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Usability Engineering and PPGIS: Towards a Learning-improving Cycle

Abstract: Public Participation GIS (PPGIS) is a field of research that, among other things, focuses on the use of GIS by non-experts and occasional users. These users tend to have a diverse range of computer literacy, world views, cultural backgrounds and knowledge. These aspects require that the systems used within PPGIS are accessible and easy to use. Usability Engineering (UE) and Human-Computer Interaction (HCI) are fields of study that focus on how to make computer systems more accessible, while focusing on user needs and requirements. Thus, the synergy between PPGIS and UE/HCI seems natural. In this paper, we discuss the aspects of this synergy, building on our experience from three workshops. We demonstrate how UE/HCI can contribute to PPGIS research, and how PPGIS research can contribute to the UE/HCI aspects of GIS in general. We conclude this paper with a call for a user-centred design approach to PPGIS projects.

Introduction

Public Participation Geographic Information Systems (PPGIS) is inherently about empowering GIS users from all walks of life and enabling them to use the technology purposefully to capture their local knowledge and advance their goals

(Talen, 2000). Although the usability of GIS products has improved immensely in recent years, they still require users to have or acquire considerable technical knowledge to operate them (Traynor & Williams, 1997). This presents major obstacles to non-expert users in terms of navigating an interface that embeds a language, world view and concepts that support the system's architecture rather than the user's work view (Goodchild, 2002; Ghose, 2001; Haklay, 2001; Elwood and Leitner, 1998; Traynor & Williams, 1995). In such situations, Usability Engineering (UE), concerned with the evaluation and analysis of the application's interface and Human-Computer Interaction (HCI) issues (Nielsen, 1993b; Preece, 1995), are vital to the success of PPGIS. Although UE and HCI aspects of GIS received attention in the first part of the 1990s (see Nyerges *et al.,* 1995; Davies & Medyckyj-Scott, 1996; Medyckyj-Scott & Hearnshaw, 1993), it seems that within PPGIS research, little attention has been paid to the influence of HCI on research and practice.

This is, in a way, unfortunate as the type of users that are being exposed to GIS in a PPGIS setting are very different from those who have been at the centre of the earlier research on HCI issues in GIS. While this early research focused on the use of GIS by specialists who try to use the system to accomplish a specific work-related task, PPGIS settings usually call for an open-ended exploration in which users experiment with the GIS and examine various issues that relate to their community and locality. Combined with the skill level and computer literacy of users in PPGIS settings, these types of applications are both interesting and challenging in HCI/UE terms.

Furthermore, within the PPGIS context, HCI studies contribute to the subject matter and not just to the improvement of the system used. Various studies have shown how HCI techniques are valuable tools in PPGIS research (Haklay & Harrison, 2002; Boott *et al.*, 2001). This is because they are geared towards understanding how people interact with computer applications and stem from techniques based on research in the cognitive and social sciences. As a result, these techniques have opened up new avenues for understanding users' expectations from a GIS, the ways in which they understand and value the system's content and the role of GIS within the wider societal context. At the same time, these techniques can assist in improving the technology by making it more accessible to a wider range of users, most of them with little or no experience of GIS.

This paper discusses the HCI techniques that were deployed in three PPGIS studies—two that focused on PPGIS research and a study that focused on usability—and will demonstrate the contribution of these techniques to PPGIS research. The paper begins with a brief overview of the links between HCI/UE research and GIS. The history of HCI research and trends is discussed with a special focus on the contributions from contributing cognitive and social sciences and the work that has been carried out within Geographic Information Science (GISc). The second part of the paper builds on this theoretical background and demonstrates how UE and HCI can contribute to PPGIS research and practice. Based on our experience, the contribution of UE techniques to PPGIS research

is outlined first. The contribution of PPGIS to usability is then explained. The final section of the paper discusses these findings within the broader PPGIS framework and suggests that an iterative development process is needed in projects and research wishing to improve the use of the technology and its applications. We conclude with suggestions for future research and developments in this area.

Human-Computer Interaction and GIS

There is currently no agreed upon definition of HCI but a working one describes it as 'a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them' (Hewett *et al.*, 2002). Hence, HCI is concerned with enhancing the quality of interaction between humans and computer systems within the physical, organisational and social aspects of the users' environment to produce systems that are usable, safe and functional (Preece, 1995). Research on these issues is based on the assumption that the needs, capabilities and preferences for the way users perform an activity within an environment should influence the design and implementation of a system in order for it to match users' requirements. Knowledge about the users and the work they need to accomplish as well as about the technology is required to meet this approach to systems design, which makes HCI a multidisciplinary field of research.

A brief history of Human-Computer Interaction

HCI's history is indicative of its multidisciplinary nature as it 'arose as a field from intertwined roots in computer graphics, operating systems, human factors, ergonomics, industrial engineering, cognitive psychology, and the systems part of computer science' (Hewett *et al*., 2002). The interest or emphasis in one or more of these and many other fields contributing to HCI has been heavily influenced by the contemporary technological developments. For instance, the origins of HCI are commonly traced back to the 1940s when Bush (1945) proposed the *Memex*, a device for individual use that could speed routine and time-consuming calculations and store, retrieve and project text and multimedia information, among other features. Although the ideas that contributed to the concept of a modern digital computer pre-date the 19th century, the technology available in Bush's time permitted their implementation into systems (Baecker & Buxton, 1987). In the following decades, their development and use triggered the interest in designing systems that could aid human problem solving and creativity (Licklider, 1960). Enriching and facilitating people's work through the use of computers is still a major concern in HCI.

During the late 1970s and early 1980s, research was driven by the interest of cognitive psychology on information processing (Lindsay & Norman, 1977), which dealt with issues such as perception, attention, memory, learning and problem solving and how they can influence computer and interface design. This was partly possible due to the research on graphical displays carried out during the 1950s and successfully developed in the 1960s (Sutherland, 1963). The importance of the quality of the interface and the need for its testing was,

therefore, on the agenda from, at least, the 1960s, as shown in the work of Engelbart (1962) and Nelson (1965). However, interest in the usability of single-user computer systems rocketed during the 1980s in response to the personal computer explosion. By that time, the field had been greatly developed and great effort was placed on laying the theoretical foundations of HCI by formalising and developing theories and methods of design that took user needs into account (see, for instance, Card *et al*., 1983).

In the late 1980s and 1990s, multi-user workstations, multimedia and multitasking shifted the emphasis of research towards group working, integration and interaction of media as well as the impact of the new technology in society (Preece *et al.,* 1994). Today, research is driven by trends that include the decreasing costs of hardware that have led to larger memories and faster systems; the reduction in power requirements and the miniaturization of hardware that have brought portability (Hewett *et al.*, 2002); and the distribution of computing and new input technologies such as voice or gesture that have broadened the possibilities of user interaction with computer systems. Some of these advances have prompted trends of special interest in PPGIS, which aim at incorporating social concerns and public characteristics in system design. Examples of this include striving for improved access to computers by disadvantaged groups such as disabled users, or interfaces that appeal to a particular age group (Muller *et al.,* 1997).

These examples also illustrate the emphasis of HCI in designing user-centred systems, or systems that, from an early stage, involve target users and experts to a great extent to influence the design of the system. In this approach, evaluation is central to ensuring the design meets the user requirements. Such a design process is highly iterative and can be quite common, in practice, as user requirements, the design and the final system usually evolve gradually (Preece *et al.*, 1994). Therefore, the design process encompasses the understanding of how people do their work in order to implement systems that can allow users to accomplish their tasks effectively and efficiently.

Usability and Human-Computer Interaction

Apart from understanding how to improve users' work processes, HCI is also concerned with understanding how people use computer systems in order to develop or improve their design. The aim is to meet users' requirements so that they can carry out their tasks 'safely, effectively and enjoyably' (Preece *et al.*, 1993). Usability deals with these aspects and the question of how the functionality provided by a system can be used (Nielsen, 1993). Usability applies to all aspects of a system's user interface, defined here as the medium through which a user interacts and communicates with the computer (Preece *et al.*, 1993; Nielsen, 1993). UE attempts to measure a system's usability in terms of its learnability, efficiency, memorability, error rate and user satisfaction (Nielsen, 1993). The ease of learning a product is measured as the time it takes a person to 'reach a specified level of proficiency in using it' (Nielsen, 1993, p. 28), assuming this person is representative of the intended users. Efficiency refers to the level of productivity that the user must achieve once the system has been

learned. Memorability measures how easily a system is remembered either after a period of not using it or by casual users. An error in the context of Usability Engineering is defined as 'any action that does not accomplish the desired goal' (Nielsen, 1993). Counting such actions provides a measure of a system's error rate. Satisfaction refers to how pleasant the system is to use. Preece and her colleagues (1994) also mentions throughput, flexibility and user attitude towards the system. Ease of use or throughput is comparable to Nielsen's efficiency and error rate as it is defined as 'the tasks accomplished by experienced users, the speed of task execution and the errors made' (Preece *et al.*, 1994, p. 401). Flexibility refers to the extent to which the system can accommodate tasks or environments it was not originally planned for. Attitude is comparable to Nielsen's user satisfaction.

All these aspects relate to intrinsic objectives of PPGIS research — to make quite a complex computer technology accessible to a wide range of users, many of them from disadvantaged backgrounds. If we are to increase the access and use of GIS for those who are bringing a diversity of knowledge, technical capabilities and cultural perspectives, we ought to provide them with a positive experience of the technology. In this sense, the principles of HCI and UE provide a sound base for the evaluation of PPGIS research. However, the specific complexity which is inherent in GIS is significant and, therefore, we now turn to discuss the relationship between HCI and GIS.

Cognitive Aspects of Human-Computer Interaction for GIS

During the late 1980s, cognitive aspects of HCI for GIS were discussed at workshops of larger conferences or as sections of books where HCI issues in GIS were not their primary focus. The 1990s, however, saw a strong international research interest in the topic. Evidence of this can be found in four workshops that were held between 1990 and 1994 in the US and Europe[1] which explicitly discussed HCI aspects in GIS, as well as in at least two books—Medyckyj-Scott and Hearnshaw (1993) and Nyerges *et al*., (1995)—published solely on the topic (Nyerges *et al.,* 1995a).

The interest in cognitive aspects of HCI for GIS can be explained by two main trends. On the one hand, the recent increased availability and power of affordable personal computers broadened their user community which was no longer restricted to 'a technical and mathematical priesthood' (Baecker & Buxton, 1987, p. 51). This new user community both desired and demanded interfaces that did not require high technical expertise as was demonstrated by the commercial success of the Apple Macintosh. On the other hand, GIS had been developing since, at least, the late 1960s and had reached a state where

[1] 'Cognitive and Linguistic Aspects of Geographic Space', July 1990, Spain, NATO Advanced Study Institute. 'User Interfaces for GIS', June 1991, USA, NCGIA Initiative 13. 'Task Analysis in Human-Computer Interaction', June 1992, Austria, 11th interdisciplinary workshop on Informatics and Psychology. 'Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems', March 1994, Spain, NATO Advanced Research Workshop.

functionality such as map production, display and spatial data analysis was commonly provided (Kuhn *et al*., 1992). Concerns in the GIS community about increasing processing speed and storage requirements were the main topics on the agenda but they expanded at the beginning of the 1990s to include how GIS were used and how they could accommodate users' needs. This had not been a matter of substantial interest as advances in GIS functionality to satisfy expert user needs were the focus of computer systems' designers and developers and the systems' manufacturers (Hearnshaw & Medyckyj-Scott, 1993). It was realised, however, that GIS were 'more likely to fail on human and organizational grounds… than on technical ones' (Medyckyj-Scott, 1992, p. 106) as the deficiencies of the systems in terms of human factors could compromise their future success.

As GIS evolved out of a number of fields including geography, cartography and database management, it requires its users to have considerable knowledge of these fields to operate the system (Traynor & Williams, 1995). Furthermore, GIS require users to be computer literate and invest enough time to use 'an interface that reflects the system's architecture' (Traynor & Williams, 1997, p. 288). Nevertheless, GIS users vary in expertise and may use the technology in one of a large number of application areas, as well as demand different functionality and analytical power. Accommodating such a wide spectrum of needs is a challenge in its own right that must take into account a number of factors such as the components and requirements of the users' work, their capabilities and limitations, the types of support the system can provide, and where it can be provided most effectively (Muller *et al*., 1997). Continuing research into the understanding of spatial knowledge sources and the representation of such knowledge can provide valuable information in the designing of effective user interface architectures that take into account these factors and can also improve the quality of the users' work.

It is not yet fully understood how spatial knowledge maps 'onto functional abilities in thinking about space' (Hearnshaw & Medyckyj-Scott, 1993, p. 237), or how well the digital representation of such knowledge in a GIS translates into intuitive human reasoning (Goodchild, 1999). Nevertheless, work in these areas has opened areas of research, of particular interest to PPGIS, concerned with enabling the accessibility of the technology to a wider public. Questions as to whether or how complex models and methods for spatial analysis should be made available to non-experts can develop from the type of research carried out in PPGIS. For example, research into appropriate visualisation (Krygier, 2002) or the use of multimedia (Shiffer, 2002), can be integrated with mainstream GISc research to improve the usability of GIS for occasional and non-specialist users. Of significance is the concern within PPGIS literature of the limited use of sophisticated functionality of GIS (Craig *et al.* 2002). In the following section, we discuss the role of usability engineering techniques in obtaining information on the interests and needs of a particular user group and the environment for designing applications that suit their requirements. Furthermore, we discuss how these techniques can benefit PPGIS research and practice.

THE SYNERGY OF USABILITY AND PPGIS RESEARCH

Building on the background of HCI and UE techniques and their applications in GIS, we move to the description of the three workshops that were conducted in a southern borough of London and the role that UE techniques played in these workshops. The section begins with a description of two workshops that were aimed at eliciting views and opinions of active publics towards the use of GIS within the physical planning process. Within these workshops, HCI/UE techniques played an important role in assisting the design and analysis. The second part of this section presents the opposite relationship and describes a testing session of an online mapping system that was designed by the local authority to provide access to planning information. In this session, where usability was the main focus, we have used knowledge from our PPGIS studies to understand the user requirements and to improve the design of the system. Together, these series of studies stress the role of a user-centred approach to design, development and deployment of PPGIS projects (Landauer 1995; Preece *et al*., 1994) which is discussed in the following sections.

Stage I: Using Usability techniques for PPGIS research

In the workshops undertaken in the inner London borough of Wandsworth, we used the focal point of environmental planning as the gateway to the use of GIS as a planning tool; the issue of brownfield development and the actions of local amenity groups and individual residents as the focus for discussions on PPGIS. The case study involved a proposed high-density development of luxury homes on the Thames that was of concern to local residents. These concerns related to the lack of provision for affordable homes and the wider environmental impacts the development would incur—for example, traffic generation and congestion and pressure on local services such as schools, playground and library provision.

As for recruitment of participants, we invited two distinctive local groups of residents to the two workshops. We recruited fourteen people for the first workshop all of who were active members of a community in the Borough of Wandsworth. For the second workshop we recruited nine participants who had objected to a planning application in the Borough during the last twelve months. Participants varied in computer literacy from the novice to the experienced. All respondents were white and predominantly middle class. In this regard participants were typical of those ‘active publics’ other studies of public participation in planning have recorded (Thomas, 1996; Rydin, 1998).

Both workshops were structured in three parts: an introductory plenary session, a practical ‘hands-on’ session and a focus group discussion. The introductory session outlined the basic features of the GIS and the database that was compiled for the workshop. In the second session participants worked around a free-standing PC in groups of two or three with a GIS facilitator or ‘chauffeur’—a person familiar with the GIS and the data content of the system. The facilitators demonstrated some of the basic tasks and then encouraged participants to take control of the mouse and keyboard and to navigate their own way through basic

operations of the system. The 'hands-on' session continued for 90 minutes, followed by a break and an hour-long focus group discussion moderated by an experienced member of the research team. All the discussions during the workshop were recorded and transcripts prepared**.** We used an off-the-shelf GIS package (ESRI's ArcView) in both workshops which also provided multimedia access to specially designed web pages or existing websites. For a full description of these workshops and the substantive outcome, see Boott *et al.* (2001) and Haklay and Harrison (2002).

There are four identifiable HCI and UE techniques that we have used within these studies which are discussed in turn in the paragraphs to follow:

- the reliance on chauffeurs to 'drive' the software,
- the use of software to record the interactions between the users and the system,
- the instruction to facilitators to encourage participants to verbalise their thoughts regarding the interactions and the development of a task list to guide the process, and
- the use of tasks or scenarios to obtain information about users' performance and attitudes towards the system.

The use of 'chauffeurs' has long been an established practice in studies of computer-supported collaborative work (CSCW) (Nunamaker *et al.*, 1991). This technique was identified and adopted in GIS studies in the mid 1990s by researchers who explored the potential of GIS within the CSCW framework (Shiffer 1995a and 1995b; Jankowski & Nyerges, 2001). In essence, the chauffeur acts as a mediator between those who need to use the GIS but lack the technical know-how, and the system. Hence, the chauffeur 'drives' the system on behalf of the users. In this study, this was especially valuable as, apart from the complexities of an unfamiliar GIS interface, world view and concepts that are encapsulated in the software itself, the user must be familiar with the datasets and the information they contain. Thus, without extensive training it is unlikely that an occasional user would make the most of an off-the-shelf GIS (Traynor & Williams, 1995). In terms of PPGIS research, the use of chauffeurs reduces the technical complexities that the participants experience when working with a GIS, as a professional assistant is always present. However, we did not assume that the same person would have the skills as a facilitator to guide the participants through the process and to encourage them to focus on the issues that were at the centre of the research project. Thus, in every group we had an experienced facilitator, with a solid background in conducting qualitative research plus a chauffeur to drive the system. One of the outcomes of our studies is that, in an ideal situation, it would be better to have a chauffeur/facilitator rolled into the same person as this will make the analysis more accurate and can make the whole experience more natural. This requires a high level of competency in GIS combined with qualitative research and facilitation training. Unfortunately, there is a lack of such researchers due to the internal 'cultural divide' in Geography, Urban Planning and related disciplines and it is hoped that the growing interest in

socio-technical topics such as PPGIS will bring to the fore a new generation of researchers with appropriate training.

For the purpose of analysing and understanding how users perform tasks with computers, HCI literature advocates the complete recording of the interactive session, including the audio and the computer screen. The recording can assist in analysing what the participants viewed on the screen during the session and provide a better understanding of the relationship between the specific images that appear at a specific point and the topics that were discussed. They can be used to time different tasks and evaluate the performance of participants in accomplishing them. For the purpose of PPGIS studies, the recording provided a much needed augmentation of the current practice of analysing the textual output in the form of transcripts. The session recording enables the researcher to associate the discussion to the results obtained by the users in each task, as well as to analyse the sequence of events that led to a specific comment about the system or the information obtained.

Within HCI/UE studies, the practice of asking participants to verbalise their experience with the software is aimed at understanding the users' conceptual model, especially with regard to their expectations of the system's behaviour, while performing a specific task. As we found out from encouraging the participants to discuss their thoughts while using the system, this practice was very useful within our PPGIS studies. Participants provided clear examples of the difficulties in respect of the concepts that are intermingled in the GIS package. For instance, participants with little computer experience commented on the difficulty to understand the meaning of operations such as 'zooming to active theme' as well as on terms such as 'butt', 'mitre' or 'pan'. For experienced GIS users, similar concepts together with their interfaces may be obvious and the fact that they draw heavily on multiple fields becomes unnoticeable. However, by asking the participants to express their thoughts, we could understand better some of the main limitations or intimidating factors to using a GIS for the user group.

In HCI/UE studies, the definition of tasks and task analysis is used to obtain a quantitative measure of performance in terms of the time it takes to accomplish a task, or success/failure rates (Preece *et al*., 1994). Task analysis frameworks such as Rasmussen's (1986) that aim at controlling complex processes by mapping them in a simple manner in a display, have been considered for GIS interface design and understanding complex user tasks (Kuhn *et al*. 1992). Within our studies, we have used this concept to guide the participants through a set of activities that were designed to provide a specific experience with the software, but also to explore PPGIS research issues. For example, towards the end of the hands-on session, we guided the participants to try to add information to the system on topics that did not exist in the system's database. This was based on the emphasis in PPGIS literature on the importance of local knowledge and the ability to integrate it into a GIS. By putting this 'task' on the list, without a clear definition of what type of information the participants were expected to fill in,

we encouraged them to discuss the type of information that they would like to capture, as well as the value of that information.

Finally, it must be noted that HCI/UE techniques were not the only influence on the design and practice of the workshop, as we have used qualitative research and analysis techniques in tandem with the HCI/UE ones. The use of focus groups and the methods that were used to elicit the substantive findings of the workshops go beyond the remit of this paper. Having stated this, it is clear that we would not have reached too many of the main results of the workshop without the reliance on the HCI/UE techniques.

Stage II: Using PPGIS research to improve usability

The next phase of the development occurred as a result of an initiative by the local authority to further develop their website. The London borough of Wandsworth is considered one of the most forward-looking in terms of public participation and innovative use of Information and Communication Technologies (Carver, 2001). It was one of the first local authorities to provide full access over the Internet to all the documents, which are used in its development planning (including letters of objection and minutes of the planning committee). The local authority also promotes public involvement in service delivery, and in the case of its planning department, this includes the involvement of advisory committees, community panels and attitude surveys. This innovative approach was recognised by the central Government, which recently (mid 2001) granted the Borough funds to further develop its website as part of the Government 'pathfinder' initiative towards e-government (DETR, 2001). As part of this initiative, the planning department decided to provide a wide range of services online, including the ability to complete an application for planning permission over the Internet. As the planning department was aware of our studies, we were asked to help in the design and testing of the system. While the original remit of our involvement in this project was to ensure that the system will be 'user-friendly and easy to use', we were able to advise the Borough based on the outcome of our studies and to integrate some of the wishes of the local residents into the system. Thus, our PPGIS studies contributed to the usability of the system and influenced the design and structure of a usability testing session.

Within this project we conducted a usability testing session based on common practices within the HCI and UE literature. Our approach was based on Nielsen's (1993a) 'Guerrilla HCI', which allowed us to run the tests with a relatively small group of participants and use the computer training facilities of the local authority. As for recruitment, we followed the method of the second PPGIS workshop. We sent email messages and posted letters to approximately 110 people who had objected to planning applications (either online or offline) in the last 12 months, a list that was compiled by the local authority's planning department. From this list, we recruited nine participants who were able to attend the testing session. Just as in the second workshop, participants varied in computer literacy from the novice to the experienced.

The testing session opened with a brief introduction of the reasons for conducting

the testing, its potential contribution to the design of the final system in terms of making it more accessible and easy to use for the Borough's community, as well as the role of the university team as independent consultants to the local authority. After explaining the purpose of the study, the participants were asked to start using the system and to follow a set of four specific tasks on the system:

- Task 1 was aimed at testing the navigation functionality and use of the predefined areas of interest as shortcuts to selected locations; the suitability of the background maps for providing contextual information about locations of interest. This task was also aimed at allowing the participants to explore the application for the first time to become familiar with its functionality. Therefore, the task was a simple one of finding a particular location by navigating the maps.
- Task 2 was aimed at testing the usability of the system for displaying layers of planning constraints and using the layer selection functionality for obtaining details about them.
- Task 3 built on this and included not only mapping further planning constraints but also navigating the map to compare map themes or layers and obtaining detailed information from selected planning constraints.
- Task 4 included using all the functionality they had learned, after at least 30 minutes of interaction with the application, to find information about the planning constraints for a particular building.

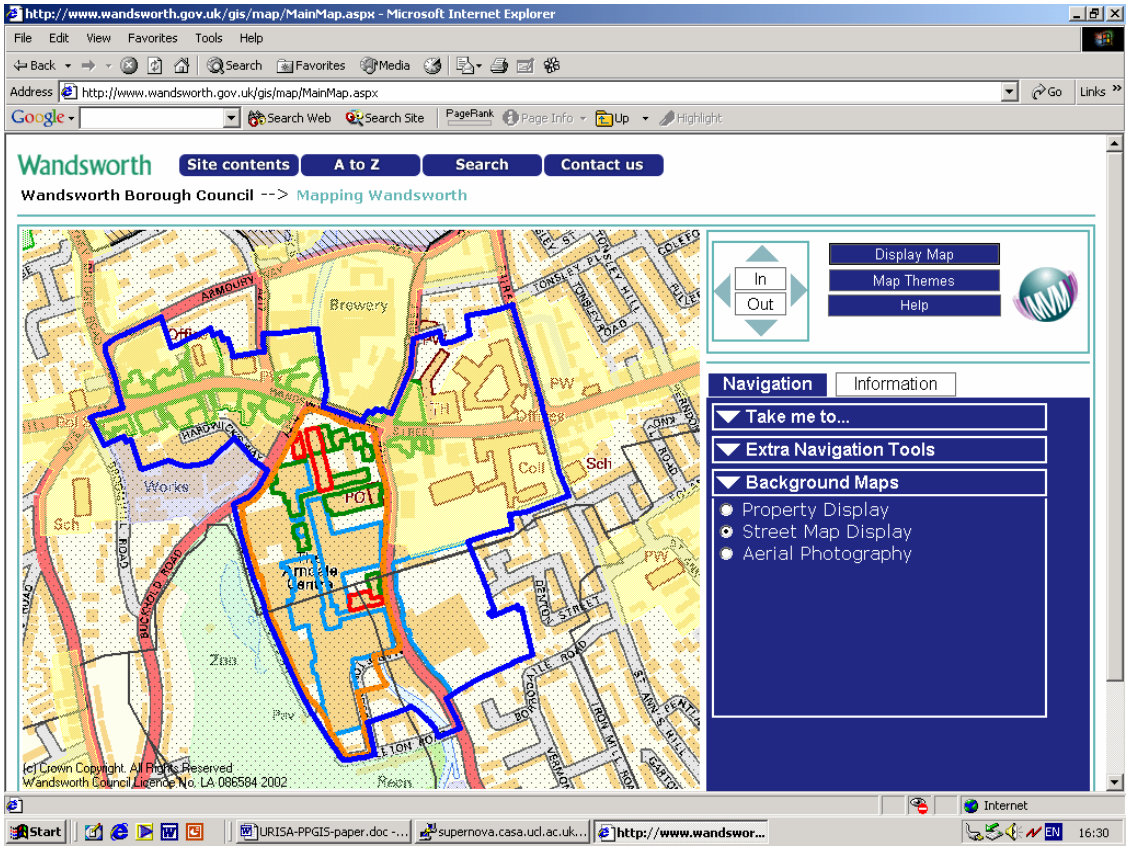
As can be seen in this list, the design was geared towards the evaluation of the system itself and our aim was to discover if the participants were successful in performing a specific task with the online application. We used recording software to capture the audio and video interactions to aid us in the analysis of the individual sessions. Each participant was encouraged to try to complete the task without help and only when it was clear that the interface was misunderstood or the participant was 'lost', an observer standing by provided hints about operating the system. The observer also completed an observations sheet to ensure that we could capture the main issues during the session. After completing the test, we asked participants to complete a questionnaire about their experience. The whole session took about 30 minutes. While the main issues and the lessons about the system that we gleaned through the usability testing were valuable and some integrated into the final system (see http://www.wandsworth.gov.uk/pathfinder/pathmappingwandsworth.htm or Figure 1), in the following paragraphs we will focus on the contribution of the PPGIS studies to this system.

Four main contributions can be identified that stem from the PPGIS studies and were integrated into the system (or were integrated into its development plan):

- alerts for planning applications,
- content and presentation of layers in the GIS,
- the navigation and control of the mapping environment, and
- the general usability of the final application.

In our PPGIS studies we found that local residents felt it was difficult to find and learn about proposed developments in their area. Within the online system, a module was devised and termed ‘My Community’ which was aimed at enabling Borough residents to interactively define a geographical area on the map that was of interest to them. Once defined, the system logs a planning application within this area and sends an email message to the user with details about relevant planning constraints, thus enabling more active participation from the user.

FIGURE 1 – WANDSWORTH COUNCIL ONLINE GIS



The way in which the system presents and integrates geographical information is based on the results of our workshops. During the early workshops, we found that participants were interested in the integration of aerial photographs with map information, so as to make it more accessible to people with limited map reading skills and to provide better contextual information about the neighbourhood and the area. Another finding of the workshops was the need for an easy and clear access to the Unitary Development Plan—a document and related maps that define the planning restrictions in different areas in the Borough and somewhat similar to zoning ordinances in the US. Participants in our workshops were interested in the ability to click on a specific area on the map and seeing which policies applied to that location, including hyperlinks to the relevant sections in the policy document. These two requests were integrated into the final system

and are available to all local residents over the Internet. During the usability sessions, participants used the different layers and followed the information on the pages to retrieve information of interest.

During the design and implementation of the online system we encouraged the developers to make the control and navigation of the map as simple as possible. The observations during the preliminary workshops suggested that even operations like zooming in and out and panning can be difficult to novice users, and that they found the concept of zooming by clicking on the map more natural than the more sophisticated method of drawing a bounding box on the screen. The final system is based mainly on one click navigation (zoom in, out and panning the map), while advanced navigation functionality is separately available. Furthermore, to get information from the system, the user only needs to click on the map while the information panel is visible.

Finally, the usability test contributed to improving the final system interface in terms of enabling non-expert users to use it more efficiently and purposefully. By running a usability test, the developers and our research team were able to locate and remove some problems with the interface. Some of these included: lack of feedback after the user had issued a command to indicate whether the system was performing any operations; lack of visual guidelines on the interface to indicate how commands were expected to be triggered; and a selection of symbology on the map and layer representation that made it difficult to read the map at some zoom levels. By ensuring that the final application was more usable and accessible, the online GIS can potentially be used by more people and increase their participation.

TOWARDS A USER-CENTRED DESIGN, DEVELOPMENT AND DEPLOYMENT CYCLE

Based on the process that the three studies started, we can envisage an iterative development cycle for PPGIS projects. By and large, such a cycle should be based on the concept of user-centred design, development and deployment as suggested in the HCI literature (Landauer, 1995; Preece *et al*., 1994). While such development is generally recommended on the premise that the system implementation is more likely to be successful, within a PPGIS setting this can prove to be vital in ensuring that the system achieves the goals of improving participation and opening up new arenas for public involvement in planning and management processes. As Elwood (2002) noted, the use of software is at the same time an empowering and disempowering process and despite advances in the Graphical User Interface (GUI) design of modern GIS, these systems still require users to hold a wide range of skills and background knowledge to operate them. This presents major obstacles for occasional or novice users, or those not interested in investing a considerable amount of time to acquire such skills.

It is significant that the sophisticated interface of advanced Web-based GIS such as ArcIMS, is using all the complex terminology and iconography of a full-scale GIS. For many users, such an approach means that the system is less

accessible and intimidating. As number studies have demonstrated, in some cases users are reluctant to ask for assistance as this is perceived as degrading or associated to social costs (Harris, 2000). Considering the range of operations that are common in the PPGIS literature (mainly local data entry and spatial queries), there should be a way to deliver this functionality within an application that is as easy to use as buying a book over the Internet or sending an email message.

As was shown, a user-centred design approach to PPGIS projects will not just contribute to the project itself but will also provide, as a by-product, rich and detailed accounts about the ways in which different users with a diversity of backgrounds and needs use GIS to advance their own goals. This means that such an approach contributes substantially to the way in which we understand how PPGIS operates as a socio-technical object. Although we have not fully analysed the transcripts of the usability session, there are some discussions and opinions about the system that are very similar to the other two workshops. In a broader project, it can be envisaged that the cycle will move on by observing the ways in which the intended users use the final system over a period of time. Using techniques such as online questionnaires or analysis of the system's log files—which record every interaction between the end-user and the system—the system designer can learn about how the system works and continue to improve it if necessary. In general, PPGIS projects should be seen as an open-ended process in which the system is being developed and adapted to the changing needs of the local community and where designers and maintainers must be sensitive to the changing goals and objectives of their end-users.

There are, of course, some issues to consider. For example, in a Web-based environment the log files can be adapted in such a way that they will provide a full account of the session and become material for research. Doing so without prior notification to the end-user amounts to surveillance and can undermine the confidence of users and their trust in the system designers. Thus, within PPGIS projects, it is doubly important to use a transparent design approach and to advise the users if such forms of interaction recording take place (and possibly to allow users to opt in or opt out of being recorded).

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

In this paper we have presented the connection between Human-Computer Interaction (HCI) and Usability Engineering (UE) and PPGIS. We have demonstrated how this connection is not just natural but also very valuable within the societal stance of PPGIS. Building on our case studies, we have suggested the adoption of the user-centred design, development and deployment approach to PPGIS projects, pointing to the main issues that ought to be taken into account when adopting such methods. There are, however, other aspects of current activities in GISc research that relate to HCI and that can be integrated into PPGIS research. First, the development of tools in the area of geographic visualisation (GVis) that allows the interactive and dynamic exploration of spatial data has renewed the interest in human factors of GI. These tools rely on the

users' perception of visual stimuli (Gahegan 2001), which in turn depends on the GUI supporting defined users' tasks. The type of tasks that these systems can support is yet to be fully understood. Research in this area may illuminate how we can better support the visual exploration of spatial data, which can be of significant value in some PPGIS settings. Second, issues surrounding naïve geography (Egenhofer & Mark, 1995) and the representation of knowledge in ways that can accommodate local perceptions and 'mental maps' can be valuable to approach and integrate local knowledge in PPGIS. Finally, natural spatial queries, such as the work on 'query by sketch' (Egenhofer 1997) can provide ways to interrogate spatial databases that reflect human understanding of spatial knowledge rather than the system's architecture (Freundschuh & Egenhofer, 1997). These are just a few of the areas that are relevant for current PPGIS research.

Probably the most important lesson from our project is that ease of use and user friendliness are characteristics of software that are more elusive than they first seem to be. Even if the PPGIS designers believe that they have managed to create something that is easy to use, only appropriate testing—even using simple methods such as Nielsen's—will show if the design is successful in meeting users' needs or not. It seems to us that in PPGIS projects, this is not just a technical obligation, but also a moral one.

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