Usability and Accessibility of Web Maps: Considering New User Groups and their Requirements

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Abstract
Today, web maps and web map applications are omnipresent in our everyday life. They are not used any longer only by GI-experts in support of e.g. spatial planning, administrative tasks, and research, but they are also increasingly used for many different purposes by the general public who also includes special needs user groups such as older people, disabled people, children and the youth. For these lay users, application usability and accessibility are important criteria. Applications developed in line with the according principles generally pay attention to user requirements, preferences, skills, and capabilities, and, thus, they are easier to use by lay users and provide better user experience. But, what problems do lay users typically face when using web maps and web map applications? What are general requirements of lay users regarding web maps and web map applications? Which recommendations can be made to support the creation web maps and web map applications usable for and accessible to the general public? These questions are treated in this paper based on results gained by different projects which aimed at building web maps and web map applications for the general public, i.e. lay users.

1. Introduction and Research Question

Today, information and communication technology (ICT) has an effect on almost every aspect of our working and private life. Desktop devices and applications, the Internet, but also mobile devices and apps are used by almost everyone in society - including special needs user groups such as children and the youth, older people, and disabled people. ICT is a central element in order to take part in many daily life activities related to education, transportation, banking, shopping, and leisure etc. However, the increasing importance of ICT strengthens the call for good usability and accessibility of applications (Dapp, 2011 and Primo, 2003).

This is as true for web maps and web map applications[1]. Today, web maps – being great information and communication tools whenever spatial information is available – are omnipresent on the Internet (Thielmann et al., 2012 and Tsou, 2003). They are not used any longer only by GI-experts (GI: geoinformation) in support of e.g. spatial planning, administrative tasks, and research. But, they are also increasingly used by general public users who must be considered GI-laymen.

Purposes and examples where web maps are used by lay users are numerous. Some are listed in the following:

- to orientate ourselves in physical space and plan a route (e.g. Google Maps),
- to navigate from place to place (e.g. Waze),
- to find addresses and particular sites (e.g. Wheelmap),
- in games (e.g. Geoguessr, Geocaching)
- to get to know geographic locations and to become spatially informed (e.g. NatureSoundMap, WebGIS Hohe Tauern National Park/ Austria, city web maps),
- to contribute, to share, or to assess spatial information (e.g. OpenStreetMap, wikiloc, FixMyStreet, EyeOnEarth, sharing economy tools such as Airbnb).

Designing and implementing web maps – that today more than ever should be line with the concepts of usability and accessibility (Atzl, 2015 and Hennig et al., 2015) – asks for paying special attention to users and their requirements.

[1]In this paper, we use the term web maps to cover both, web maps and web map applications. Web maps refer to map components embedded in GUIs which provide no further functionalities related to the map (apart from the basic ones such as zooming and panning, switching between base maps). Regarding web map applications, the map is the central element which not only is embedded in the GUI, but the GUI also provides additional functionalities related to the map (e.g. search of addresses, locations, and POIs, turn layers on/off, plan routes, add your own spatial data).

This refers to aspects such as devices to be supported, the design of the graphical user interface (GUI) and the map, as well as the range and properties of functionalities to be implemented (Freckmann and Huckriede, 2004, Kramers, 2008, Neuschmid et al., 2012 and Tsou and Curran, 2010). Here, Tsou (2003) outlines that web map developers are much challenged by addressing the needs of lay users who are a lot more diverse and unfamiliar to them compared to traditional GI users. As stressed by Tsou (2003: 231), these "… users may lack sufficient cartographic training to manage or interpret the dynamic representation of geospatial information." Further, addressing general public users, it must be taken into account that over a billion people, about 15% of the world's population, suffer from a form of disability. This number is steadily growing due to two reasons: first, since in many countries populations are ageing and older people have a higher risk of disability; second, because of the global increase in chronic health problems associated with disability, such as diabetes, cardiovascular diseases and mental illness (WHO, 2015). The number of disabled people is even higher if people with "temporary disabilities" such as a broken arm or with slight impairments such as color blindness are considered as well. Thus, for instance, 10% of men suffer from color blindness. They have problems distinguishing e.g. between red and green colored features and, thus, face difficulties in reading a map if features are colored this way (Neuschmid et al., 2012 and W3C, 2005). In consequence, concerning usability and accessibility, general public users require solutions and support the web map developers might not be aware of.

Even though general guidelines and recommendations on usability and accessibility exist, there is a lack of such information regarding the development of web maps. Despite the increasing efforts made to provide applications being usable for and accessible to laymen, these users still often face problems when dealing with web maps. In order to provide usable and accessible applications, it is important to have a solid understanding of future users as well as their requirements and preferences. But, what are common problems that lay users face when using web maps? What are lay user requirements regarding web maps? Which recommendations can be made to deliver usable and accessible web maps to the general public? These questions are investigated within this paper based on results gained from different projects that aimed at generating web maps for lay users and in particular special needs user groups.

2. Background on Usability and Accessibility

Even though the concepts of usability and accessibility focus on different aspects, they are closely related. Objectives, approaches, and guidelines overlap significantly. This is the reason why both should be considered together when creating applications for lay users (W3C, 2010). Both concepts are presented below, and their relationship is briefly outlined.

2.1 Usability and Web Usability

Usability is a software quality factor. Other quality factors refer e.g. to software reliability, maintainability, and functionality (e.g. ISO 9126). There are various definitions of usability. In simple terms, usability assesses whether a system is easy to use or not (Borsci et al., 2012). A more comprehensive definition, provided by ISO 9241-11, defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." To measure usability, it is decomposed in five quality components as listed in Table 1. However, while usability focuses on software in general, web usability refers to the ease of use of websites and web applications.

Apart from being a quality factor, the concept of usability also refers to methods for making products and systems easier to use and matching them more closely to user needs and requirements (Nielson, 2012). To do so, a wide range of standards and methods exists. A selection can be found at New Zealand Web Usability Standard (2010), Usability Net (2010:1) and Usability Net (2010:2).

Table 1: Quality components of usability (based on Nielson, 2012)

Quality Components	Description
Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?
Efficiency	Once users have learned the design, how quickly can they perform tasks?
Memorability	When users return to the design after a period of not using it, how easily can they reestablish proficiency?
Errors	How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
Satisfaction	How pleasant is it to use the design?

2.2 Accessibility and Web Accessibility

On the concept of accessibility, there is no unique and complete definition. Generally, accessibility is about ensuring an equivalent user experience for people with disabilities. This means that all people, including also disabled people, can use a product – being a software application or e.g. a transportation mean, or a ticket vending machine – equally without barriers. Accessibility addresses all types of disabilities that affect access to a product: visual, auditory, physical, speech, cognitive and neurological disabilities. Since older people often suffer from changing abilities due to aging they also benefit from accessibility.

According to this, web accessibility means that people with disabilities can use the Web without facing any problems, i.e. that they can perceive, understand, navigate, and interact with the Web. Therefore, web accessibility focuses on the removal of technical barriers that hamper disabled people from accessing information provided on websites (W3C, 2005 and ITU/G3ict, 2014). To improve web accessibility the World Wide Web Consortium (W3C) has set up the Web Accessibility Initiative (WAI) which published the Web Content Accessibility Guidelines (WCAG; W3C, 2008). This set of guidelines aims at making web content more accessible to people with disabilities and indirectly to users in general. Its four principles with twelve guidelines (and further with 63 recommendations) are presented in Figure 1.

2.3 The Relationship between Usability and Accessibility

The relationship between usability and accessibility is widely discussed in the literature (Borsci et al., 2012, Mifsud, 2011 and W3C, 2010). Based on this and the above definitions the following can be concluded:

- A web site (or any product) is not usable unless it is accessible (Krug, 2006). Thus, accessibility is a subset of usability (Brajnik, 2000).
- Involving users with disabilities in product development processes allows identifying usability issues more easily since people with disabilities are often more sensitive to usability problems (W3C, 2010).
- An accessible website (or product) benefits all users, not just those who are disabled (Matera et al., 2006). Focusing on accessibility issues can lead to making products work better and being more usable for more people in more situations (W3C, 2010).

3. Projects and Methods Applied

In the last years, we were involved in several projects which aimed at developing and implementing web maps for lay users and in particular for special needs user groups (Table 2). In all of these projects important tasks were, on the one hand, the identification of problems the intended user group faces when using web maps and, on the other hand, the collection of requirements of these users. Based on this, recommendations that in principle are useful when creating web maps for the general public were elaborated.

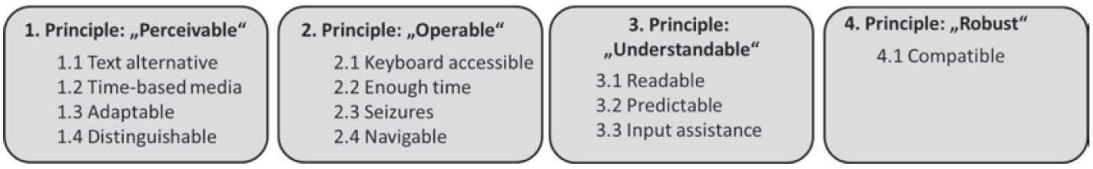

Figure 1: WCAG 2.0 with its four principles and twelve guidelines (based on W3C, 2008)

Table 2: List of referred projects aimed at developing web maps for lay users and in particular for special needs users

Project	Funding	Intended user group	Methods applied
YouthMap 5020 (2013-2014)	funded by the Austrian BMVIT in the FFG program Talente Region	children and the youth	survey methods, observation methods, document-centric methods, AoSS, participatory design
NatureSDIplus (2009-2012)	funded by EU eContentplus program	the general public, non-GI experts	survey methods
geomedia 55+ (2013)	self-funded by Austrian University of Salzburg, Z_GIS	older people, i.e. older than 55 years	observation methods, document-centric methods, AoSS, participatory design
senTOUR (2014-2016)	funded by the Austrian BMVIT in the FFG program Benefit	disabled people and older people	survey methods, document-centric methods, AoSS
AccessibleMap (2011-2013)	funded by the Austrian BMVIT in the FFG program Benefit	visually disabled people	survey methods, document-centric methods, AoSS

A wide range of methods exists to gain understanding of users, their problems and preferences, and to gather user requirements (Pohl and Rupp, 2011, Richter and Flückiger, 2013 and Usability Net, 2010: 2). Out of these methods – widely used in requirements engineering and usability engineering – the following were applied in the projects listed in Table 2:

- survey methods: interviews and questionnaires
- observation methods: direct observation of users
- document-centric methods: research of literature, standards and guidelines etc.
- analysis of similar systems (AoSS): identification and analysis of similar systems to draw awareness to best practice solutions

Further, the approach of participatory design played a pivotal role in two of the projects: YouthMap 5020 and geomedia 55+. Participatory design is a process that aims at directly and actively involving representatives of the intended user group in the application design and development process (Baek et al., 2007). The intention is to bring user knowledge (tacit knowledge; aspects usually not known to developers) into the development process. By incorporating the future users, who are experts on their own requirements and needs, it is possible to create applications which let users do whatever they aim to do in a better way (Muller and Druin, 2012 and Steen et al., 2007).

4. Recommendations

Related to the user problems identified and the requirements gathered in the projects listed in Table 2 recommendations generally valid for developing web maps for lay users were elaborated. They are in line with standards, guidelines and heuristics on usability and accessibility. Selected problems, requirements, and recommendations are outlined below.

4.1 Devices and Additional Tools

Today, different digital devices such as smartphones, tablets, or desktop computers are preferred to be used by different user groups. Thus, for instance, children and the youth highly prefer to use smartphones (YouthMap 5020 project). If developing web maps for young people (e.g. educational purpose) one should be aware of this. Enabling users to use applications on devices preferred by them is an important point in order to obtain user satisfaction.

Supporting devices as required by the users also refers to the possibility to allow users to choose between different input devices such as the mouse, keyboard, or even touch screen. This aspect is also stressed by WCAG 2.0 (principle: operable, guideline: keyboard accessible) and was considered important by users involved in the senTOUR and AcessibleMap project.

Particularly for older persons and persons with disabilities, the use of assistive technology (AT) is a relevant aspect (WCAG 2.0 principle: robust; projects: senTOUR, AccessibleMap). Assistive technology refers to any product, device, or equipment that is used to maintain, increase, or improve the functional capabilities of individuals with disabilities. Common computer-related assistive technology products are screen magnifiers, large-key keyboards, alternative input devices such as touch screen displays, over-sized trackballs, speech recognition programs, and text readers etc. (TechTarget, 2011).

4.2 GUI Design

Both, usability and accessibility guidelines, outline the relevance of a design that should be kept simple and consistent, clearly laid out, and predictable (e.g. WCAG 2.0 principle: understandable, guideline: predictable; Nielson, 1995). The relevance of a well-designed GUI was outlined by users involved in all five projects. Thus, for instance, in the YouthMap 5020 project young users were not using any functionality which was not found at first glance, starting an application. They underlined the demand for a GUI structure with no nested control elements and without the need for scrolling. In addition, older users (projects: senTour, AccessibleMap) found that positioning elements such as map navigation tools or base map switchers within the map component reduces map readability and is confusing to them. They demanded these elements to be placed outside the map component.

For all users a predictable GUI is important. Thus, control elements (e. g. map navigation tool) should always be placed at the same position in GUIs (e.g. upper left part of the GUI or the map). Predictability is a principle applied in many other types of applications (e.g. office software packages). It allows users to easily use applications even if they had never before used them.

Regarding the layout, especially for older persons and persons with visual impairments, it is important that textual information is easy to read, and that symbols and images can be recognized without problems. Suitable font size, high contrast between text and background as well as symbol

size, choice of color, the contrast between symbol and background etc. play an important role.

4.3 Map Component Design

Base maps and overlays generally make up the content of web maps. The design of both should be in line with user needs. This is also underlined by usability principles (Nielson, 1995) and accessibility guidelines (WCAG 2.0 principle: perceivable; guideline: distinguishable). Particularly, visual variables (position, size, shape, color, orientation, and texture) should be leveraged to present an easy-to-read map picture. Important, therefore, are font size, color choice, and contrast between different elements. Icons well-known to users facilitate map reading.

Regarding the provision of base maps, in the different projects, it became obvious, that not only young but also older users are indeed excited about satellite images. However, in terms of orienting themselves on satellite images they often face problems. Hence, the provision of satellite images asks for providing some means in support of orientation such as labels.

4.4 Design and Range of Functionalities

Functionalities typically implemented in web maps refer to map navigation (zoom, pan), switching between different base maps, turning layer visibility on and off, search for addresses/ locations, and providing (multimedia) context information (due to e.g. feature pop-ups). Moreover, while the youth is very interested in social media services (to network, to share content, to build groups etc.), older people and people with disabilities ask for functionalities that allow for accessing assistive technology, switching between input devices, customizing GUI design and map picture etc. Regardless the types of functionalities addressing the particular application purposes and/or user needs, the following recommendations should be considered when implementing functions:

- The number of functions should be reduced in order to not overwhelm the users and to keep the GUI simple and clear as well as easy to use and to understand. Thus, function overload should be avoided by providing only functions that are really relevant to the users.
- The GUI should be kept clearly arranged and complexity should be decreased by prioritizing functions, and implement functions properly. Important things should always be directly accessible without first clicking a button or scrolling.
- Functionalities must be intuitive, explanatory and understandable at first sight - without the need for any additional support. Thus, for instance, lay users are not necessarily aware that sometimes map features have pop-ups. This must be communicated, explained, or shown to them.

4.5 Use of Language

The use of language, i.e. terms familiar to the audience, plays an important role. This is outlined by usability as well as accessibility guidelines (e.g. WCAG principle: understandable, guideline: readable). It was also approved in our projects (e.g. YouthMap 5020, NatureSDI plus, geomedia 55+): technical terms unknown to the users scared them away from using applications. Users refused to click buttons labelled with terms unfamiliar to them, and instead they closed the application. In consequence, we learned to not use terms like base map, layer, or POI.

4.6 User Support

Even though usability recommendations outline the provision of help and user support (Nielson, 1995), it is difficult to provide user support in a way that it will really be used by the users. In our research (e.g. Youthmap 5020; geomedia 55+) we found that users refuse to use tutorials or any kind of information that needs to be read. The provision of videos or animations might provide user support being more likely to be used.

5. Conclusion and Outlook

For lay users, application usability and accessibility are important criteria, in which usability or accessibility must be considered as related concepts. While usability in general, refers to the ease of use, accessibility addresses the fact that everyone (i.e. also disabled people) can perceive, understand, and interact with a product equally without barriers. Existing standards and guidelines are important means in order to develop usable and accessible applications. But, regarding the generation of web maps and web map applications usability and accessibility standards and guidelines are still missing. Based on the work done in several projects that aimed at creating web maps, or web map applications, for lay users, a list of generally relevant recommendations was elaborated. The recommendations focus on aspects such as the use of devices and additional software (e.g. assistive technology) being relevant for users, GUI and map design, range and design of functionalities, use of language, and user support. Here, it has to be outlined, that the recommendations presented in this paper are just a starting point for becoming more specific on usability and accessibility guidelines for

web maps and web map applications. However, additionally, there is the urgent need for building up spatial literacy on the part of the general public, since the provision of suitable web maps and web map applications is only one step towards a spatially-enabled society.

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