

## A META-EVALUATION OF USER STUDIES ON WEB-DELIVERED CARTOGRAPHIES

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### ABSTRACT

This paper outlines the current state of user and usability research in diverse fields of the geo-domain. It delineates basic requirements and the exemplary application of different methods and techniques of user research in the fields of geographic information systems, geovisualization and multimedia cartography, web-mapping and geo-mobile devices.

### INTRODUCTION

The technological advances of the last decades, first and foremost the global permeation of the World Wide Web and the ever increasing popularity of mobile consumer electronics, brought with them a fundamental shift of communication paradigms and methods of information provision. Maps and mapping tools are omni-present in the Web and are not only viewed on desktop computers, but more and more on mobile devices such as PDAs, smart phones, or tablet computers. These new omnipresent devices facilitate fast and inexpensive access to web maps. Built-in GPS receivers enable ‘at location mapping’ and a constant Internet connection allows instantaneous data transfer with the Web.

The roles of map makers and map users are suddenly not clear-cut any more: User-generated maps, respectively map mash-ups with user provided content are rapidly advancing. The way we deal with spatial information has changed considerably. Different user expectations have led to new genres of maps, in diverse use contexts and with varying device requirements, making the need to conduct thorough use and user research in this discipline paramount.

### CARTOGRAPHY AND USER RESEARCH

Van Elzakker (2005) identified two broad categories of research involving map users: functional map use research with more holistic approaches, and perceptual and cognitive research. Cartography has a tradition of researching the cognitive and perceptual aspects of map use and communication processes. The user was first considered in cartographic science by Robinson (1952). User studies about the perception of map symbology and colors have been carried out for instance by Dobson (1975) and Brewer et al. (1997). In his book “How maps work” MacEachren (1995) investigated the perceptive and cognitive processes relevant for map usage.

With the upcoming computerization the interest in cognitive and perceptual user studies decreased in favor of research focusing on the evolving and advancing technologies. “The design of digital cartographic representations has been dominated by a motivation to improve computational speed and flexibility, solve technical issues in applying new technology and capitalize on the possibilities for geospatial data interaction” (Van Elzakker and Wealands 2007, p. 490).

Most cartographers have readily embraced new technological and social developments such as Web-maps, multimedia mapping, virtual reality, augmented reality, maps on mobile devices, location-based services, ‘at-location mapping’ and collaborative mapping utilizing “Social Media” (Kaplan and Haenlein 2010, p.61). The design of digital cartographic representations was mostly technology-centred – referred to as “Ghee-Whiz attitude” by Cartwright and Hunter (2001, p.292). In many cases it disregarded the map users, their goals, requirements, and expectations (Van Elzakker and Wealands 2005).

Although several user studies have been carried out on newly developed systems, Meng (2004, p.7) points out that “[map] usability tests hitherto mainly concern the effectiveness and efficiency of map use. [... while the map] does not necessarily satisfy all the user requirements”. Koua and Kraak (2004) state that “the map use studies usually conducted in the field of cartography are not necessary(!) fully applicable in new interactive visualizations”. In their research agenda for geovisualization, MacEachren and Kraak (2001, p.7) identified a “lack of established paradigms for conducting cognitive or usability research applied to highly interactive visual environments”.

Recent years have shown that the philosophy of User Centred Design (Nielsen 1993) increasingly found its way into cartographic application design (cp. Bhowmick et al. 2008, Kramers 2008, Van Elzakker et al. 2008). However, the field of user research and usability testing is a highly complex one and “there are not yet many textbooks in the cartographic discipline with chapters specifically devoted to use and user research” (Van Elzakker and Wealands 2007, p. 501). Design criteria and complementary evaluation

methods have had to be adapted or developed, to be applied to the new types of distributed or omni-present mapping products. Still, subject-specific guidelines and principles for testing and improving the usability of Web-based mapping products for desktop environments and mobile devices are not well established.

A handbook on user and usability research is currently drafted by the Commission on Use and User Issues of the International Cartographic Association – the author is actively participating in this endeavor. Still, yet there exists no general textbook on user and usability research specifically addressing the geo-domain. Although individual studies convey findings about usability problems of web mapping applications and strategies for overcoming them, only few publications try to collate these findings and introduce general principles that are specific to Web-delivered mapping applications.

#### USER CENTERED DESIGN

The philosophy of user centered design (UCD) originates from the research area of Human-Computer Interaction (HCI). It provides instructions on how to meet user requirements and reach high quality product levels by incorporating the needs, wants and limitations of the end-users in various iterative design stages throughout the whole life cycle of interactive computer systems. The ISO 13407 standard (Human centered design processes for interactive systems) describes UCD “as a multi-disciplinary activity, which incorporates human factors and ergonomics knowledge and techniques with the objective of enhancing effectiveness and productivity, improving human working conditions, and counteracting the possible adverse effects of use on human health, safety and performance” (URL: UsabilityNet, 2006, tools and methods – reference material).

The purpose of UCD approaches is to identify user groups, their requirements and to improve the overall application usability in regard to interfaces, user interaction and user specific visualization methods. Applications are optimized around how people work, so that they do not have to change their habits to accommodate to functionalities that are incorporated into an application. By following a user centered design approach, application developers should be able to almost guarantee an effective and efficient end-product with a high degree of user satisfaction. (Schobesberger, 2009)

#### USABILITY

The International Organization for Standardization (ISO) 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” (URL: UsabilityNet, 2006, tools and methods – reference material). In his book on Usability Engineering Nielsen (1993) provides a list of 5 elements through which the usability of a product can be defined. These are learnability, efficiency, memorability, errors (low error rate, easy error recovery) and user satisfaction.

By balancing these components of usability it can be generally assured that the system is usable for a predefined set of users with predefined use needs. Balancing these elements of usability is a main task for application developers and is determined by user groups, their requirements and actual usage. Quesenbery (2004) argues that while a specialist might primarily need an application to be efficient for daily activities, a non-expert who seldom uses the application might need elements that focus on items like ease of learning, error tolerance and user acceptance.

#### USER RESEARCH IN GIS

The discipline of cartography has changed in its foundation since the move from paper to digital and especially through the advances of geographic information systems. A renaissance in user research was perceptible: Map users, their background, requirements, abilities, limitations, and expectations became important considerations for the design of geographic information systems. Due to a vast array of functionalities and the generic construction of precomposed (non-purpose-built) GIS they usually require a large amount of user training and support. Usability studies gave the big developers rather poor reviews (e.g. Zafiri 2006) which indicate that there is a lot of catching up to do. Nowadays companies like ESRI put strong effort in designing GIS interfaces according to user requirements. The overarching goal is to improve the usability of these fairly complex systems, with their thousands of functionalities. A considerable amount of literature exists on the usability of geographic information systems (Gould 1993, Davies and Medyckyj-Scott 1996, Haklay and Tobon 2003) with a special emphasis on the graphical user interfaces (Kuhn and Frank 1991, Cartwright et. al. 2001).

Most user studies in this area include focus groups or representative users for setting up the requirements and use contexts for a GIS in everyday use. Participatory or non-participatory observations of users respectively diary-keeping and talking-aloud are established methods to discover GIS usability problems. Screenshot studies (cp. Zafiri 2006) and log files can help to learn about common configurations of toolbars and work environments within generic GIS packages. Additionally feedback questionnaires are a

prevalent method to reach out to a large community of specialists that is not seldom discontent by the way GIS products impede efficiency and effectiveness during their everyday work and are willing to help improve the products and thus their means of working.

#### USER RESEARCH FOR GEOVISUALIZATION/ MULTIMEDIA CARTOGRAPHY

Other streams of functional research examined the usability of various geo-visualization applications such as virtual reality (MacEachren et al. 1999), augmented reality, multimedia products (Cartwright and Hunter, 2001) and animated maps. This area and the resulting products are very heterogeneous. It is often argued that the users are not aware of the possibilities of modern geovisualization and multimedia packages and thus product designers should not rely too strongly on user expectations. But in order to create purposeful means of communicating spatial information it is necessary to at least incorporate the requirements of specified target users. Task analysis can be an appropriate method for deriving the requirements of geovisualization users (cp. Knapp 1993). Subsequently it is important to design applications iteratively and to evaluate them with prospective real world users to ensure understanding and usability of the final products. Cartwright and Hunter (2001) delineated evaluation strategies for geomultimedia products based on the GeoExploratorium project. They state that different approaches might be needed to elicit responses especially in an early stage of multimedia product design.

#### USER RESEARCH FOR CARTOGRAPHIC ONLINE APPLICATIONS

In the area of web-based cartographic information systems a shift towards placing the user in the center of design considerations can also be observed. Pucher (2008) constitutes that “the most significant advances in software during the last few years are actually advances in user experience, not in technology.” Alongside publications concentrating on the evolving technology, an increasing number of publications on user and usability studies have been disseminated (Nivala et al. 2008, Kramers 2008). The notion of User Centered Design has advanced strongly in this area and the above mentioned publications are proof that UCD can help enhancing the overall system design, both in terms of usability and user satisfaction. The methods that are mainly used for gaining insight on the requirements of web mapping applications are basically the same as utilized with GIS products. The main difference is that whilst GIS are specialist systems, most web mapping applications serve more generic communication purposes and cater for wider audiences. The focus of ensuring usability for such web maps is on keeping the interfaces simple, easily learnable and providing the user with a positive user experience.

In this field general design principles and impulses on how to increase usability can partially be gained from web design. The iterative design of prototypes for the web can be assisted by regular online surveys that come along with the prototypes that are to be evaluated. The web also facilitates the procedure of constantly tracking the users. Pucher and Schobesberger (elsewhere in these proceedings) describe a methodology for evaluating the usability of such systems by perpetually logging all user-system interactions and finding ways to interpret these log files. Heil (2009) showcases the application of eye-tracking – a technique widely applied in the area of website design – for the evaluation of a natural hazard information system.

#### USER RESEARCH FOR CARTOGRAPHY ON MOBILE DEVICES

Another field of cartography where user/usability research and user centred design have been applied rigorously in the past few years are map applications for mobile devices (cp. Goodman et al. 2004, Kjeldskov et al. 2005, Nivala 2007, Van Elzakker et al. 2008). This is a fact that is not surprising at all, since there is much commercial interest in such applications. These systems have to be designed to work properly in regard to user requirements and usability, especially in the use context of small displays and dynamic/mobile use, as bad user reviews would result in badly effecting device profile, and thus sales.

Van Elzakker et al. (2008) propose a combination of methods for testing the usability of geomobile applications stating that a combination of laboratory and field-based testing should be applied. It is important to test the application not only in laboratory conditions because the outdoor use context and real users might stumble upon usability problems that one might not discover indoors (e.g. environmental influences). They used a combination of observation/recording, think aloud method and semi-structured interviews to evaluate the usability of different geomobile applications.

#### CONCLUSION

User and usability testing play an important role in all parts of application design within the geo-domain. Use context and user groups strongly influence the methods that should be selected for evaluating the usability of such devices. Numerous methods of user and usability testing exist that hold their advantages and disadvantages. There is a need for establishing guidelines on which methods to use with which kinds of products and in which stages of application development.

This paper delineated the current state of user research in the geo-domain with regard to specific product types. It exemplified the utilization of methods and techniques of user and usability research in regard to these products without the pretence of completeness. In his doctoral thesis the author tries to compile holistic frameworks for ensuring/testing the usability of different categories of applications in the geo-domain.

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