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## **Disciplines**

Computer and Systems Architecture | Human Geography | Remote Sensing | Urban, Community and Regional Planning

## **Comments**

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# Web-based PPGIS for Wilhelmsburg, Germany: An Integration of Interactive GIS-based Maps with an Online Questionnaire

*Alenka Poplin*

**Abstract:** *The aim of this paper is to study the implementation of a Web-based public participation geographic information system (PPGIS) with open-source technology and its integration with an online questionnaire. Its theoretical foundations are based on previous work in PPGISs, online surveys, field research, and map-based surveys. The concept of a PPGIS that interlinks interactive GIS maps with an online questionnaire was developed. The concept was implemented with open-source technology and tested in a public participation process designed with the European project SWITCH. The study case was taken from a city district, Wilhelmsburg, in Hamburg, Germany. The combination of the GIS maps combined with the online questionnaire enabled the inhabitants of Wilhelmsburg to draw their answers directly into the online maps. The results of the participation processes were saved directly into the central database. The paper concludes with a critical discussion and directions for further research.*

## INTRODUCTION

The concept of a public participation geographic information system (PPGIS) has been extensively discussed since the middle of the 1990s (Pickles 1995; Rinner 1999; Kingston, Carver et al. 2000; Carver 2001; Al-Kodmany 2001). The main idea at that time was to enable and enhance communication between citizens and decision makers with the help of a geographical information system (GIS). Rinner (1999, 2005, 2006) contributed a model known as argumentation maps that modeled relations of geographically referenced objects with the opinions of citizens. One of the first implemented PPGIS applications was titled Virtual Slaitwaite and developed in 1998. It was “arguably among the first such systems available to the public which allowed a two-way flow of information” (Carver, Evans et al. 2012). Research at that time mostly focused on discussions about a variety of participatory functionalities that could possibly be integrated into a GIS (Steinmann, Krek et al. 2004).

Around 2005, the enthusiasm about PPGIS began to fade, but the research community still had several very interesting study cases and applications implemented mostly by universities. The conceptual ideas were inspiring but did not lead to user-friendly implementations in practice. Several possible issues led to such a development: (1) The complexity of the applications was criticized by several researchers (Basedow and Pundt 2001; Craig, Harris et al. 2002; Haklay and Tobón 2003; Steinmann, Krek et al. 2004); (2) the computer skills of the participants in public participation processes were not taken into consideration; and (3) the interaction with online interactive maps was rather complex and in many cases too difficult for non-GIS experts. Carver (2001: 64) pointed to the problem in the following way: “Access to GIS alone does not, however, provide the public user with a satisfactory means of active participation in the decision process. GIS is far too complex

a technology to allow effective use by the nonspecialist with little or no previous training or experience in this field.”

More than a decade later, we experience emerging collaborative mapping processes in which citizens contribute their knowledge via open-source platforms such as OpenStreet Map. The researchers refer to these processes as “volunteered geographical information” (Goodchild 2007), “neogeography” (Turner 2006, Goodchild 2009), or “geography without geographers” (Sui 2008). This new development demonstrates the interest of the citizens to participate and use map-based participation tools. Perhaps now is the appropriate time for further developments of the PPGIS concept and its implementations.

The aim of this paper is to study the implementation of a PPGIS with open-source technology and its integration with an online questionnaire. This research builds on the previous work in PPGIS and research conducted by Sidman, Swett et al. (2005) and Al-Kodmany (2001). Sidman, Swett et al. (2005) focused on the development of a paper, nondigital questionnaire that was sent to the participants of the survey in the mail. Their responses were manually inserted into a GIS and later communicated to the focus group. Al-Kodmany (2001) and his research colleagues at the University of Illinois at Chicago (UIC) developed an online survey tool, but a GIS program was used “only at a later stage for analyzing the composite participants’ data and integrating it with other GIS layers” (Al-Kodmany 2001).

This novel contribution is in the integration of an online questionnaire with interactive GIS-based maps. Specifically, it is in the technical implementation that enables the users to interact with a GIS-based map. The online questionnaire is directly linked to the interactive online map and the answers to the questionnaire and those answers entered on the map are stored in a GIS database on the server. No comparable implementation that presents a

similar innovation of PPGIS has been found. The main research questions were: How can an online questionnaire be integrated with interactive GIS-based maps? How can the citizens' responses be gathered and stored in a common database? How should the online map be designed to enable a pleasant interaction by the user with the content of the map as well as to encourage citizens to contribute their opinions? To investigate these research questions, a concept that directly links an online questionnaire with online interactive GIS maps was designed. The concept was implemented in the study case of the city district of Wilhelmsburg in Hamburg, Germany. Wilhelmsburg is the largest inhabited river island in Europe and is characterized by a number of canals. The PPGIS for Wilhelmsburg aimed to stimulate the discussion about the current use of the canals by the inhabitants and their wishes for their use in the future. The results of the participation process were used for the development of the Water Sensitive Urban Design concept within the European research project SWITCH.

This paper is structured as follows: The next section provides an overview of the previous work related to online survey research, PPGIS, and map-based surveys. Then the study case in Wilhelmsburg is introduced. In the following section, the research questions and goals are highlighted. Next the technical implementation of the PPGIS for Wilhelmsburg is described. The focus is on the design of the online questionnaire, interactive GIS maps, and the user interface. The next section describes the executed public participation process and the results of the public participation process executed with the help of PPGIS for Wilhelmsburg. Finally, the developed application and its usability are critically assessed and research perspectives are discussed. The paper concludes with further research directions.

## PREVIOUS WORK

### Online Survey Research

The past decade has seen a tremendous increase in Internet use and computer-mediated communication (Nie and Erbring 2000; Fox, Rainie et al. 2001; Horrigan 2001; Nie, Hillygus et al. 2002). As an increasing amount of communicative activity takes place through this relatively new medium, there also has been a significant increase in research on virtual communities, online relationships, and a variety of other aspects of computer-mediated communication (Matheson 1991; Walther 1996; Flaherty, Pearce et al. 1998; Preece 1999; Wright 1999; Wright 2000a, 2000b; Preece and Ghazati 2001; Walther 2002; Nonnecke, Preece et al. 2004). Studies of online communities have led to an increase in the use of online surveys, presenting scholars with new challenges in terms of applying traditional survey research methods to the study of online behavior and Internet use (Bachmann and Elfrink 1996; Stanton 1998; Yun and Trumbo 2000; Andrews, Nonnecke et al. 2003). Two forms of electronic surveys have emerged in the past 15 years (Andrews, Nonnecke et al. 2003): asynchronous e-mail surveys and synchronous Web-based surveys. The first asynchronous e-mail surveys date back to 1986 (Kiesler and Sproull 1986) and indicate that sending the survey to the

participants and their responses to the survey occur at different times. They include responses either embedded directly within e-mail messages or attached as word documents. They must be manually transferred and entered into a digital storage. E-mail is a "push" technology that allows researchers to directly communicate with prospective respondents. The second synchronous Web-based survey, started around 1994 (Kehoe, Pitkow et al. 1997), signifies the survey available online enables the participants to respond immediately. This provides the ability to automatically verify and store survey responses using database technology and an HTML (hypertext markup language) user interface.

More than ten years of research resulted in suggestions and criteria for designing online questionnaires that collect reliable and valid data. "An accurate survey is one where the questions collect the data in a reliable and valid way. If the questions ask respondents things they do not know, then it can result in inaccurate data. Some additional things to consider about the relevancy and accuracy of survey questions are the ways in which the questions are written and their overall length" (SurveyMonkey 1999–2011). Iarossi (2006) suggests considering the following criteria:

- Address the wording style, type, and question sequence.
- Make the survey interesting and notice the survey length or how long it takes to answer the entire survey.
- When designing a survey, the author should try to put himself or herself "in the position of the typical, or rather the least educated, respondent" (Moser and Kalton 1971).

None of these efforts include maps; they are based on online questionnaires designed for the purpose of a survey. Until recently, creating and conducting online surveys was a time-consuming task requiring familiarity with Web-authoring programs, HTML code, and scripting programs. Today, survey-authoring software packages and online survey services make online survey research much easier and faster. One such example is Survey Gizmo (Survey Gizmo 2011) that offers easy and quick possibilities for designing online questionnaires. A simple version that can be used for research purposes is available online, free of charge. The advantages associated with conducting survey research online include access to individuals in distant locations, the ability to reach difficult-to-contact participants, and the convenience of having automated data collection, which reduces researcher time and effort. "Disadvantages of online survey research include uncertainty over the validity of the data and sampling issues, and concerns surrounding the design, implementation, and evaluation of an online survey" (Wright 2005).

### Public Participation GIS

Public participation GIS has been extensively discussed since the mid-1990s by many pioneering researchers (Pickles 1995; Schroeder 1996; Rinner 1999; Talen 1999; Kingston, Carver et al. 2000; Al-Kodmany 2001; Basedow and Pundt 2001; Carver 2001; Jankowski and Nyerges 2001; Craig, Harris et al. 2002; Schlossberg and Shuford 2005; and Georgiadou and Stoter 2010).

It represented a novel idea in which a geographical information system (GIS) has been used as the main technology, extended by some public participatory functions. PPGIS aimed at advancing the level of citizens' involvement into decision making in urban planning by using online, GIS-based, and interactive maps. One of the main ideas was to enhance the decision-making process and enable novel digital visualization possibilities. Craig and his coeditors (Craig, Harris et al. 2002) collected different methodologies and study cases in their book. Sieber (2006) provides a thorough overview of the contributions of a variety of researchers in this subject area, looking back at more than 15 years of research.

In PPGIS and other applications that facilitate map-based discussions, the communication between the citizens and decision makers is based on online maps. Rinner (1999, 2001, 2005, 2006) contributed an argumentation map model that models relations between geographic and opinion objects. Objects from the real world such as houses, trees, and canals are modeled as geographic objects; and the opinions of the citizens are modeled as opinion objects. The ideas presented in his conceptual model can be implemented in many different ways. In some cases, the citizens can send their annotated maps to the planning authority (Steinmann, Krek et al. 2004) or leave a comment directly on the online maps (Rinner 1999, Al-Kodmany 2001, Rinner 2005, 2006).

Some of the researchers took a very positive view on these new developments; for example, Schlossberg and Shuford (2005) state that "PPGIS represents a broad notion that the spatial visualization and analysis capacities inherent in GIS present a unique opportunity for enhanced citizen involvement in public policy and planning issues." Thus, it can be used to augment traditional methods of participation such as public meetings (Steinmann et al. 2004: 1). The advantage of PPGIS for planners, often stressed by some of the researchers (Kingston, Carver et al. 2000), is that data collected online is georeferenced and easier to process and analyze than data that is collected from traditional public meetings. At a public forum, a note taker would have to record the comments or people would have to be surveyed using traditional telephone surveys or manual map making (Nasar 1998).

Several researchers focused on the analysis of functionalities integrated in PPGIS applications. Thompson (2000) concentrated on GIS and the possibilities it enables for data sharing. Basedow and Pundt (2001) analyzed the comments of an urban planning project and their spatial relation. Based on their results, they suggest that GIS functionalities are suitable for a map-based discussion. Haklay and Tobón (2003) looked at the usability aspects of PPGIS. Another analysis of the selected online PPGIS applications with the focus on the application's functionalities was performed by Steinmann, Krek et al. (2004). In their research, the authors report on the complexity of the applications and the problems users might have while using them, which could possibly result in rational ignorance of the citizens, the concept suggested by Krek (2005). According to the rational ignorance condition, citizens decide to be irrational, ignoring, for example, an urban planning participation process because participating would require a high

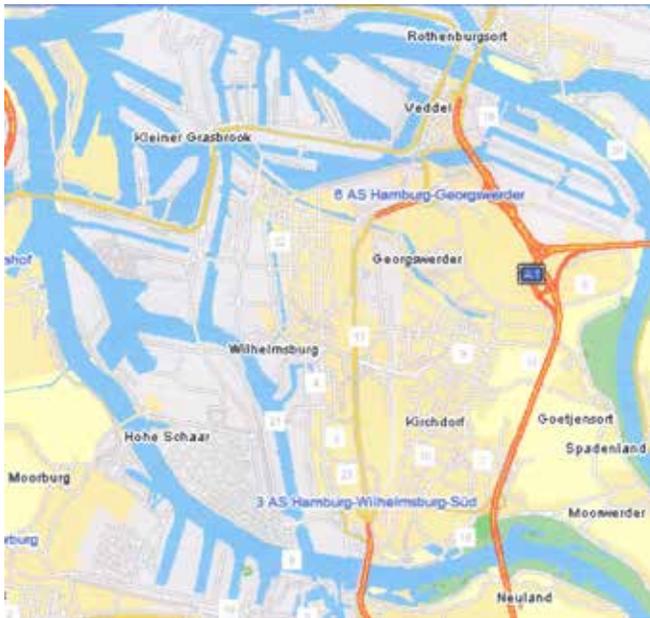
investment of time and effort to ascertain the current planning situation (Poplin 2011).

### Online Map-based Surveys

Map-based questionnaires are a novel research area; there are only a few examples of research available. Sidman, Swett et al. (2005) developed a paper questionnaire that was sent to the participants of the survey in the mail. Their responses then were manually inserted into a GIS and later communicated to the focus group. The disadvantage of inserting the data from analogue questionnaires into a GIS is that it requires additional time and effort for this activity. Several errors are possible with this process: not intended omissions of the data drawn on the paper map, imprecise input of the data into the computer-based system, false interpretation of the data inferred from the paper map, etc.

One of the first experiments with an online map-based survey was undertaken by Al-Kodmany (2001) and his colleagues at the University of Illinois at Chicago (UIC). They developed a Web-based map survey tool that was linked to a GIS through a server. It aimed at advancing a community-planning process and was based on the theories provided by Lynch (1960) and Nasar (1998). They emphasized the importance of discovering how city design affects citizens. The main goal of the online survey was to collect local spatial knowledge about the Pilsen community in Illinois. It was based on interactive online maps displaying an aerial picture with a grid and enabled two-way communication with the citizens of this community. "The project advances the prospect of allowing citizens to comment, using Web-based maps, upon government actions and development proposals" (Al-Kodmany 2001: 332). The researchers at UIC focused on the evaluation of the appearance of their community by asking what particular places the citizens like and dislike. "Once all responses were received, two composite GIS maps were created—one showing the areas of the community that were liked and the other showing areas of the community that were disliked" (Al-Kodmany 2001). A GIS program was used in the later stages for analyzing the participants' data and its integration with other GIS layers. In the summary of the ways to improve the tool, Al-Kodmany (2001) and his colleagues suggested improving the "optimum" map design/survey tool to further explore how different map designs could lead to different kinds of information. This would provide some kind of feedback to the respondents and expand the tool to provide a larger geographic area. They suggested exploring and possibly including some established survey standards.

A practical integration of a questionnaire and a map also can be seen in the example of the land-use planning for the city of New Orleans. The citizens are invited to respond to the question "What do you think?" Six detailed questions are described on the Website (<http://www.nolamasterplan.org/whatdoyouthink.asp>) and three of them are linked with a map. The displayed maps are static and do not enable any interactive communication with the participants. One of the main disadvantages of this Website is that there is no direct possibility to answer the questions on the



**Figure 1.** Case study in Wilhelmsburg (©2009 Infoware and Tele Atlas)

Website and to deliver the opinion about the issues in question. The attached maps are static and do not allow for any interaction with the map content.

## STUDY CASE AND GOALS OF PUBLIC PARTICIPATION IN WILHELMSBURG

### Project Background

The research presented in this article was accomplished within the research project SWITCH, founded by the European Commission. SWITCH stands for Sustainable Water Management Improves Tomorrow's Cities Health ([www.switchurbanwater.eu](http://www.switchurbanwater.eu)). The project focused on innovative water management for the city of the future. Its aim was to initiate a paradigm shift in urban water management from existing ad hoc solutions to a more coherent and integrated approach. One of the key features of the SWITCH methodology was an establishment of city learning alliances. These were groups of interconnected people that typically included public sector, private sector, and civil societies. The project started in 2006 and was completed in 2011. More than 33 partners from all over the world were involved in SWITCH; the HafenCity University Hamburg (HCU) and the Technical University of Hamburg-Harburg were research project partners. HCU proposed the city of Hamburg as one of the study cases in the SWITCH project. The city of Hamburg is home to more than 1.8 million people, and it is situated on the Elbe River in north Germany. The port of Hamburg is the second largest (after Rotterdam) in Europe and handles approximately 10 percent of Germany's foreign trade. The urban development of the city



**Figure 2.** A scene from Wilhelmsburg (©2009 Beate Weninger)

mainly concentrates on the south of the city, in particular on the river island of Wilhelmsburg (see Figure 1). In 2006, Wilhelmsburg was selected as the main study case in which the researchers concentrated on the analysis of the environmental quality of the water system as well as potential risks and water problems related to global environmental change. A new innovative water-management approach was needed that would be able to combine new water-management techniques and modern urban planning, as well as to support a more efficient water-management system.

### Study Area: Wilhelmsburg in Hamburg, Germany

Wilhelmsburg is situated on the homonymous island between the northern and southern branches of the Elbe River, south of the city center of Hamburg (as shown in Figure 1). The largest inhabited river island in Europe, it is characterized by a number of expanses of water with diverse water canals. Figure 2 shows the canal scenery in Wilhelmsburg with typical architecture in the background. Many parts of Wilhelmsburg are below the water level of the Elbe River, which is the reason for drainage channels in this area. The district is located close to the harbor of Hamburg and is surrounded by docks and waterways as well as by the riverbanks of the Elbe River. Currently, it is the focus of various planning initiatives in Hamburg.

Wilhelmsburg developed from a rural community into an important industrial and residential district at the end of the 19th century. The result of this development is a patchwork of different land uses, including port areas, areas with one-family houses, agricultural land, allotments, and nature-conservation areas. After the flood in 1962, the economic and social situation of Wilhelmsburg declined because of the lack of maintenance of the buildings and structural changes in the harbor. Today, Wilhelmsburg is a socially disadvantaged neighborhood, with low income levels, a high unemployment rate, a high number of Social Security benefit recipients, a large migrant population, and a low level of education. In 2010, according to the statistical office of Hamburg and Schleswig-Holstein (Dickhaut, Hoyer et al. 2006), the city district of Wilhelmsburg had 50,250 inhabitants, of which 33,365 are Germans and 16,885 are foreign. It covers,



**Figures 3 and 4.** Workshop discussion on the future development in Wilhelmsburg (Photos: K.M. Dietrich) (Dickhaut, Hoyer et al. 2006)

in total, an area of 35.3 square kilometers (14 square miles), with a population density of 1,419/km<sup>2</sup>. In 2010, there were 3,961 jobless inhabitants in this city district and 12,775 receiving Social Security. Average housing size was 67.7 m<sup>2</sup>, which is 28.1 m<sup>2</sup> per inhabitant. In total, 6,698 crimes were recorded in 2010, which is 134 per 1,000 inhabitants.

### Learning Alliance Organized in Wilhelmsburg

To comply with the methodology proposed within the SWITCH project, a panel called the Learning Alliance (LA) was established in Wilhelmsburg. Its main role was to work on the design of an integrated urban water-management system. Initially, in 2007, the LA consisted of a rather small “core” group of urban planners, researchers, ministries such as the Ministry for Urban Development and Environment, and nongovernmental organizations such as the Chamber of Commerce of Hamburg, the District Advisory Urban Development Committee of Wilhelmsburg, and the Union for Environmental Protection and Conservation of Hamburg. The research involved the partners HafenCity University Hamburg (HCU) and the Technical University Hamburg-Harburg. Since its initial formation, the membership has expanded to also include people interested in nature conservation in Wilhelmsburg and various citizen groups representing the needs of the inhabitants. Figures 3 (left) and 4 (right) show the members of the LA at a workshop, discussing ideas about the future development of Wilhelmsburg.

HafenCity University Hamburg was one of the members of the LA and played a key role in coordinating and managing the alliance. The research conducted by HCU was accomplished by two groups located in two different university departments. The first research group focused on the Water Sensitive Urban Design and concentrated on the combination of technical water-management problems (flood risks, stormwater management, etc.) and urban planning demands (water as an element to develop attractive locations, planning in urban transformation processes, etc.). The second group, under the leadership of the author of this article, worked on the design and implementation of an online map-based participatory process, which enabled collecting additional digital data needed for the Water Sensitive Urban Design. Both groups first focused on the analysis of the current use of the canals in Wilhelmsburg, the inhabitants’ wishes for their use in the future,

and the possible conflicts between the naturally protected areas and the areas used for the inhabitants’ activities.

## RESEARCH GOALS OF THE WEB-BASED PPGIS FOR WILHELMSBURG

### Goals of Public Participation in Wilhelmsburg

The first goal of public participation executed in Wilhelmsburg aimed to understand possible conflicts in land use between the naturally protected areas and the needs and wishes of the inhabitants of Wilhelmsburg for recreational places. Some of the canals, especially in the southern part of Wilhelmsburg, are defined as protected nature areas. The inhabitants and visitors are not allowed to use these protected areas for recreational or social activities such as barbecues, canoeing, or swimming. The regulation that prevents recreational use of these protected areas can possibly conflict with the wishes and needs of the inhabitants and visitors. The questions of interest to the urban planners, the alliance, and the HCU Hamburg researchers were: How are the canals used in Wilhelmsburg? What kind of activities are performed along the canals? How are the recreational areas along the canals used? What particular wishes do the inhabitants have related to the canals? What is their perception of the protected areas in Wilhelmsburg? The second goal was to determine the wishes of the inhabitants about the possible future use of the canals. How would the inhabitants like to use the canals in the future and for which activities in particular? The third goal was to use the results of the public participation process executed in Wilhelmsburg for the concept of Water Sensitive Urban Design. The state-of-the-art land use, the actual use of the canals, and the wishes of the inhabitants about the future use of the canals were inserted into ArcGIS. The result was a GIS-based analysis of the study area in Wilhelmsburg.

### Technical Requirements

The main idea was to design a participation platform that would enable the users to directly interact with the maps. In this way, they could directly insert their information related to the use of canals and waterways in Wilhelmsburg. The main technical requirements for the Web-based PPGIS created for Wilhelmsburg application were:

- Web-based and available online during the participation process to all inhabitants of Wilhelmsburg;
- GIS-based, to enable the researchers to store the acquired data in a common database and combine it with the data gathered from other data sources;
- Interactive, to enable the inhabitants to interact with the online maps and insert their information directly into the system;
- Usable and designed in such a way that diverse users from Wilhelmsburg, some of them not skilled in GIS, can use it;

- Functional and operational, to be used for the execution of a real participation process and not designed solely for research purposes;
- Based on an open-source technology, because of the limitations of the budget available for the implementation of the application.

Research questions related to the technology were: Which combination of the open-source technology could enable the implementation of such applications? How should it be designed to attract various inhabitants from Wilhelmsburg to participate?

### Design of the Online Questionnaire Interlinked with GIS Maps

One of the main research goals was to explore integration and implementation of an online questionnaire interlinked with online interactive GIS maps. In our research of the previous work of map-based online questionnaires, we were not able to find any directly comparable example. The research as presented in this paper is novel because it directly interlinks the online questionnaire with online interactive GIS-based maps. The data inserted by the inhabitants is stored directly in a GIS database on the central server. The research questions included the following:

- How should an online questionnaire be designed to collect reliable and valid data?
- Which questions can be linked with a GIS online map, and how should these questions be designed to be clear and understandable possibly to all participants in the participation process?
- How can the data be inserted in the interactive GIS map and saved in a common database?
- Which drawing functionalities can be included and how should they be designed to be clear and understandable possibly to all participants in the participation process?
- How should the user interface be designed to attract as many participants as possible?

We strived to design simple and short questions that could be easily understood by the participants. After designing the first set of questions, we tested them in an offline survey. We collected the feedback from five inhabitants who responded to the first set of questions in person. We executed a pilot study with five inhabitants interviewed in a field survey in Wilhelmsburg. In these interviews, we aimed to check if the designed questions could be understood by a variety of possible potential users of our application. After the pilot study, we revised the questions according to the feedback and came up with the final version of the questions, which was later integrated into the online survey.

## IMPLEMENTATION OF THE WEB-BASED PPGIS

### Entrance Page

The entrance page of the Web-based PPGIS for Wilhelmsburg is designed in a simple way. It is available at <http://digimap.hcu-hamburg.de/wilhelmsburgamwasser> and implemented in the German language (see Figure 5). At the top of the page, the participants can see the logo in blue and green colors, indicating the main topics of the survey: the water and canals (blue) and naturally protected areas (green). The question “Wie wollen sie die Wilhelmsburger Gewässer gerne nutzen?” translated into English: “How do you want to use the waters/canals in Wilhelmsburg?” aims to invite participants to participate in the survey.

The left side of the entrance page includes three blue buttons, which help the participants navigate among the sections Home, Information, and Contact. The Home section explains the goals of the designed Web-based PPGIS for Wilhelmsburg. It provides the information about the duration of the survey, which is estimated at 20 to 30 minutes. It includes a direct link to the survey and invites the inhabitants of Wilhelmsburg to participate in the survey. The Information section provides some basic information about the SWITCH project and the link to the official SWITCH Website. It explains the main goals of public participation in Wilhelmsburg and provides three pictures of Wilhelmsburg to illustrate the case study. The Contact section provides information about the two involved research groups at the HafenCity University Hamburg and their contact information.

### Design of the Map-based Online Questionnaire

The questionnaire includes 26 main questions displayed online on 26 Web pages. It starts with two questions related to the gender and age of the participant. Some researchers (Thiensch and Weltzin 2009) suggest to include such questions at the beginning of the online questionnaire in case of a possible high dropout rate.



Figure 5. The entrance page of the Web-based PPGIS for Wilhelmsburg



Figure 6. The second page includes a GIS-based interactive map

This design later enables researchers to analyze who dropped out and when. In our case, the participants could select among the suggested categories:

- Gender: Male or female
- Age category: Under 25 years, 25–40 years, 41–60 years, more than 60 years old

The second page includes a question that is linked to the GIS-based interactive map (shown in Figure 6). The question is displayed on the top of the Web page and continues with the question “Do you take walks along the canals in Wilhelmsburg?” Two answers are possible and the Website explains what to do in each of the two cases:

- If yes, then draw three lines along those canals where you take a walk.
- If no, choose the button “weiter”/“continue” and continue with the online survey.

A short text gives instructions on how to draw the lines, instructing the participants to use the icon with the pencil and draw the line with it. Participants can complete drawing a line with a double-click. They can draw up to three lines, which appear in three different colors. If they click on the globe icon, they can freely explore the map. With the icon plus top right on the Website, they can change the view from a map to a satellite image and turn the layer with waters on or off.

The following three questions (3 to 5) have the same structure as the set questions and are all related to the interactive GIS-based map displayed under the question:

- Do you ride a bike along the canals in Wilhelmsburg?
- Do you walk your pet along the canals in Wilhelmsburg?
- Do you use the canals in Wilhelmsburg for boat trips?

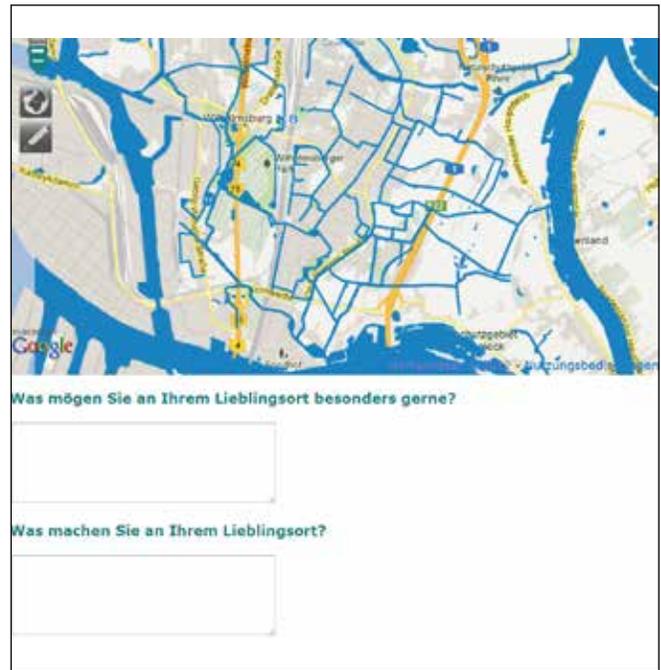


Figure 7. Question 12 combines an interactive map with two additional questions

The questions 6 to 11 require inserting points instead of lines. The points can be inserted with the three pencils visible on the left side of the Web page (see Figure 6), used in the same way as the lines. It is possible to insert up to three points on the map. The explanation of how to draw the points of interest is displayed below every question.

- Do you grill or barbecue along the canals in Wilhelmsburg?
- Do you fish in the canals in Wilhelmsburg?
- Do you swim or bathe in the canals in Wilhelmsburg?
- Do you observe the nature at the canals in Wilhelmsburg?
- Do you or your children exercise at the canals in Wilhelmsburg?
- Is there any activity, not mentioned yet, that you might do at the canals in Wilhelmsburg? If yes, please enter the activity and draw the sites of this activity at the canals in Wilhelmsburg.

The next question, 12, enables a participant to draw/designate one point on the map representing the favorite or most beloved place in Wilhelmsburg (see Figure 7). Two additional questions are related to the qualities of this place and the activities of the participant at this place. Question 12 consists of the following three questions (Figure 7):

- Which is your favorite place in Wilhelmsburg?
- What do you particularly like at this place?
- What do you usually do at this place?

The following set of questions is related to the future use of the canals in Wilhelmsburg. If you would like to take walks,



Figure 8. The interactive map with standard OpenLayers functions

walk your pet, make boat trips, grill/barbecue, fish, bath or swim, observe or enjoy nature, or exercise in the future along different canals in Wilhelmsburg, please draw them on the map. These are questions 13 to 21. The last one in this set, 22, includes:

Is there any other way/activity in which you would like to use the canals in Wilhelmsburg in the future? Please describe and mark the places on the map.

The next three questions address possible issues related to the protected nature areas.

- Can you imagine that certain activities should be restricted to certain places? If yes, please explain why. If no, please explain why.
- Which natural areas in Wilhelmsburg do you consider especially worth protecting? Mark three places on the map. Please explain why you find these places particularly worth protecting.
- How clean or dirty do you find the water in the canals in Wilhelmsburg? Mark on the scale from 1 (very clean) to 5 (very polluted). Which of the canals do you find the most polluted? Please mark them on the map.

The last set of questions is related to the place of residence of the participant.

- Do you live in Wilhelmsburg?
- How long have you lived in Wilhelmsburg?
- Please mark your home district on the map.
- How did you get to know about this participatory process and our online survey?
- Here is a place for your comment. Is there anything else you would like to share with us?

The questions were designed so that the citizens could answer them or skip those that they did not want to or could not answer. Skipping a question or several questions did not prevent them from continuing the participation. With this strategy, we

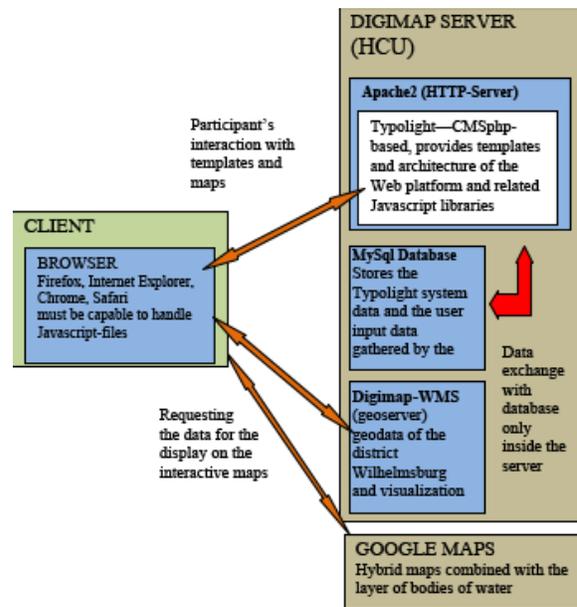


Figure 9. Technical architecture (Fessele and Poplin 2010)

aimed to allow the participants to answer the questions that were of interest to them.

### Design of the Interactive Maps

The design of the interactive map includes the design of the map itself and the design of the user interface, including the basic functionalities needed for the interaction with maps. The basic maps were taken from Google Maps, which were combined with the specific data related to Wilhelmsburg and gathered within the project SWITCH (shown in Figure 8). The maps combine the following data sources: a Google map, a Google hybrid map, and a layer with the canals in Wilhelmsburg acquired within the SWITCH project.

The interactive maps were integrated into the Website (<http://digimap.hcu-hamburg.de/wilhelmsburgamwasser>) with the open-source technology OpenLayers (OL). OpenLayers enables the display of data sources such as Google Maps, Bing Maps, Yahoo, Open Street Maps, as well as data coming from Web Map Server (WMS) or Web Feature Server. It provides interactive maps with standard navigation functions such as zoom and pan. We developed two different modes: the navigation and the edit mode. The navigation mode enables respondents to zoom and pan to the area of interest and to switch the layers with geographic information turned off and on. The edit mode enables them to add points or lines on the displayed map. The participant can switch between the two modes selecting either the globe icon for turning on the navigation mode or the pencil icon for the edit mode.

In the online map-based questionnaire, the participant has the possibility to construct up to three geometries for each question in the corresponding map. The geometries offered, depending on the question, are points or lines. Figure 8 shows three pencil

**Table 1.** Gender and age of the participants

Question	Online Responses	
	Number	Percentage
Gender (Together)	98	100
Female	38	39
Male	49	50
No response	11	11
Age (Together)	98	100
Under 25	18	18.5
25–40	47	48
41–60	19	19.5
Above 60	4	4
No response	10	10

icons enabling the participants to draw up to three lines. Every button uses a different color for the line or point drawn on the interactive map.

### Enabling Technology and Technical Architecture

The online map-based survey was implemented in a classical client-server architecture using standard Web 2.0 technology (see Figure 9). The HCU DigiMap server was based on the virtual system VSphere provided by VMWare. This system enabled us to host a virtual server independent from the hardware. The operating system was a Linux-System Ubuntu 10.04 LTS (Lucid Lynx), and for the HTTP-Server we used Apache 2 from the Apache Software Foundation.

To be able to provide the Website with a high degree of participants' confidence and comfort, we integrated the content management system (CMS) Typolight 2.8 providing the HTML pages. The questionnaire templates were embedded in the CMS. Typolight 2.8 is an Open Source CMS and is shipped with a support for a variety of templates; it is php-based and provides templates and architecture for the map-based survey application and related Javascript libraries. The template support of the CMS did not include any support for the integration with the interactive maps; therefore, we used the Open Source Javascript library and OpenLayers to develop the interactive maps.

The interactive maps were embedded in the forms of Typolight using the HTML-form field support of Typolight. We integrated MySQL 5.0 database, which stores the Typolight system data and the user input data gathered by the questionnaire. The application does not include any direct traffic between the client and the database. All input data is sent to the HTTP server and afterwards transported to the database by Typolight. This means that the participant using the application on his or her browser does not need any permission for the access of the data in the database. All communication with the database is between Typolight and MySQL on the server side. This solution enables a better security and protection of the data given by the respondents of the survey. This, therefore, is designed in a rather simple way, being able to use and integrate the input from the respondents, using a variety of different browsers such as FireFox, Internet Explorer, Chrome, Google, Safari, etc.

**Table 2.** Responses related to the activities of the participants

Activity	Number	Percentage
Take a walk		
Answer yes	38	39
No answer	60	61
Ride a bike		
Answer yes	15	15
No answer	83	85
Walk a pet		
Answer yes	2	2
No answer	96	98
Boat trips		
Answer yes	8	8
No answer	90	92
Grill/barbecue		
Answer yes	16	16
No answer	82	84
Fishing		
Answer yes	3	3
No answer	95	97
Swimming, bathing		
Answer yes	12	12
No answer	86	88
Observing nature		
Answer yes	22	22
No answer	76	78
Sports		
Answer yes	9	9
No answer	89	91

## RESULTS OF THE ONLINE PUBLIC PARTICIPATION

### Execution of the Participation Process

The online PPGIS for the Wilhelmsburg application was completed in May of 2010 and available online until the end of July of 2010. The second group of researchers from the HCU needed the results in August of 2010; therefore, we had six months available for the development of the PPGIS and a relatively short period for the execution of the participation process. The Learning Alliance and the HafenCity University Hamburg (HCU) advertised the designed online PPGIS for Wilhelmsburg and the possibilities for the inhabitants of Wilhelmsburg to express their opinions about their city district. Specially designed flyers were created and sent to all households in Wilhelmsburg. Posters designed for advertising the Website were placed in the public buildings in Wilhelmsburg and at HCU. A special-interest group was created on Facebook where we advertised the implemented PPGIS for Wilhelmsburg and invited interested inhabitants to participate. After two months of advertising activities, 98 citizens visited the online PPGIS for the Wilhelmsburg platform. Following is a summary of results gathered in the online participation process.



**Figure 10.** The data collected with the online survey (background map ©LGV Hamburg)

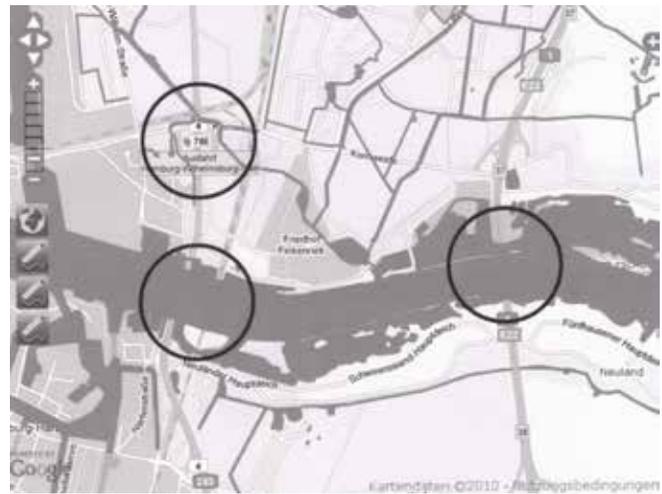
### Age and Gender of the Participants

All together, 98 inhabitants entered their opinions via online PPGIS for Wilhelmsburg. Ninety-eight inhabitants answered at least one of the questions in the survey. All answers to the questions were registered in the central database and were considered valid. The analysis was conducted separately for every question. Thirty-eight female and 49 male inhabitants started the survey and answered the first question related to the age and gender. Eleven participants decided not to answer this question. The majority of the participants were between 25 and 40 years old (46 percent), followed by participants between 41 and 60 (19.5 percent), younger than 25 years (18.5 percent), and 4 percent were older than 60.

### Summary of the Responses to the Questions

The online responses related to the current activities along the canals in Wilhelmsburg are summarized in Table 2. The majority of the participants enjoy most taking walks along the canals, riding a bike, or swimming.

In the future, the participants would like to take walks along the canals (16 participants), bike (9), walk a pet (1), boat trips (6), barbecue (8), fish (1), swim (9), observe nature (8), sports (3). Only 10 participants, which represents 10 percent, agree with additional regulations for natural protection, and 11 are against (11 percent). The water in the canals was evaluated on the scale from 1 (very clean) to 6 (very polluted). The majority of the participants (13 percent) evaluated it at 4.



**Figure 11.** Problems integrating the layer of canals with Google Maps



**Figure 12.** Example of an accidentally drawn line marked with the black arrow

### Responses to the GIS Maps

The responses on the interactive GIS maps were collected in a common database. Figure 10 shows all data entered by the 98 inhabitants in the online PPGIS for Wilhelmsburg. Answers to every question were combined and saved as a separate layer. This map shows all entered lines and points. The darker lines are the most preferred paths along the canals.

Further analysis of the collected material revealed that the recreational activities on the one side and the high ecological value of the canals on the other side provoke conflicts based on concurring and conflicting demands. Based on the results of the questionnaire and mapping of the canals, strategic directions were developed

within the project SWITCH to improve the actual management of the canals, aiming toward sustainability and an improved balance of the concurring demands, needs, and restrictions.

## DISCUSSION AND RESEARCH PERSPECTIVES

### Design of Online Interactive Maps

The maps designed for the PPGIS for Wilhelmsburg are based on Google Maps. The layer with the canals was generated within the SWITCH project. We tried to integrate data coming from these two different sources. The layer with the canals is displayed on the top of the layers, representing streets and bridges (see Figure 11). Figure 11 shows inconsistencies in data quality and compatibility that are marked with circles. The bridges and parts of the streets are missing. The integration of additional datasets with Google Maps was relatively easy to implement, but we were not able to solve data inconsistencies in the relatively short time of the project duration of six months.

In designing the concept of PPGIS for Wilhelmsburg based on Google Maps, we assumed that many online participants are familiar with Google Maps and interact with them. In further research of Web-based PPGIS applications integrated with a questionnaire, it would be interesting to evaluate the usability of these maps and the participants' literacy related to the use of Google Maps in general. Further research should investigate if alternative visualizations could potentially lead to better results with fewer inconsistencies in the datasets.

### Navigation and Edit Mode

Drawing the elements on the maps required a switch between the navigation and the edit mode. The explanation on how to do that was given below every question in the questionnaire. Despite this explanation, the participants had problems switching between these two modes. Figure 12 shows one of the lines that makes no particular sense; it is marked with the black arrow on the image (it is a straight line in the middle of the map). Such lines demonstrate the inability of some participants to delete the lines and/or switch between the navigation and the edit mode.

On the basis of the entered data, we can assume that the need to switch from one to the other mode was not self-explanatory. The other possibility for such results could be the inability of the participants to find the delete function or to finish the drawing operation. To be able to finish the drawing of the line, the participants had to use their right button on the mouse and click it once. This function is often used by skilled GIS users, but the users of other software programs might not know it.

### Dropout Rate

Online questionnaires often face a problem of a high dropout rate (Thielsch and Weltzin 2009). The dropout rate is the number of

participants who exit the questionnaire without completing the questionnaire. It is a specific problem of online questionnaires because online there are no interviewers that lead the interview and are able to motivate people to complete the tasks and answer all the suggested questions. In our application, the majority of users dropped out when they had to start using the online interactive GIS map. While the first question about the age and gender was responded to by 87 inhabitants, only 38 responded to the second question asking them to draw a line of the walks that they take along the canals in Wilhelmsburg. We can clearly see that this most likely represented a barrier that was set too high for many participants in our online survey. Another reason for some people dropping out might be the length of the questionnaire. Additional research is needed to understand the reasons for such behavior and to relate it to the other computer skills, age, gender, or educational background of the participants. Additional research also should investigate the techniques and strategies for lowering the dropout rate. Also a dynamic help integrated within the application and a feedback could possibly improve the dropout rate. Al-Kodmany (2001: 339) recommends: "Have the survey tool return feedback to the respondent." A feedback given to the participants could motivate them to continue with their activity.

### Suggested Improvements of the PPGIS for Wilhelmsburg

Suggested improvements of the implemented PPGIS for Wilhelmsburg and similar applications include the following:

- *Drag an element to the point of interest:* With this method, a point of interest could be placed on the exact location on the map. The elements that could be possibly dragged on the map could be suggested by the application. An example for a question where this function is suitable is "Where would you like to have trees planted?" The participant has a choice of the icons for different kinds of trees and is able to drag them on the map to the point desired. In this way, the participant has the chance to decide which tree he or she wishes to place where and how many.
- *Mark the element on the map:* An additional layer with clickable elements could be added to the map that would allow less experienced participants to point to the graphical element on the map. Participants asked to choose a canal (line) or a region could click on a line or polygon to mark it. A question for this kind of input could be "In which city district do you live?" Al-Kodmany and his colleagues (2001) used this kind of method in their "Web map-survey."
- *Marker including text comments:* The participants place a marker, e.g., a small flag, somewhere on the map and add a comment to this flag. This is a popular method often used within Google Maps.
- *Sketch function:* A drawing tool that would allow the participant to draw on the map using different colors and line types. Asking rather "how" than "where" this tool is an option for some skilled participants. The results might not

be analyzed automatically in an easy way, but would have to be evaluated qualitatively.

- *Barrier-free Web-based PPGIS*: Barrier-free Web was suggested by the World Wide Web Consortium (W3C) under the Web Accessibility Initiative. The main objective of the W3C is to make the WWW accessible to as many people as possible. This refers to people with different disabilities, for example, who are not able to work with an ordinary keyboard or, instead of a screen, need a different depiction of the content. Additional research needs to be conducted in defining what a barrier-free PPGIS application is, how can it be defined, designed, and implemented. When can a PPGIS be barrier-free and how can we achieve a self-explanatory stage in which all users understand the functionalities of the application?

To make the PPGIS for the Wilhelmsburg application easier to operate, it would be helpful to make drawing possible without switching between the two modes. In the future, the buttons included should be tested also by their affordance capabilities. Gibson (1977, 1979) defines affordances as “action possibilities” latent in the environment, objectively measurable and independent of the individual’s ability to recognize them, but always in relation to the individual and, therefore, dependent on the individual’s capabilities. In more simple words, an affordance is a quality of an object or an environment that allows an individual to perform an action. For example, the chair affords to sit on it; the button in an online application affords to draw a line.

## Conclusions and Further Research Directions

In the research presented in this article, we concentrate on the implementation of a PPGIS for Wilhelmsburg. We explored the possibility of combining interactive online GIS maps with an online questionnaire. After the implementation of the application and completion of the research, we conducted a usability test of the PPGIS for Wilhelmsburg. During the intense phase of the work on the project, the implementation of the PPGIS for Wilhelmsburg, and the pressure to gain the opinions from the inhabitants of Wilhelmsburg on time, there was not enough time to conduct a usability study prior to the execution of the participatory process. The usability study was conducted separately as part of the lecture on usability testing and conducted with 29 students of urban planning from HafenCity University Hamburg. Their responses indicate that “How to draw a line . . .” was “not at all clear” or “not clear” for 31 percent of the students and “To finish the line . . .” was very difficult or difficult for 39 percent of the urban-planning students. These students represent a young generation that is used to searching on the Internet and using Google Maps, etc. Despite our assumptions that the included functionalities represented standards in using online interactive maps, we seemed to overestimate the online map literacy of the participants in the online participation process in Wilhelmsburg. The students’ answers on the questions related to the difficulty in using some of the functionalities show that 31 percent to 39 percent of them had problems with some of the functionalities

included in the PPGIS for Wilhelmsburg.

These results clearly demonstrate the need for additional research in the area of PPGIS and its use in public participation processes. Several research questions are worthwhile to explore further and are part of our broader research agenda. These questions include the following:

- How should the maps be designed to be better accepted by the participants?
- How to enable an easy and pleasant interaction with maps?
- How to integrate functionalities that seem easy to use to a variety of users?
- Which elements of the application can result in positive feelings while using them?
- How to design maps for mobile public participation applications?

One of the interesting research questions is “How to design the user interface to improve the affordance?” Norman (1988) discusses the design issues in his earlier book titled *The Design of Everyday Things*. Later, he explored the characteristics of the emotional design (Norman 2004). According to him, there are three aspects of emotional design that need to be taken into consideration: visceral, behavioral, and reflective. The main idea is that emotions enable people to understand the world and learn about it in a particular way. For example, aesthetically pleasing objects appear to the user more effective. Our future research will deal with the design of the user interface and the buttons included in the user interface. How can they be designed in a more intuitive and aesthetically pleasing way?

Online games can possibly bring new dimensions and a novel approach in space representation, offering alternatives to maps. Especially, serious games (Abt 1970, Michael and Chen 2005, Zyda 2005) can contribute with their concepts and innovative ways of including stories and playful elements in the process of learning. How can they be integrated in online public participation processes? Usability and accessibility issues should have a high priority while designing map-based applications to attract as many participants as possible. Goodchild (2010) stresses the importance of the map design in the following way: “Now, more than ever, we need a technology of design that can work in tandem with human decision-making processes, bringing what we know about how the planet works to bear on the decisions that have to be made about its future.”

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