicate both to users with and without a geographical background.

The respondents' performances on the tasks are ranked. As mentioned earlier, during the tasks, screen captures (video) and audio recordings were made to enable a post-evaluation of the respondents' activities during each of the tasks. These actions were documented and visualized in activity roadmaps, enabling a comparison between the actions, time taken, and answers of each of the respondents (figure 18, 20 & 21). To do so, the documented actions performed by the respondents have been subdivided and color coded into different classes based on their spatial location on the platform (See Appendix F for further elaboration). As the activity roadmap plots the needed time of the task against the performed activities on the platform, it can visually detect similar or different activity patterns between respondents with different personal backgrounds, and perceived opinions. To compare the usability of the tasks with respondent-specific characteristics or reflections, the outcomes of the tasks have been ranked based on the efficiency and eventual outcome or error rate (table 5). Efficiency was measured here by the time the individual respondents needed to perform the tasks, error rate by whether they succeeded in performing the individual tasks. Respondents who were not able to succeed automatically were places at the last position. Memorability was tested by comparing results of the first two subsequent tasks with the third.

After gathering this information, it is possible via exploratory data analysis, to compare the performances of respondents (measured via their ranking) with their proficiency. Boxplots will be used to visualize the differences between both types of users, since they can rapidly summarize and interpret tabular data (Traynor & Williams, 1997). Boxplots make it able to (a) compare the average values between groups, (b) compare if there is a significant difference between the groups or not, and (c) compare the distribution within the groups (including the outliers) (Traynor & Williams, 1997).

To be able to compare the opinion of respondents on the usability with their performance, linear regressive methods were used to search for interesting correlations. To do so the questions on their opinion are formatted via the use of a Likert scale (Bryman, 2016), which makes it able to score the answers (table 4, Appendix D).

Table 4: Scoring of answers based on Likert scale

Scoring of the answers				
Totally disagree	Disagree	Neutral	Agree	Totally agree
←→	←→	←→	←→	
1	2	3	4	5

In comparing the scores of the respondents' opinion with the ranks on their task, the correlation coefficient (R^2) reveals the strength of the connection between the two variables. It also indicates, in case of a weak correlation, if other variables are of influence. The directional coefficient indicates the strength and direction of the correlation (+/-). It is possible to perform more advanced regression analysis. However, in case of this research the goal was only to reveal if there are positive or negative correlations between the asked questions and performances in a simple matter. Therefore, it was chosen only to use linear regressive methods and not perform more advanced regressions, since this makes the regression results to complex for this research.

The focus will be on the correlation between the respondents' opinion on the main aspects of the portal (visualization and navigation) and their performances.

4. Results

This chapter discusses the results of the usability study performed as part of this research. The chapter starts with an overview of the respondents' main characteristics and subsequently discusses their performances in using the geoportal RO-Online, the eye-tracking results indicating the most visible aspects of RO-Online, and the revealed usability of RO-Online with respect of the communication and visualization of geographical information.

4.1 Respondents' characteristics

A total of 15 respondents performed the usability test, with six of them being active in the field of geography (figure 17). All respondents participating in the research were familiar with geographical orientated program's such as web maps and navigation systems. The respondents range in age between the low twenties and high fifties.

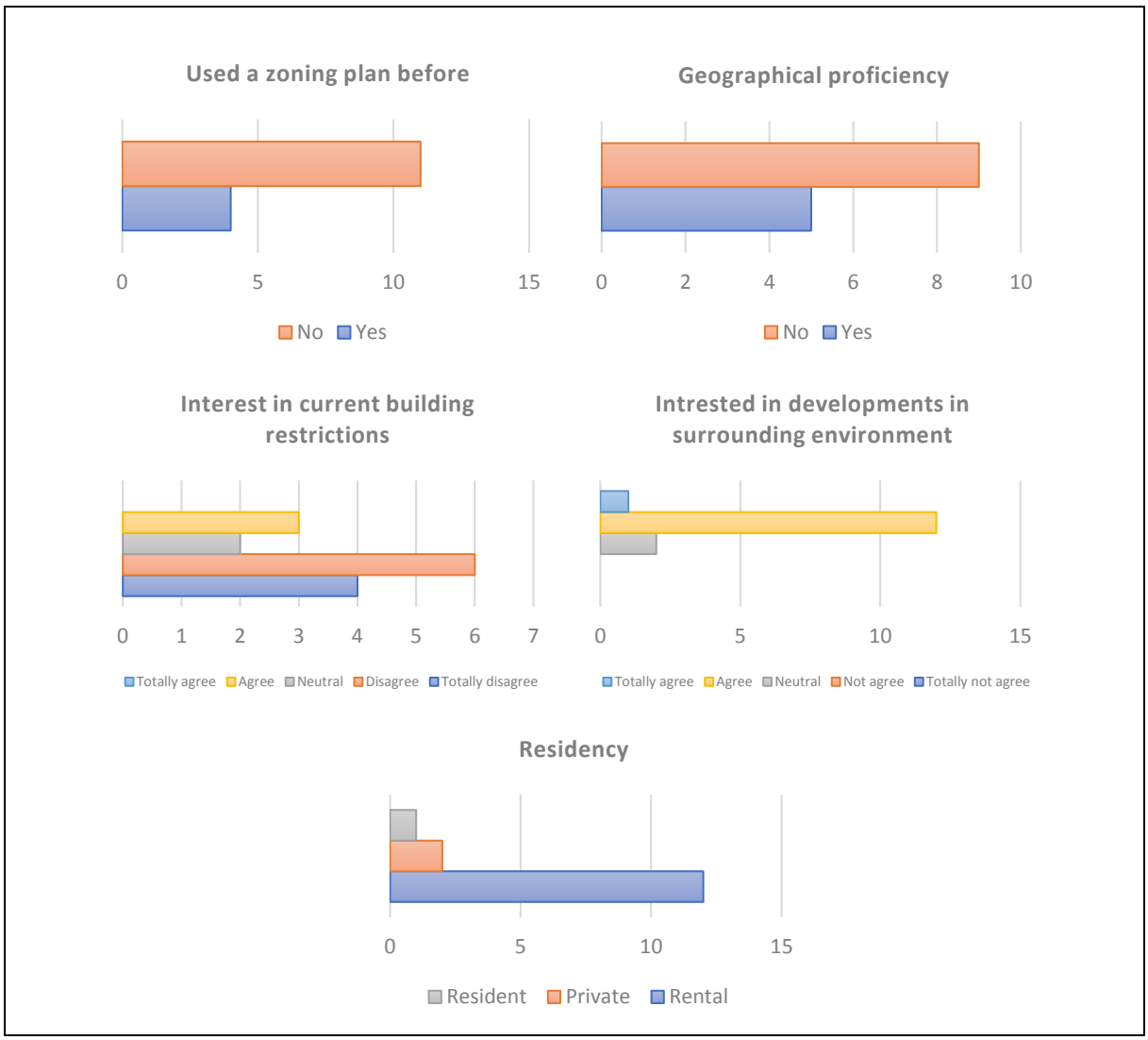


Figure 17: Respondent characteristics showing the number of people that: (a) used RO-Online before; (b) are active in the geography working field; (c) show an Interest in current building restrictions; (d) are Interested in development in surrounding environment; (e) live in a specific type of residency.

Most of the respondents (10 out of 15), regardless of their professional background, are not particularly interested in the regulatory possibilities and restrictions regarding their own home (figure 17-c). Which seems logical since approximately the same number of respondents are renting their living space instead of owning a house (figure 17-e). In contrast to the interest in possibilities regarding their own home, a total 12 respondents did answer that they are interested in developments that impact their direct environment (figure 17-d). It must be said, though, that most of the respondents (11 out of 15) did never consult a zoning plan before (figure 17-a), let alone that they are familiar with the website RO-Online. Only two persons made use already of RO-Online before participating to this study.

4.2 Performed tasks to measure usability

The respondents were asked to perform a number of tasks, set-up to analyze the usability of RO-Online and its web-map. As described in the previous chapter, the respondents had to find an answer on three questions by making use of the platform RO-Online. Each of these questions related to one of the key aspects of usability: visualization (Task 1), navigation (Task 2), and memorability (Task 3).

Performance of the respondents in each of the tasks was monitored: by looking at the actions or steps taken, their efficiency (time spent) and their level of success. Subsequently, the respondents were ranked based on their performance in each of the individual tasks as well as on their overall performance. Ranking the respondents across the different tasks enabled the evaluation on whether the respondents performed consistently across the different tasks or whether any variation in performance for the different tasks occurred.

Table 4 shows the respondent's ranking for each of the tasks whilst figure 18 summarizes the performance for the different tasks over respondents with a geographical and respondents without a geographical background. Three respondents have not been able to perform any of these tasks correctly and hence got the lowest rank appointed. The two respondents with the highest overall rank also performed best in task 2 and task 3, respectively. The respondent that performed best in task 1 had an overall rank of only 9, due to relatively bad performances in task 2 and 3 (rank 10 for both).

During the first task the respondents were asked to discover the zonal function for a pre-determined location. The overall success rate, which relates to the 'error' usability criteria, was 73.3 percent (table 5). The fastest successful answer, which relates to the 'efficiency' usability criteria, was found in 12 seconds whilst the slowest correct answer was given in 125 seconds. On average respondents took 45 seconds to arrive at the correct answer (table 5, figure 19). In finding the correct answer, 7 respondents made use of the maps legend, while 4 respondents directly went to the extended documents. The remaining 4 respondents were not able to find the answer at all (figure 19). When taking a closer look at the performed actions of the respondents that failed, two of them managed to navigate through the extended documents (containing the correct answer) but were not able to find final dropdown boxes. None of the respondents that failed in finding the correct answer used the

legend to interpret the geographical information and thereby to arrive at the correct answer. Thus, it could be said that these respondents were simply not aware of the maps choropleth function.

Table 5: Needed time and rank per performed task for each of the respondents.

	Task 1		Task 2		Task 3			Total
Respondent	Time	Rank	Time	Rank	Time	Rank		Rank
1	20	3		11	110	9		10
2		12		11		10		13
3	12	2	70	8	50	8		6
4	22	4	43	5		10		7
5	50	8	10	1	24	4		1
6	125	11		11	20	2		11
7		12		11		10		13
8		12		11		10		13
9	30	7	25	3	40	5		4
10	121	10	15	2	10	1		1
11	24	5	57	7	20	2		3
12	10	1	90	10		10		9
13		12	75	9		10		12
14	55	9	50	6	40	5		8
15	25	6	42	4	44	7		5
Average	45		47,7		39,8			

When splitting up the results for task 1 between the respondents with and the respondents without a professional background in geography, we find a significant difference in the success rate (figure 18-a), as well as the needed time for a successful answer (figure 19). All respondents with a geographical background found the correct answer, and 5 out of 6 within only 30 seconds (figure 19-b). In case of the respondents without a geographical background, only 5 out of 9 people found the right answer of which only 2 within the first 30 seconds (figure 18-c). Also, the diversity in needed time to find the right answers is much larger for respondents without a geographical background, compared to respondents with a geographic background (figure 19-b/c). This can also be seen when looking at the ranking of the respondents in their performance of task 1 (figure 19-a).

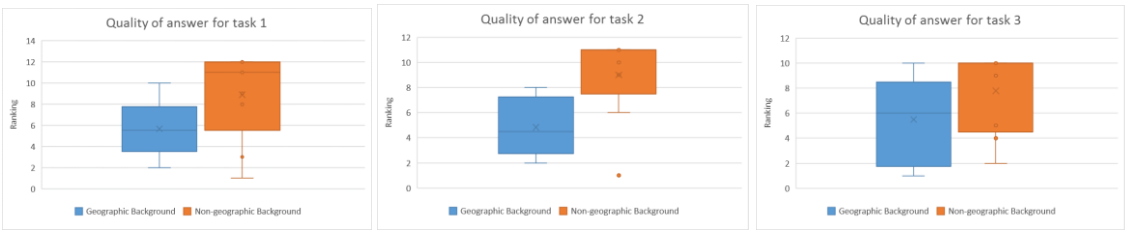


Figure 18: Difference in quality of answer between respondents with and without a geographical background, based on their performance ranking. For: (a) task 1; (b) task 2; and (c) task 3.

The average ranking of respondents with a geographical background was 5, compared to an average ranking of 9 for the respondents without a geographical background. As such, the results of task 1 indicate that respondents without a geographical background are generally less efficient and make more errors in finding an answer in visualization related tasks regarding RO-Online.

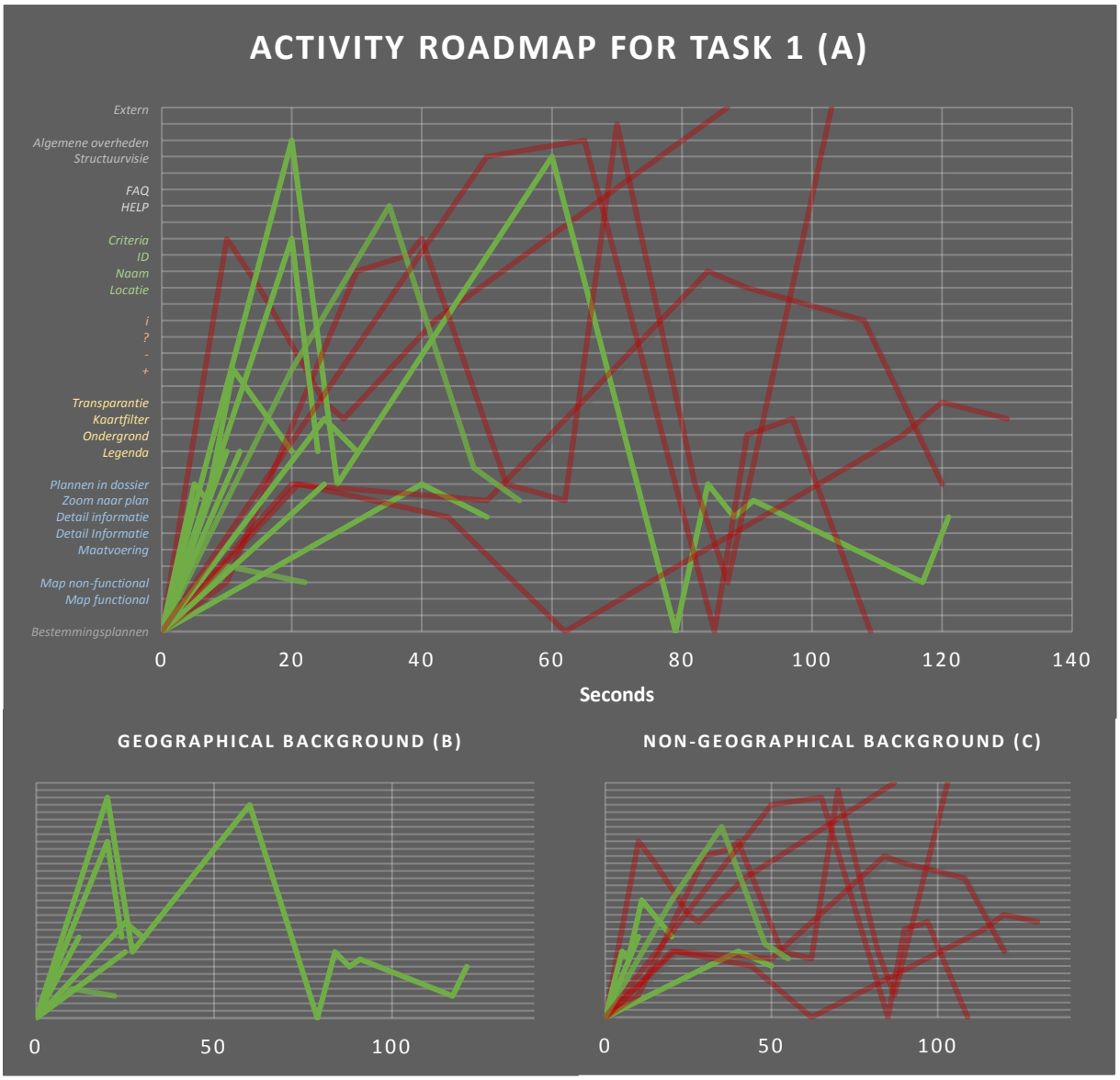


Figure 19: Activity roadmap for task 1 (visualization): (a) for all respondent; (b) for respondents with a geographical background; (c) for respondents without a geographical background.

The second task performed in this study focused on the usability of the RO-Online functionality to navigate to the needed information. The fastest set time in finding the right answer was 10 seconds whilst the slowest time was 120 seconds, with an average of 47.5 (table 5). In total, 10 out of 15 people found the correct answer for this task. Once again, the range in in quality of the answers for respondents with a non-geographical background was found to be bigger than the range in answers for respondents with a geographical background (figure 17-b). In other words, there is more diversity in performance when looking at the respondents without a geographical background, compared to respondents with a geographical background when it comes to navigation related tasks. In general, respondents without a geographical background needed more time, indicating they are less

efficient in performing the navigation task on RO-Online. The average rank in performance for respondents without a geographical background is a 7th place, while respondents with a geographical background ranked 5th (table 5). When taking a closer look at the activities of respondents during this task, it is striking to see that all respondents who failed to give the correct answer were not aware of the maps' ability to navigate. Moreover, the respondents that made use of the navigational function of the map, all used it during their first action.

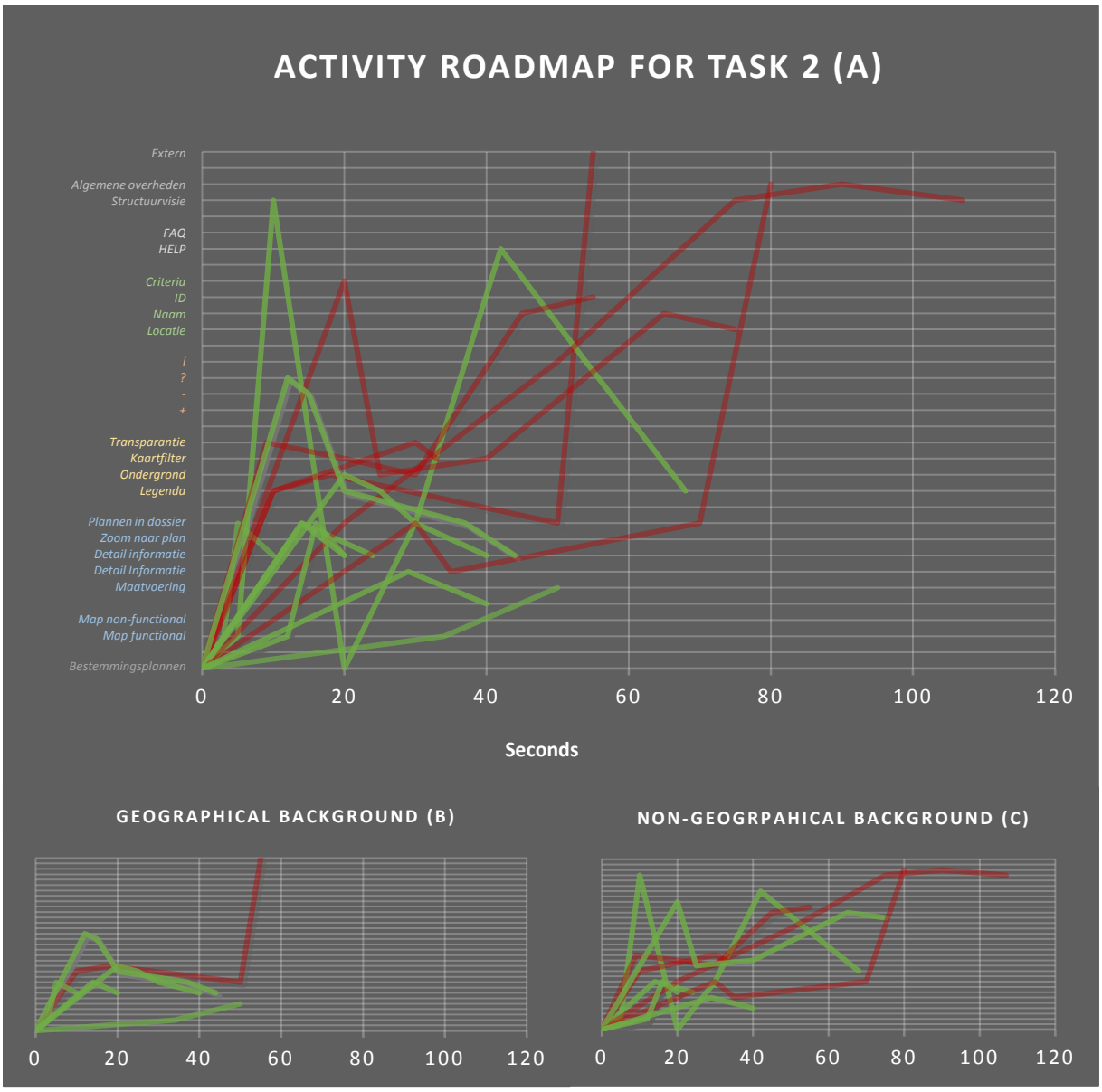


Figure 20: Activity roadmap for task 2 (navigation): (a) for all respondent; (b) for respondents with a geographical background; (c) for respondents without a geographical background.

The third task was setup as a memorability task for which the respondents had to find out what is understood by 'mixed zoning' for the location specified as their 'home' location. This task forced the user to reuse the search techniques that had to be applied during the first two tasks. This task had a success rate of 66.7 percent. In total 11 out of 15 people found the answer on the question within the set time (table 5). The fastest answer was found in 10 seconds, while the slowest answer in 90 seconds, with an average of 47.7 seconds (table 5, figure 21). Similar to the previous two tasks, the range in case of respondents with a geographical background that were

able to find the right answer in time is much smaller than the range of the users without a geographical background (figure 17-c).

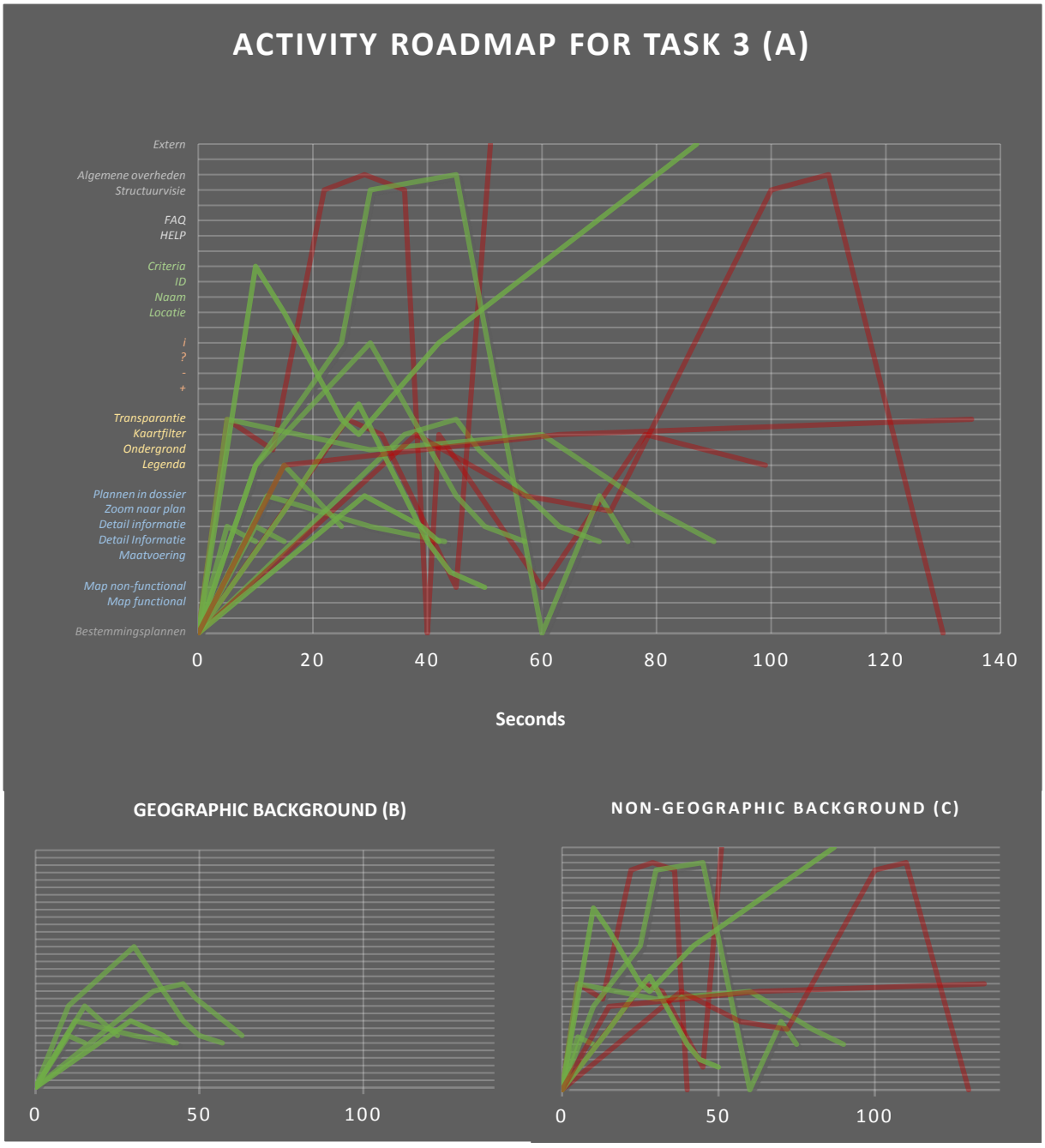


Figure 21: Activity roadmap for task 3 (memorability): (a) for all respondent; (b) for respondents with a geographical background; (c) for respondents without a geographical background.

4.3 Eye-tracking

Figure 22 shows a heatmap summarizing the eye-tracking results of all respondents and thereby highlighting the most eye-catching locations on the RO-Online geoportal. When looking at the heatmap, we find that most attention is paid to the 'tools and menu' in the upper left corner of the RO-Online portal as well as on the map itself. Also, a fair amount of attention is paid to the file-tabs on the right-hand side. The search function and possibilities for help show to draw only very little attention of the respondents. This indicates a clear potential for improved visibility of these functionalities in the RO-Online geoportal.

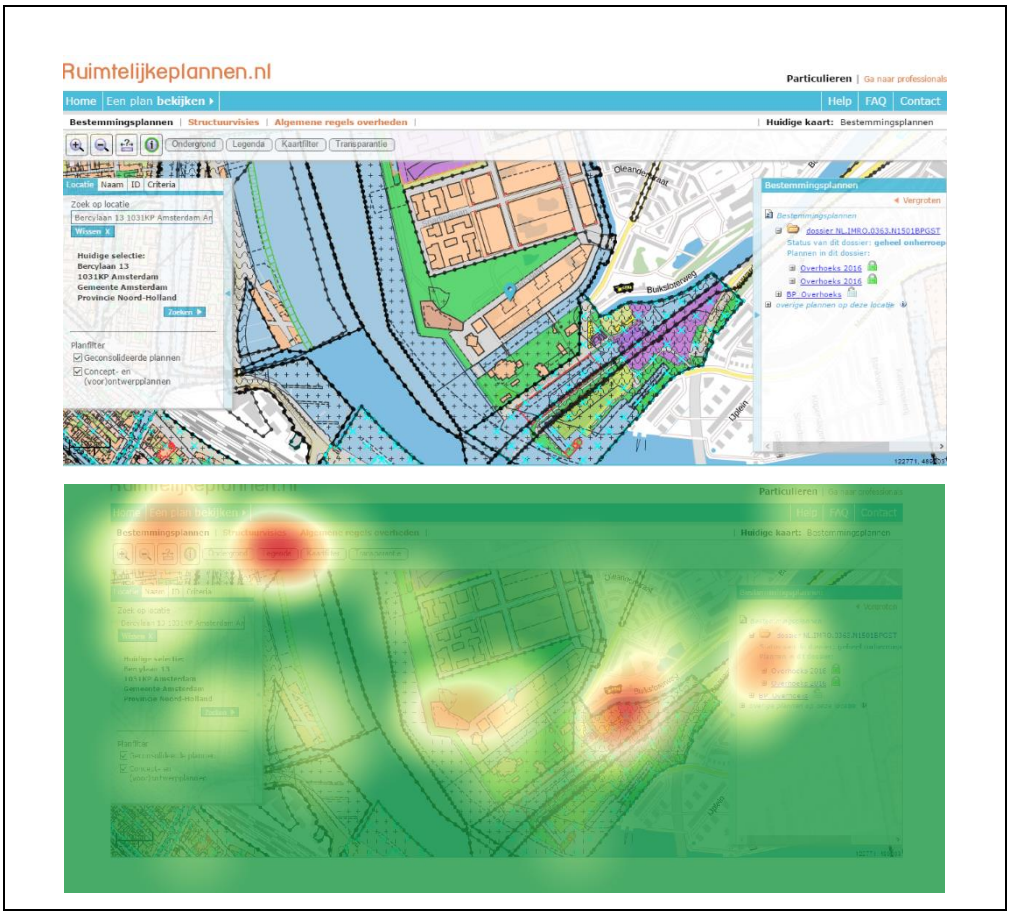


Figure 22: Heatmap indicating the most eye-catching locations on the RO-Online geoportal using an eye-tracking test. The red colors indicate high visibility whereas green colors indicate low visibility.

When comparing the eye-tracking test results with the first action of the respondents during the first task (figure 23), no direct match was found between what people see at first glance and what their first action is. In figure 23, the blue band represents the extended documents section whereas the yellow band represents the legend section in the RO-Online geoportal. Moreover, the green dots represent those respondents who succeeded the task and were extremely quick (t < 30 seconds). The blue triangles represent the respondents who succeeded the task but were less quick (t ≥30 seconds). Finally, the red crosses represent the respondents who were not able to succeed the test (see appendix F for further explanation).

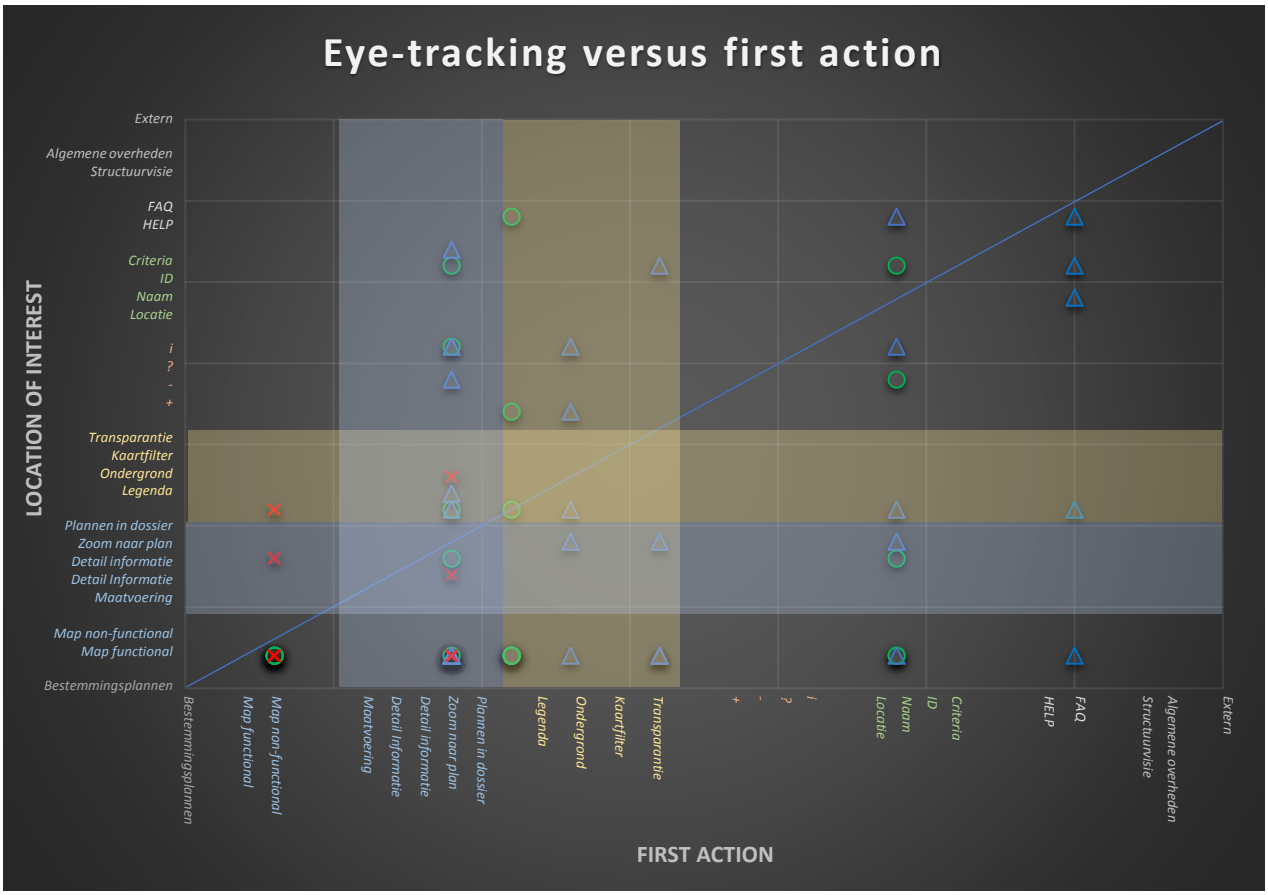


Figure 23: Results of the eye-tracking test versus a respondents' first action. The graph shows for each of the respondents its eye-tracking results (Y-axis) in comparison to its first action (X-axis), split out over different functionalities of RO-Online. The blue bands indicate those functionalities that relate to the extended document sections whereas the yellow bands relate to the legend sections of RO-Online. Respondents are classified as respondents with: (green) a correct answer in a fast time; (blue) a correct answer in a slow time; (red) no correct answer to the given task.

No concrete conclusions could be made when comparing the eye tracking results with the performance of respondents. What could be said though, is that despite a high visibility of the map functionality of RO-Online (tracking a lot of attention), this does not automatically translate into actual direct interaction of the respondents with the web map (i.e. using it in performing the task). The same could be said about the tools that support the navigation through the map. None of the respondent made use of any of the these tools, while it was a location that received a lot of attention in the eye-tracking test.

4.4 Revealed opinion on usability of RO-Online regarding visualization and navigation

Finally, the respondents were asked to answer multiple questions in order to reveal their opinion on the performed tasks using RO-Online specifically, and regarding the RO-Online geoportal in general. As discussed in the data and methods chapter, these questions enabled a further evaluation of the earlier performed tasks. Namely, questions 11 and 12 relate to the general question about navigation and visualization respectively; question 13 is the control question for question 11 and relates to the performance measured in task 2, looking specifically at navigation; question 14 is the control question for question 12 and relates to the performance measured in task 1, looking into the visualization aspects of the portal. Questions 15 and 16 provide, finally, a further outlook/means of evaluation of the perceived usability of multi-dimensional visualization, testing the opinion on the current 2-D dimensional representation and the potential added value of a 3-D dimensional representation. Table 5 shows for each of the question-task combination the strength of the correlation coefficient (R^2) as well as the direction (+/-) of the correlation between the revealed opinion and the performance (ranking) of each of the respondents. The following paragraphs deal with each of these aspects individually.

Table 6: Strength of the correlation coefficient and direction and strenght of the correlation (+/-) between the question on revealed opinion and peformance in the corresponding task related to visualization (task 1) and navigation (task 2).

Question	Task 1: Visualization	Task 2: navigation	Overall performance
11		**0.19 (-0.15)**	
12	**0.07 (-0.08)**		
13		**0.40 (-0.24)**	
14	**0.12 (-0.11)**		
15			0.15 (-0.11)
16			0 (-0.002

5.4.1 Revealed ease of use of navigation versus the respondents' performance in the navigation task

First of all, the respondents were asked whether they thought it was easy to navigate through the RO-Online geoportal in general. In total 8 respondents disagreed with this statement, of which 3 totally disagreed. On the other hand, 5 people agreed and only 2 people had a neutral standpoint. In short, relatively more respondents are negative about the RO-Online's usability for navigation than the number of respondents that were positive. When plotting these outcomes against the professional background of the respondents, it becomes clear that people with a geographical background in general tend to find it easier to navigate through the geoportal compared to respondents without a geographical background (figure 24-a).

The control question (figure 24-b) that discusses the ease of use of finding the answer on the specific task related to navigation, shows similar patterns. Here, 10 people responded with a negative opinion on usability, 3 people were positive and 2 people were neutral in their answer. When splitting these results, again respondents with a geographical background tend to be more positive about finding an answer on the task related to navigation in comparison with respondents without a geographical background.

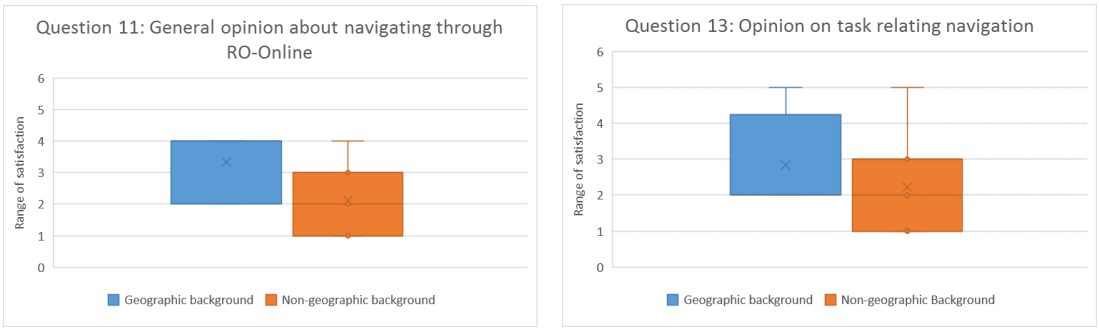


Figure 24: Proficiency plotted against: (a) the general revealed opinion on navigation through RO-Online; (b) the revealed opinion on the performed task related to navigation.

When comparing the performance of respondents on task 1, with the level of satisfaction in navigating through the geoportal, we find a negative correlation (corr-coeff:-0.15, R^2: 0.19). In other words, people who had a lower rank (i.e. were relatively more successful) in performing the task concerning navigation, showed a higher judgement (i.e. were more positive) about the overall quality of navigation in the RO-Online geoportal in comparison with people that performed the tasks less successful. However, an R^2 of 0.19 indicates that the variation in revealed opinion on the task can only be partially explained by the actual performance of the respondents in this particular task. Also other factors play a role that determine the variation in revealed opinion (figure 25-a).

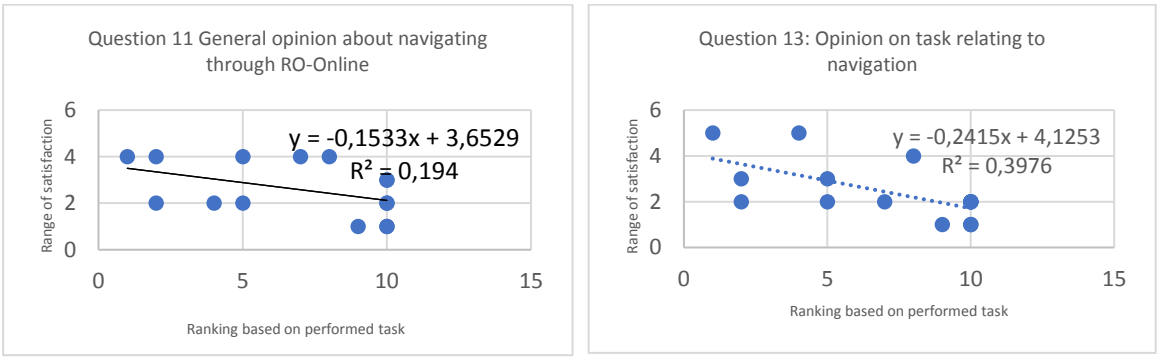


Figure 25: Performance plotted against: (a) Q11: the general revealed opinion on navigation through RO-Online; (b) Q13: the revealed opinion on the performed task related to navigation

When comparing the performance of respondents with their opinion on the task specific question (figure 25-b), we see a stronger correlation, both when looking at the trend as well as when looking at the R^2. It seems that respondents who are performing better seems to be more positive in case of the task related question in comparison with the general question about navigation. Moreover, with an R^2 of ~0.40 a significant larger portion of the respondents' variation in revealed opinion can be coupled to their performance related to this specific task. Nevertheless, still a significant portion of the respondents revealed opinion should be explained by other variables.

Overall, the respondents, directly as well as indirectly, perceive it to be relatively difficult to navigate through the RO-Online geoportal. People with a geographical background are however less negative about its

functionality compared to people without a geographical background. Also, the answers to both questions in relation to the respondents' performance on the given task hint towards a negative correlation between the performance and their revealed opinion. With the R^2 and the correlation coefficient being stronger in case of the specific task related question on navigation relative to the respondents' overall opinion about navigation, this indicates that the answer for this question could be explained for a much bigger part on performance compared with the general question.

4.4.2 Revealed ease of use of visualization versus the performance

When comparing the revealed opinion of the respondents on the overall quality of visualization, there is a small difference between the general question and the control question that relates to the specific task (task 1). In case of question 12 about the general quality of visualization, relatively more respondents gave a positive evaluation compared to those giving a negative evaluation. Seven respondents were positive about the way information is visualized in the RO-Online portal, two respondents were neutral, and six respondents were negative. However, when looking at question 14 (control question with respect to task 1) relatively more respondents responded negatively than positively. In total, seven people regarded it as not easy to find an answer on task 1, while three were neutral and five were positive. A small difference thus exists in how the respondents perceived the quality of visualization in general and how they experienced it during the specific task that focused on visualization specifically.

When splitting the outcomes over the proficiency of the respondents (figure 26), those respondents with a geographical background showed to be more positive about the way in which the information is visualized in RO-Online compared to respondents without a geographical background. However, in case of the task specific question their opinion is more alike. Here, respondents with a geographical background tend to be a little bit more negative compared to their general opinion whereas for the respondents without a geographical background their opinions remains equal.

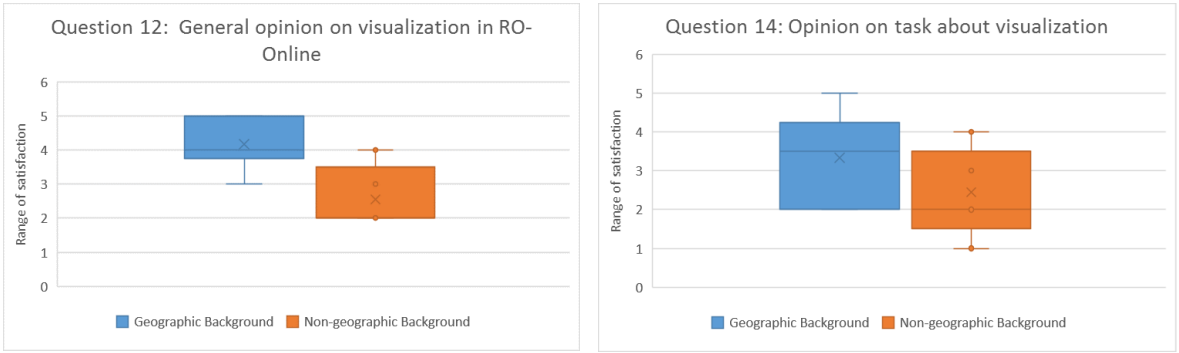


Figure 26: Proficiency plotted against: (a) Q12: the general revealed opinion on visualization through RO-Online; (b) Q14: the revealed opinion on the performed task related to visualization.

When looking at the correlation between the answers of the general question and the control question on visualization and the performed tasks related to the visualization aspect, we find only a very low negative correlation (corr-coeff:-0.08, R^2:0.07) between the performance of the task related to visualization and the

respondents' evaluation on the visualization of data in the geoportal (table 5, figure 26). The negative correlation between how respondents performed and their opinion on the easiness of that task is relatively stronger. Not only in terms of its correlation coefficient (-0.11) but also when looking at its R^2 (0.12). Correlation coefficients are found to be negative for both revealed-opinion questions. In other words, people that are performing relatively well on the tasks that concentrate on the portals ability to visualize geographical information are slightly more positive about the way in which this information is visualized in general in the geoportal. A similar conclusion could be drawn when comparing the performances within the visualization oriented tasks with the associated task-related evaluation question. With a relatively higher R^2 found for the task-related question we can, again, conclude that other variables are relatively less important in determining the opinion in the task-related questions, as compared to possible determinants for the opinion in the general question related to the visualization aspects of the RO-Online geoportal.

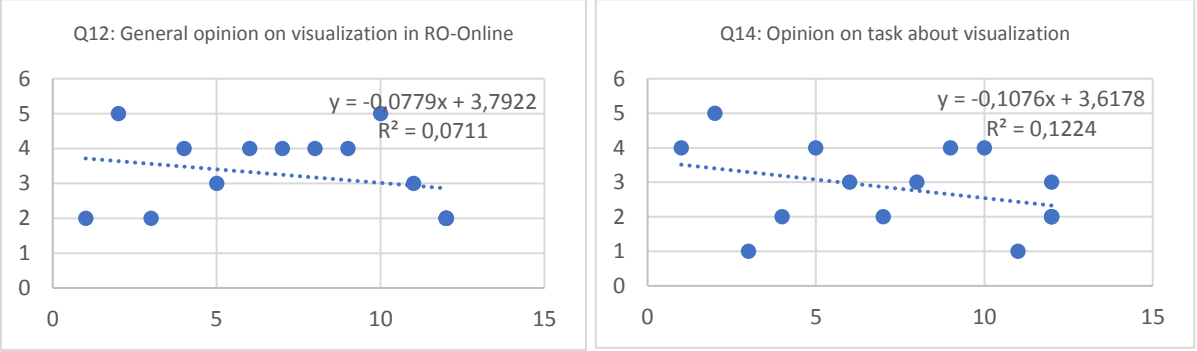


Figure 27: Performance plotted against: (a) Q12: the general revealed opinion on visualization through RO-Online; (b) Q14: the revealed opinion on the performed task related to visualization.

To summarize, respondents tend to be relatively negative about the navigation functionalities in the RO-Online geoportal, both when looking at the direct as well as the indirect questions evaluating the perceived usability of navigation. While in case of the visualization they are overall more positive than negative, but in case of the task related question this is the other way around. When comparing these questions with their performances, it could be said that in case of the visualization aspects the actual performance plays a less important role, compared to the influence of performance on evaluation of navigational aspects of the portal. An explanation for this observation could be that the task related to navigation requires more steps, and therefore has more room for different opinions, while the task about visualization is more straight forward, and therefore has less room for variance. What all questions have in common though, is that respondents with a geographical background tend to have a more positive opinion on the usability of the RO-Online geoportal than respondents with no geographical background, both when looking at the general opinion as well as when evaluating the task-specific opinion.

4.4.3 Perceived opportunities for further development of RO-Online

The questions that are reflecting on the opportunities for further development display a predominantly negative opinion of the respondents towards the current used the two-dimensional form of visualization to represent the geographical information in the RO-Online geoportal. In total, nine respondents regarded it as not enough, one respondent was neutral, and five were positive. No significant difference between the respondent's professional

background and their judgement was found, whilst a marginal negative correlation (-0.11) was found between the respondents' performance and their opinion on this subject, with an R^2 of 0.15. When asking the question about the added value of a three-dimensional representation of the geographical information currently displayed in the RO-Online portal, seven respondents regarded it as a positive development, four respondents were neutral, and four respondents did not immediately saw this as positive development. A marginal negative correlation of -0.002 (R^2: 0) was found between the way people perform and how they regard the added value of a 3-D dimensional representation as compared to a 2-D visualization. People that performed well on the visualization related task are marginally more negative on implementing three-dimensions on the platform compared to people that performed worse, seeing the 3-D dimensional representation as a potentially added value. However, the very low R^2 values for both questions indicate that a clear correlation between performance and opinion could not be found and that other aspects play a role in determining the respondents' revealed opinion on this matter.

When asking for a preference on the type of visualization in case a three-dimensional representation was added to the RO-Online geoportal, no significant difference in preference was found between the respondents with a geographical or without a geographical background. Neither did we find a correlation between the preference of the respondents on this matter in comparison to the quality of the performed tasks. In case of their own home, most people preferred a top down view, while in case of the whole neighborhood, most respondents desire the birds view.

5. Conclusion, discussions & recommendations

The first part of this chapter discusses the most important conclusions of this study and links it with the earlier discussed theories. Thereafter, the second sub-chapter discusses certain limitations that should be considered when interpreting the results of this study, and elaborates on the position of the findings to other studies. Finally, a number of recommendations are being made for policy and future research.

5.1 Conclusions: Results and theory

This study tried to analyze the current perceived usability of the geoportal RO-Online regarding its representation and communication of land use regulations to ordinary citizens, while also trying to investigate possible opportunities for future systems. The creators of geoportals, and in this case RO-Online specifically, have – over time- become more aware of the importance of creating an understandable platform also for non-geographical users (Wolters, 2015). Earlier studies have shown that ordinary citizens have problems with the way information on this portal is communicated, specifically when it comes to used ways of visualization and navigation (Wolters, 2015). This research evaluated these perceived opinions and opportunities of ordinary citizens, in more detail, about the currently used system integrated into RO-Online. And also, tried to compare the users' opinions with their actual performances. This was done by a number of research questions that will be discussed individually in the following sections.

5.1.1 What is the current role of (multi-dimensional) visualization within the communication and representation of zoning schemes and land use regulations via geoportals to ordinary citizens?

In the first part of this research, we discussed the essence of a visualization, which can be understood as a data message between sender and user (Whyte, 2002). The important aspects of a data message are its type of visualization to present the information, as well as its used framework to communicate the information (MacEachren, 1995). The idea about how those data messages ideally should be communicated changed over time from the visual thinking perspective for personal use to a visual communication perspective for public use (MacEachren, 1995). The way in which those data messages are designed depends on multiple variables: (1) what audience is targeted?; (2) what level of interaction is expected?; and (3) what data-relation is there with the audience? After asking these questions a visualization could be designed that has a general goal, either to explore, analyze, synthesize, present or a combination of each of the preceding (MacEachren, 1995).

The way those data messages were communicated in case of information about land-use plans transformed significantly in recent decades, due to more technical possibilities as well as new legislation (Keenleyside et al., 2014). Therefore, the use of geoportals as tool for communication became very popular, since they were practical and gave the user the ability to explore and analyze the geographical information in more efficient and advanced ways (Resch & Zimmer,2013). The most essential components of such platforms are: (1) presence of a map; (2) presence of search dialog; (3) presence of user's search results; (4) use of proper symbols and icons; and (5) more general usability aspects (i.e. loading times, legends, pop-up windows, etc.) (Resch & Zimmer, 2013). The use of

a topographic base map allows the map user and the map producer to localize the thematic information (i.e. navigation), and helps explaining the geographic distribution of the thematic information (i.e. visualization) (Resch & Zimmer, 2013).

Originally geoportals were mainly targeted towards users with a geographical background that could handle platforms with a high interaction and focused on revealing the unknowns for private use (MacEachren, 1995). Due to the changing environment with a growing involvement of ordinary citizens, the platforms targeted audience, including her data-relation and expected level of interaction changed (Steenbekkers et al., 2016). Therefore, the platform had an urge to rethink the way their data message should be constructed, to make it more understandable for their new targeted audience (Wolters, 2015). Something that has also been underlined by earlier performed studies, that revealed that ordinary citizens do not regard the current portal as user friendly (Wolters, 2015), especially due to problems with navigation and visualization (Wolters, 2015).

5.1.2 What are ways to measure and test the (perceived) usability of online platforms currently in use presenting such information (i.e. future zoning schemes and land use regulations)?

RO-Online is considered as a geoportal. It makes geographical information (however mainly in the form of documents) available to citizens via an online public portal. There are certain methods to improve the usability of such systems. ISO 13407 (Meng, 2003), for example, provides guidance on achieving quality in use by incorporating user-centered design activities throughout the life cycle of interactive computer-based systems. Part of this cycle is the evaluation of the current used design.

Usability testing focuses on measuring a product's capacity to meet its intended purpose. The system's usability can be measured empirically in terms of its: (1) learnability, (2) efficiency, (3) memorability, (4) error rate, and (5) satisfaction (Nielsen 1993b; Haklay & Tobón, 2003). Methods to measure these terms are via tasks focusing on the first four variables and a questionnaire dealing with the fifth aspect (Haklay & Tobón, 2003). Several moderating techniques were used in support of the measurement techniques, such as audio recordings, activity capturing and alternative eye tracking techniques (Masciocchi *et al*. 2012). These aspects made it possible to compare the perceived opinion with the actual performance of respondents. This research focused on the usability of the essential elements of the current used data message to communicate land use plans (the geoportal). Therefore, the usability study was focused on the quality of its most important aspects: (1) the used map; (2) search dialog; (3) the user's search results; (4) the used symbols and icons; and (5) more general usability aspects (i.e. loading times, legends, pop-up windows, etc.). Apart from the earlier described more hands-on functions, this study focused in a much broader sense on RO-Online's overall function for navigation and visualization, since they were negatively evaluated in earlier research (Wolters, 2015).

5.1.3 What is the (perceived) usability of RO-Online by ordinary citizens?

An important outcome that relates to the specific respondents of the usability study performed as part of this research, is that there is currently a lack of interest of citizens regarding land-use plans. Most respondents are not interested in the building restrictions regarding their current home, probably since most of them are not a private house owner. Nonetheless, 13 out of 15 respondents had an interest for the developments in their surrounding neighborhood. This indicates that people do have an interest in zoning plan related subjects. But mainly when it directly affects their neighborhood due to actions of others. Only 4 respondents, all with a geographical background, were already familiar with the website RO-Online before participating in this research.

This research focused on the platforms usability for navigation and visualization, since those aspects are regarded as essential elements of the geoportal and were evaluated negatively in earlier performed research (Wolters, 2015). The respondents' opinion about these subjects was measured via general questions, as well as task related questions. Regarding the platform's main functions for visualization, a balance was found between respondents who regard it as easy to understand the visualizations and respondents who do not. Overall six respondents were positive about the current visualizations and seven respondents were negative. Respondents with a geographical background tend to be extremely more positive in their answer on the general question about the platform's quality of visualization compared to respondents without a geographical background. In case of the task specific questions, opinions of the respondents with a geographical background are a bit more negative and more comparable with the non-geographic respondents. Seven respondents were negative, three were neutral, and five were positive in their answer on the task specific question related to visualization. Similar to the platform's function for visualization, respondents are in case of its function for navigation also slightly more negative than positive. Especially in case of the task related question (10 out of 15). Regarding the general question, respondents without geographical background are less positive in their experience than respondents with a geographical background. While in case of the task related question there is less difference in their opinion. It could therefore be concluded that respondents are in general less negative and more positive in their opinion about the way of navigation compared to their experience with the task related question. Similar to the question regarding the visualization, in case of their opinion on the general functionality of navigation, respondents with a geographical background tend to be more positive in their answer compared to respondents with no geographical background. Their opinion in case of the task related question shows similar patterns.

The results show that respondents without geographical knowledge evaluate the platform on multiple aspects reasonably negative, both in general as well as based upon the performed tasks. Respondents with a geographical background tend to be relatively neutral on the platforms function for navigation, both in case of the general question as well as the task related question. However, in case of its function for visualization, they are extremely positive in their general judgement but less positive in case of the task related questions, although still higher compared to respondents without a geographical background.

The earlier mentioned tasks, performed by the respondents, relate to different components of the portal. The first task related to its function for visualization, the second to its function for navigation, and the third task was a combination and focused on the respondents' memorability. In case of the first task on visualization, in total 73.3 percent of the respondents found the right answer. All respondents with a geographical background were successful, while only 5 out of 9 respondents with no geographical background found the right answer. None of the respondents who were not successful in finding the right answer made use of the maps legend. Therefore, they were not aware of the maps ability to visualize the information through the choropleth map.

When comparing the times the respondents needed to succeed, respondents without a geographical background needed in general more time to find the right answer compared to respondents with a geographical background. A small negative correlation was found between the respondents' performance on the task related to visualization, and how they evaluated this part during the questions. The correlation is significantly stronger when comparing the correspondents' performance with the question related directly to the task. In short, how people perform on the task about visualization is of less influence on how they assess the quality of visualization in general compared to the quality in case of the specific task. In case of the second task on navigation, in total 10 out of 15 respondents found the right answer. This time there was one respondent with a geographical background that not succeeded in finding the right answer. Also, respondents with a geographical background tend to find an answer more efficiently compared to respondents without a geographical background. There is a small negative correlation between how respondents performed on the task and how they evaluated on the questions. The correlation is a lot stronger, though, in case of the task related question. In short, respondents slightly tend to be more positive about the navigation on the portal when performing better during the tasks, this is especially the case when looking at the task specific question related to navigation.

To sum up, similar to the conclusions made by Wolter (2015), there is a need for an alternative way to enthuse and trigger respondents with no geographical background to make use of RO-Online. Currently they are not aware of its existence, they are not extremely enthusiastic about its current design both in general and in practice, and they are underperforming. On the other hand, the platform seems to reach the respondents with a geographical background relatively well. They are also positive about the platforms functionalities in general, but are however less positive about visualization in practice. Participants with a geographical background also seem to perform better on the tasks compared to respondents without geographical background. It is therefore advisable for the platform focus first on an increase of the performance of the non-geographical users. Especially given the slightly negative correlations found between how respondents perform on the platform and how they evaluate its usability.

A second point that has to be taken into account when working on the usability of RO-Online is that, although users with a geographical background rate RO-Online generally relatively high when it comes to usability, the ratings among experienced users decrease when it comes to the actual performance of tasks. Although the platform looks nice and functional at first glance the actual user-experience is given a relatively lower rate. First

hints to deal with this issue can be found when comparing the eye-tracking results with the first actions taken when navigating through the portal. Although several functionalities catch the eye they are not being used by the user to perform the task, and vice versa. Creating a better coupling between the functionalities that are clearly apparent on the portal and those functionalities that mostly support the portals function (navigation and visualization) could partially solve this issue. It must be noted, nevertheless, that the correlation coefficients found in this study reveal that performance is only one of the variables influencing the respondents' opinion. Also other factors that have not been tested in this study determine for a significant part the respondents perceived usability of RO-Online. These factors are crucial to consider in further research. Since respondents are aware of their own lack of knowledge, it is for instance possible that they evaluate the system based on their own perceived experience.

5.1.4 What are future possibilities to enhance the perceived usability of RO-Online for ordinary citizens, improving the communication of future zoning schemes and land use regulations?

Upon the discussed results in the previous paragraphs, it could be said that there is an urge for RO-Online to adjust the platform (i.e. data message) to fulfill the amount of satisfaction for its targeted audience, since citizens without geographical background perceive the usability platform negatively, and perform less on the tasks. In response, several possibilities have been identified to enhance the perceived usability of RO-Online.

In general, since there is a notable disconnect between the tools that are being used and the tools prominently displayed in the application, RO-Online should consider to do an overall re-design. The eye-tracking study in combination with the activity roadmap revealed that there is under respondents an awareness of tools used for zooming and measuring, but that these tools are simply not often used. Also, there is relatively little attention for the extended documents compared to other functionalities of RO-Online, while these are an essential element in finding the right answer. Therefore, the documents should take a more prominent role on the platform. Generally, most respondents who did not succeeded on the tasks found their way to the extended documents, but were not aware of the dropdown boxes that are situated within the documents. Also, only 7 out of 15 respondents made use of the map in finding the right answer on the visualization related task.

Moreover, respondents think that there is an added value for implementing a three-dimensional map into the platform, and consider the current two-dimensional map as not sufficient. It should be of interest for further research to examine whether respondents perform better on the tasks and perceive the usability higher when making use of a three-dimensional map. Also, respondents would favor a top-down view in case of information about their own home, while they prefer a birds-eye view in case of information about the surrounding environment. It should be of interest for RO-Online to experiment with these perspectives in case of different types of information.

5.2 The discussion

This sub-chapter will elaborate on the biggest limitations of this research and will discuss its position in relation with other studies.

When interpreting the results of this study a few limitations should be considered, and are items of internal discussion. First, a higher rate of response among respondents would increase the robustness of the results. Currently the outcomes of this study are based on the responses of 15 participants. While the activities of these respondents give a good insight into the most important problems regarding the portals usability, it remains challenging to draw conclusions about the perceived usability that are representative for the intended population (the potential users of the platform). Since a sample size of 15 is equal to a margin of error of 25 percent. To minimize the margin of error, a much bigger sample size is needed. For example, to reach a margin of error of 10 percent, a sample size of 88 is needed based on a population of 1000. This research was not solely focused on a representative outcome of the perceived opinion users of the platform, since this was already done by the Kadaster (Wolters, 2015). This research also tried to verify if the perceived opinion of users in case of earlier research is backed-up by actual performances. To measure these performances, this research had to focus on more extensive individual tests, consisting of multiple tasks and questions on a predetermined location. Therefore, a bigger sample size, which equals a lower margin of error, was in case of this study not realistic. In the future, a more elaborate research should repeat the tasks and questionnaire with a higher number of respondents.

Secondly, the questionnaire could have been further optimized to suit the purposes of this research. Because of a change in scope and focus, some of the questions that were part of the questionnaire have not been optimally exploited in the current analysis, whereas a number of additional questions may have shed more light on the results. For example, some reflections became less important since the scope of this research changed from a focus on future perspectives to a more comprehensive usability study of the currently used systems. Therefore, the final questions regarding the used perspectives in case of the own home and surrounding environment do not fit that well anymore. Future research should therefore expand and further adapt the developed questionnaire and perform an extensive pre-testing before rolling-out the questionnaire and performing the research.

Thirdly, the results of the eye-tracking research were not conclusive enough to be able to perform sensible and concrete evaluations. No interesting correlations were found between actions and focus points. Causes that may have contributed to this are the relative low response rate of this study and the measurement-techniques of the eye-tracking methodology applied. As we do think, however, that eye-tracking does have a high potential for the evaluation of both the visualization and navigation aspects testing the usability of geoportals we encourage future research to look further into the opportunities for using these techniques in their evaluation and assessment.

Finally, as the current research is predominantly focused on the perceived usability of the geo-system currently in use it turned out to be relative difficult to make concrete recommendations for future design. Only the perceived opinion of respondents was asked. Future research should focus therefore on testing prototypes for implementation, weighing the usability of different types of design in combination with different functionalities. Currently, the municipality of Rotterdam is experimenting with the use of story maps supported by ArcGIS Online (http://arcg.is/1funu8). The results of this study would provide an interesting insight in the possibilities and potential of future design. Also, there are currently prototypes that focus on the user interface (http://watmagwaar.nl) It would be interesting to perform similar tests on their prototypes.

Despite these limitations, this research tried to contribute in finding new ways in measuring the quality and usability of communication of current land use plans. While the outcomes of earlier research in case of the quality of communication were mainly based upon opinions rather actual usability (Wolters, 2015), this research tried to adapt alternative interpretations on quantifying and measuring usability (Meng, 2003), also in case of geoportals (Resch & Zimmer, 2013). The added value of this research upon the already existing research is that it also tried to measure in what extent the opinions of users about usability rely on their performance. In doing so this study attempted to quantify the performance of the users (via tasks) in support of the perceived usability. The outcomes regarding the difference in opinion show similar patterns with the earlier performed studies by Wolters (2015), the added value is however that it could be stated that this is also partly reflected by actual performances. However also other factors are of influence.

5.3 The recommendations

There are multiple recommendations for further research, both method related as well as case related. Regarding the used methods, it would be interesting to focus more on the correlation between perceived opinions of users and actual performances in case of these types of portals. In this research, it became clear that the correlation between the respondents' performance and their opinion is marginal, both when looking at the visualization and navigation aspects of usability. This indicates that also other factors influence their perceived usability. It could be possible that respondents, especially those with a non-geographical background, are aware of their own lack of knowledge about the subject and include this in their perceived opinion. This research, however, does not include further analysis on this topic, and more research is needed hereto.

When focussing on the case itself, it would be interesting to explore the added value of a three-dimensional view in more extensive ways. The perceived opinion on this matter is that respondents are overall enthusiastic about such an implementation. In case of such an implementation it would be an added value to experiment with different types of perspectives depending on the type of user and needed information as well. Further research should focus on the difference in use of perspectives for different types of users. A similar recommendation could be made about the used navigational design. It is a challenge to create a platform that fulfill the needs of multiple types of users.

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Appendix A: Digital files

Table of Content of the ZIP file / DVD that accompanies the thesis report

- Report (word, PDF)
- Midterm & Final presentation (PPT)
- Questionnaires
- Datasets with answers questionnaire & correlations (Excel)
- Audio recordings & screen captures
- Literature
- Eye-tracking results

Appendix B: Setup usability evaluation

To be able to perform a proper evaluation several steps should be considered:

Figure 28: Steps to evaluate current design

Planning a test

One of the first steps regarding usability tests is the development of a plan. The purpose of the plan is to document what you are going to do, how you are going to conduct the test, what metrics you are going to capture, the number of participants that are involved and the scenarios that you will use. The first steps to think about are:

1. To figure out what is going to be tested during the usability study.
2. To figure out what the main purpose is for performing a usability test.
3. To setup a schedule for testing and choose a suitable location.
4. To think about the intended length of the test sessions.
5. And to think about what equipment is needed to perform the tests.

Recruiting participants

The second step within the usability test process is to recruit the right participants for the test. In performing a quantitative study the input of at least 15 respondents is necessary for a reliable outcome. The composition of the test group should be representative for the actual users of the product.

Moderating technique

There are many techniques possible in testing the usability of an application, depending on the goal of the study. Probing techniques are for instance popular, since they let a participant work on different tasks while it is possible for the researcher to observe and interfere in case they say something interesting or do something unique.

The article '*Usability Evaluation and PPGIS: towards a user-centered design approach*' underestimates four crucial techniques that could be used to evaluate the usability of a system. In first by making use of a chauffeur to 'drive' the software. In second, by using software to record the interactions between the users and the system. In third by encouraging participants to verbalize their thoughts regarding the interactions. And finally, to make use of tasks or scenarios to obtain information about the users' performance and attitudes towards the system.

1. ***Making use of chauffeurs to 'drive' the software.***

The chauffeurs are the mediators between the people who need to use the GIS but have a lack in technical knowledge, and the system. The chauffeur is both the facilitator and the person who performs the qualitative research. The chauffeurs can help the participant during a test.

2. ***Using software to record the interactions between the users and the system.***
   To understand how users, perform certain tasks, the interactions should be recorded both on audio and visually. Recording the interactions could assist in analyzing what the participants are viewing on the screen during the sessions. Recording the sessions, both visually as well as audibly enables the researcher to connect the discussions with the performed tasks, as well as to analyze the sequence of events that led to a specific comment about the system or the information obtained.

   A specific type of recording, specified in registering behavioral information of the participant is the eye tracking technique. Eye-tracking systems allow designers to test whether their program or environment guides users' fixations to important locations.

3. ***The instruction to facilitators to encourage participants to verbalize their thoughts regarding the interactions.***
   In asking the participants to express their experiences and thoughts, it is possible to understand some of the main limitations when using GIS related program's. By performing a questionnaire could be very useful in exposing those shortcomings. The questionnaire will focus on the range of satisfaction of the existing application, the identified needs and some user context related information.

4. ***The use of tasks or scenarios to obtain information about users' performance and attitudes towards the system****.*
   The tasks could help to guide the participants through a system by creating a set of activities to provide the user a specific experience with the software (Haklay & Tobón, 2003).

Pilot testing

Prior to conducting the usability test a pilot test will be performed to test the equipment and check if the questions and scenarios are clear to the participant.

Usability test evaluation

Finally, the outcomes of the performed tests on respondents will be evaluated and compared with each other, to be able to do specific recommendations for a three-dimensional prototype.

Appendix C: Validation interest point eye-tracking technique

Using traditional eye tracking techniques to measure a systems usability are in most cases extremely useful. However, the costs must not outweigh the benefits. A given that also counts for this research.

Major constraints in performing a traditional eye tracking research regarding this research are:

1. The absence of an available proper eye-tracking equipment and a test location. Most proper geo-related eye tracking facilities are situated in Enschede and Wageningen, while the research is performed in Amsterdam.
2. Simply performing the test in one of those cities is not a realistic possibility since the usability test focusses on a Dutch website, while the population of the universities in Enschede and Wageningen have an international origin.
3. The eye tracking test is only a small part of the usability test. It tries to investigate why ordinary citizens are not finding the right information on the RO-Online website. By making use of a traditional setup, could distract and influence the rest of the usability research (Masciocchi *et al*, 2012).

Therefore, the much simpler interest point method is used to investigate spatial attention. Since to certain studies (Masciocchi *et al*, 2012) there is a strong correlation between the fixations of normal eye tracking techniques and the interest point selection. To be completely sure, also a small validation test is performed within this research.

Five different participants in a traditional eye-tracking setup were asked to watch for 30 seconds to a random picture without giving further information. Thereafter the volunteers were asked to highlight five locations on the picture they just watched according the point of interest method. The results show some major similarities between the two approve to a certain extend the use of the interest point technique.

Figure 29: Points of interest appointed by participant 1(a); locations gazed by participant

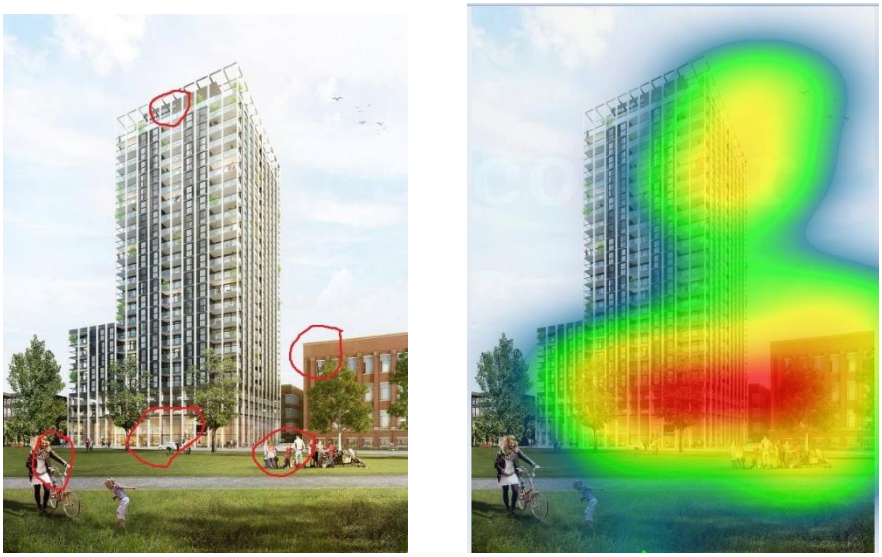


Figure 30: Points of interest appointed by participant 2(a); locations gazed by participant (b).

Figure 31: Points of interest appointed by participant 3(a); locations gazed by participant (b).

Figure 32: Points of interest appointed by participant 4(a); locations gazed by participant (b).

Appendix D: The Questionaire

1. Bent u bekend met geografisch georienteerde programma's, zoals webmaps, navigatie systemen of Google maps?
   - Ja
   - Nee

2. Mijn huidige woonsituatie is:
   - Huurwoning
   - Koopwoning
   - inwonend

3. U bent geinteresseerd in de huidige bouw restricties t.a.v. mijn eigen woning
   - Helemaal mee oneens
   - Mee oneens
   - Niet mee eens /oneens
   - Mee eens
   - Helemaal mee eens

4. U bent geinteresseerd in de (toekomstige) ontwikkelingen t.a.v. uw directe woon omgeving.
   - Helemaal mee oneens
   - Mee oneens
   - Niet mee eens /oneens
   - Mee eens
   - Helemaal mee eens

5. Waar haalt u op dit moment uw informatie vandaan met betrekking tot de huidige bouw restricties

.....

.....

.....

6. Waar haalt u op dit moment uw in informatie vandaan met betrekking tot de ontwikkelingen in de directe omgeving?

.....

.....

.....

7. Heeft u in het verleden weleens een bestemmingsplan geraadpleegt?
    - Ja
    - Nee

8. Indien ja, Waarvoor heeft heeft u deze geraadpleegt?
    - Professioneel
    - Persoonlijk

9. Heeft u weleens een digitaal bestemmingsplan op het internet bekeken?
    - Ja
    - Nee

10. Bent u bekend met ruimtelijkeplannen.nl?
    - Ja
    - Nee

Voor het volgende onderdeel surft u naar de website www.ruimtelijkeplannen.nl en beantwoord u een aantal vragen ten aanzien van de website ten aanzien van een specifieke case.

Case:

U gaat verhuizen naar een nieuwe woning gelegen aan de Bercylaan op nummer 13, een woning op de 4e etage van een nieuw gebouwd woon complex in Amsterdam Noord. Surf naar de website www.ruimtelijkeplannen.nl, en vul de postcode: **1031 KP**, met het huisnummer: **13**.

Kunt u mij 5 verschillende punten aanwijzen die u opvallen aan de pagina waar u zich nu op begeeft?
Alvorens u gaat verhuizen wilt u echter een aantal zaken weten, hierover een aantal vragen:

1. Wat is de bestemmingsfunctie van uw locatie?
2. Wat is de maximale bouwhoogte van de bouwing grenzend aan uw locatie?
3. Naast de woonfunctie is er op uw locatie ook nog ruimte voor andere functies. Kunt u aangeven welke functies dat betreft?

11. Het navigeren door Ruimtelijkeplannen.nl is gebruiksvriendelijk.
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens /oneens
    - Mee eens
    - Helemaal mee eens

12. Informatie op Ruimtelijkeplannen.nl over uw eigen woning begrijpelijk gevisualiseerd.
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens /oneens
    - Mee eens
    - Helemaal mee eens

13. Het is makkelijk om informatie te vinden over de maximale bouwhoogte?
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens /oneens
    - Mee eens
    - Helemaal mee eens

14. Het is makkelijk om informatie te vinden over de aangewezen functies in het besproken gebied?
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens /oneens
    - Mee eens
    - Helemaal mee eens

15. De huidige tweedmensionale informeert u voldoende over de boven genoemde informatie.
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens/oneens
    - Mee eens
    - Helemaal mee eens

16. Het visualiseren van de bestemmingsplannen in 3D heeft een meerwaarde op de huidige 2D representatie.
    - Helemaal mee oneens
    - Mee oneens
    - Niet mee eens/oneens
    - Mee eens
    - Helemaal mee eens

17. Welk perspectief is naar uw mening het meest geschikt in het visualiseren van de ruimtelijke informatie over uw eigen woning?
    - De huidige twee-dimensionale boven aanzicht (Kaart perspectief)
    - Een drie-dimensionale boven aanzicht (vogel perspectief)
    - Een eerste persoons aanzicht (vanuit de ogen van een persoon)

18. Kunt u aangeven om welke reden?

    .....

    .....

    .....

    .....

19. Welk perspectief is naar uw mening het meest geschikt in het visualiseren van de ruimtelijke informatie over de omgeving?
    - De huidige twee-dimensionale boven aanzicht (Kaart perspectief)
    - Een drie-dimensionale boven aanzicht (vogel perspectief)
    - Een eerste persoons aanzicht (vanuit de ogen van een persoon)

20. Kunt u aangeven om welke reden?

    .....

    .....

    .....

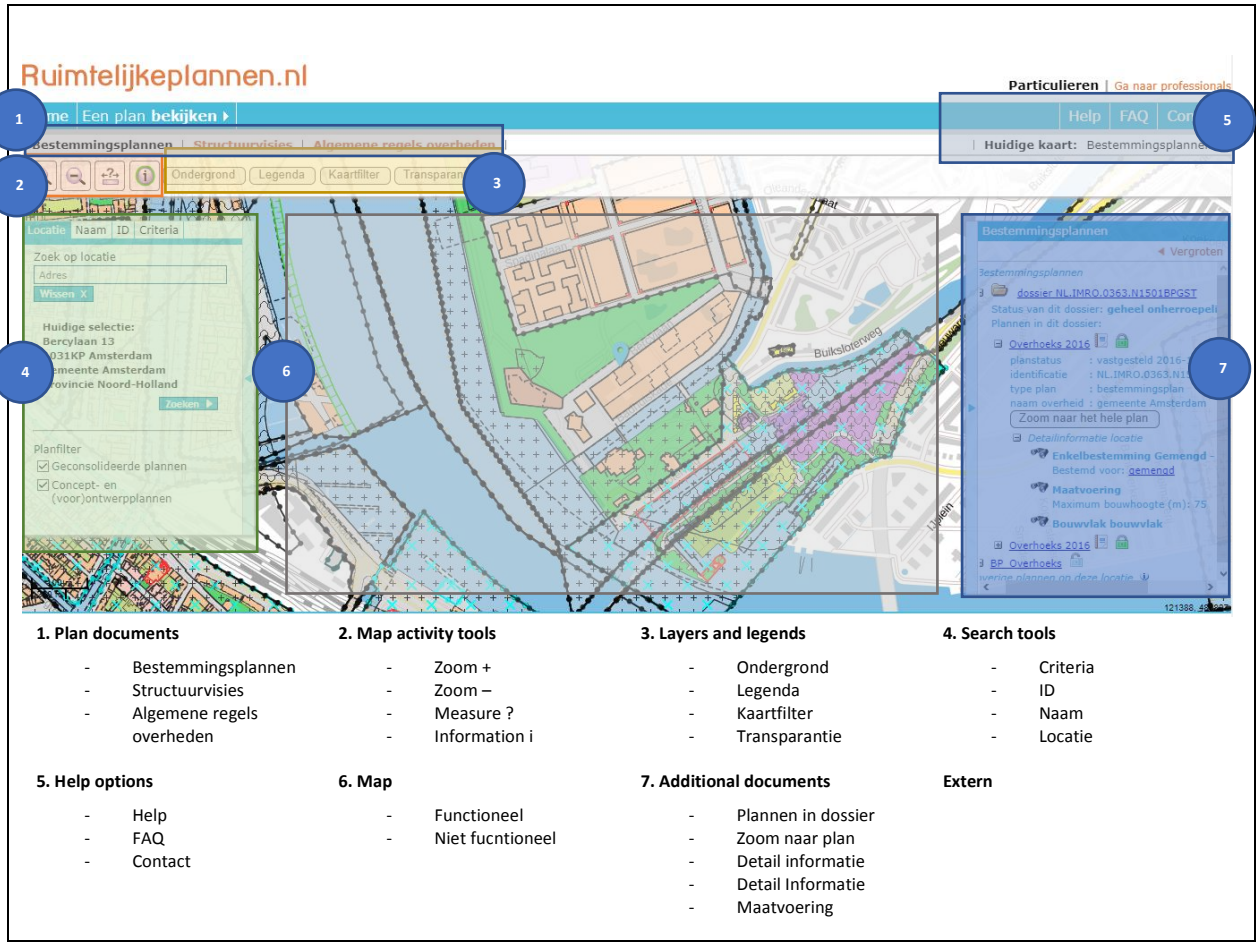
    .....

Appendix E: The Respondents

Respondent	Geography skilled:	Proficiency:
Michiel Stapper	Yes	P.H.D. Human geography
Nicolien van Eijck	Yes	Master Urban studies
Bas van Woesik	Yes	Teaching Geography (Master Human Geography)
Isabella Mulder	No	Bachelor Social Sciences
Margreet Mulder	No	Teacher
Tico Beekman	No	Student
Daniel Aijtink	No	Student
Melle Dotinga	No	Copy writer
Martin Laduc	No	Administrative worker
Auke de Geest	Yes	Rijkswaterstaat / Master Human Geography
Robin van Kuijk	No	Student
Ismay Dotinga	Yes	Master Urban Studies
Martin Blauw	No	Working in communications
Emil Rijcken	No	Student
Noor Cornelisse	Yes	Master Urban Studies

Appendix F: Quantifying the respondents' performance

To be able to track actions of respondents and design activity roadmaps, the expected activities are spatially categorized partly based on the most important aspects of a geoportal as described in chapter 2.3. The website contains 7 main components: (1) Plan documents; (2) Map activity tools; (3) Layers and legends; (4) Search tools; (5) Help options; (6) The map; (7) Additional documents that could be subdivided in multiple sub-components (See figure 33).



1. Plan documents

- Bestemmingsplannen
- Structuurvisies
- Algemene regels overheden

2. Map activity tools

- Zoom +
- Zoom –
- Measure ?
- Information i

3. Layers and legends

- Ondergrond
- Legenda
- Kaartfilter
- Transparantie

4. Search tools

- Criteria
- ID
- Naam
- Locatie

5. Help options

- Help
- FAQ
- Contact

6. Map

- Functioneel
- Niet fucntioneel

7. Additional documents

- Plannen in dossier
- Zoom naar plan
- Detail informatie
- Detail Informatie
- Maatvoering

Extern

Figure 33: Most important components main page RO-Online

Based on these activities it is possible to create an activity roadmap that plots the respondents' actions with the needed time (See figure 33). The green lines represent successful performed tasks while the red lines represent the failed tasks. This makes it able to analyze the respondent's actions during their search for the right answer.

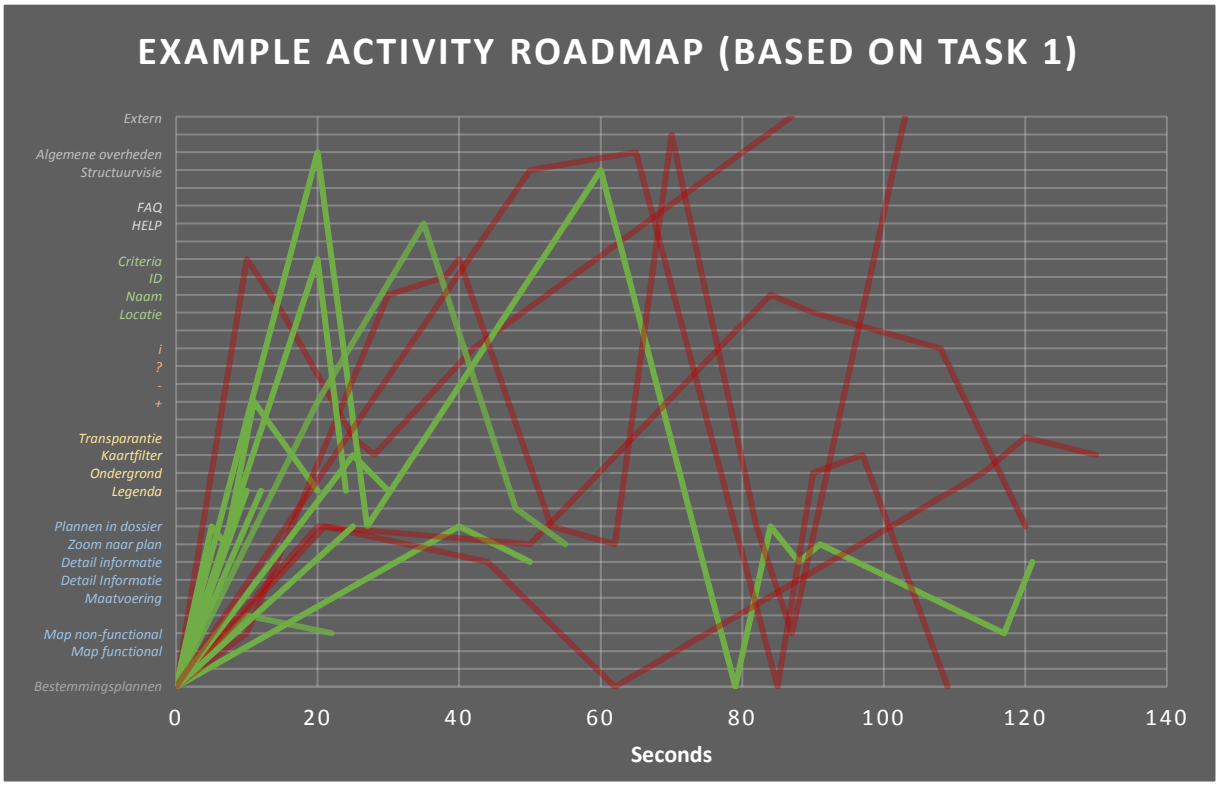


Figure 34: Example activity roadmap (based on task 1)

Since we are interested in the correlation between how people perform, their personal characteristics and their opinion, the tasks are ranked based on the needed time and quality of answer (See table 7). As an example, in case of the first question, 3 respondents were not able to find the right answer at all within the set time, and are given a shared 12th place.

Table 7: Performance of respondents

	Task 1		Task 2		Task 3			Total
Respondent	Time	Rank	Time	Rank	Time	Rank		Rank
1	20	3		11	110	9		10
2		12		11		10		13
3	12	2	70	8	50	8		6
4	22	4	43	5		10		7
5	50	8	10	1	24	4		1
6	125	11		11	20	2		11
7		12		11		10		13
8		12		11		10		13
9	30	7	25	3	40	5		4
10	121	10	15	2	10	1		1
11	24	5	57	7	20	2		3
12	10	1	90	10		10		9
13		12	75	9		10		12
14	55	9	50	6	40	5		8
15	25	6	42	4	44	7		5
Average	45		47,7		39,8			

To be able to plot the outcomes of the tasks with the opinion of respondents, the answer that give an insight into their opinion are scaled from negative (giving a score of 1) to positive (giving a score of 5) (See figure 34). This makes it able create scatterplots and perform regression analysis on multiple questions for multiple tasks (See figure 36).

Question 11: Is it easy to navigate through the geoportal?				
Totally disagree	Disagree	Neutral	Agree	Totally agree
←→	←→	←→	←→	
1	2	3	4	5

Figure 35: Quantifvying an opinion

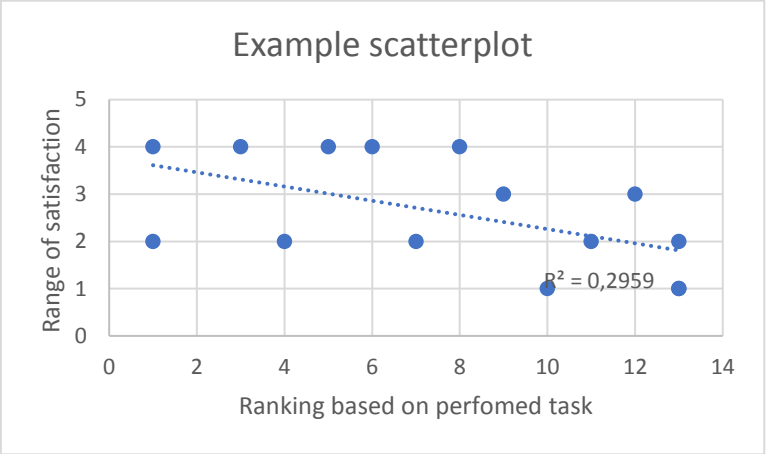


Figure 36: Example of a correlation between performance and opinion

Appendix G: Summary of research Kadaster

Resultaten

- Opvallend is de lage respons ten opzichte van de vorige metingen, 330 respondenten is 80% minder dan de 2-meting in 2014;
- Bedrijven en overheden vinden steeds beter wat ze zoeken, particulieren niet;
- Opvallend is de stijging in gebruiksfrequentie voor zowel overheden als bedrijven: 53% van de respondenten binnen de klantgroep 'overheid' raadpleegt de site dagelijks (dit was 43%), bij respondenten uit de klantgroep 'bedrijven' geldt dat voor 43% (was 34%);
- De kaartviewer wordt verreweg het meest gebruikt, op nummer 2 de pagina met Frequently Asked Questions (FAQ's);
- Bij overheden en bedrijven is sprake van een stijging van de tevredenheid ten opzichte van de vorige meting, bij de particulieren is sprake van een daling behalve wat betreft de aspecten snelheid en zoekfunctie
- De kaartviewer wordt opvallend veel beter beoordeeld door zowel overheden als bedrijven

Conclusies

- Ruimtelijkeplannen.nl is een goede site voor de professionele gebruiker in het RO-werkveld. Voor de particulier is de aard van de informatie en de wijze van ontsluiten veelal (te) ingewikkeld.
- Particulieren maken –naast de viewer- het meest gebruik van de FAQ pagina. Deze pagina wordt door de professionals veel minder geraadpleegd. Het lijkt goed naar de opzet en inhoud van de FAQ pagina te gaan kijken en deze (primair) aan te passen op de doelgroep 'particuliere gebruikers'.
- Voor de professionele gebruiker voorziet Ruimtelijkeplannen.nl duidelijk in een behoefte.
- De verschillen in 'beleving' tussen de professionele -, en de particuliere gebruikersgroepen worden bevestigd vanuit het Klant Contact Center Ruimtelijkeplannen.nl. Men ervaart daar bij de klantvragen hetzelfde beeld. De beheerorganisatie van Ruimtelijkeplannen gaat aan de slag met deze geconstateerde verschillen.
- Het aandeel 'zeer ontevreden' gebruikers loopt bij alle gebruikersgroepen en voor alle aspecten sterk terug.
- Het aandeelpercentage 'tevreden' en 'zeer tevreden' vertoont bij de professionele gebruikers een stijgende trend.
- Bij de particulieren neemt de tevredenheid af, wellicht ook als gevolg van het groeiend aantal plannen (meer informatie die moeilijk inzichtelijk is).
- 'Ongewenst uitzoomen naar het hele plan', 'het verouderde adressenbestand' en 'beperkte zoekfuncties' zijn veelgenoemde ergernissen van gebruikers. Al deze ergernissen zijn met de implementatie van release 2.2.10 (op 9 juli 2015) opgelost. De naar verwachting positieve effecten op de gebruikerstevredenheid zijn –gezien het moment van de release- nog niet in dit onderzoek meegenomen.

Aanbevelingen

Veel van de opmerkingen die particulieren maken hebben betrekking op onduidelijkheid van de manier waarop ze kunnen vinden wat ze zoeken. Het werken met / vanuit de kaart wordt vaak als onduidelijk benoemd. Daarnaast komen de ontbrekende adressen of postcodes (vanwege het verouderde adressenbestand) vaak voorbij. Meerdere particulieren doen de suggestie de legenda duidelijker te maken.
Ook wordt gesuggereerd het 'type gebruiker' als ingang voor de userinterface te gebruiken. (particulieren dan niet via de kaart, maar een andere interface?)