AN EMPIRICAL USABILITY EVALUATION OF A WEB-BASED PUBLIC PARTICIPATION GEOGRAPHIC INFORMATION SYSTEM AND DISCUSSION FORUM

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PREFACE

This technical report is a reproduction of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering in the Department of Geodesy and Geomatics Engineering, August 2007. The research was supervised by Dr. David Coleman and support was provided by the Natural Sciences and Engineering Research Council of Canada.

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Dedication

To,

my parents

and

in loving memory of my grandfather.

Abstract

The study of Public Participation Geographic Information Systems (PPGIS) focuses on the use of GIS by non-experts and regular citizens, which requires that such systems be accessible and easy to use. Review of PPGIS literature reveals, however, a lack of documented research about how non-expert users and the general public are using PPGIS tools.

Building on earlier PPGIS research, a GIS-enabled Online Discussion Forum prototype named GeoDF has been implemented and evaluated. In this thesis, Human-Computer Interaction (HCI) principles are drawn upon and a rigorous set of usability evaluation procedures are designed to empirically evaluate the usability and user acceptance of the GeoDF software.

Evaluation results confirm that the *GeoDF* is not only an effective communication platform, but also a useful participatory tool that encourages participants to be more involved in land use planning procedures. Results also show that by enhancing usability, lowering the cost of entry, and providing effective communication channels would result in greater user acceptance of the PPGIS technology. A two-sample t-test analysis proves the research results to be statistically significant.

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I sincerely appreciate Dr. David J. Coleman, my supervisor, for his guidance and support throughout the entire research. His encouragement, valuable suggestions, and stimulating discussions have guided me to PPGIS research and considerably improved the quality of this research. The three years of study and research with him have been one of the best periods in my life.

I would also like to express my gratitude to Teresa Tang, for building up the foundation of this research, sharing her knowledge, and providing technical support on the implementation of GeoDF.

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Thanks also goes to the test subjects who willing took part in the usability experiment. Their valuable comments and inputs were greatly appreciated.

Finally, a very special thank you to all members of my family especially my parents, for their love and support throughout my study in Canada.

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List of Abbreviations

AD	Anderson-Darling
AHD	Areas of Hottest Discussion
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
CSUQ	Computer System Usability Questionnaire
CTG	Community Technologies Group
ESRI	Environmental Systems Research Institute
HCI	Human Computer Interaction
HTML	HyperText Markup Language
I19	Initiative 19
ICT	Information and Communication Technology
IIT	Institute for Information Technology
IT	Information Technology
GeoDF	GIS-Enabled Online Discussion Forum
GGE	UNB Department of Geodesy and Geomatics Engineering
GIS	Geographical Information System
GUI	Graphic User Interface
NGO	Non-Government Organization
NBLA	New Brunswick Lung Association
GRO	Grass Roots Organization
PEOU	Perceived Ease of Use
PPGIS	Public Participation Geographic Information System
PU	Perceived Usefulness
REB	Research Ethics Board
SE	System Error
SWOT	Strength, Weakness, Opportunity, and Threat
TAM	Technology Acceptance Model
TNC	Task Not Completed
TOC	Table of Contents

UCGIS	University Consortium for Geographic Information Science
UI	User Interface
UNB	University of New Brunswick
V0	Version 0
V1	Version 1
V2	Version 2

Chapter 1

Introduction

As is evident from the increasing amount of information available to the public at the the touch of a few keys, governments have caught on to the “point-and-click” phenomenon. Most government Web sites offer vast arrays of facts about governmental structures, laws, special initiatives, and geography. Information requests are often accommodated by providing links to related sites.

As the Information Technology (IT) revolution has changed the role of government, community organizations, citizens and their relationships to each other by introducing powerful new tools of communication within the private and public sectors, Ammouri [2002] affirms, in a networked society, Information and Communication Technologies (ICTs) have enabled citizens to have a more active role in public service delivery. Canada has been at the forefront of this e-government revolution. According to the annual report of the Canadian Government Online program [Government of Canada, 2006], online services account for 30% of public sector transactions. Consequently, social demand for participation in the planning process is on the rise and public participation has become vital to the land use planning processes.

ICTs overcome temporal and geographical barriers to exchange of information and have, potentially, a huge impact on the most critical process in collaborative decision-making: how and whether people communicate [Sproull and Kiesler, 1991]. Geographical Information Systems (GIS) and Web-mapping tools have been introduced into traditional community planning[1] procedures to facilitate collaboration among participants so that concerns about the geographic environment may be resolved.

Some researchers view new technologies such as ICTs, GIS, Web-mapping and the Internet as powerful tools that facilitate democracy and promote equal opportunity; others suggest that they do not simply just cross time and space, but also cross hierarchical and departmental barriers and empower citizens in the decision-making processes. Lacking empirical evidence, however, it is difficult to know whether or not technological advances lead to improvements suggested by their proponents.

1.1 Background

A growing body of research on Public Participation Geographic Information Systems (PPGIS[2]) has emerged as a result of the use of Web-mapping and spatial analysis in participatory planning processes. Because community planning deals with issues that have implicit or explicit geographical dimensions, maps and GIS are frequently used to facilitate discussion. PPGIS applications, which involve relevant stakeholders (including but not limited to individual citizens, developers, interest groups and government officials), are established to find consensual solutions

[1] The term "community planning" is most often interchangeable with "urban planning" and "city planning" in planning literature.

[2] Sieber [2001], Schlossberg and Shuford [2005], and Tulloch [2003] state that the "S" of PPGIS should stand for "Science" rather than "System". Other scholars have stated that the use of PPGIS is inconsistent across applications and uses, therefore, the readers are advised to verify the term's meaning in context.

to given challenges by encouraging and promoting informed citizen involvement in policy formulation and decision-making [Obermeyer, 1998]. The increasing need for information and the availability of geospatial data on the Internet make Web-based PPGIS applications more and more widespread [Chua and Wong, 2001].

An extensive literature review of recent PPGIS research and applications reveals an emphasis on the technological aspects involved in developing PPGIS applications. A large number of Web-mapping tools and methods have been developed and made accessible to the general public [Kingston, 2002; Evans et al., 1999; Kesler, 2004; Voss et al., 2004]. PPGIS, especially Internet based applications, are designed to be used directly by the public, a very heterogeneous group of users with a diverse range of world views, cultural backgrounds and knowledge. These aspects require that the PPGIS be readily accessible and easy to use. There is, however, a surprising lack of documented research about how citizens are using PPGIS tools. To date, relatively few research have explored whether or not technological advances lead to enhanced rates of participation.

Although GIS has been accepted as the best method of handling and analyzing spatial data [Carver, 2003], GIS has been deemed still far too complex to be used effectively by nonprofessionals [Pickles, 1995]. Although the usability of GIS products has improved immensely, many still require users to have considerable technical background and mapping-related knowledge to operate them effectively [Traynor and Williams, 1995]. Human Computer Interaction (HCI) is thus vital to the success of PPGIS.

HCI is concerned with the usability or effectiveness of the interaction between people and machines, and the ways in which computers affect individuals, organizations and society [Butler, 1996]. Therefore, applying HCI principles in PPGIS research would help researchers better understand user expectations and how citizens deploy, understand, and value the system [Haklay and Tobon, 2003]. Quantitative and qualitative data acquired from empirical study provides valuable information on the role of PPGIS within a wider societal context, but in existing PPGIS literature, researchers and practitioners have focused more on the development of theoretical frameworks than on the practical implementation of PPGIS applications [Steinmann et al., 2004]. Lacking empirical evidence, certain questions remain unanswered:

- How do different stakeholders react to using technology?
- How much are different stakeholders willing to interact by means of a computer?
- How effectively do these technologies encourage and increase local citizen participation?
- How can it be ensured that different stakeholders have equal rights to participate and hierarchical, bureaucratic barriers are reduced or eliminated?
- Does a "digital divide" remain for some, and what is its nature?
- Does a "cultural divide" exist between GIS experts/developers and non-expert participants?
- How can PPGIS tools best be integrated with existing information systems and infrastructure in land use planning procedures?

This research, which began with these questions, presents an empirical assessment of the usability of a PPGIS application and evaluates whether or not these technologies lead to better public participation. This research further documents how and when the public currently employs PPGIS tools.

1.2 Research Context

Two other PPGIS research projects have been conducted in the Geodesy and Geomatics Engineering Department (GGE) of the University of New Brunswick (UNB) prior to this research. In 2002, a prototype virtual workplace, "Land Gazette 2000"(LG2000), was designed to enhance government service delivery and citizen participation [Ammouri, 2002]. The prototype provided IT tools and static maps to enable better citizen communication with the municipal government; map-based public input was incorporated into the process. The LG2000 research identified the need for, and feasibility of, applying IT to facilitate public participation.

In the second PPGIS research project, which took place from 2004-2006, a GIS-Enabled Online Discussion Forum (*GeoDF*) prototype system was designed and developed by Teresa Tang [2006] to enhance location-related discussion. The design and development of Tang's *GeoDF* prototype identified that PPGIS can not only enable exploration of spatial data, but may also be used as a platform to facilitate the exchange of ideas.

1.3 Objectives

The research projects mentioned above emphasize the design and development of a new set of communication tools to improve public decision-making procedures. Built on existing research, the primary objective of this study was to empirically evaluate the *GeoDF* software in the belief that improved usability and enhanced social collaboration will increase the effectiveness of social cooperation and result in greater participation. In particular, the research aimed at

- Implementing the *GeoDF* prototype in conjunction with government partners to evaluate usability and user acceptance of the software; and

- Continuing evaluation and development of the *GeoDF* prototype with the objective of refining and optimizing software capabilities based on user feedback.

The degree to which these objectives were achieved was assessed by means of quantitative metrics and qualitative observations. Analyses were based on interviews, focus group studies, user surveys and usability test workshops with selected government partners, city residents and campus volunteers. The following criteria were used to measure the degree of acceptance of the *GeoDF* prototype as a means of public participation:

- Usefulness
- Ease of use
- Cost of entry
- User demographic
- User satisfaction

"*Usefulness*" refers to whether the goals of participatory planning can be achieved with the use of the *GeoDF* prototype; "*Ease of use*", to whether the participants found the prototype user-friendly; "*Cost of entry*", to the level of user physical and mental investment while interacting with the prototype; "*User demographic*", to the demographic background of users testing the prototype; and "*User satisfaction*", to the degree of positive regard or emotion that users attribute to the interaction with the prototype.

Detailed qualitative and quantitative analysis is presented in Chapter 3 and Chapter 5 respectively.

1.4 Hypothesis

One of the most important goals of a democratic planning process is to involve citizens and stakeholders in the planning process and from the earliest possible opportunity [Hansen and Prosperi, 2005]. The effectiveness of any such process is largely determined by the degree to which administrative authorities, planners, and members of the public can work together [Hodge, 2003]. Mutual trust, engendered by good communication, is vital.

This study focused on optimizing the existing *GeoDF* prototype so as to facilitate online interaction in participatory planning. The improved prototype integrates social collaboration tools, Web-mapping tools, and participatory techniques. It was hypothesized that enhancing the usability of the *GeoDF* prototype, lowering the cost of entry, and providing effective communication channels would increase the degree to which the general public, planners, and authorities work together, which would in turn improve the social awareness of individual participants and, thus, greater participation.

1.5 Methodology

The study's methodology was based on the author's internship experience at Community Technology Group (CTG), Microsoft Research, where she worked with several experienced HCI researchers and was exposed to various usability evaluation techniques. The author also incorporated HCI principles and usability evaluation techniques from usability engineering literature, as well as recommendations from experienced HCI researchers at the Institute for Information Technology (IIT) of the National Research Canada (NRC). Figure 1.1 illustrates the approach adopted to achieve the research objective.

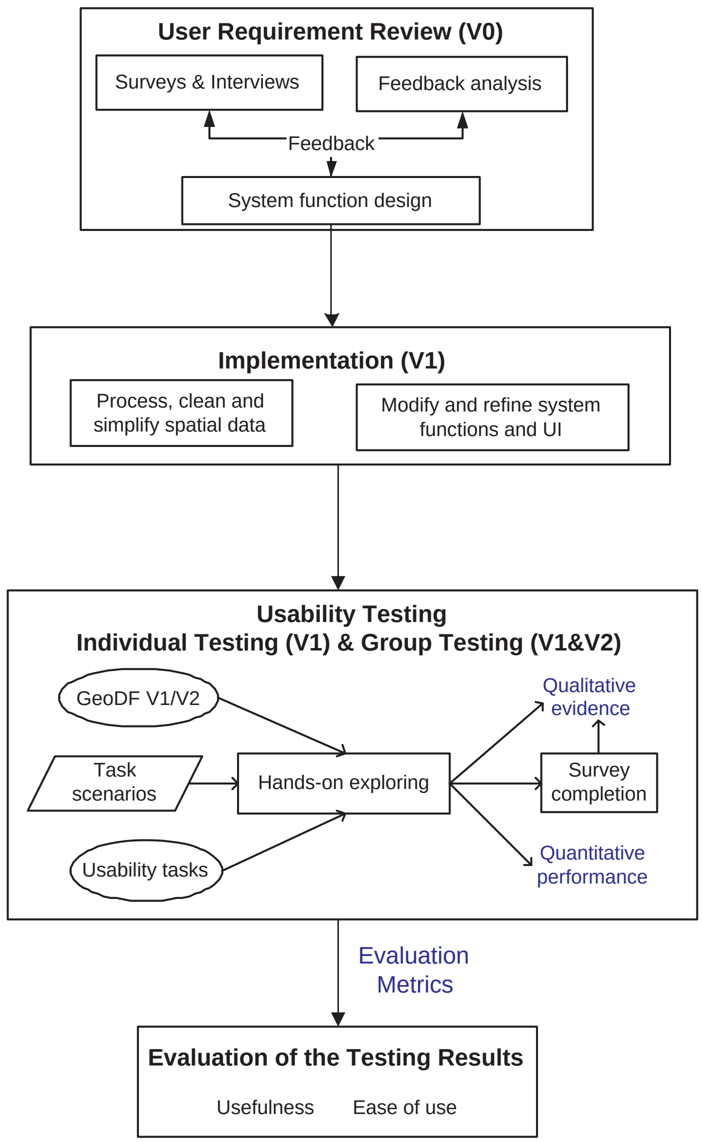


Figure 1.1: Research methodology

- **Literature Review:** A literature review was conducted to understand existing theories and practices concerning PPGIS, HCI, usability evaluation, Web technologies, wikis, tagging, and Web 2.0 social networking - all important aspects of this work.

- **User Requirements Review:** Tang [2006] implemented her *GeoDF* prototype as a "proof of concept": she designed the system based on an extensive literature review and implemented key components and features at minimum developmental costs. To analyze *GeoDF*'s potential as a "real world" application, the types and levels of additional functionalities needed in prototype Version 0 (V0) has to be determined. In order to facilitate equal access to information, an Information User Requirements review that included surveys was conducted. Interviews with 11 program managers and technical support staff of the City of Fredericton and New Brunswick Lung Association (NBLA) – two organizations heavily involved in planning processes involving public consultations – were completed. The objective of the interviews and surveys was to discover user requirements for tools and functions, and thus enable better community participation in the planning process from the perspective of those responsible.

- **Implementation:** Feedback and comments gathered from meetings with the city and NBLA, were analyzed, served as refinement guidelines for additional system functionalities. The User Interface (UI) and *GeoDF* functionalities were optimized and modified based on feedback from the User Requirements Review phase. Spatial data were also processed, cleaned and simplified according to usage requirements from the data provider, the City of Fredericton. An heuristics evaluation [Nielsen, 1993] was carried out to identify general usability defects of the *GeoDF* V0. The end product of the

User Requirements Review and implementation phase was a refined prototype: *GeoDF* Version 1 (V1).

- **Usability Evaluation:** A two-stage usability evaluation test plan was designed according to the usability testing procedures. First, an observational evaluation [Nielsen, 1993] was carried out to identify the general usability defects of the *GeoDF* V1 (see Chapter 4). Five participants were recruited by personal invitation and individual one-on-one meetings were conducted. These five participants' interaction with the *GeoDF* V1 were video-taped and comments audio-taped during the test. This process was carried out until the encountered problems started to repeat and not much new was found - 5 times for this study. Next, group evaluation workshops were organized. Usability defects found in *GeoDF* V1 were fixed beforehand according to stage 1 feedback. The improved version – Version 2 (V2) together with *GeoDF* V1 – were presented to two different sets of participants. Group workshop participants were recruited using a snowball[3] sampling procedure from academic and non-academic backgrounds. At the end of both stages, the participants were asked to fill out two questionnaires geared towards usability and user acceptance of the prototype.

- **Results Analysis:** For *GeoDF* V1, video and audio tapes of individual testing sessions were annotated and analyzed to measure how long each task took for the user to complete, and how many errors participants made. Users' mental, physical, and performance demand were measured by annotating audio recordings and videotapes, questionnaires, feedback and comments gathered during each one-on-one meeting. Users ratings gathered while testing

[3]The snowball method refers to that once a contact person has been recruited, s/he will be asked to put us in contact with people who might be interested.

GeoDF V2 were then analyzed and compared with ratings of *GeoDF* V1 so as to measure whether or not the research hypothesis was correct. Usability evaluation results were analyzed and summarized to reflect lessons learned from the City of Fredericton experience, as well as recommendations, limitations, and trends for future development and implementation of PPGIS applications.

1.6 Significance of the Research

Implementation of the *GeoDF* prototype makes a positive contribution to local municipalities, non-governmental organizations and society at large. The empirical study:

- Provides a foundation for further research on public participation and the public's collaborative behavior in a group based environment;
- Reinforces the link between the research community and potential users by providing tips to improve user response, as well as greater and wider communication of functionalities and methodology;
- Adds value to existing IT and GIS by providing a user-centered design guideline;
- Provides a public participation tool usable by non-specialists;
- Decreases the time and cost of public participation by providing more efficient tools; and
- Improves the understanding and cooperation of the general public in civic planning and decision-making processes by means of spatially-anchored discussion threads.

1.7 Thesis Organization

The thesis is organized into six chapters. Chapter 1 provides an overview of the research as well as the objectives and approaches. The scope and significance of the research. Chapter 2 discusses existing research about theories and principles of public participation in the context of community planning decision-making; it shows the need for this research. Chapter 3 develops the evaluation criteria; Chapter 4 presents the usability experiment procedures. Chapter 5 analyzes the results and makes recommendations; Chapter 6 summarizes the work herein completed and suggests opportunities for future research.

Chapter 2

Public Participation GIS in Community Planning

As Sproull and Kiesler [1991] point out, "the consequences of new technology can be usefully thought of as first-level, or efficiency, effects and second-level, or social system, effects... People are likely to emphasize the efficiency effects and underestimate or overlook potential social system effects...". Looking beyond efficiency at "behavioral and organizational changes", they say, allows insight into second-level leverage that is, social effects.

Decades ago, community planning was characterized by strict, top-down, hierarchical planning mechanisms. Most people generally obeyed planning authorities without questioning their decisions; only a few became involved unless there was strong opposition to a proposed plan. Especially over the past decade, citizens have become more and more conscious of their perceived powerlessness and have begun to demand far more involvement in decision-making procedures [Innes and Booher, 2000; Ghose and Elwood, 2003]. In order to execute planning tasks in a more cooperative way, integrative capabilities and support in decision-making processes were required from engagement with new technologies. It is not until recently that advances in ICTs have created tremendous opportunities for multi-directional communication. Advances in Web-based GIS and Web-mapping have allowed easier access and dissemination of spatial information among the general public. As this evolution has occurred, GIS research has expanded into the broader public domain and covered by one umbrella term: PPGIS [Evans et al., 1999; Chua and Wong, 2001; Kingston, 2002; Kesler, 2004; Voss et al., 2004; Tang, 2006]. Questions have arisen concerning whether and how such technologies lead to the improvements suggested by PPGIS proponents: increased trust of government, increased participation rates, increased quality of participation, increased social inclusion, and more efficient decision making [Kingston, 2002; Craig et al., 2002].

This chapter highlights current uses of geographical information to facilitate wider involvement of the general public in the decision-making process. It also reviews the development and technical efficiency of Web-based PPGIS applications and human factors that influence acceptance of PPGIS technology in a societal context. System features and functionalities of the *GeoDF* software prototype (V0) are then introduced. Because of the wide range of possible users in the target user group, the *GeoDF* must be accessible and easy-to-use at all levels – the motivation for this study. The missing link between HCI research, usability evaluation, and PPGIS is identified and a brief history of HCI research discussed, followed by a detailed review of usability studies in the PPGIS research field. Prior PPGIS research established a basis for the user requirements review, as well as the implementation and evaluation of a modified *GeoDF* prototype. Details are in subsequent chapters.

2.1 Public Participation

Craig et al. [2002] defined public participation a key issue in a democratic society as “grassroots community engagement”. At the community level, public participation has long been recognized as an important component of the planning process, for it facilitates involvement of citizens in social and economic change [Carver, 2003]. Public participation occurs in areas such as environmental planning, rural development, urban regeneration, and transport allocation [Craig et al., 2002]. Here, the focus is on improving involvement of the public in land use community planning.

Tang [2006] noted in her thesis that local knowledge is crucial for planning authorities to better understand a neighbourhood, and decision-makers have therefore begun to acknowledge the benefits of public participation, which provides formal channels for collection of local wisdom and knowledge. As people have become more informed through a variety of communication channels, they are noticeably more conscious of decisions made on their behalf. When the public is more involved in the planning process, it is more likely that interests of the participants can be better reflected in the final outcome, giving social legitimacy to proposed changes.

The ultimate goal of public participation is the facilitation of consensus building and to the integration of “well developed citizen opinion into collective actions and decisions” [Innes and Booher, 2000]. In order to achieve this, proponents must properly collect and act upon evidence, opinions, and perspectives from all interested or affected stakeholders, and from the earliest possible stage of planning [Hansen and Prosperi, 2005]. Until relatively recently, however, participation has often been limited to the voting process.

To achieve better democracy and increased public participation, it is believed a better understanding of stakeholders' participation would result in more accurate project outcomes. Schlossberg and Shuford [2005] describe public participation in two broad areas:

1. It is characterized broadly in terms of power, e.g. Arnstein [1969]'s participation ladder; or
2. Delineations of types of participation techniques.

2.1.1 Defining the "Stakeholders"?

Hodge [2003] defines community planning as a process whereby "stakeholders" decide upon their local area's future environment. Who are the stakeholders? Are they special interest groups, individuals, government officials, business owners, or neighborhood associations? "Stakeholder" is often defined as "one who has a share or an interest, as in an enterprise", a definition implying any group or individual who can affect, or is affected by, decision-making procedures. Schlossberg and Shuford [2005] further propose that stakeholders can be grouped into at least three general categories:

1. Those affected by a decision or program;
2. Those who bring important knowledge or information to a decision; and
3. Those who have power to influence and/or affect the implementation of a decision.

Here, stakeholders include players in New Brunswick's land use management decision-making process: appointed officials, and elected officials, special interest groups, and individual citizens.

2.1.2 Degrees of "Participation"

Stakeholders participate differently because of variations in inclination or skill. The level at which the general public is involved varies with legislation and the attitude of other stakeholders [Hansen and Prosperi, 2005]. Craig et al. [2002] stated that for public participation to be effective, it requires the public to be well informed and kept aware of possibilities to participate. Depending on the needs of the situation and the disposition of those in control of decision making, public participation in community planning has ranged from evasion to full empowerment [Hodge, 2003].

Arnstein's Ladder of Citizen Participation [Arnstein, 1969] frames participation in terms of citizen power. Arnstein's ladder specifies eight rungs (incorporating three levels) of citizen participation corresponding to different purposes, which range from zero opportunity to participate to full public control and responsibility for final decision. Arnstein's ladder describes the potential reversal of power structures by means of public involvment (See Figure 2.1, left).

Weidemann and Femers [1993] adapted this theory to environmental decisions about hazardous waste management, revising Arnstein's concept: involvement increases with the level of access to information as well as knowledge of citizen rights in decision-making processes (see Figure 2.1, middle). According to Wiedemann and Femers, higher rungs can only be reached by fulfilling all requirements of the ladder's lower rungs, a theory considered more applicable to today's planning context.

Smyth [2001] provided an "e-participation ladder" to account for advances in the Internet technologies. The bottom rung of Smyth's ladder represents online delivery of government services, where the flow of information is only one-way: from the government to citizens. Climbing up this "e-participation ladder", Internet use enhances the degree of interactivity and participation, according to Smyth. At the upper rungs, ICT tools not only break communication barriers, but also enable multi-directional communication through sharing of information (see Figure 2.1, right).

<table>
<tr><th></th><th>Arnstein</th><th colspan="2">Weidemann and Femers</th><th>Smyth</th><th></th></tr>
<tr><td rowspan="6">Increasing level of participation ↑</td><td rowspan="2">Citizen power</td><td>Public participation in final decisions</td><td>Rung 6</td><td rowspan="2">Online decision support systems</td><td rowspan="6">Increasing level of communication ↑</td></tr>
<tr><td>Public participation in assessing risks and recommending solutions</td><td>Rung 5</td></tr>
<tr><td rowspan="2">Tokenism</td><td>Public participation in defining interests, actors and determining agenda</td><td>Rung 4</td><td>Online opinion surveys</td></tr>
<tr><td>Public right to object</td><td>Rung 3</td><td>Online discussion</td></tr>
<tr><td rowspan="2">Non-participation</td><td>Informing the public</td><td>Rung 2</td><td>Communication barrier</td></tr>
<tr><td>Public right to know</td><td>Rung 1</td><td>Online service delivery</td></tr>
</table>

Figure 2.1: Three participation ladders
Arnstein [1969], Weidemann and Femers [1993]'s ladder, and Smyth [2001]'s E-participation ladder

Scholars and practitioners worldwide have used the "ladder analogy" to design and evaluate citizen participation processes. The next section presents the taxonomy of conventional participation. The ladder typology is used to assess public participation and its development over time.

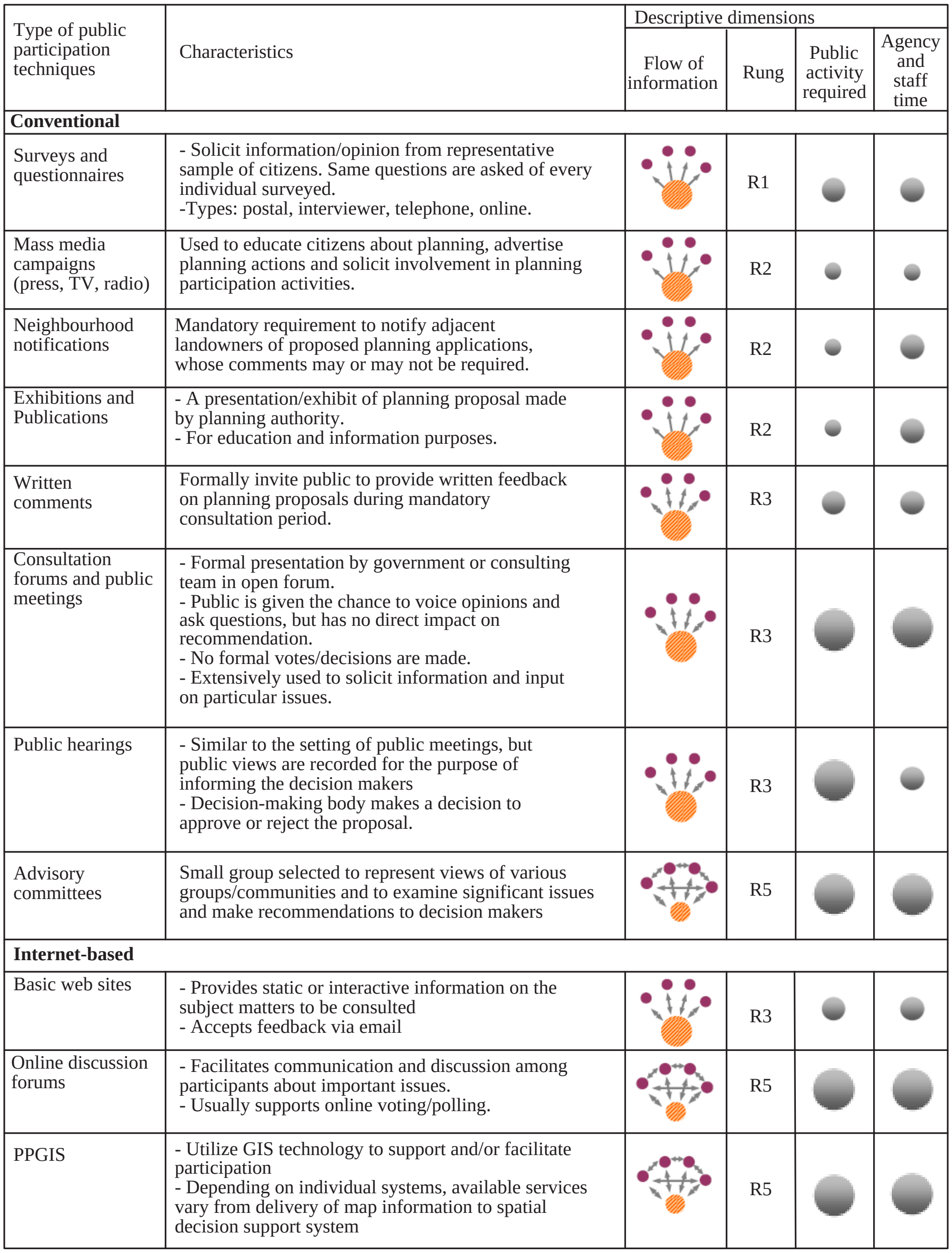
2.1.3 Taxonomy of Public Participation Techniques

Many techniques were developed to facilitate dialogue among various stakeholders and to improve public decision making outcomes. At the plan preparation stage, for example, surveys and questionnaires are commonly used to collect background data. At the interim stage, public meetings are often conducted to obtain input concerning preliminary drafts. Moore and Davis [1997] first classified participation techniques in the context of land use planning. Tang [2006] shows the distribution of decision-making power and flow of information according to corresponding level on the Wiedemann and Femers ladder. In Figure 2.2, frequently used methods are also summarized. Alongside each method, characteristics of the method, the flow of information, the degree of public activity required, and the degree of agency or staff time required are presented based on Wiedemann and Femers participation ladder.

2.1.4 Drawbacks of Conventional Techniques

Many researchers, for example, Sanoff [1990] and Carver et al. [2001], have criticized conventional methods for possessing disadvantages that limit the degree of public participation:

- Planners have difficulty communicating effectively with participants who may not understand basic concepts of design and map reading;
- Planning meetings separate speaker and audience. Such meetings reinforce the feeling that authoritative decision-makers are keepers of knowledge and that an ill- or partially-informed public sets the stage for confrontation;
- Meetings often have a fixed time and place, excluding from participation those with other time commitments;
- Conventional public participation strategies are based upon managerial face-to-face meetings. However, planning meetings can easily be dominated by a "vocal minority" and potentially result in unequal participation;



Type of public participation techniques	Characteristics	Descriptive dimensions: Flow of information	Rung	Public activity required	Agency and staff time
Conventional					
Surveys and questionnaires	- Solicit information/opinion from representative sample of citizens. Same questions are asked of every individual surveyed. -Types: postal, interviewer, telephone, online.		R1		
Mass media campaigns (press, TV, radio)	Used to educate citizens about planning, advertise planning actions and solicit involvement in planning participation activities.		R2		
Neighbourhood notifications	Mandatory requirement to notify adjacent landowners of proposed planning applications, whose comments may or may not be required.		R2		
Exhibitions and Publications	- A presentation/exhibit of planning proposal made by planning authority. - For education and information purposes.		R2		
Written comments	Formally invite public to provide written feedback on planning proposals during mandatory consultation period.		R3		
Consultation forums and public meetings	- Formal presentation by government or consulting team in open forum. - Public is given the chance to voice opinions and ask questions, but has no direct impact on recommendation. - No formal votes/decisions are made. - Extensively used to solicit information and input on particular issues.		R3		
Public hearings	- Similar to the setting of public meetings, but public views are recorded for the purpose of informing the decision makers - Decision-making body makes a decision to approve or reject the proposal.		R3		
Advisory committees	Small group selected to represent views of various groups/communities and to examine significant issues and make recommendations to decision makers		R5		
Internet-based					
Basic web sites	- Provides static or interactive information on the subject matters to be consulted - Accepts feedback via email		R3		
Online discussion forums	- Facilitates communication and discussion among participants about important issues. - Usually supports online voting/polling.		R5		
PPGIS	- Utilize GIS technology to support and/or facilitate participation - Depending on individual systems, available services vary from delivery of map information to spatial decision support system		R5		

Figure 2.2: Descriptive dimensions of public participation techniques.

(extended from Ball, 2002; Tang, 2006. The size of the dot indicates the level of involvement: low, medium, or high)

As depicted in Figure 2.2, most conventional means of public participation can reach Rung 3 of the Wiedemann and Femers' ladder, a two-way flow of information. Most of the time, planning meetings are used by governments and the planning authorities to inform the public and convince the public to adopt proposals. The public is invited only to vote "for" or "against" rather than express new ideas, maintaining power in the hands of paid employees and government officials.

2.1.5 Comparing Conventional and Wed-based Public Participation

There is a wide consensus that participation in planning processes is positive and should be supported by new technologies [Craig et al., 2002; Kingston, 2002], thus many techniques have been developed to foster it. Previous research by Ammouri [2002] on using Internet-based methods demonstrated that the Internet is encouraging formation and proliferation of online communities by facilitating formal and informal communication within and among government, private, and non-profit sectors. Compared to conventional methods, ICT brings several advantages:

- Participation is not limited to any fixed time and location. Access to information is 24/7 (e.g. 24 hours a day, 7 days a week) and not necessarily geographically constrained;
- Participants can express their views in a relatively anonymous and less confrontational manner, which often reduces domination by a "vocal minority";
- The consultation process is less structured and can be tailored for public consumption;
- The participation process is accessible to anyone with an Internet connection;

- Participation is more cost-effective. Online systems can be used to help educate users at their convenience, and terms defined and illustrated to convey complex concepts.

Al-Kodmany [2002] found that even residents who had lived in an area for a long time had difficulty remembering small details about specific sites, which hinders their ability to apply their knowledge and expertise. Because planning issues are concerned with geographic matters and many planning decisions are spatial decisions, GISes have been used for over two decades to facilitate community planning. Nonetheless, technology cannot ensure an outcome is well-accepted by the public unless it is actively involved in the process.

2.2 Public Participation GIS

PPGIS research calls for widening public participation in the planning process and aims at developing a GIS that is adaptable to "input from ordinary citizens and other non-official sources" [Obermeyer, 1998; Chua and Wong, 2001; Sieber, 2001; Kingston, 2002; Craig et al., 2002; Steinmann et al., 2004; Kesler, 2004; Tang, 2006].

By the mid 1980's, the potential of GIS for planning had been observed by many scholars. Innes and Simpson [1993] realized that they could design GISes primarily for expert use or make them accessible to lay professionals and the general public. In June 1996, the University Consortium for Geographic Information Science (UCGIS) met and developed a set of ten GIS research initiatives. Initiative 19 (I19) "*GIS and Society: the social implications of how people, space, and environment are represented in GIS*," focused on assessing the value of GIS at the local level. Questions were raised, including how GIS would affect relationships between government agencies and citizen groups associated with those agencies, and whether GIS could be used to increase participation in public decision making.

The concept of PPGIS came from I19, which defined PPGIS as “a variety of approaches to make GIS and other spatial decision-making tools available and accessible to all those who have a stake in official decisions” [Schroeder, 1996]. The definition set the stage for active involvement by PPGIS researchers, who broadly diffused GIS technology to those normally outside of the GIS mainstream: non-governmental organizations (NGOs), grass roots organizations (GROs), economically challenged communities, and under-represented special interest groups [Sieber, 2001].

However, there have always been debates about the definition of PPGIS. Sawicki and Peterman [1998] defined PPGIS as a type of system, while other scholars considered it a field within Geographical Information Science [Sieber, 2001]. Tulloch [2003] argued that PPGIS be treated as a science, not simply a technology. A fuller definition made by Tulloch [2003] described PPGIS as “a study of the application of GIS and/or GIS technology, used by members of the public, that is non-officials, both as individuals and grass-root groups; for participation in public processes that affect their lives; and a normative field that should do good: whether it empowers marginalized peoples, promotes social inclusion, builds capacity, furthers democracy, etc”.

Craig et al. [2002] brought together the key researchers and displayed a wide variety of PPGIS applications in the book “*Community Participation and Geographic Information Systems*”. Numerous application examples were illustrated in the context of neighbourhood regeneration and urban planning, environmental management such as nuclear waste disposal, and resource management such as forest management – to name just a few. Later, Carver [2003] illustrated the complicated issue of PPGIS research through a Strength, Weakness, Opportunity, and Threats (SWOT) analysis.

- The capability to incorporate local knowledge into the decision-making process, the ability to visualize environmental information and communicate this information to interested stakeholders are the major *strengths* of PPGIS;
- However, the fact that the public generally do not possess the required knowledge or relevant information to understand the generally complicated matters such as planning, environmental impact assessment is the main *weakness*;
- The real *opportunity* for PPGIS lies in making the citizens more accountable for decisions made by given them more responsibility; and
- The real *threats* are related to the antipathy against the politicians and other decision-makers.

The increasing availability of geospatial data on the Internet and recent GIS and ICTs advances have improved many aspects of the field, and provided new information system tools to improve the participation process.

2.2.1 Web-based PPGIS Applications

Many aspects of the PPGIS field have been enriched in a Web-based environment. Carver et al. [2001] point out that the use of the Internet makes it easier for the authorities to reach out to the community and obtain the widest sweep of opinions and information. Carver et al. [2001] also conclude that the Internet reduces the dominance of the activists or the powerful elite and allows the more cautious and reserved citizens to express their opinion as well.

Web-mapping technology is the backbone to Web-based PPGIS applications [Tang, 2006]. The rapid development of software platforms for Web-based GIS applications has led to enhanced use of Web-mapping for planning purposes. Figure 2.3 shows the framework of Web-based PPGIS. Depending on the technologies and architecture of the application, the levels of service in a PPGIS range from the lowest level at the lower-left corner to the highest level at the upper-right corner. The lowest level of service only deals with Web browsing and general information distribution, whereas the highest level of service offers the citizens a much more active role in building scenarios and suggesting alternatives [Peng and Tsou, 2003]. There is a clear similarity between the participation ladder (See Figure 2.1) and Peng's PPGIS framework.

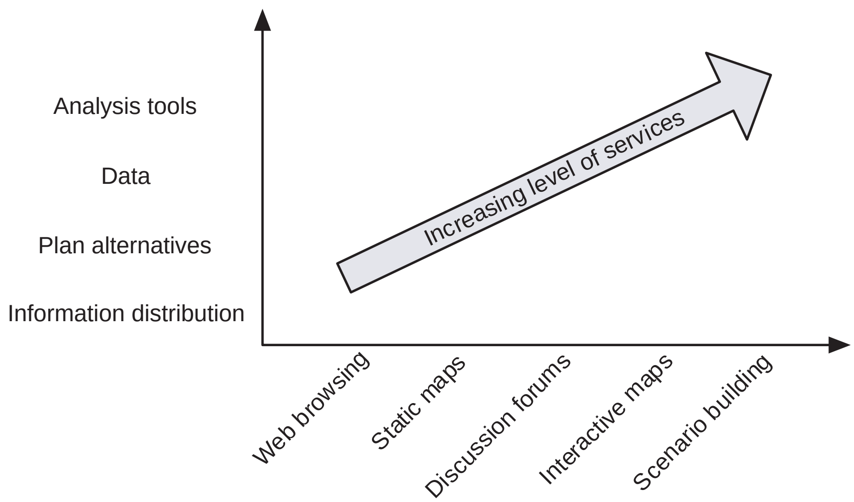


Figure 2.3: Framework for Web-based public participation systems (after Peng and Tsou, 2003)

Many of the commercial Web-mapping software programs such as *ArcIMS* from ESRI, *GeoMedia WebMap* from Intergraph, and *mapGuide* from Autodesk, or open source applications such as *MapServer*, and *GeoServer* have introduced dynamic and interactive Web-mapping to the public domain, in which users can query a database, create customized maps, or conduct data analysis. These software programs can add client-side scripts such as JavaScript to make the plain Hypertext Markup Language (HTML) dynamic, and/or client-side applications like plug-ins, Active X controls, and Java applets to enable client side processing of user requests, which in turn increases the level of interactivity and intelligence.

In the last couple of years, the introduction of the *Google Maps* Application Programming Interface (API) signals the arrival of Web-based geographic information into the broader public imagination [Darlin, 2005]. *Google Maps* features a map that can be navigated by dragging the mouse or using the mouse wheel to zoom in (mouse wheel up) or out (mouse wheel down) to show detailed street information. By performing asynchronous network requests with Asynchronous JavaScript and XML (AJAX), *Google Maps* achieves greater user interactivity and make itself an attractive platform for building interactive Web mapping system by amateur Web developers.

2.2.2 Human Factors in PPGIS

Despite the technological advances in ITCs and GIS, public participation remains troublesome in practice. There are questions that remain unanswered: How much indeed can PPGIS empower or marginalize the general public? How can we evaluate whether or not PPGIS activities are successful? What are appropriate ways of organizing PPGIS activities? This section outlines that social networks, rational ignorance, and digital divide also influence the adoption of PPGIS applications.

2.2.2.1 Social Network

Putnam [1993] claimed that civic responsibility and a greater sense of belonging come from social participation. People tend to see themselves validated, forming a strong and empowered community inside their social networks. Carver [2003] further suggested that it is necessary to focus on social and cultural factors influencing how people perceive decision problems and respond to them as individuals and as members of social groups. Previous research on the subject of online social networking has proven that trust and credibility among the participants and the sharing of information and resources could be greatly enhanced in an invitation-based social networking environment [Farnham et al., 2004]. In response to social and technological phenomena occurring in Web 2.0, tools for visualization of online social relationships, known as online social networking tools, have became available. In such online social networking tools, an initial set of users sent out messages inviting friends of their own networks to join the site. New members repeated the process, and eventually increasing in the total number of members and links in the network. As a result, trust, credibility, and the sharing of information and resources among users are greatly enhanced in such an invitation-based social networking environment.

2.2.2.2 Theory of Rational Ignorance

Questions were raised regarding how to engage the public if they are tired or do not have time. In the process of trying to involve citizens, scholars [e.g. Steinmann et al., 2004] observed the effect of "rational ignorance". Ignorance about an issue is said to be rational when the cost of educating oneself about the issue sufficiently to make an informed decision can outweigh any potential benefit one could reasonably expect to gain from that decision, and so it would be irrational to waste time doing so. For most citizens, the cost of participation and learning how to use a PPGIS is relatively higher than the personal benefits of getting involved in planning activities. Therefore, they rather decide to ignore the opportunities of participation.

2.2.2.3 The Digital Divide

The term "digital divide" refers to the unequal distribution of digital and information technology, it describes the gap between those with regular, effective access to technology, and those without this access [Steyeart, 2002].

Groups often discussed in the context of a digital divide include socioeconomic (rich/poor), racial, or geographical (urban/rural). Steyeart [2002] argues that technological diffusion has followed existing social stratifications, i.e., higher-income white males have the greatest access to technology, and the digital divide negatively impacts democracy and social equality. According to Smith [2007], digital-divide researchers examine the situation more closely and find out that "the real issue is not so much about access to digital technology but about the benefits derived from it". He further argues that "upper-to-middle classes have high-quality access to digital technology because the profit motive pushes technologists to work hard at creating solutions designed specifically for them. However, the poor are ignored because the assumption is that designing solutions for them will not be profitable". The result is that even where the poor are provided access to digital technology, it could be low-quality solutions, which end up being harmful rather than beneficial. For example, years ago, people considered the spread of Internet café s as an example demonstrating that the digital divide was shrinking. But when a local youth in a Cambodia village ignored his school work and instead playing violent video-games at a local Internet café, he was not really benefiting from the technology. Simply giving digital technology to the poor may actually add to the causes of poverty [Smith, 2007]. This, in turn, widens the digital divide.

The advancement of the high-powered personal computer hardware, the lowering of the software costs and the increasing bandwidth capacity have all helped popularize geospatial data on the Internet. GIS has become more accessible to those individuals not trained as GIS professionals. Chua and Wong [2001] argue that the Internet is greatly enhancing the dissemination of spatial information. The Internet takes care of the needs specific to users of different capacity. It also opens new avenues to data democracy because community users can create Web pages and become information providers. Even though technology has made it easier to organize and analyze the vast volume of spatial information and data, the Internet is not sufficient enough to popularize PPGIS and raise the GIS skills of every user to the same level. There is a huge difference in technical capacity among PPGIS users [Chua and Wong, 2001], which implies that the gap persists.

2.2.3 The GIS-enabled Online Discussion Forum Prototype

As mentioned in Section 1.2, this research is a follow-on to the *GeoDF* research project. The *GeoDF* prototype (see Figure 2.4) aimed at helping facilitate community planning in a land use planning application. It enables citizens to provide more in-depth feedback to government through the use of Web-based mapping and online collaboration tools [Tang, 2006]. The prototype supports the participants to submit and share feedback, as well as to initiate discussions about their concerns. Participants can express their views not only with text messages, but also sketches and annotations on the GIS map. In order to better convey a participant's perspective, the map extent and the map layers that one is viewing are stored by the system and shared among the participants. Moreover, the discussion contributions (i.e., the text messages, GIS map, sketches, and annotations) are organized and presented in a structured way to facilitate the understanding of the evolution of ideas throughout the discussion process. Please refer to Tang [2006] for details on GeoDF functionality and capabilities.

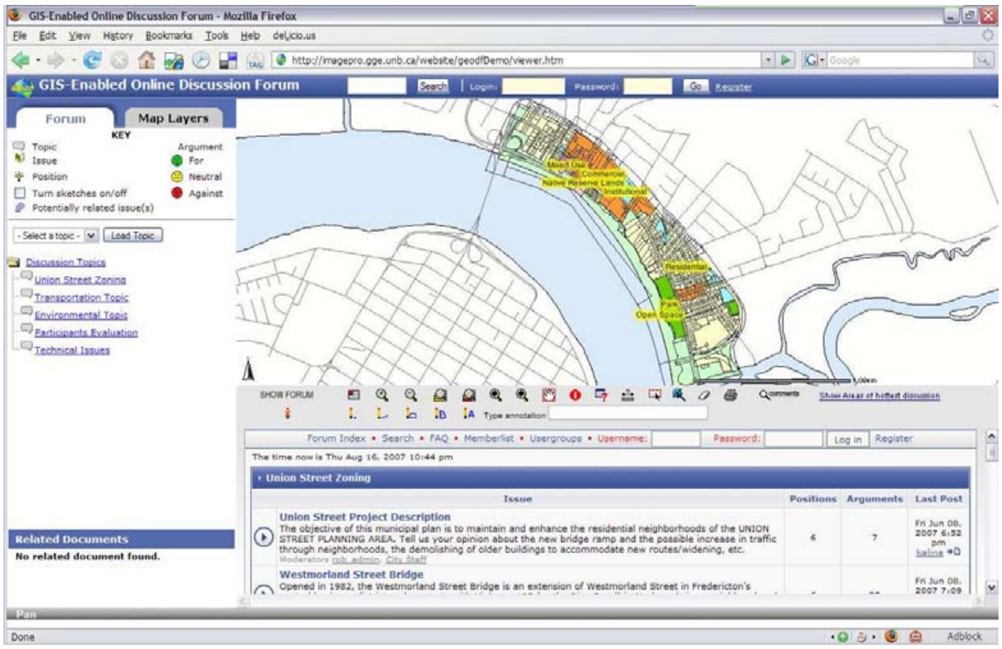


Figure 2.4: The *GeoDF* prototype
(Web-mapping component to the upper right, discussion forum to the lower right. Data source: City of Fredericton)

Based on an extensive review and assessment of technologies available at the time, Tang [2006] implemented the key components and features of the prototype at minimum development costs. Due to limited time resource and the research scope, empirical research was not incorporated into the *GeoDF* research. The target user group for the *GeoDF* prototype is the general public. Due to the wide range of possible users in this group of users, the prototype system must be accessible and easy-to-use for all levels of users. This introduces the motivation for conducting an empirical study of the *GeoDF* prototype with real users in a participation discussion environment.

2.3 Human Computer Interaction and Usability Evaluation for PPGIS

Human Computer Interaction (HCI) examines the interaction between humans and computers [Preece et al., 2002]. Usability studies form a small part of the larger field of HCI research, investigating the extent to which a computer system supports users to achieve specified goals in an effective, efficient, and satisfactory manner [Nielsen, 1993].

Preece et al. [2002] defined HCI as "a discipline concerned with design, evaluation and implementation of interactive computer systems for human use and with the study of major phenomena surrounding them". As long as there have been computers, developers have been concerned with how the machine and its software would be used. The major concern in HCI is how to facilitate and improve people's work through the use of computers. HCI studies also aim to meet the needs and requirements of the users with computer systems that are safe, efficient and enjoyable [Preece et al., 2002]. In HCI, "usability evaluation" refers to the process of systematically collecting data on how users use the system for a particular task in a particular environment [Preece et al., 2002]. The objectives of HCI and usability evaluation are to make computer technology accessible and easy to use for a wider range of users. Usability includes considerations such as: Who are the users? What do users want or need to do? What is the general background of the users? What is the context in which the user is working? All these usability considerations are intrinsic goals of the PPGIS research - making GIS more accessible and easy to use in order to enhance citizens' roles in decision-making processes.

2.3.1 Using Usability Techniques for PPGIS

Examples of Web mapping tools and methods developed and refined for widespread use by the general public have been described by Kingston [2002], Evans et al. [1999], Kesler [2004], and Voss et al. [2004], among others. A recent review of PPGIS research and applications reveals that, however, more emphasis has been placed on technological aspects involved in developing the applications rather than empirical assessment of whether the tools are usable or how these tools are being used [Craig et al., 2002; Haklay and Tobon, 2003; Steinmann et al., 2004]. Chua and Wong [2001] described four barriers that particularly exist in Web-based PPGIS: cost of interactivity, user diversity, data and copyright costs, and trust and legitimacy. Steinmann et al. [2004] conducted a qualitative expert analysis evaluating twelve PPGIS applications according to their usability, interactivity and visualization, and made comparisons between the US and Europe. Sidlar and Rinner [2006] employed a quasi-naturalistic[1] case study and focused on the general usability aspects such as cost of entry, efficiency, interactivity and connectivity of the Argumentation Maps prototype. Demsar [2007] introduced a low-cost methodology for performing usability evaluation which combined formal and exploratory usability evaluation methods, and then assessed how the participants used the geovisualization tool on a real data set. Among these PPGIS applications, a number of usability experiments have been carried out (e.g., Haklay and Tobon, 2003; Sidlar and Rinner, 2006; Demsar, 2007) which have indicated valuable connections between HCI, usabilty engineering, and PPGIS - HCI and usability engineering studies contributed to evaluating the usability of a PPGIS, contributed towards understanding how PPGIS tools support spatial data explor-

[1]Quasi-naturalistic studies use a 'real-world' context but are used with such controls so that both evaluation and collecting of information are easier, and therefore a deeper investigation can be achieved.

ing, and influenced the design and structure of a user-centered design approach to PPGIS projects.

Haklay and Tobon [2003] contend that HCI issues are vital to the success of PPGIS. PPGIS is designed to be used directly by a "general public" possessing potentially a diverse range of world views, cultural backgrounds and knowledge. In such situations, HCI techniques, including usability evaluation methods, would help the PPGIS researchers better understand users' expectations as well as the ways in which they use, understand and value the system. Finally, Haklay and Tobon [2003] suggest that PPGIS should be easily usable and understandable by a broad public audience, and quantitative and qualitative data from HCI and empirical studies would help to achieve this goal by providing valuable information on the usage and the role of PPGIS within a wider societal context.

It is believed that Web-based GIS increases the availability of geospatial data, reduces end-user cost, and offers flexible and customized user experiences through the use of Web clients [Peng and Tsou, 2003; Rattray, 2006]. For example, Web-mapping applications that aid users in obtaining driving directions as well as property information systems for municipalities. Many of these systems significantly improve the ability of the public to begin using Web mapping. Steinmann et al. [2004] however pointed out that the specialized functionality that supports online GIS increases the complexity of a conventional browser experience.

Nonetheless, without empirical evidence, it is hard to tell whether or not advances in technologies will actually benefit and empower the general public -i.e., whether or not existing PPGIS tools will really lead to increased participation, equality and better democracy. It is therefore difficult to measure:

- Are these tools used?

- What are the tools used for?

- How would the stakeholders use these tools?
- To what degree are these new tools accepted?
- What are the social influences of these PPGIS tools?

2.3.2 Technology Acceptance Model and System Acceptability

The Technology Acceptance Model (TAM) developed by Davis [1989] offers researchers and practitioners a relatively simple and cost-effective way to predict the ultimate measure of system success - whether or not that system is good enough to satisfy all the needs and requirements of the users. It is an information systems theory that models how users come to accept and use a technology. The goal of TAM is to predict information system acceptance and diagnose design problems before users have any significant experience with a system. Davis defined two constructs in TAM (see Figure 2.5):

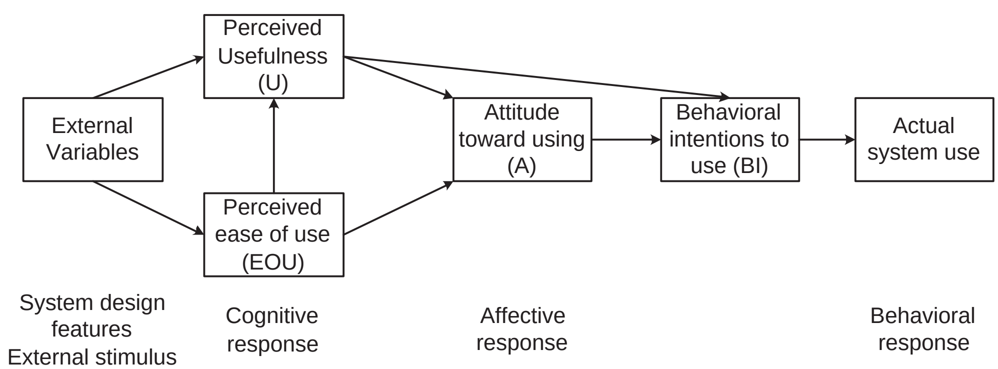


Figure 2.5: Technology acceptance model
(after Davis, 1989)

Perceived usefulness (PU): “the degree to which a person believes that using a particular system would enhance his or her job performance”; and *Perceived ease-*

of-use (PEOU): "the degree to which a person believes that using a particular system would be free from effort". For example, on an examination dealing with the Netscape World Wide Web browser, Morris and Dillon [1997] reported the *PU* with a reliability of .92, the *PEOU* with a reliability of .90, and *Attitude toward Using* with a reliability of .85, they further concluded that the *PU* was found to have a stronger influence on people's intentions, while the PEOU had a smaller but still significant effect that subsided over time.

Nielsen [1993] considered usability as one of the many attributes of system acceptability (see Figure 2.6). The overall acceptability of a system is a combination of its social and practical acceptability. Social acceptability shows if the system is meant for ethical purposes. For example, hacking personal data from a hospital database is not considered socially acceptable. Practical acceptability is the generalization of acceptability of system's cost, compatibility with existing systems, reliability, available support, usefulness and other such considerations. Nielsen [1993] also stated that "usefulness" is the issue of whether the system can be used to achieve some desired goal. Usefulness can be further divided into "utility" and "usability". Utility is the question whether the functionality of the system in principle can do what is needed and usability is the question of how well users can use that functionality.

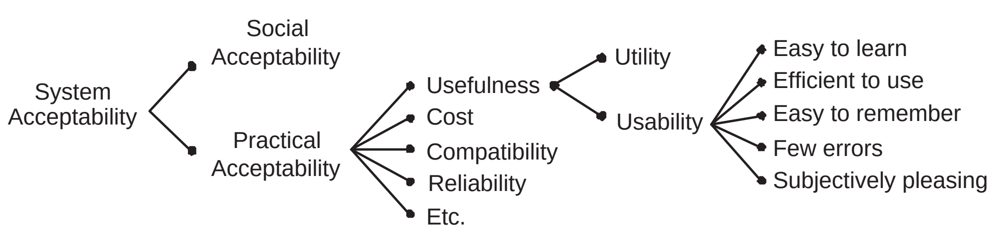


Figure 2.6: Nielsen's definition of usability
(after Nielsen, 1993)

The elements of system acceptability are very important from the general viewpoint. Based on lessons learned from the author's internship experience at Microsoft Research, users have infinite potential for making unexpected misinterpretation of the system elements, a common practice for designing and implementing a software program is usually to conduct user study at the earliest possible stage. HCI researchers at the Community Technologies Group generally would create several prototypes (paper prototype, including pencil drawing or screen mockups) in order to evaluate the conceptual foundation of the design of the system before implementing a software program. For the *GeoDF* software, although, the design and initial development have both completed, it would still be helpful to evaluate the usability, user acceptance, and effectiveness of the *GeoDF* prototype to verify the research hypothesis.

2.4 Summary

In this chapter, the author calls attention to the second-level effects of new technology. The chapter goes on to delineate the "public" and "participation" within the scope of this study. The author then continues to discuss the various degrees of public participation with special reference to the participation ladders, the various conventional, and Web-based participation methods. By comparing the pros and cons of conventional and Web-based methods, the discussion leads to the history of PPGIS. Moreover, it points out that technology alone cannot solve all issues in community planning. The human factors such as social network, rational ignorance, and digital divide influence the outcome of a land use planning project. The next part introduced the *GeoDF* prototype, and described the motivation of an empirical assessment for this prototype. The last part of this chapter presents a review of the HCI research and usability evaluation in PPGIS, which provides a theoretical basis for the design and evaluation of the *GeoDF* prototype. In the next chapter, the author examines the HCI principles and usability evaluation methods, and then presents the design of a low-cost usability experiment for assessing the current *GeoDF* prototype.

Chapter 3

Design of a Low-Cost Usability Experiment for GeoDF

This chapter elaborates the design of the usability evaluation methodology. The experiment was performed using limited resources: there was only one person (i.e., the author) available for the re-design, development, and evaluation of the *GeoDF* software. There was no funding available for hiring expensive usability professionals. Therefore, a low-cost methodology was developed, based on the suggestions from an experienced HCI researcher at IIT of the NRC [Lumsden, 2007] and recommendations from discount usability engineering [Nielsen, 1993, p.17].

3.1 Usability Engineering Considerations for PPGIS

HCI and related usability evaluation techniques focus on how to make computer systems more efficient, enjoyable and accessible, while focusing on the user needs and requirements. Contrary to what some might think, usability is not just the appearance of User Interface (UI). Usability relates to how a system interacts with the users. Nielsen [1993] defined five basic attributes for usability: "learnability", "efficiency", "user retention over time", "error rate", and "satisfaction" (see Figure 2.6). The target user group for the *GeoDF* software is the general public. Due to the wide range of possible users, it requires that the system must be accessible and easy to use for all levels of users. Especially in a world in which users cannot afford to spend a long time learning how a system works, usability is critical for user system acceptance - if users do not think the system will help them perform their tasks, they are less likely to accept it and it is possible they won't use the system at all or will use it inefficiently after deployment [Ferre and Juristo, 2001].

There have been user needs studies for GIS since the early 1990s [Tomlinson and Boyle, 1981], the type of users that has been exposed to PPGIS are very different from those to GIS [Haklay and Tobon, 2003]. Haklay and Tobon pointed out that early HCI research and usability evaluation focused on the use of GIS by specialists who use the system to accomplish a specific work-related task. By comparison, the use of GIS in an actual community setting usually involves an open-ended exploration in which users experiment with the GIS and examine various issues that relate to their community and questions that tie to geographic locations. When it comes to the usability evaluation of a PPGIS, the challenges lie not only in the varying level of computer skills and the literacy of its target users, but also in the different contexts in which the users would employ it.

Tang [2006] implemented the *GeoDF* prototype as a "proof-of-concept" and concluded that the prototype is efficient in fulfilling the communication needs that arise from the principles of participatory planning. As a follow-on research to Tang's initial effort, the goal of this study is to evaluate the effectiveness of the prototype through rigorous usability evaluation procedures to determine the measurable extent to which improved usability and enhanced social collaboration capabilities in a Web-mapping system will result in greater public participation in a planning process.

3.2 Usability Evaluation Lifecycle

Usability evaluation has been considered similar to other types of software quality assurance testing. Usability testing *uncovers* but does not fix design problems. Therefore, it is important to carefully consider the user interaction from the beginning and throughout the development cycle in order to increase user efficiency and satisfaction and, consequently, productivity [Nielsen, 1993]. Nielsen further summarized the lifecycle stages of the usability engineering (see Figure 3.1). This model emphasizes that one should not rush straight into the design. Ideally, usability engineering should take place throughout the lifecycle of a product, with significant activities happening at the early stages before the user interface has even been designed [Nielsen, 1993, p.71]. This may make it possible to avoid developing unnecessary features.

3.3 Usability Assessment Methods

3.3.1 Heuristic Evaluation and User Testing

For computer software for which usability engineering has not taken place during the development, *user testing* and *heuristic evaluation* can be applied also for ready product. It is possible to find problematic aspects and so to know the most urgent needs for development for the next version of the software. User testing and heuristic evaluation differ in their nature considerably and they complement one another.

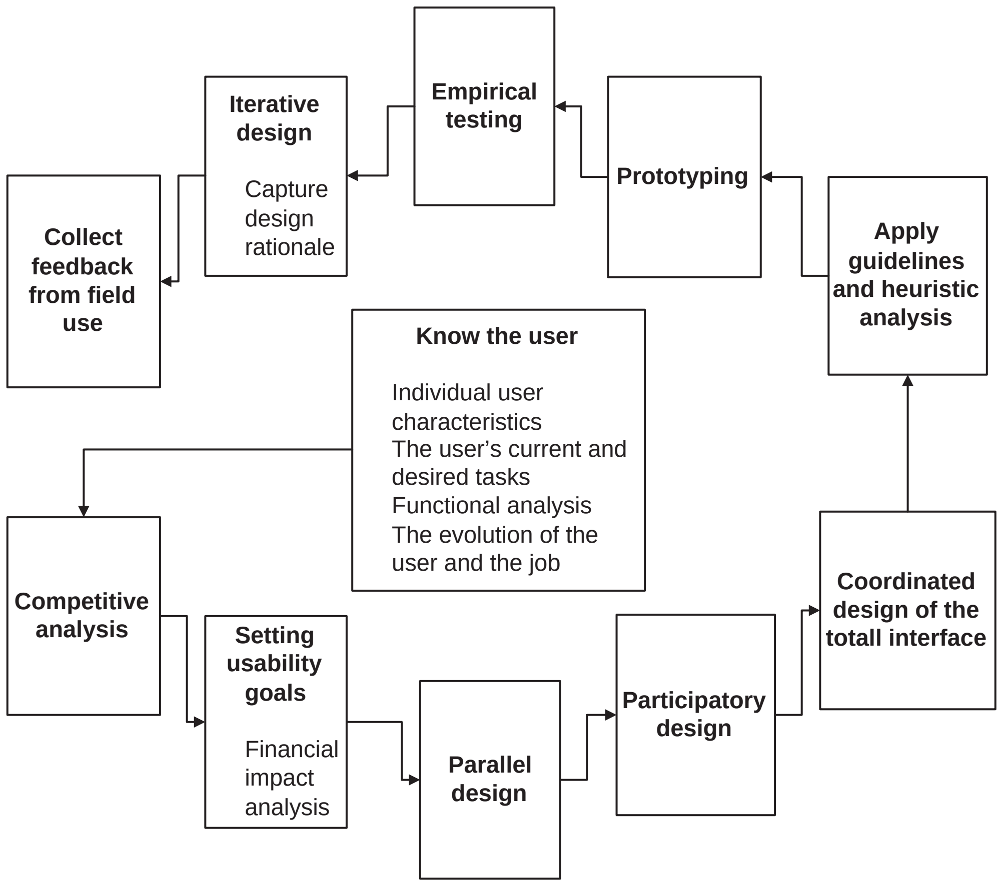


Figure 3.1: The stages of the usability engineering lifecycle model.
(after Nielsen, 1993, p.72)

Heuristic evaluation involves having a small set of evaluators examine the interface and judge its compliance with recognized usability principles. Most people would perform it on the basis of their own intuition and common sense instead. Nielsen [1993] suggested 10 usability heuristics for desktop based applications:

1. Simple and natural dialogue;

2. Speak the user's language;

3. Minimize user memory load;
4. Consistency;
5. Feedback;
6. Clearly marked exits;
7. Shortcuts;
8. Good error messages;
9. Prevent errors;
10. Help and documentation.

Nielsen [2000] further described important Web-based usability heuristics to consider, the ones suitable for Web-mapping applications are listed here:

1. The four most important reasons why people return to the same Web site are: quality content, currency, fast response times, and intuitive interface;
2. Attention should be paid to the layout of the Web pages - how much of the space is spent on actual content, navigation, advertisement, design, and how much is left empty;
3. The page should not have a link back to itself;
4. Links should be highlighted and have text description of the topic instead of providing URL or "click here" link;
5. There should separate version for printing of contents pages;
6. It should be possible to use Web pages with different strategies. Approximately half of the people prefer using search, 1/5 follows links, and the rest use some combination; and

7. The page should fit to screen whenever possible.

User testing involves inviting some representative users to perform representative tasks with the design. For traditional user testing, the objective is to discover the mistakes users make when using the software, and the observer is therefore not allowed to provide more help than absolutely necessary.

Both approaches have pros and cons (see Table 3.1). In general, heuristic evaluation can be made in earlier development phases and is faster and cheaper.User testing on the other hand may give surprising results about users' ways of thinking and action. Usually the best results are achieved when both methods are used together.

Table 3.1: Comparison of user testing and heuristic evaluation.

	User Testing	**Heuristic Evaluation**
Pros	- Involving representative users; - Reveals real usability problems.	- Fast and cheap; - Finds individual usability problems; - Can be used in early stages of development; - Can be made with half-ready prototypes; - Can address expert user issues.
Cons	- A working product or prototype is needed; -Organizing a test takes time.	- Does not involve real users, so does not find "surprises" relating to their needs.

3.3.2 Usability Assessment Methods Beyond Testing

User testing and heuristic evaluation form the cornerstone of the most recommended usability engineering practice [Nielsen, 1993], but there are several other usability methods that can be used to gather supplementary data.

1. **Performance Measurement**: User performance is measured by having a group of test users perform a predefined set of test tasks while collecting time and error data. For example, the "efficiency of use" can be measured by the average time it takes the users to perform a certain number of usability tasks. The major advantage is that this method gives quantitative data and the results are easy to compare. Therefore, it is most often used in the usability engineering lifecycle for assessing whether usability goals have been met.

2. **Thinking Aloud**: Usability engineers consider thinking-aloud the single most valuable usability engineering method [Nielsen, 1993]. In a thinking-aloud test, the observer basically has a test subject use the system while continuously thinking out loud, which enables the observer to understand how the test subjects view the computer system, and makes it easy to identify the users' major misconceptions. Because this method shows how users interpret each individual interface item, the observer can obtain a very direct understanding of what parts of the dialogue cause the most problems.

3. **Observation**: This is an extremely important usability method with applications both for task analysis and for information about the true field usability of installed systems. Observation involves visiting one or more users and observing how the users perform their work and use the system in the same way they normally do. The observer stays quiet most of the time in order not to interfere with users' work.

4. **Questionnaires and Interviews**: From a usability perspective, questionnaires and interviews are indirect methods. They are best for studying the subjective satisfaction, possible anxieties and user's opinions about a user interface.

5. **Focus Groups**: This method is a somewhat informal technique that can be used to assess user needs and feelings both before the interface has been designed and after it has been in use. In a focus group, six to nine users are brought together to discuss new concepts and identify issues over a period of about two hours. The moderator of the focus group follows a script to bring up issues that need to be discussed.

6. **Logging Actual Use**: Logging involves having logging scripts automatically collect statistics about the detailed use of the system. Normally, logging is used as a way to collect information about field use of a system after release. When used in user testing, logging can also be used as a supplementary method to collect more detailed data.

7. **User Feedback**: User feedback is initiated by the users, so it shows immediate and pressing concerns from the users. It also quickly show any changes in the users' needs, circumstances, or opinions.

Table 3.2 provides a summary of the usability methods mentioned in this section. These methods are intended to supplement each other, since they address different parts of the usability engineering lifecycle, and their pros and cons can partly make up for each other.

3.3.3 Choosing Usability Methods

To achieve best results, this study combined both heuristic evaluation and empirical user testing. The preliminary design and development of *GeoDF* V0 had been already completed. It is hard, however, to determine whether or not it would actually lead to the improvements suggested by Tang [2006]: enable participants to communicate more effectively in a spatially-related discussion situation.

Table 3.2: Summary of the pros and cons of different usability methods.
(extended from Nielsen [1993])

Method Name	Lifecycle Stage	Users Needed	Pros	Cons
Heuristic evaluation	Early design	None	-Find individual usability problems; -Can address expert user issues; -May cover entire problem space.	-Do not involve real users; -Difficult to standardize or categorize rationale for design changes.
Performance measures	Competitive analysis, final testing	At least 10	-Quantitative data, results easy to compare.	-Does not find individual usability problems.
Thinking aloud	Iterative design, formative evaluation	3-5	-Pinpoints user misconceptions; -Very close approximation to actual individual usage. -Less expensive.	-Think aloud instruction rarely works well; -Unnatural for users to verbalize.
Observation	Task analysis	3 or more	-Ecological validity; -Reveals users' real tasks; -Suggests functions and features.	-Appointments hard to set up. -No control over the observation.
Questionnaire	Task analysis, follow-up studies	At lease 30	-Finds subjective user preferences; -Easy to repeat.	-Pilot work needed to prevent misunderstandings.
Interviews	Task analysis	5	-Flexible, in-depth attitude and experience probing.	-Time consuming; -Hard to analyze and compare.
Focus groups	Task analysis, user involvement	6-9 per group	-Spontaneous reactions and group dynamics.	-Hard to analyze. Low validity.
Logging actual use	Final testing, follow-up studies	At least 20	-Finds highly used/unused features; -Can run continuously.	-Analysis programs needed for huge mass of data; -Violation of users' privacy.
User feedback	Follow-up studies	Hundreds	-Tracks changes in user requirements and views.	-Special organization needed to handle replies.

In this study, two technical staff members from Engineering and Public Works department of the City of Fredericton were invited to the heuristic evaluation to examine the design of the *GeoDF* prototype. Their observations and comments eventually contributed to the modifications in subsequent GeoDF versions.

For user testing, representative users were recruited from academic and non-academic backgrounds. It is not always possible to perform all the recommended usability activities in any given project [Nielsen, 1993, p.112]. Due to limited resource and budget of this study, performance measurement, thinking aloud, observation, questionnaire, interviews, and focus groups were chosen to perform a low-cost usability evaluation. Detailed usability evaluation methodology is described in more detail in Section 4.3.

3.4 Usability Evaluation Methodology

Under varying levels of resource constraints, a usability experiment does not need to include every possible refinement of all the stages and can still be successful. Ferre and Juristo [2001] had abstracted a generic usability process from the different usability approaches (see Figure 3.2). The author adopted the generic usability process and prioritized the usability activities to include the following usability procedures: user analysis, task analysis, usability benchmarks, conceptual design, and visual design.

As depicted in Figure 3.2, in the preliminary analysis phase, user analysis is taken as input for task analysis. Task analysis ends when the discovered the task set is evaluated collaboratively with users. Usability benchmarks are then defined based on tasks specified in task analysis. In the design phase, the findings of the user and task analysis are summarized in the conceptual design stage and serve as the basis for a preliminary prototype. The conceptual design also ends with evaluating the results with users. The final step is visual design, where the UI's appearance is defined. The deliverables of the visual design stage are prototypes that must be tested and evaluated. This usability process may be carried out several rounds until the desired usability level is achieved. The detailed procedures for this study is explained in the next section.

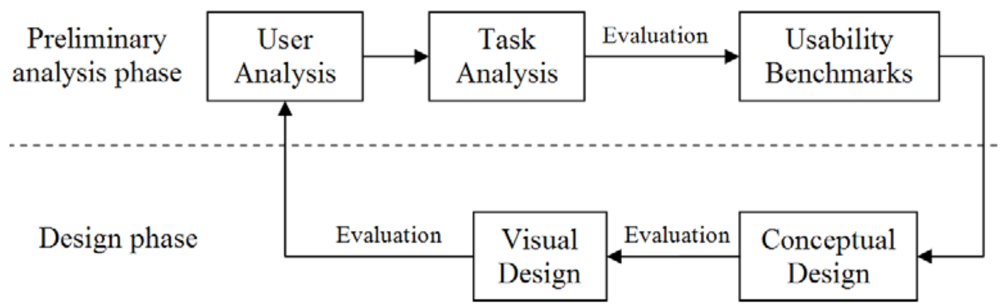


Figure 3.2: Usability process
(after Ferre and Juristo, 2001)

3.4.1 User Analysis

3.4.1.1 Approach

The first step in the usability process was to study the demographic background of the intended users and examine how they would use the prototype system. Individual user characteristics and variability in tasks are the two factors with the largest impact on usability [Nielsen, 1993], so the user demographic needs to be studied carefully. The concept of "user" should be defined to include everybody whose life/work is affected by the system in some way (refer to section 2.1.1).

In order to analyze *GeoDF* as a 'real world' application, a user analysis with different players in land use management was conducted. Knowing the users' work environment, education level, previous computer experience, and age made it possible for the system designer (i.e., the author) to anticipate user learning difficulties to some extent as well as to better set limits for the complexity of the *GeoDF* software.

This step also aims to: (a) better understand the needs and requirements of the different players in land use planning processes; (b) investigate the respective responses and reactions from the different stakeholders to using Web-based mapping and online collaboration tools as a means for public participation.

Site visits, interviews and focus group meetings were carried out during the period from February to September 2006 in the City of Fredericton and NBLA. The players included appointed officials (five from the City of Fredericton), program managers (one from NBLA, two from Caris[1]), GIS staff (two from the City of Fredericton, one from NBLA) and IT support staff (two from the City of Fredericton, two from NBLA).

The primary source for gathering user information is **site visits**. During the site visits to the City of Fredericton and NBLA, the planners and other planning project related program managers were observed in their working environment to see how they perform their tasks without PPGIS tool. In addition, they were interviewed to understand their motivation and the strategies behind their actions.

A **focus group** is an organized discussion with a selected group of users in order to gather information about users' views and experiences concerning a topic. Focus groups are good for quickly getting a sampling of user's opinions and viewpoints about the same topic [Krug, 2005]. During the focus group meeting held in February 2006, the *GeoDF* V0 was demonstrated to the eight city staff members. Two planners, two GIS staff, two IT staff and two appointed officials were invited to the focus group to assess the design of the *GeoDF* prototype and discuss

[1] a local GIS software company that was developing the public health GIS framework for NBLA at the time.

whether or not the integration of a Web-mapping component and an online collaboration forum was sufficient in assisting the city planners and decision-makers to gather valid public input and widen public participation.

Derived data includes data interpreted based on the user goals, user expectations and information gathered from site visits, contextual interviews and focus group meetings. The findings of the user analysis is presented in the next section.

3.4.1.2 Findings of User Analysis

The city staff was highly interested in employing the *GeoDF* prototype in one of their upcoming planning projects. The *Union Street Secondary Plan* was chosen as the pilot project because such a planning project has potentially controversial topics and is likely to generate more discussion. Participants are more likely to discuss issues like the effect of the new bridge ramp, the possible increase in traffic through neighbourhoods, and the demolishing of older buildings to accommodate new routes, etc.

The findings of the user analysis phase included:

1. **Issues about user sign-up and password protection.** In order to make sure an input is valid and prevent from domination of the discussion forum by a small group of malicious users, the focus group members were concerned about the identification of the participants. Therefore, a user sign-up and password protection mechanism was incorporated into the *GeoDF*. Identification of the user was checked in the registration process to prevent the discussion forum being dominated by either a particular lobby group or a small group of malicious users. In response to the registration mechanism occurring in Web 2.0, *GeoDF* was then implemented as user self-registration as well as invitation-based registration (refer to section 2.2.2.1).

2. **Concerns over a moderated versus non-moderated discussion list.** The focus group members raised the concern over pre-filtering comments to eliminate inflammatory/pornographic comments/personal links. A moderated forum was then put in place for the city staff to keep the discussions relevant to the topic and keep them going. This will also make sure that the most valuable and relevant user inputs as well as popular local community issues reach the decision-makers.

3. **Issues about spatial data permission and interoperability.** Both spatial and aspatial data were required for the setup of *GeoDF*. Spatial data included Union Street area map layers and the associated attributes. Spatial data in the *GeoDF* must be in ESRI shapefiles (*.shp, *.shx, and *.dbf) format, which is the only file-based format supported in ArcIMS. Data were then acquired from the city of Fredericton with verbal permission to publish on the Internet. Depending on the issues to be discussed and the quality of the data, modifications to the spatial data were required. For example, the spatial data provided by the City of Fredericton were in Caris NTX format, therefore, were converted to ESRI shapefiles to be used in ArcIMS. Digital orthophotos were also acquired from the City of Fredericton covering the Fredericton area. Aerial photograh was flown and orthophotos were generated in August 2005 to a resolution of 15 cm [Lunn and McCarthy, 2006]. The original 24-bit images slow down *GeoDF* data transfer over the Internet. Modifications were made to process the orthophotos from 24-bit to 8-bit while preserving the original resolution. In addition, considerable data modifications were made to improve the readability of the map data, such as simplifying the attribute table for each map layer, performing spatial analysis to reclassify detailed classes into broader ones, registering non-projected

layers.

4. **Issues about collaboration and documentation needs arise from the planning process.** Feedback from the focus group meetings indicated that the planners were generally satisfied with the existing features in the discussion forum. In addition, they would like to see more collaboration and documentation features. These additional features requested included documentation function (print, save, and add attachment), notification function (Forum digest), and polling function.

5. **Issues over cross browser compatibility.** The client software platform is essential for *GeoDF* to function correctly. For "proof-of-concept", *GeoDF* V0 employed a large number of Internet Explorer(IE) dependent scripts that only worked with Microsoft IE 6 and under. The later *GeoDF* V1 was implemented and tested to *function* with major Internet browsers, such as Mozilla Firefox.

6. **Issue over system installation, deployment and upgrade.** Feedback from the focus group meetings indicated that the installation, deployment and upgrade of the *GeoDF* software could be a troublesome process. The *GeoDF* software integrated available spatial components and online collaboration software. The installation and deployment of the *GeoDF* could be troublesome, as it required that Web Server, servlet container, *ESRI ArcIMS*, PHP, *MySQL Server*, and phpBB2 forum software all be installed and configured beforehand. Furthermore, there were a large number of customized codes in all system components, upgrading to newer versions of the above components would involve intensive re-engineering of all system components.

Feedback and comments from these focus group meetings were analyzed and served as the refinement guideline for additional functionalities needed. The end product of the user analysis was a refined prototype system - *GeoDF* Version 1. Figure 3.3 summarizes a complete list of additional features that were added into V1. There were only minor changes from V0 to V1 in the user interface.

3.4.2 Task Analysis

The second step was task analysis. A "task" in the usability study is an activity meaningful to the user. Nielsen [1993] suggested that focusing on a small set of tasks helps rationalize the software development and design effort. Therefore, it is essential to prioritize the set of tasks by their importance and usage frequency to get a small task set for the usability evaluation. This approach guarantees that the most important functionalities can be evaluated and the corresponding usability tasks completed by the users in a limited period of time during the test experiment.

The goal of the task analysis was to determine user anticipation and information requirement during the planning process in a Canadian setting. Tang [2006] translated the principles of the participatory planning [Rittel, 1972] into six goals. Here, a set of user tasks for achieving these goals was further derived as shown in Figure 3.4. These tasks were then further translated into particular actions that the user would perform to be able to participate effectively. Table 3.3 and Table 3.4 show the *GeoDF* system functions and corresponding user tasks. The discovered user tasks were then presented to test subjects using real-world scenarios in the usability tests (refer to Appendix C for usability tasks used during the experiment).

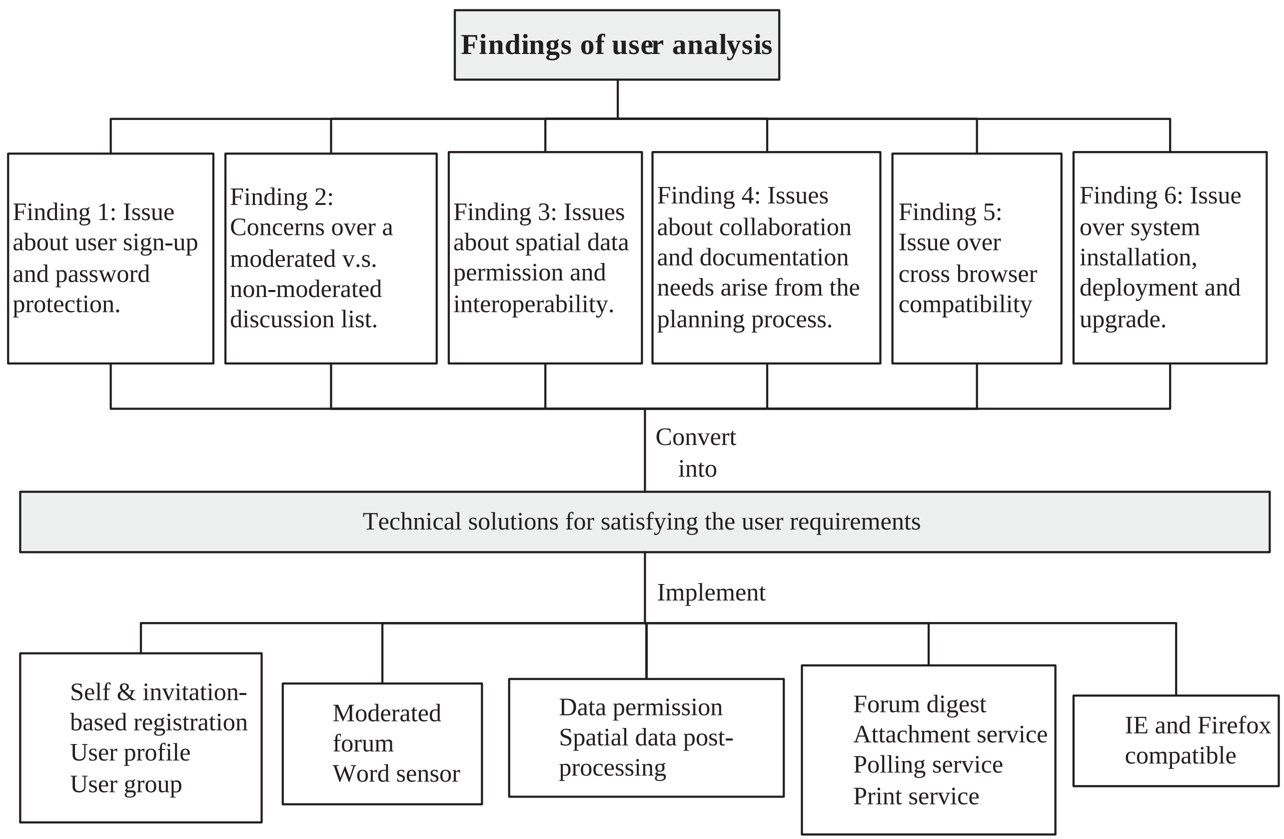


Figure 3.3: Findings of user analysis

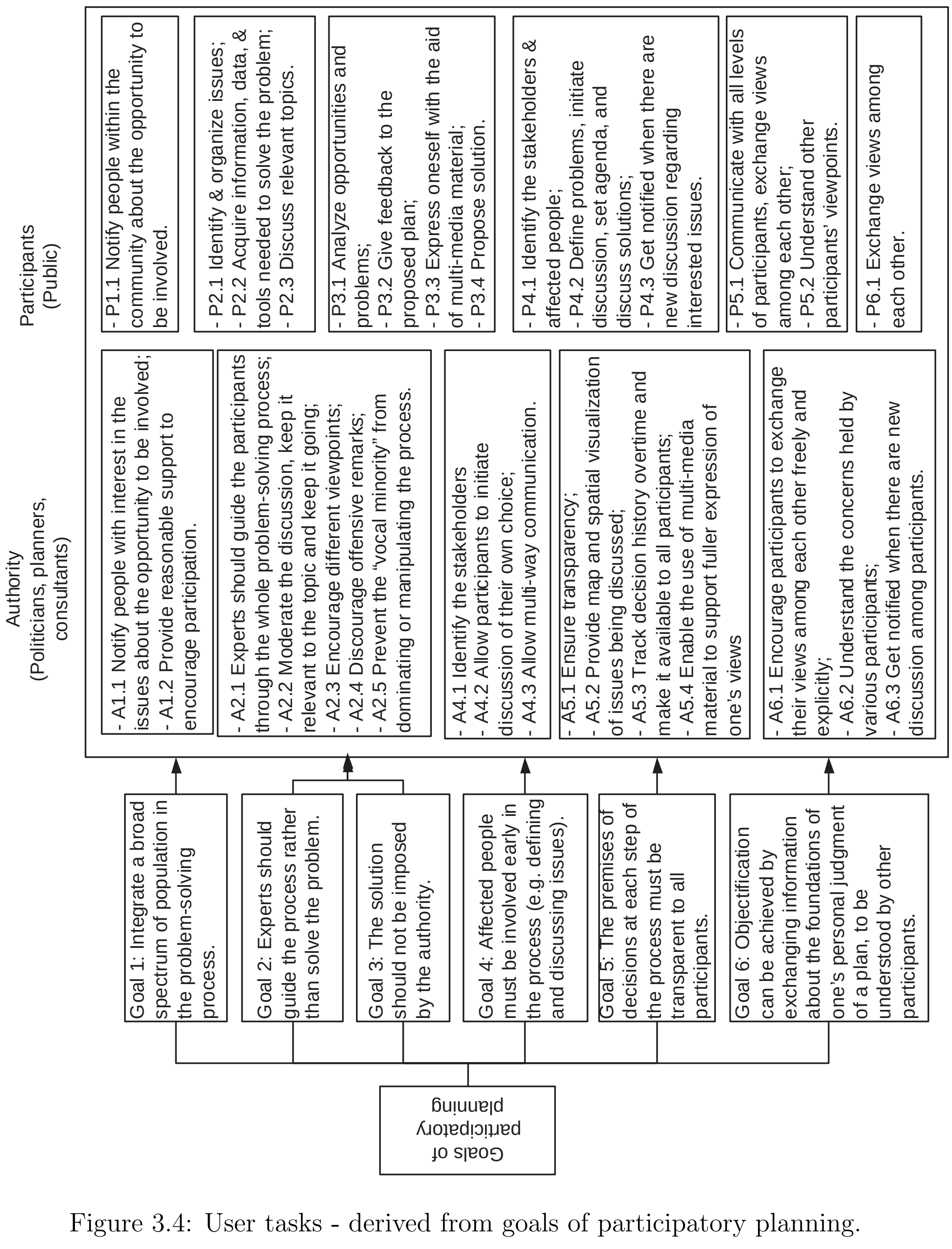


Figure 3.4: User tasks - derived from goals of participatory planning.

Table 3.3: System functions and user tasks as identified in the user analysis

System functions \ User tasks	A1.1	A1.2	A2.2	A2.3	A2.4	A2.5	A4.1	A4.2	A4.3	A5.1	A5.2	A5.3	A5.4	A6.1	A6.2	A6.3
Display maps		x									x		x			
Pan map		x									x		x			
Zoom in/out map		x									x		x			
Measure distance on map		x									x		x			
Identify feature(s) on map		x									x		x			
Spatial query on map		x									x		x			
Control map layers		x									x		x			
Sketch and annotate		x									x		x			
Spatial search of discussion		x									x		x			
Hottest area of discussion		x									x		x			
View discussion			x									x				
Initiate discussion				x												
Join existing discussion			x	x												
Spatial context		x								x	x		x			
Search forum (text)		x														
User groups		x					x									
User profile		x				x	x									
Word Sensor					x	x			x							
Moderate the discussion			x		x	x			x			x				
Send invitation	x	x								x				x		
Announcement	x		x							x				x		
Forum digest												x			x	x
Add attachment		x											x			
Add poll													x			
Register/login							x									
Notification for new reply																x
Viewpoint(for/against/neutral)				x									x	x	x	
Print map/forum													x		x	
Setup forum permission			x					x	x							

Table 3.4: System functions and user tasks Cont'd

System functions \ User tasks	P1.1	P2.1	P2.2	P2.3	P3.1	P3.2	P3.3	P3.4	P4.1	P4.2	P4.3	P5.1	P5.2	P6.1
Display maps			x	x										
Pan map			x	x		x	x							
Zoom in/out map			x	x		x	x							
Measure distance on map			x	x		x	x							
Identify feature(s) on map			x	x		x	x			x				
Spatial query on map			x	x		x	x			x				
Control map layers			x	x		x	x			x				
Sketch and annotate			x	x		x	x			x				
Spatial search of discussion		x	x	x	x									
Hottest area of discussion		x	x	x	x									
View discussion		x	x		x							x	x	x
Initiate discussion				x						x		x	x	x
Join existing discussion			x	x	x	x			x			x	x	x
Spatial context			x	x	x	x								
Search forum (text)		x	x		x									
User groups			x		x				x					
User profile			x		x				x					
Word Sensor														
Moderate the discussion														
Send invitation	x													
Announcement	x													
Forum digest			x								x			
Add attachment				x		x								
Add poll				x		x		x						
Register/login				x										
Notification for new reply			x								x			
Viewpoint(for/against/neutral)			x	x	x	x		x				x	x	
Print map/forum														
Setup forum permission														

3.4.3 Usability Benchmarks

The third step was to set usability goals. Those identified sets of tasks from the second step were used as the basis for building the usability specifications. Since Tang [2006] had finished the *initial* V0 of system design, the usability benchmarks were important in assessing the value of the usability attributes for *subsequent* refinement and modification to the *GeoDF* software.

As depicted in Figure 2.6, usability is not a one-dimensional property of a system. Nielsen [1993] suggested that usability is traditionally associated with five attributes:

- **Learnability** The system should be easy to learn so that the user can rapidly get involved in land use planning with the *GeoDF* software;
- **Efficiency** The system should be efficient to use, so that once the user has learned the system, a higher level of productivity is possible;
- **Memorability** The system should be easy to remember, so that the general user is able to retain what he or she has learned about using the *GeoDF* software after some period of not having used it, without having to learn everything all over again;
- **Error rate** The system should have a low error rate, so that users make few errors during the use of the system, and so that if they do make errors they can easily recover from them;
- **Satisfaction** They system should be pleasant to use, so that users are subjectively satisfied when using it.

Normally, usability attributes are not given equal weight in a given system design. For example, learnability, efficiency, and satisfaction are especially important for the *GeoDF* software because non-expert users would be constantly involved in land use planning and returning to participate with *GeoDF* if their previous experience were pleasant and beneficial.

Usability benchmarks are quantitative usability goals, which are usually defined before the system design begins [Nielsen, 1993] and are based on these five basic usability attributes and/or their sub-attributes. Here in this study, the author prioritized the usability aspects on the basis of earlier task analysis and adopted the following usability engineering procedures. [Good et al., 1986; Ferre and Juristo, 2001]

- Define usability through metrics;
- Set planned levels of usability;
- Analyze the impact of design solutions;
- Measure current usability level;
- Analyze the sources of user difficulty;
- Predict possible usability improvements;
- Incorporate user-derived feedback; and
- Iterate until the planned usability levels are achieved[2].

The benchmarks were determined prior to the usability evaluation based on an expert user's (i.e. the author) completion of the usability tasks. As a result of the expert's scores, benchmarks were then established by estimating how a beginner might perform. The benchmarks are defined in a way that makes them calculable

[2]Ideally, integrative design would be beneficial for verifying the research hypothesis, due to time and resource constraints, the procedures were not repeated in this study.

through observation in a usability test experiment and through a user satisfaction questionnaire.

Five items are defined for each attribute: the measuring technique, the metric, the worst-case level, the planned level, and the best-base level. The author began with an effort to identify the learnability, error rate, efficiency, perceived usefulness, users' acceptance, and users' subjective satisfaction of *GeoDF* V1 using the specifications depicted in Table 3.5. Table 3.6 shows the desired improvement of usability from V1 to V2.

The *GeoDF* prototype is evaluated against these specifications defined here to determine the measurable extent to which improved usability will result in greater public participation in a planning process. The observation results of V1/V2 usability will be discussed in detail in subsequent chapters.

Table 3.5: Usability specification table for *GeoDF* V1.

Usability Attribute	**Measuring Technique**	**Value to be measured**	**Worst-case level**	**Planned target level**	**Best-case level**
Learnability	Usability tasks	% of task completed	40%	60%	100%
Error rate	Observation	User error using the system	60%	30%	5%
Efficiency	Usability tasks	# of posted arguments	0	1	8
Perceived usefulness	Questionnaire $\hat{*}$	Average score (Q1-Q4))	3	5	7
User acceptance	Questionnaire	Average score (Q5-Q8)	3	5	7
Ease of use	Questionnaire	Average score (Q9-Q12)	2	4	7
Information Quality	Questionnaire	Average score (Q13-Q15)	3	5	7
Interface Quality	Questionnaire	Average score (Q16-Q20)	2	4	7

$\hat{*}$ The post-test questionnaire is based on 1-7 Likert Scale. Refer to (D.2) for corresponding question – Question 1-4 was designed for *perceived usefulness*; Question 5-8 for *user acceptance*; Question 9-12 for *ease of use*; Question 13-15 for *information quality*; Question 16-20 for *interface quality.*

Table 3.6: Usability specification table for *GeoDF* V2.

Usability Attribute	**Measuring Technique**	**Value to be measured**	**Worst-case level**	**Planned target level**	**Best-case level**
Learnability	Usability tasks	% of task completed	Same as V1	20% $\geq$ V1	100%
Error rate $\hat{*}$	Observation	User error using the system	n/a	n/a	n/a
Efficiency	Usability tasks	# of posted arguments	Same as V1	20% $\geq$ V1	8
Perceived usefulness	Questionnaire	Average score (Q1-Q4))	Same as V1	20% $\geq$ V1	7
User acceptance	Questionnaire	Average score (Q5-Q8)	Same as V1	20% $\geq$ V1	7
Ease of use	Questionnaire	Average score (Q9-Q12)	Same as V1	20% $\geq$ V1	7
Information Quality	Questionnaire	Average score (Q13-Q15)	Same as V1	20% $\geq$ V1	7
Interface Quality	Questionnaire	Average score (Q16-Q20)	Same as V1	20% $\geq$ V1	7

$\hat{*}$ "Error rate" was measured by observation and elapsed time (refer to Table 3.9), which were not included in the assessment of V2.

3.4.4 Conceptual and Visual Design

The conceptual design deals with the basic user-system interaction and the contexts in which interaction takes place [Ferre and Juristo, 2001]. The findings of user and task analysis are the basis for the conceptual design. Once the conceptual design has completed, the final step is to define the UI's appearance, which is the visual design.

The major part of system functionalities and user interface design had been completed in Tang's research. The conceptual and visual design in this study focused on the the improvement of system functionalities and user interface according to the evaluation results of the usability experiment.

3.5 Development of Evaluation Criteria

As depicted in Table 3.7, the criteria were derived from system acceptability (see Figure 2.6), TAM (see Figure 2.5), and user-based usability testing [Sweeney et al., 1993] in order to: (1) examine the system acceptability of the *GeoDF* software from several categories, such as usefulness, cost, and reliability; and (2) evaluate the learnability, efficiency, and memorability of, and satisfaction with the functionality of the *GeoDF* prototype.

Sweeney et al. [1993] classified three main approaches to evaluate human-computer interaction: "*user-based approach*", "*expert-based approach*", and "*theory-based approach*". The user-based approach was selected for this research as more than one user are involved in the test to complete more than one tasks in an appropriate environment. Table 3.8 shows which data capture methods were used during the usability experiment. Detailed test procedure is described in Section 4.3.

The usability testing covered a selection of user-based indicators, including *user's performance*, *behaviour*, *attitude*, *cognition*, *stress* and *motivation*. Sweeney et al. [1993] offered the most accessible and frequently employed data capture methods to match relevant usability indicators. Data capture methods for this testing included observation of users during the experiment, video-recording of user interaction, audio-recording of user comments, user's post-hoc comments, elapsed time, user interview and user questionnaire survey and rating scale. Table 3.9 shows the usability indicators and the corresponding data capture methods that were used in this research.

Table 3.7: Evaluation criteria for *GeoDF*.

Evaluation Criteria	**Explanation**
Usefulness	Usefulness refers to whether the system can achieve the goals of participatory planning. This also refers to the trade-off between providing sophisticated functionality and maintaining simplicity.
Ease of Use	Ease of Use refers to whether the users find the system easy enough to use. This is reflected in the levels of speed, completeness and correctness in the user's performance during the testing.
Cost of Entry	Cost of entry refers to the level of user investment. It is measured by both physical and mental complexity and stress/anxiety of the users.
User Demographic	"User Demographic" refers to the demographic background of the different users that are testing the prototype.
User Satisfaction	Satisfaction refers to the degree of general positive regard or emotion that the users attribute to the interaction with the *GeoDF* software. This is reflected in the level of positive attitude/opinion which is reported by the users.

Table 3.8: Usability and acceptability indicators for *GeoDF*.

Usability Indicators	**Data Collected**
Performance (user)	Task time, % completed, Error rates Duration of time in help, Continuance of usage, Range of function used (objective)
Non-verbal behaviour (user)	Eye movement, Orientation duration Frequency of documentation access (objective)
Attitude	User's attitudes and opinions, Questionnaire and Survey responses,Comments from interviews and ratings,Answers to comprehension questions (subjective)
Cognition	Verbal protocols, Post-hoc comments (objective)
Stress	Galvanic skin response, Heart rate, Event-encephalograms, Rating or comments (objective and subjective)
Motivation	Enthusiasm, willingness and effort (subjective)

Table 3.9: Data capture methods

Data Capture / Usability Indicators	Observation of users during the experiment	Video-recording of user interaction	Audio-recording of user during interaction	User's post-hoc comments	Elapsed time	User interview	Questionnaire survey and rating scale
User's Performance	V1&V2	V1			V1		
Behaviour	V1&V2	V1					
Attitude			V1	V1&V2		V1&V2	V1&V2
Cognition			V1	V1&V2		V1&V2	
Stress			V1				V1&V2
Motivation			V1	V1&V2		V1&V2	V1&V2

3.6 Summary

This chapter presents the design of a low-cost usability experiment for evaluating the *GeoDF* software. The software intends to facilitate the general public to participate in the ongoing discussion of spatially-related issues. The author wishes to determine whether or not the *GeoDF* software will actually benefit the general public, whether or not the *GeoDF* will enable participants to express their opinions more effectively in a spatially-related discussion situation. To cater for a large group of users, the *GeoDF* software is evaluated through rigorous usability engineering procedures. This chapter explains rationale for the design of the usability experiment, including the usability engineering considerations for PPGIS, usability evaluation lifcycle, usability assessment methods. The author then continues to present the methodology of a low-cost usability test with special focus on the development of the usability benchmarks and the usability evaluation criteria. In the next chapter, the usability experiment test design and procedures are presented.

Chapter 4

The Usability Evaluation Experiment

This chapter describes the design and actual procedures of the test experiment. In order to evaluate the usability and acceptability of the *GeoDF* software, the author carried out a two-stage test plan during May/June 2007.

Simple data capture methods were used instead of expensive ones, and the participants were recruited by recruitment emails and personal invitation from a combination of academia and non-academia individuals who have varying degrees of familiarity with Web-based systems and GIS systems.

4.1 GeoDF User Interface

The *GeoDF* software was designed to be used as an additional method to gather public input in public participation process. Participants in this study were invited to participate and discuss local issues and concerns about the Union Street area using the *GeoDF* participation platform.

The *GeoDF* V1 user interface at start up mode is shown in Figure 4.1. To facilitate the textual message of individual discussion contribution to be read alongside the corresponding spatial context, the *GeoDF* Web page is made up of several frames. Each frame works in coordination with other frames to support spatially-related discussions. There are five distinct areas of the interface: title & login area(top), discussion tree & map layer Table of Content (TOC) (left), map area (top right), *GeoDF* toolbar (middle right), and finally the forum area (bottom right).

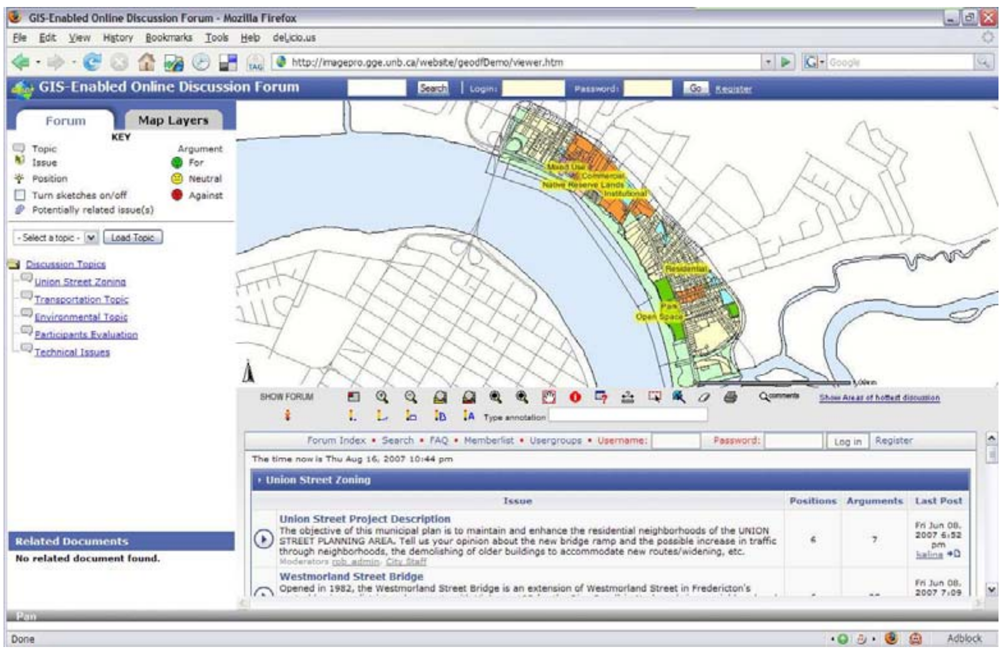


Figure 4.1: *GeoDF* V1 interface at start up
(loaded with Union Street planning data)

The map component employs a traditional Web-based GIS interface. It allows the participants to customize the map and determine which map layers, what sketches and annotations should be incorporated into the map to better express their opinions. The forum component makes use of an open source PHP-based online discussion forum - phpBB2. The original design of the phpBB2 follows the Web design guidelines and provides online collaboration capabilities, such as discussion, polling, and notification.

The discussion & map layer TOC is controlled by switching between the *Forum* and *Map Layer* tab. As shown in Figure 4.1, the discussion tree is placed under the *Forum* tab, in which the contributions are organized in a "threaded" structure. The tree structure does not only show the course of discussion, it also allows access to individual discussion contributions and is the control panel for turning on and off the spatial context of individual contributions. Figure 4.2 shows the content under the *Map Layer* tab - the map layer TOC, which organizes map layers into different themes and displays the map legend for each map layer.

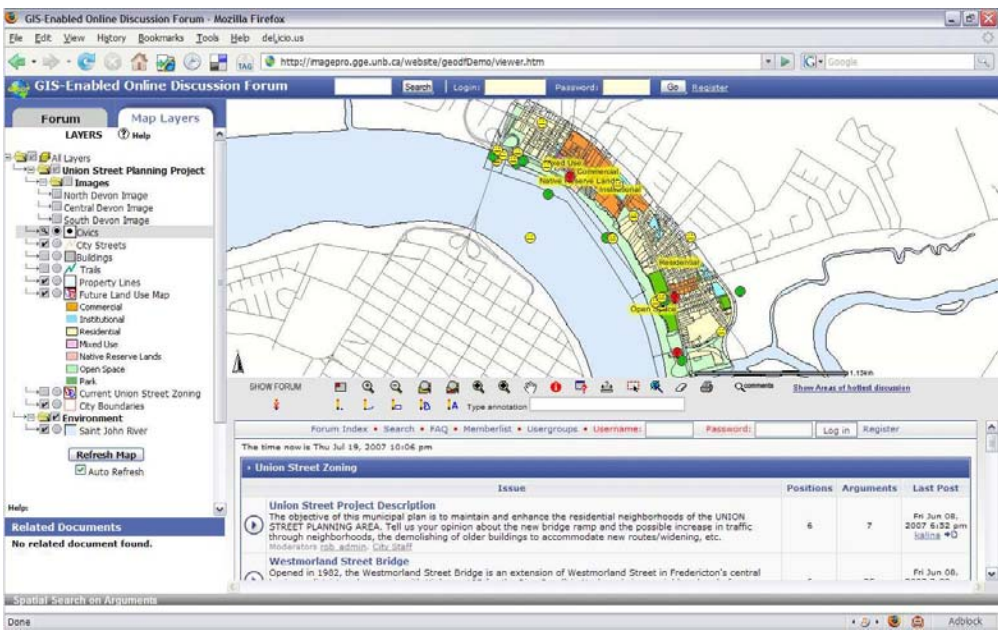


Figure 4.2: *GeoDF* V1 interface
(showing map layers and distribution of discussions for the project area)

On the map toolbar, there are standard map navigation tools (pan, zoom in-/out, zoom to full extent, zoom to active layer, identify), spatial analysis tools (measure, select, spatial query), sketch tools (draw point/line/polygon and add annotation) and customized *GeoDF* tools (spatial search for arguments and show hottest area of discussion). The use of the *GeoDF* map tools is the most challenging part for non-expert users. Figure 4.2 shows the distribution of the smiley icons on the map, which represent discussion contributions in the forum. These icons are placed at the center point of each contribution's map coverage. Green happy faces represent "For", yellow neutral faces represent "neutral", red sad faces represent "against". The contributions can be retrieved based on locations by dragging a box over certain area using the "spatial search" tool.

4.2 Test Design

Preece et al. [2002] outlines five categories of usability evaluation methods: *analytic*, *expert*, *observational*, *survey*, and *experimental*. An "analytical evaluation" employs "interface descriptions to predict user performance". An "expert evaluation" uses identified experts in the related field to analyze and evaluate the system. An "observational evaluation" reviews and assesses the behavior and reactions of users when using the system. A "survey evaluation" solicits users' opinions on the use of the system through the use of a questionnaire or interview. Finally an "experimental evaluation" utilizes the scientific practice of controls to analyze the prototype. In this line of research, the author combined user-derived impact analysis Good et al. [1986], analytic, observational and survey evaluation methods in order to measure whether or not the *GeoDF* software fulfills its initial goals defined by [Tang, 2006].

4.2.1 Usability Tasks

Usability tasks should be chosen to be as representative as possible, and to provide a reasonable coverage of the most important parts of the user interface and system functions [Nielsen, 1993]. Derived from the participation ladders, the author designed the usability tasks based on the findings derived from user analysis (see Section 3.4.1) and task analysis of how users actually use the *GeoDF* software (see Section 3.4.2).

Table 4.1 shows a list of participation actions and respective usability tasks and subtasks that were used during the experiment.

Table 4.1: Participation actions with respective tasks.

Participation Actions	**Specific Task in the Study**
-Get notified about the planning issue	-Get invitation to participate from *GeoDF* Moderator
-Have access to proper information/data	-Explore forums for existing discussions
-Analyze data and information (spatial/non-spatial)	-Navigate map, identify features to be discussed, identify discussion distribution
-Initiate relevant issues	-Start a new discussion
-Discuss relevant issues	-Join a existing discussion
-Use relevant material to support one's view	-Use spatial context to better express one's view
-Comment on the reliability of one's comment	-Ensure identification of other participants
-Involve more participants	-Send invitation to those who might be interested

These tasks were grouped into four usability tasks (refer to Appendix C):

- Task 1 was aimed at testing the navigation functionality and the retrieving of the saved spatial context to selected positions and arguments; the suitability of the spatial context for providing contextual information about topics 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 relative simple one - explore the *GeoDF* software to find participants' suggestions of the placement of the Westmorland Street bridge ramp in the Union Street area;

- Task 2 was aimed at testing the usability of the system for its participation capability. The task consisted of four parts. Part 1 was aimed at testing the usability for user registration and log-in; Part 2 for map navigation, displaying layers of planning area, layer selection, feature selection, and advanced spatial query functionality; Part 3 for sketch and annotation functionality; and Part 4 for the discussion functionality. Thus, the task was a complex one that had combined the registration/log-in process, the use of the map and sketch tools, the preparation of the spatial context, and finally the discussion functionality.

- Task 3 was aimed at testing the memorability of the system for its participation capability. This task included using all the functionality they had learned, after at least 30 minutes of interaction with the *GeoDF* software, to initial a discussion about the planning constraints for a particular topic. It was aimed at testing how much the participants can remember after had just performed a similar task; and

- Task 4 gave the participants the freedom to explore the prototype in any way they wanted. The task was aimed to gather further feedback and comments about how easy or difficult they found the whole process to be.

4.2.2 Test Subjects Sample Size

The *GeoDF* software is intended to facilitate the general public to participate in the ongoing discussion of spatially-related issues. For this study, representative users were recruited. Test subjects were recruited from a combination of academia, and non-academia individuals (18 years of age and above) who have varying degrees of familiarity with Web-based systems and GIS systems.

The test subjects can be categorized in to these two groups:

- Fredericton residents who are active members of their local community; and
- Students/Staff from the University of New Brunswick who are interested in participating in this PPGIS user study.

Seven participants were recruited by personal invitation for the individual testing meetings. This number may seem small, but it has been shown that the maximum ratio between the benefit and the cost in terms of time and effort for testing is achieved when using five to eight participants. Most Web site usability engineerings believe that additional participants are less likely to add new information about possible usability problems [Nielsen, 1993; Lewis, 2006; Lumsden, 2007]. After the encountered usability problems start to repeat and not much new is found, there is no need to continue with more tests.

Participants involved in the group testing were recruited using a "snowball" sampling procedure from a combination of graduate student and non-UNB individuals in order to have various backgrounds. In order to measure whether or not the increased usability would result in greater participation, Dr. Joanna Lumsden, a research officer at IIT of the NRC, suggested that, for a statistically rigorous test, the author needed to recruit two groups of approximately 20 participants each, and then test the improved version against the older version separately in two different workshops.

4.2.3 Questionnaire Design

There were two questionnaires (see Appendix D) used for assessing the usability of the *GeoDF* software.

A *user information questionnaire* was designed to ask participants about their participation in online discussion forums, familiarity with GIS and Internet/computer knowledge, previous involvement with local community planning decisions, as well as demographic variables like gender, age, occupation, education level. The objective of this questionnaire was to identify the participant characteristics as well as their ability to understand and contribute to spatially-related discussions.

A *post-test questionnaire* was also designed to assemble participants' opinions about the *GeoDF* GUI, clarity of functions, design and layout, and suitability for the purpose of community planning. This study extended the IBM Computer System Usability Questionnaire (CSUQ) method, which is mainly a close-ended questionnaire that has been found to be both a reliable and valid instrument for lab-oriented usability evaluations [Lewis, 1995]. The term "system" or "computer system" was replaced by "Web site". Each question in post-test questionnaire is a statement and a rating on a 7-point Likert scale of "Strongly Disagree" to "Strongly Agree" with higher numbers indicating higher levels of satisfaction. The questionnaire is designed to analyze across three categories: system usefulness, system interface quality, and information quality. As mentioned in Section 2.3.2, *system usefulness* or *perceived usefulness* refers to the degree to which a system can improve one's task performance - enhance one's participation in this case. It is considered one of the most important psychometric variables because it has been closely linked to user acceptance and adoption of information technology [Davis, 1989]. System *interface quality* refers to the perception of the user interface layout. The final category is *information quality*. It refers to information with which the system provides the users with helpful and important information to complete the usability tasks. This could include help messages, error messages, and clear display of information content. Beside CSUQ, a set of open-ended questions was also included in the questionnaire, which was used to gather opinions about user comments and the best and worst aspects of the *GeoDF* software.

Questions 1-4 focuses on evaluating the perceived usefulness of the *GeoDF* software. The remainder of the questionnaire considers topics that refer to the prototype Graphic User Interface (GUI), clarity of functions and terminologies, design and layout of the prototype, and suitability of the prototype for the purpose of land use planning.

The participant characteristics are eventually linked with the user ratings and answers on the post-test questionnaire to cross reference and analyze the usability of the *GeoDF* software and measure whether or not it would be beneficial to planning processes.

4.3 Test Procedures

The usability experiment was conducted in two stages - individual testing and group testing. Both stages were structured in three parts: (1) an introductory session to describe to the participant about the PPGIS concept and expectation of the usability test; (2) a hands-on session in which the participants explored the prototype and completed a set of predefined tasks; and (3) an interview/questionnaire session, which aims to gather qualitative data and subjective ratings.

4.3.1 Individual User Testing

The individual user testing aimed at detecting the usability problems of *GeoDF* V1 and to create a PPGIS that would be usable by any community members regardless of their familiarity with either online collaboration tool or GIS. The total number of participants was seven, two of which took part in the pilot study in order to reveal possible problems with the test environment, instructions, and the software and hardware before the actual testing. The remaining five participants took part in the main tests. Since *GeoDF* was a new system that was yet to be distributed to any users, none of the participants had experience with it. During the main tests, all five participants were exposed to the same presentation - *GeoDF* V1. There were no monetary incentive offered, and the participants took part in the test on a voluntary basis.

The tests were carried out in the Usability Laboratory at the Information Technology Centre of UNB. Separate test times were scheduled for each test subject. In the usability laboratory was a Windows XP desktop computer with *GeoDF* loaded on the Web browser, mouse and keyboard, and evaluation equipment and software such as colour video cameras, microphone, video/audio capture software.

A think-aloud protocol was used for this study. For the purpose of analyzing and understanding how users perform tasks with the computer, HCI literature advocates the complete recording of the interactive session, including the audio and the computer screen. Therefore, the user interaction on the screen and subject's think aloud comments were all videotaped.

During an individual testing session, the test subject was first introduced into the staging area, where the observer (i.e. the author) explained the purpose and expectations of the usability test. The observer described the PPGIS concept with the Union Street Secondary Plan, and then drew the *GeoDF* interface and system components on a white board before the subject used the system. At the end of the introductory session, the subject was asked to sign the informed consent form and fill out a user information questionnaire.

The subject was then guided to the participant room, where s/he received the usability tasks (refer to Appendix C) for the hands-on session. The participant room is a sound-deadening room with a half-silvered mirror wall, a microphone, and video cameras so that the observer can watch the subject's interactions from the TV output located in the observer room without causing unnecessary interference to the subject. This room created an environment for the subject to work with the *GeoDF* on their own just like they would normally use *GeoDF* in real situations. The same computer was used through out the testing, which means that the hardware and software settings were the same for all participants. The hands-on exploration lasted about 1.5-2 hours, during which the subject was asked to think aloud as he/she was using the *GeoDF* software. The observer remained in the observer room and prompted only when it was absolutely necessary. No personal help was given during the test, only online help and digital user guides were used. If the subject was not able to complete the task, s/he was asked to reset the interface to start up mode and proceed to the next task. Once the subject completed all the listed usability tasks, he/she was asked to fill out a post-test questionnaire (refer to Appendix D.2).

4.3.2 Group User Testing

The group meetings aimed to test the user acceptance and usefulness of the *GeoDF* as opposed to the user interface. Therefore, the group meetings followed the same logistics individual meeting sessions, however, without thinking-aloud and video/audio-taping the test.

According to data analysis results and observations in the individual testing stage, the usability defects of V1 were fixed and the user interface were refined before the group testing. The improved version - *GeoDF* V2, together with *GeoDF* V1, were presented to two different sets of participants.

Test subjects involved in the group workshops were recruited using a "snow-ball" sampling procedure from a combination of students, professors, staff, and non-UNB individuals in order to have various backgrounds. Initially, an invitation email was sent out to the UNB "e-daily" distribution list, which is an announcement board for UNB staff and faculty members. Five people replied within one week showing interest in the usability experiment. Follow up emails were sent to different departments in UNB, 16 people replied within 10 days. Along with the participants who replied, the author received three additional contacts from non-academia. Due to difficulty in recruitment, only 19 people were able to attend the group meetings. To even out the number of participants evaluating V1 and V2, of all the 19 subjects, five of which were added to assess *GeoDF* V1, the other 14 were exposed to *GeoDF* V2. For their participation, test subjects were paid $5. Approval was granted from the University of New Brunswick Research Ethics Board (REB) before the commencement of the study.

The group meetings were carried out in one computer lab at UNB, which could accommodate more than five test subjects at a time. Ideally, for each version of *GeoDF*, a sample size of 20 subjects is statistically meaningful. Due to the time and resource constraints, however, the usability evaluation analysis in this study is based on the resources available. It was assumed that findings based on the small sample size in this study would not reach levels of statistical certainty. However, statistical analyses were performed to suggest whether or not the differences both between and within conditions could be significant.

4.4 Summary

A usability experiment was designed and carried out to evaluate the usefulness and user acceptance of the *GeoDF* software. This chapter explained the test design and test procedures. In the individual meetings, the users were asked to think aloud so that the comments could be recorded and linked together with the user interaction. The group meetings were carried out to gather user satisfaction and user acceptance of the *GeoDF* software in a quick and simplified way so that the study could be completed within a master's thesis project time frame.

In the next chapter, findings of the usability experiment are discussed. Individual testing and group testing results are analyzed to measure whether or not the research hypothesis was correct.

Chapter 5

Results and Discussion of the Usability Experiment

The main purpose of this empirical study is to better understand the strengths and limitations of the current *GeoDF* software in supporting community planning from both a technological and citizen's perspective. The previous chapters of this thesis presented a usability experiment of the *GeoDF* software. In this chapter, qualitative and quantitative analysis based on information collected during the experiment is presented. The first half of this chapter summarizes the findings during the individual meetings. Measurements in this stage included elapsed time, think-aloud comments, erroneous actions, questionnaire, interview and user satisfaction rating. Rationale for modification to the user interface and findings during the group testing are then presented, followed by discussions of the experiment findings and data analysis results. This chapter concludes with discussions on the test results between V1 and V2.

The findings and analysis results in this study formalized a baseline which would assist PPGIS practitioners, researchers, citizens, and agencies to make better choices when selecting participation strategies.

5.1 Testing Results of Individual Meetings

This section presents observations and findings collected during the initial five individual tests. Data was extracted from videotapes as well as questionnaires. The videotapes were analyzed to obtain task time, erroneous actions, and think-aloud comments. The questionnaires were complied using a Microsoft Excel^{TM} spreadsheet to tally the answers to the specific questions posed. These tallies were been summarized into graphs and charts to highlight the responses. The gathered information was then analyzed to identify the usability defects in *GeoDF* V1.

5.1.1 Characteristics of Subjects

Background user information surveys were conducted using the pre-test questionnaire (refer to Appendix D.1) at the beginning of each individual meeting. The survey results depicted the initial participants' profiles in terms of technical experience, their viewpoints towards land use issues, and their willingness to participate in any form of decision making processes.

As depicted in Table 5.1, these survey results also allowed for a comparison between the subjects' profile and cross-referencing the answers and questionnaire ratings to each individual subject. The summary helps to better understand technical requirements of different types and levels of potential users. It also helps answer questions like: Do they use the Internet at all? For what reasons? What is their technical experience? Is there any difference in functionality requirements between different levels of users? What are local community members' expectations in exercising their citizenship through the information highway?

Table 5.1: Summary of user characteristics

	S1	S2	S3	S4	S5
Age	25-34	55-64	55-64	45-54	55-64
Gender	Female	Female	Male	Male	Female
Computer level	Intermediate	Beginner	Beginner	Intermediate	Intermediate
GIS familiarity	Beginner	Beginner	None	Beginner	Beginner
Web-mapping systems					
Google Maps	Yes			Yes	Yes
Google Earth	Yes			Yes	Yes
Map Quest	Yes	Yes	Yes		Yes
Yahoo! Maps				Yes	Yes

What's their technical experience?

Survey results summarized in Figure 5.1 showed that the subjects were generally familiar with the Internet and Web-based applications. Four of the subjects would use the Internet several times a day. The beginner user, however, would only use Internet once a day. Two of the subjects possessed only beginner level Internet skills, and the other three possessed Intermediate Internet skills. They were not, however, as familiar with GIS as they were with the Internet: two subjects had absolutely no previous GIS experience, and the remainder only had limited GIS knowledge and claimed to be beginner users of GIS (refer to Figure 5.2).

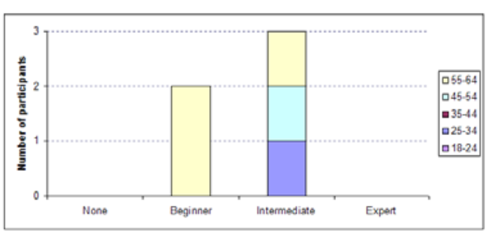


Figure 5.1: Participant's age/Internet skills distribution (V1)

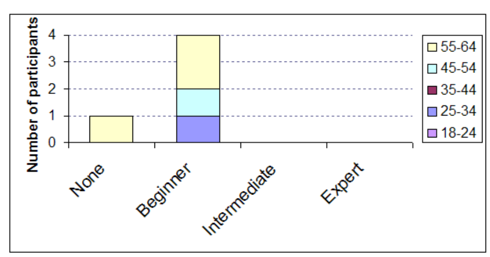


Figure 5.2: Participant's age/GIS skills distribution (V1)

What do participants use the Internet for?

The subjects were five adults aged 30 to 64 years old. Three of the five subjects were female and two were male[1]. They were recruited by personal invitation from a non-academic subject pool. The survey results show that all of the subjects have been using computer for more than three years. As shown in Figure 5.3, all five subjects have access to the Internet either from home or at work. The majority of respondents have been using the Internet for work, email, and information seeking. As shown in Figure 5.4, only one subject who belongs to the 25-34 year-old age group have used the Internet chat facility. Concerning the kind of information searched related to public services, all five the subjects have used the Internet to search for government services and the majority of them have searched for city services and programs (see Figure 5.5). With the increasing popularity of Web-mapping applications nowadays, all five subjects had either used MapQuest, Google Earth, Google Maps, and/or Yahoo!Maps (refer to Figure 5.6).

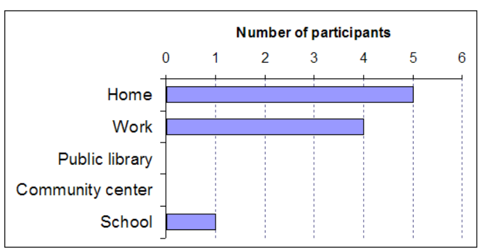


Figure 5.3: Access to the Internet (V1)

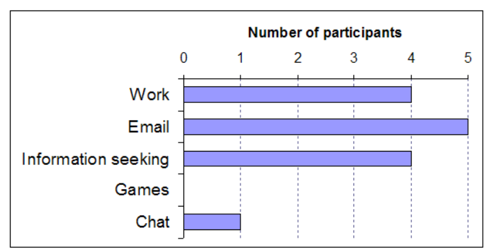


Figure 5.4: Main use of the Internet (V1)

What is their opinion about land use issues?

When asked about their opinions on public participation or community planning, three subjects felt a part of the neighbourhood where they lived in, while two did not. Only two subjects had been involved in planning activities more than three times in the past 12 months (acted as coordinator and/or committee member), one had previously participated in public forums, one had sought infor-

[1]There were two other subjects participated in the pilot study to help finalize the test procedures, questionnaire design, therefore, their information was not included in the final assessment.

mation from City Hall, and one had not been involved in any form of participation processes at all. When asked about whether they are interested in participating in the future, four stated “Yes”, only one indicated “Issue Dependent” - for example, he is the property owner.

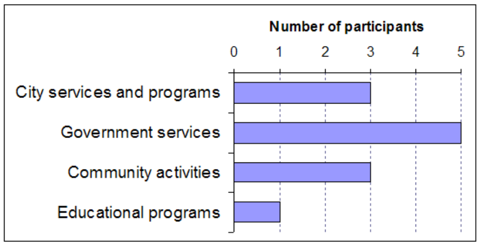


Figure 5.5: Kind of information searched (V1)

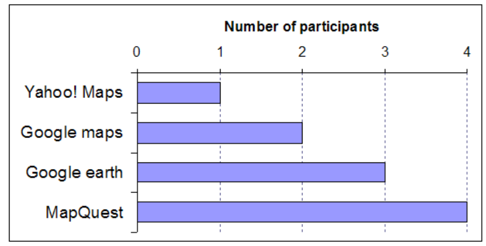


Figure 5.6: Participant’s Web-mapping experience (V1)

5.1.2 Content Analysis of the Videotapes

The following four criteria were considered when identifying usability defects (adopted from [Nielsen, 1993]):

- **Task time** - the time it takes for the participant to complete each task and subtasks;
- **Erroneous action** - an action that did not get the user closer to their goal of solving the problem;
- **Problem space** - an action that represents a different method of solving a question sub-goal from what was previously attempted; and
- **Think-aloud comments** - the action of the test subject verbalizing his/her thoughts to all the aspects of the software.

Erroneous actions represent user actions such as: (1) right-clicking on the map area trying to bring up a map tool menu which does not exist; or (2) trying to pan the map by dragging the *Pan* tool in the Web-mapping component that does not accept the *drag* mouse event. **Problem space** instances are problems, which need several workarounds to solve them. For example, the *Zoom to initial map extent* task could be a problem space instance if a participant had difficulty in finding a direct way to zoom back to the initial map extent and would then revert to use the *zoom back history* tool or the *Back* button on the Web browser to complete the task. Erroneous actions might occur during a new instance of a problem space so these criteria are not necessarily mutually exclusive.

By reviewing videotapes of the users' sessions, the time to complete the usability tasks was calculated for each subject and shown in Table 5.2. There was no time limit given to the subjects. However, if the subject felt stressed and had been stuck at one point for more than 20 minutes, s/he was asked to reset the interface and proceed to the next task. The uncompleted task was marked TNC (Task Not Completed) and System Error was marked SE as shown in Table 5.2.

The analysis of the videotapes also revealed a list of 18 interaction problems, which are shown in Table 5.3. "–" in the table means that the subject did not encounter the problem listed. Due to the varying level of Internet/GIS skills, different subjects discovered different problem spaces.

The total Problem Time versus Test Time revealed the importance of previous acquaintance with GIS, Web-mapping, and spatial data. Those subjects who were not familiar with Web-mapping had greater difficulties in understanding the representation of the spatial data and had longer learning curve to correctly navigate the map. This significantly resulted in uncompleted usability tasks.

As depicted in Table 5.2, most subjects could perform the given usability tasks correctly, except S2 and S5 who had more than 20% problem time and only completed 53.8% of the usability tasks.

Table 5.2: Time taken to complete usability tasks (hours, minutes, seconds)

Test Subject	S1	S2	S3	S4	S5
Task 1					
Explore the forum and maps	19'18"	33'50"	42'40"	36'15"	35'25"
Find people's suggestion for the Westmorland Street bridge ramp	6'48"	11'02"	3'42"	3'44"	TNC$\hat{*}$
Task 2					
Register	1'51"	3'16"	4'15"	2'22"	17'41"
Activate account	SE$\hat{*}$	TNC	1'36"	4'17"	7'7"
Login	18"	2'54"	44"	10"	19"
Navigate the map (zoom/pan)	2'27"	24'12"	6'19"	0	12'47"
Measure and spatially search	14'26"	10'30"	8'12"	18'54"	TNC
Draw sketches	3'57"	TNC	3'12"	1'09"	TNC
Prepare the spatial context	TNC	TNC, SE	1'48"	3'24"	TNC
Join discussion (reply to a message)	13'10"	6'15"	5'05"+2'08"	6'49"+47"	TNC
Task 3					
Initiate new discussion	TNC	TNC	1'40"	3'10"	26'39"
Start a poll	TNC	TNC	TNC	2'10"	4'12"
Task 4					
Free exploration	42'37"	TNC	13'27"	27'55"	TNC
Total Problem Time$\hat{**}$	**10'48"**	**53'02"**	**7'38"**	**1'12"**	**33'56"**
Total Test Time $\hat{***}$	**1:54:33**	**1:22:58**	**1:28:21**	**1:23:28**	**2:10:50**
Total Number of Posts	**1**	**1**	**3**	**3**	**1**

$\hat{*}$ TNC: Task Not Completed; SE: System error (SE was also calculated into the total problem time).

$\hat{**}$Refer to Table 5.3: Time spent due to problems.

$\hat{***}$ Total **Test Time** was calculated from the moment subject sat in front of the computer until they completed all the usability tasks, which includes **Task Time**, **Problem Time**, time on reading the instructions, and time on verbalizing their thoughts.

Table 5.3: Time spent due to problems (minutes, seconds)

Problems	**S1**	**S2**	**S3**	**S4**	**S5**
Don't know where to get started	–$\hat{*}$	3'16"	–	–	2'38"
Map displaying	39"	5'39"	–	–	–
Map navigation (zoom/pan)	–	32"	–	–	28"
Mistaken icon for forum as link to forum	–	10"	–	–	–
Activate user account	5'20"	2'12"	–	–	–
Confused between mouse events	–	2'40"	–	–	–
Draw polygons	55"	–	–	–	–
Add annotation	1'27"	–	–	9"	–
Confused between menus	–	–	10"	–	–
Erasing sketches	–	–	9"	–	–
Lost map frame after registration	–	–	–	39"	4'14"
Double click for spatial search	2'05"	2'39"	–	–	–
Feel disoriented in forums	–	26'04"	–	–	16'8"
Data loading bar always appearing	–	2'38"	6'29"	–	–
Layer selection	22"	6'15"	45"	10"	–
Others' sketches mess up the map	–	–	5"	14"	2'47"
Tab key in registration process	–	–	–	–	7'41"
Spatial server crashed	–	57"	–	–	–
Total Problem Time	**10'48"**	**53'02"**	**7'38"**	**1'12"**	**33'56"**

$\hat{*}$ "–" means the subject did not encounter the problem listed. Due the varying levels of computer/Internet/GIS knowledge, however, the encountered problems were different among beginner users and intermediate users.

S2 was a beginner user of both the Internet and GIS. S2 belonged to the 55-64 year-old age group and had been using computer for 3-5 years and would only access the Internet once a day when she needed to check emails or search for information. Although S2 had some experience with MapQuest, she still could not control the *GeoDF* map GUI after had used *GeoDF* for more than one hour. As depicted in Table 5.3, for the first 3'16", S2 was only looking at the *GeoDF* start up page, moving her mouse around, but did not click on anything on the screen. The discussion tree and the frame layout of *GeoDF* made S2 feel confused and disoriented. After having used *GeoDF* for more than 30 minutes, S2 commented that *"I am still confused. I really don't know what I should be doing here, or what I can be doing here."* S2, however, did manage to finish all the non-spatial part of the usability tasks - find people's suggestion for the bridge ramp, register/login the forum, reply to an existing discussion. After S2 had finished the non-spatial tasks, at the 1:22:58 time mark, when S2 showed fatigue and loss of concentration, the observer ended the test session.

S5 and S2 have some commonality in their profile. S5 also belongs to the 55-64 year-old age group, but is more computer-literate than S2. Besides checking email and seeking information on the Internet, she would use Google Earth or MapQuest to search for location information, was familiar with the map control tools such as "zoom" and "pan" and had no difficulty in picking up the *GeoDF* map control GUI. Her difficulty was in understanding the organization and terminology of the discussion forum. S5 had the longest test time, which was due to the fact that S5 spent more then 30 minutes trying to figure out the answer to the first usability task, and thus prolonged the test time.

5.1.3 GeoDF V1 Usability

In Section 3.4.3, the author estimated the usability benchmarks for *GeoDF* V1. The observed usability level after the first round testing is shown in Table 5.4.

Table 5.4: GeoDF V1 Usability (after individual testing)

	S1	S2	S3	S4	S5	**Mean**	**Max**	**Min**	**StDev**
Time taken	1:54:33	1:22:58	1:28:21	1:23:28	2:40:50	1:46:00	S5	S2	n/a
% of task completed (Learnability)	69.2%	53.8%	92.3%	100%	53.8%	73.8%	100%	53.8%	n/a
# of posts posted (Efficiency)	1	1	3	3	1	1.8	3	1	1.09
Error rate	9.42%	63.92%	8.62%	1.43%	25.93%	21.86%	S2	S4	n/a
Perceived usefulness	5.75	4.25	6.25	5.5	5	5.35	6.25	4.25	0.76
User acceptance	5.4	3.5	6.25	6.25	5.25	5.4	6.25	3.5	1.14
Ease of use	4.35	3.25	4.75	5.5	3.5	4.35	5.5	3.25	0.95
Information quality	4.00	3.33	4.67	3.67	3.33	4.00	4	3.33	0.78
Interface quality	4.68	2.8	5.6	5.6	4.8	4.68	5.6	2.8	1.15

Equation 5.1 and 5.2 define the *Learnability* and *Error rate* respectively, where $N_{correct}$ is the number of correctly completed tasks, and N_{total} is the total number of tasks and subtasks; $T_{problem}$ is the time spent due to problems, and T_{total} is the total test time.

$$Learnability = \frac{N_{correct}}{N_{total}} \tag{5.1}$$

$$ErrorRate = \frac{T_{problem}}{T_{total}} \tag{5.2}$$

Due to the small sample size in the first round, it was assumed that Perceived Usefulness (PU), User Acceptance (UA), Ease of Use (EoU), Information Quality (InfoQ), and user interface quality (InterQ) would not reach levels of statistical certainty. However, the results as shown in Table 5.4 were satisfactory compared to the estimated benchmarks. The calculated *Mean* for most of the criteria were slightly higher than the planned target levels defined in Table 3.5. While the Information quality was one point lower than the planned target level, it was still higher than the worst-case level.

During the second round of group testing, another five subjects were chosen to test *GeoDF* V1. Data generated from the group testing were collected and *GeoDF* V1 usability was then re-calculated. Further statistical analysis were performed at the conclusion of the group testing to determine whether the differences among different technical levels, age groups, and willingness to participate could be shown significant.

5.1.4 Sources of User Frustration

In Questionnaire 2 (refer to Appendix D.2), Question 21 asked subjects to identify the problems and difficulties they encountered during the course of the experiment. In addition to these user-identified problem space instances, a list of existing problem spaces observed from the videotapes (refer to Table 5.3) was also compiled and summarized into the following seven categories.

1. Register/login process, including user registration, activation of user account and login;
2. Join discussion, including create new discussion topic and reply to existing discussion;
3. Exploration of the discussion forum, including the retrieval of spatial context, exploration of text content of the forum, and understand the *GeoDF* terminology;

4. Understand the map, including understand vector and raster representation, and map legend of different themes;

5. Navigate the map, including zoom in/out, pan, zoom to full extent, zoom to active layer, and map layer selection;

6. Add sketches and annotations, including draw points, lines, polygons, and add annotations;

7. Perform spatial search to search for arguments by point-and-click on the map.

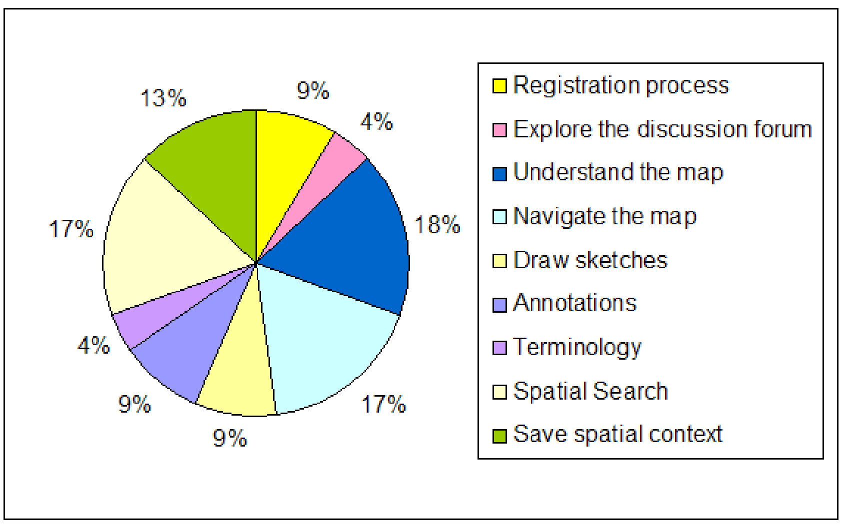


Figure 5.7: Problem spaces for GeoDF V1

These instances were further divided into nine subcategories as shown in Figure 5.7). The four most commonly-encountered problems included: "understanding the map" (18%), "navigating the map" (17%), performing "spatial search" (17%), and "saving spatial context" (13%). Linking back to the user profiles, it is not difficult to find why most of the difficulties occurred with the Web-mapping component. As shown in Figure 5.2, the subjects participating in individual testing were not very familiar with GIS and spatial data.

Several subjects commented that their first impression with *GeoDF* was that it is a busy screen and they did not know where to get started and that the information that *GeoDF* provided was overwhelming. S4 had the first impression that *"It seems to me quite busy here, it might take a while for the users to get used to the layout here. Is there a how to get started page?"*

The subjects also found the structure of the discussion tree was confusing, and switching to other discussion topics was difficult. S5 commented that the terminology used in the forum was not intuitive enough, instead of using the "Topic → Issue → Position → Argument" hierarchy, she would suggest use plain English language, such as " Category → Forum → Topic → Comments".

The problem with the spatial search feature, however, was caused by a software bug. The *spatial search for arguments* tool (see Figure 5.8) shows the distribution of the smiley icons on the map, and would only perform correctly with users drawing a rectangle around the target ones. The user's intuition was to (double) click on the target smiley icon. This action, however, would cause the system to throw out a blank map page.

Another design problem involved "saving spatial context". S4 suggested that either there should be user controls on whether to save the current map or not, or there should be a system message to remind the user that they are saving the current map as the spatial context for their text message, therefore, ask the user to make sure proper spatial context is in use[2].

[2] Due to time constraints, this feature was not implemented in *GeoDF* V2

Figure 5.8: Show AHD with spatial distribution of arguments turned on

5.1.5 Suggestions for Improvement

At the end of each individual meeting, beside the questionnaire survey, the subjects were also interviewed for their opinion on the desirability of existing features and their suggestions for improvement. Table 5.5 summarizes user's opinion about how desirable each feature is. The Likert Scale used here was "Extremely undesirable" (1) to 'Extremely desirable'" (7), with a score of "4" being "Neutral". The number under each column represents the number of subjects who had circled on the scale. S2 became frustrated in the end. Most of her answers to the survey were "No answer", because she did not come across the listed features with her experience.

As illustrated in Table 5.5, the subjects have a mixed opinion about the discussion tree, ranging from "Slightly undesirable" to "Extremely desirable". This is related to their understanding of the *GeoDF* spatial context concept and understanding of the system structure. The lower scores were given by S2 and S5. The other three participants, who had better understanding of the whole system design generally, thought that the discussion tree is a desirable feature and should

Table 5.5: Test subjects' opinion of the desirability of each GeoDF feature

	1	2	3	4	5	6	7	No answer	Mean$\hat{*}$
Forum features									
Discussion					2		3		6.2
Discussion tree			1	1	1	1	1		5
Registration					3	1	1		5.6
Search		1		2			2		4.8
Private messages	1	2		1				1	2.25
Online survey (Polls)				1	1	2	1		5.6
User groups			1	1		1	1	1	5
User profiles				2		2		1	5
Forum permissions				1	1	1	1	1	5.5
Attachment				2	1			2	3.5
Invitation				1	2	1		1	5
Spatial context						1	3	1	6.75
Viewpoint(smiley icons)			1	1		2		1	4.75
Print				2		1	1	1	5.25
Web-mapping features									
Toggle forum/map				1		2	1	1	5.75
Pan				1		1	2	1	6
Overview map				2		1	1	1	5.25
Zoom in/out			1			1	3		6
Zoom to full extent				1	1	1		2	5
Zoom to active layer			1	1	2			1	4.25
Zoom back history				2		2		1	5
Print map				3			1	1	4.75
Measure					1	1	2	1	6.25
Select features			1			3		1	5.25
Identify visible features						2	2	1	6.5
Spatial search					1	2	1	1	6
Show AHD					1	3	1		6
Draw sketches & annotations					2	1	1	1	5.75
Map layer control					3		1	1	5.5
Spatial queries				2		2		1	5

$\hat{*}$ The "Mean" values are calculated using ONLY the responses from those people who actually provided an opinion.

not be left out. "Private message" is a feature that the majority of the subjects think it is undesirable.

For the map component, although the map navigation tools like zoom and pan were "Desirable" according to the user rating, S3 still commented that *"The map loading would have to be much quicker...this would be easier if this map move like MapQuest does, that one I understand. I am not interested in learning a new method, so it's unfamiliar to me, so being unfamiliar, it becomes confusing, because it's confusing, I probably wouldn't use it. This wouldn't hold my attention long enough to teach myself some new way of interacting. Because map to me has been taught to me by MapQuest and Google Earth. "*

"Zoom to active layer" is a feature that caused some confusion. By reviewing the videotapes, the author found that most of the subjects did not understand what "active" layer is in GIS, and have used the tool and other related features incorrectly. For example, in order to perform a "Spatial search", users would have to "active" the target layer first.

Although map tools such as "Spatial query", and "Identify visible feature" received high score, S4 who comes from a surveying background, commented that *"The query tool is powerful; however, we wouldn't be using it to do detailed investigation of ownership, and maybe specific zoning, I am not sure of the purpose of building in this functionality. I think if you are just trying to get general public participation on this sort of forum, I am not sure of the benefits to the users. I like the 'Identify visible layers' feature. As a member of the public, I want to see the Parcel ID, I want to see the address and zoning, but I don't think I need to see anything else."*

In the next section, the findings and analysis from the first round of individual testing were compiled and subsequently served as the rationale for modifications to the *GeoDF* V2 user interface. Because the re-design of *GeoDF* V2 interface also considered time constraints and implementation cost, the V2 interface is not necessarily the "best" interface but the "optimal" interface considering these constraints.

5.1.6 GeoDF Interface: V1 to V2

As previously described, the *GeoDF* V1 interface can be divided into five distinct areas: **title & login bar**, **discussion tree&map layer TOC**, **map area**, **toolbar**, and finally the **forum area**. The first round of individual testing revealed under-use, over-use, and/or mis-use of features caused by usability defects in the interface design of V1. The discovered usability defects are described here for the purpose of detailing the modifications made to the interface. In the meantime, the modifications also followed the Web usability heuristics (refer to Section 3.3.1), which is considered the design guideline for Web sites.

5.1.6.1 Title & Login area

The title & login bar (see Figure 5.9) was at the top of the *GeoDF* V1 interface. It served as the title bar and is the place where users login to the system and perform text search.

Figure 5.9: Title & Login area for V1

According to observations from the usability experiment, however, four out of five subjects totally ignored the top bar. Because there were a few other places in the forum area where users could login/register and perform search action, the information and search box provided in the title bar was simply just duplicate information. The first heuristic suggested that the user interface should be simplified as much as possible. The title & login bar was therefore removed from *GeoDF* V2 to simply the interface and reduce information duplication.

5.1.6.2 Discussion tree & map layer TOC

The discussion tree TOC is the control panel for turning on and off the spatial context of individual contributions and is therefore the most important feature in *GeoDF*.

By reviewing the videotapes, the author found that most subjects had difficulties in understanding the structure and/or organization of the *GeoDF* V1 TOC (see Figure 5.10). As shown in Figure 5.12, once a link (discussion topic) was clicked, the discussion topic was then opened as the root of a new discussion tree and with all the nodes (discussion contributions) expanded. To switch to a different discussion topic, the user would have to select a different topic from the drop-down list above the tree and press the "Load topic" button.

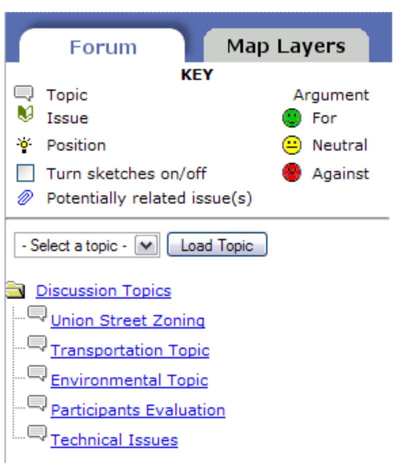


Figure 5.10: Discussion tree TOC in V1

Figure 5.11: Discussion tree TOC in V2

S1 suggested that *"The organization of the discussion tree is initially confus-*

ing. The arguments about the Westmorland bridge was interfered by other topics. It's better to start with all the topics/forums collapsed." S3 said that his first impression was that *"This doesn't show me how to get into a discussion quickly. I tend to go to the topics that I'm interested in and start to read through some of the opinions. The discussion pieces I see here, it's not giving me topic. There would be too much clicking for me to get to where I want to be."*

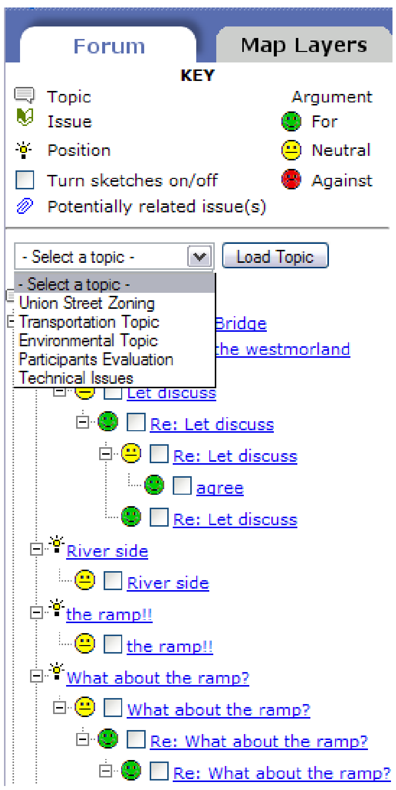


Figure 5.12: Discussion tree TOC in V1 with tree expanded

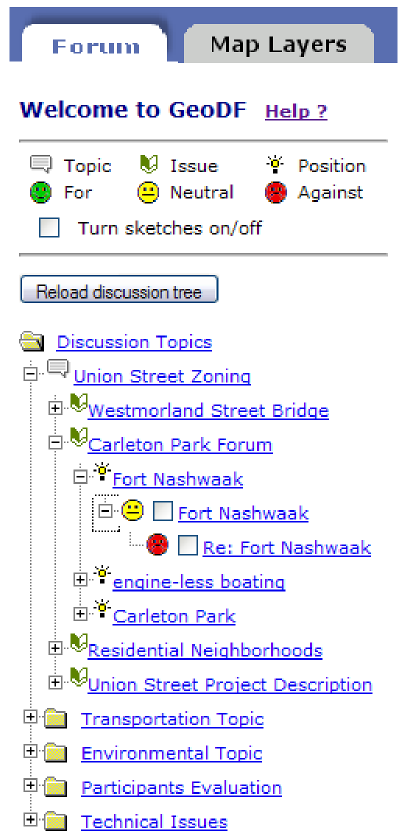


Figure 5.13: Discussion tree TOC in V2 with tree expanded

Nielsen [1993] mentioned in the third usability heuristic, "Minimize user memory load", that interfaces based on recognition rely to a great extent on the visibility of the objects of interest to the user. Nontheless, displaying too many objects and attributes will result in a relative loss of salience for the ones of interest to the user, so a system should match object visibility as much as possible with the user's needs. As usual, "less is more". Therefore, the discussion tree TOC was re-designed in *GeoDF* V2.

As shown in Figure 5.11 and 5.13, the drop-down list on the top was replaced with a "Reload discussion tree" button. The discussion tree TOC was initially loaded with all the topics collapsed in the same tree. Issues, positions, and arguments are opened under the same root and follow the threaded structure to display the evolution of ideas. These modifications increased the usability of the TOC by reducing the information displayed, meanwhile, still maintain the depth and width of useful information.

As previously mentioned in Section 5.1.5, novice or amateur GIS users did not understand the concept of "active" layer and other related features, such as "Activate a layer", "Zoom to active layer", and "Spatial query[3]".

The initial map layer TOC in V1 (see Figure 5.14) managed the map layers and controlled whether or not a layer was visible and/or active. In the V1 map layer TOC , the map layer name appeared like clickable hyperlink when hovered over, therefore, users' intuition was to click on the map layer name and wait and see what would happen. This action, which might not be users' intention, would accidentally activate a map layer. Thus, the active layer feature was removed in *GeoDF* V2 (see Figure 5.15). In the meantime, the map legend was start with all map legend collapsed for the same "less is more" rule.

[3]Spatial query is a feature that users could query on fields in active layer, this feature comes with the ArcIMS package.

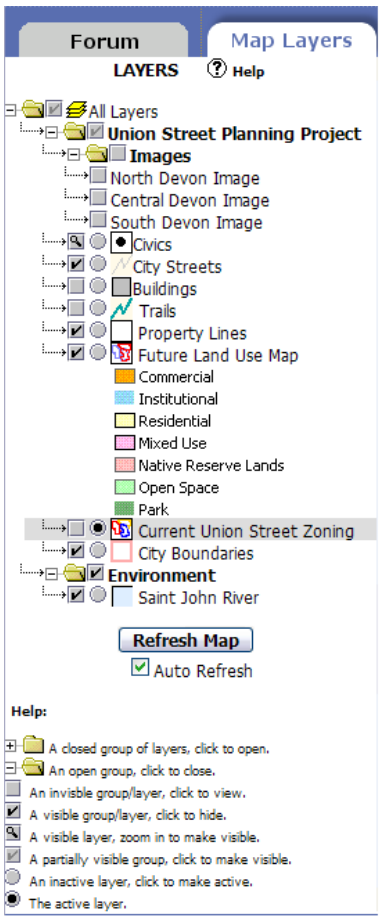


Figure 5.14: Map layer TOC in V1

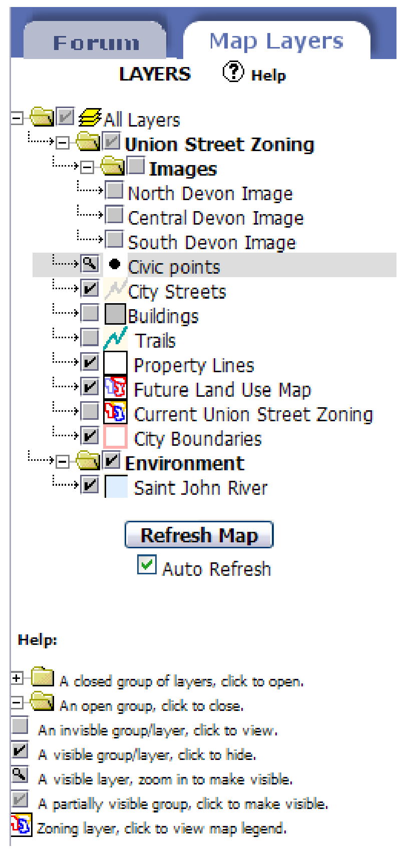


Figure 5.15: Map layer TOC in V2

5.1.6.3 Map area and toolbar

As previously discussed, novice Internet/GIS users would some difficulties in using the map tools, for example S2. During the usability experiment, S2 became frustrated because she could not remember what function each tool provided, and thus had to refer to the tool-tips over and over again. S1 also commented on the toolbar – *"I totally missed out the 'Show Forum' button, I thought it was not clickable."* S3 suggested that *"There are button icons mixed with text and links on the toolbar. It's better to have a standard button-based interface."* (refer to Figure 5.16). S1, S2, and S4 also mentioned that they were not used to see the toolbar down in the middle of the screen. They expected the toolbar to appear closer to the top.

Based on survey results as shown in Table 5.5, undesirable features were removed, such as "Overview map", "Zoom to active layer", "Spatial Query" and "Select" (see Figure 5.17).

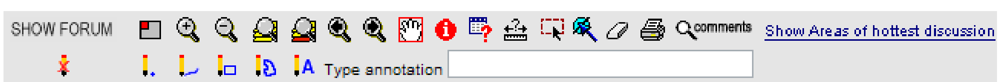


Figure 5.16: Toolbar in V1

Figure 5.17: Toolbar in V2

The suggestions and comments from the subjects were considered to re-design the map toolbar. The icons were re-drawn to provide a standard button-based toolbar, and tool name was provided on each tool button to minimize user memory load. The toolbar was then moved to the top of the map area and the software bug with "Spatial search on arguments" was fixed, which allowed users to click on the target smiley icon and retrieve the correct spatial context and text message associated with that icon. A Help file (see Figure 5.18) was also made available in HTML format with explanations and instructions on how to use the map tools.

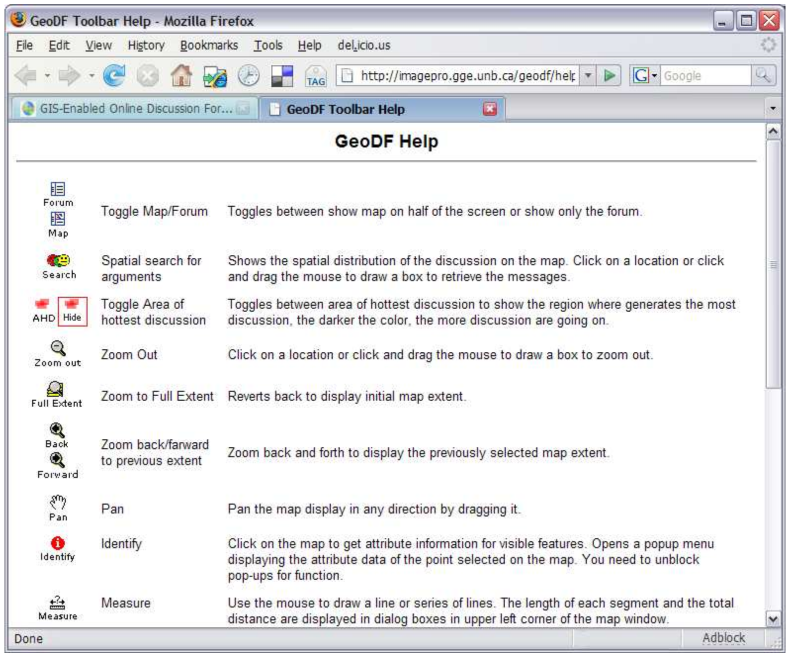


Figure 5.18: Online help file in V2

5.1.6.4 Layout of GeoDF V2 Web page

The final user interface of *GeoDF* V2 is shown in Figure 5.21. The layout of the Web page was simplified to make the screen look less busy. Due to time constraints, *GeoDF* V2 (see Figure 5.20) still followed the frame layout of V1 (see Figure 5.19). As shown in Figure 5.19, below the TOCFrame/DFTOCFrame was the DocFrame where users could access documents (such as text, audio/visual files, and so on) that are relevant to the selected issue. The "Attachment" feature was incorporated into the forum, therefore, the DocFrame was removed to leave more space for DFTOCFrame/TOCFrame.

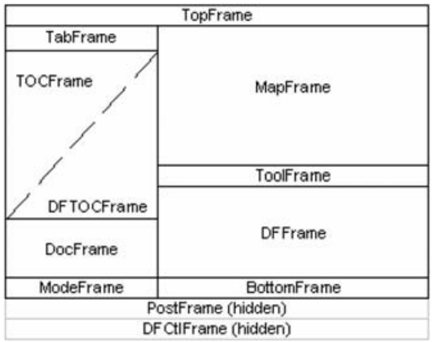


Figure 5.19: Frames layout of GeoDF V1 Web page

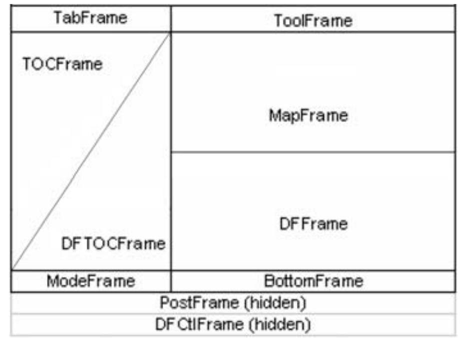


Figure 5.20: Frames layout of GeoDF V2 Web page

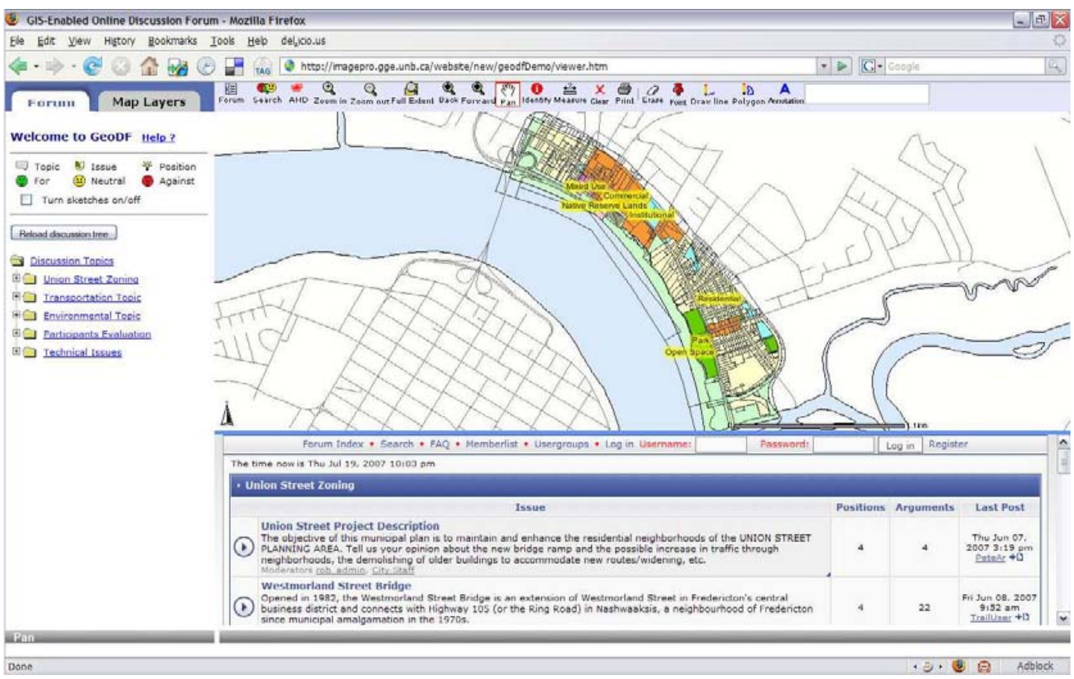


Figure 5.21: The final GeoDF V2 interface

5.2 Testing Results of Group Meetings

This section compares the user-testing findings and observations between the two versions of the *GeoDF* software. The group testing aimed at understanding how different levels and types of users would react to PPGIS technology and how effectively the enhanced usability would increase and encourage local citizen participation. Measurements in this stage mainly included questionnaire, interview and quantitative analysis of subjective user satisfaction ratings. The same methods as employed earlier were used to compile the questionnaire and tally the answers. The gathered information was then analyzed and cross referenced with different types and levels of users. *Minitab* statistical analysis software was used to perform statistical comparisons to assess the significance of the experiment findings.

5.2.1 Characteristics of Subjects

There were 19 subjects recruited for the second round of group testing. Five subjects were randomly assigned to assess *GeoDF* V1, while the remaining 14 evaluated *GeoDF* V2. All factors (usability tasks, test procedure, questionnaires) were held constant between the two groups with the exception of the difference in the *GeoDF* software.

The 14 subjects evaluating V2 aged 18 to 54 years old, which included eight students, three librarians, two UNB technical staff, and one non-UNB individual. Because the participants in this round were mostly recruited from academia, the subjects were mostly experienced Internet users - intermediate or expert (refer to Figure 5.22). Their GIS experience ranged across all four levels – from users who have no previous GIS experience to those who are experienced expert (refer to Figure 5.23). Therefore, it was expected that they would not have too many technical difficulties operating the *GeoDF* software.

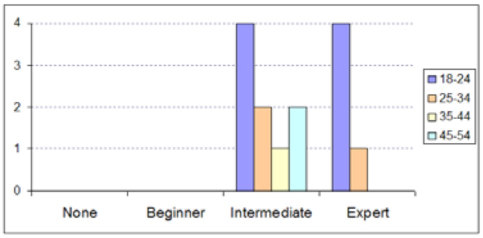


Figure 5.22: Participant's age/Internet skills distribution (V2)

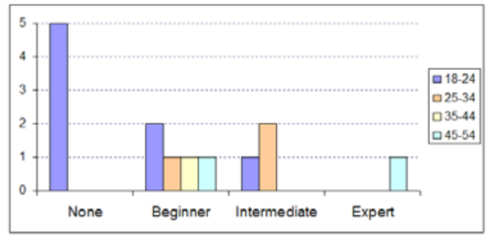


Figure 5.23: Participant's age/GIS skills distribution (V2)

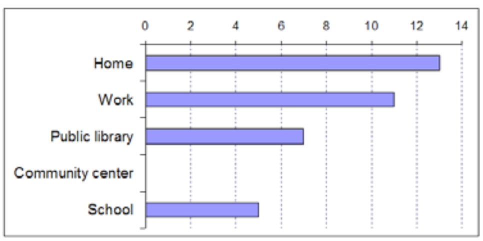


Figure 5.24: Access to the Internet (V2)

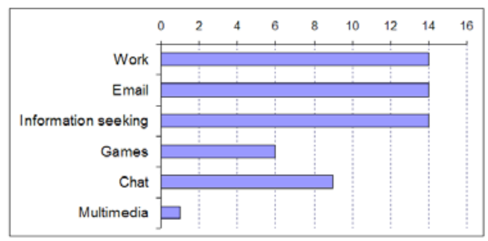


Figure 5.25: Main use of the Internet (V2)

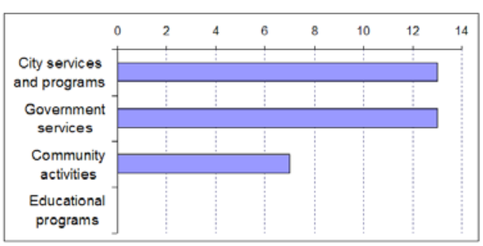


Figure 5.26: Kind of information searched (V2)

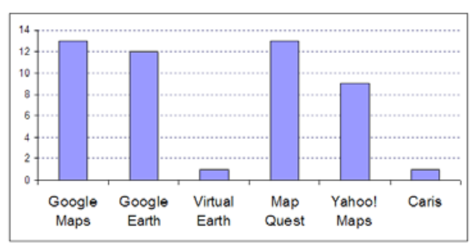


Figure 5.27: Participant's Web-mapping experience (V1/V2)

All members of this group were experienced users who have been using computer for more than 5 years. All 14 subjects have regular access to the Internet from home (refer to Figure 5.24), work or at school and the majority of which would access the Internet several times a day. The younger subjects in this group used the Internet for email and information seeking, but also for gaming, chatting, and multimedia (refer to Figure 5.25).

The majority of this group had searched for information related to public services, such as government services and city services and programs (see Figure 5.26). In terms of Web-mapping experience, nearly everyone in this group had used Google Earth and Google Maps, the majority of them had used MapQuest, and/or Yahoo!Maps, one user had tried Microsoft Virtual Earth and another had tried Caris (refer to Figure 5.27).

5.2.2 Results Comparison

The post-test questionnaire were analyzed at the conclusion of the group testing. V1 usability was re-calculated based on data gathered from a total of 10 subjects (5 from individual testing, 5 from group testing) and compared with V2 usability.

Table 5.6 shows the observed usability of V1. Since the group testing aimed at collecting data on user satisfaction and user acceptance, videotapes were no longer used to record user interaction. The results of V1 show that the subjects were able to complete most of the usability tasks (mean = 80%) within the 2-hour experiment timeframe. The averge number of posted arguments during the testing were 2.9. One subject posted a total of 7 arguments and a review of which revealed that each posted argument was just reply message to an existing thread, this particular subject did not initial any discussion. Descriptive statistics showed an increase in the usability attributes between the versions. The highest rating was given to "Perceived usefulness" with an average score of 4.92 and the "user acceptance" received the second highest rating of 4.73, which were closer to 5 (slightly agree) on the 7 point scale. The discussion tree TOC was considered the most confusing feature and thus resulted in the lowest satisfaction rating for "Information quality" (mean = 4.20). In summary, the overall rating of V1 was 4.67, with a standard deviation of 0.998.

The "observed levels" of V1 were then used as the "current levels" of V2. The target usability level of each usability attribute in V2 was expected to be 20% greater than "observed level" of V1. As shown in Table 5.7, V2 target levels were calculated and presented together with the observed levels.

By comparing the "current level" and "observed level" in Table 5.7, there was an increase in the "% of task completed" from 80% in V1 to 98% in V2. There was a drop in the average "# of posted arguments", however, from 2.9 to 2.5. This was because the subjects were only asked to reply to an existing message and then create a new discussion, which was a total number of 2. A review of the questionnaire and interview data showed that the subjects who showed higher interest to *GeoDF* tend to post more than the required number of arguments - this finding also applies to *GeoDF* V1.

The greatest change in satisfaction rating was "information quality", which had an increase of 25.2% - from 4.2 to 5.26. This increase was mainly due to the changes made to the discussion tree & map layer TOC. The second greatest increase was "user acceptance", which had an increase of 19.7% - from 4.73 to 5.66. The least increase occured to "perceived usefulness", which only had an increase of 12.2% - from 4.92 to 5.52 (see Figure 5.28).

Table 5.6: GeoDF V1 Usability

Usability Attribute	**Measuring Technique**	**Value to be Measured**	**Target level$\hat{*}$**	**Observed level**	**Max**	**Min**	**StDev**
Learnability	Usability tasks	% of task completed	60%	**80%**	100%	53.8%	-
Efficiency	Usability tasks	# of posted arguments	1	**2.9**	7	1	1.91
Error rate	Observation	User error using the system	n/a	**n/a**	n/a	n/a	n/a
Perceived usefulness	Questionnaire	Average score(Q1-Q4)	5.00	**4.92**	6.25	2.5	1.17
User acceptance	Questionnaire	Average score(Q5-Q8)	5.00	**4.73**	6.25	2.25	1.46
Ease of use	Questionnaire	Average score(Q9-Q12)	4.00	**4.48**	5.75	3.25	0.91
Information quality	Questionnaire	Average score(Q13-Q15)	5.00	**4.20**	6	3	0.96
Interface quality	Questionnaire	Average score(Q16-Q20)	4.00	**4.52**	5.8	2.8	1.01
Overall rating	**Overall rating: Mean = 4.67; StDev = 0.998**						

$\hat{*}$As mentioned in Section 3.4.3, the benchmarks were determined prior to the usability evaluation based on an expert user's (i.e. the author) completion of the usability tasks. The benchmarks were then established by estimating how a beginner might perform and rate. See Table 3.5.

Table 5.7: GeoDF V2 Usability Level

Usability Attribute	Measuring Technique	Value to be Measured	Current level	Target$\hat{*}$ level	Observed level	Increase rate	Max	Min	StDev
Learnability	Usability tasks	% of task completed	80%	96%	**98%**	**21%**	100%	92%	-
Efficiency	Usability tasks	# of posted arguments	2.9	3.48	**2.5**	**-16%**	4	2	0.65
Error rate	Observation	User error using the system	–	–	–	–	–	–	–
Perceived usefulness	Questionnaire	Average score(Q1-Q4)	4.92	5.91	**5.52**	**12.2%**	6.50	3.75	0.81
User acceptance	Questionnaire	Average score(Q5-Q8)	4.73	5.67	**5.66**	**19.7%**	6.75	4.25	0.78
Ease of use	Questionnaire	Average score(Q9-Q12)	4.48	5.37	**5.04**	**12.5%**	6.50	4.00	0.84
Information quality	Questionnaire	Average score(Q13-Q15)	4.2	5.04	**5.26**	**25.2%**	6.67	3.00	1.03
Interface quality	Questionnaire	Average score(Q16-Q20)	4.52	5.42	**5.37**	**18.8%**	6.60	3.00	0.99
Overall rating	**Overall rating: Mean = 5.37; StDev = 0.689**								

$\hat{*}$Refer to Table 3.6, the worst-case level is same as V1, the planned target level is 20% V1.

The data suggested improvement in all five usability attributes from V1 to V2. Due to the small sample size, further statistical analyses were performed in the next section to determine whether the increases from V1 to V2 could be shown significant.

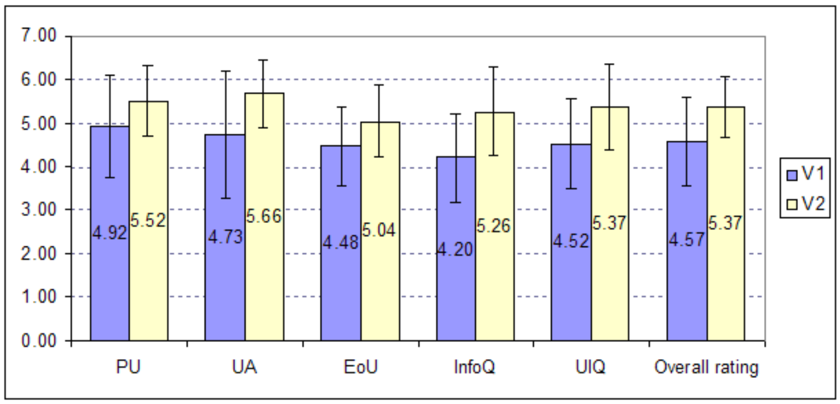


Figure 5.28: GeoDF V1 vs V2 Usability Level

5.3 A Two-Sample T-test Statistical Approach

It is usually hard for student researcher to have enough time or resources to get a sample of optimum size. A small sample size does not guarantee the results and observations of the empirical study to be statistically reliable, which was the exact challenge for this study.

In statistics, a result is called *significant* if it is unlikely to have occurred by chance. The observed difference between the means of two random samples is described as statistically significant, when it can be demonstrated that the probability of obtaining such a difference by chance only, is relatively low. The significance of a result is also called its *p-value*. P-value measures the strength of the evidence against the null hypothesis - the smaller the p-value, the stronger the evidence is against the null hypothesis.

Significance is usually represented by α (alpha), which is the maximum acceptable level of risk for rejecting a true null hypothesis and is expressed as a probability ranging between 0 and 1. Popular levels of significance are 5%, 1% and 0.1%, the smaller the α value, the less likely it is to incorrectly reject the null hypothesis. The selection of α-level depends on the nature of the testing and involves a compromise between significance and power. For this study, the most commonly used 0.05 α-level was chosen. If the test of significance gives a p-value lower than 0.05, the null hypothesis is rejected. Such result is referred to as 'statistically significant'.

5.3.1 Null Hypothesis

The research hypothesis formalized at the beginning of this study (refer to Section 1.1) was that "increased usability of a PPGIS would encourage people to be more involved in public participation". A hypothesis test was used to evaluate whether the statement could be supported by the data.

It was assumed that increased usability would result in a greater satisfaction rating. If the hypothesis were true, the overall rating of V1 would be less than that of V2. Therefore, the null and alternative hypotheses were formalized:

Null hypothesis: H_0

H_0:μ=0

Alternative hypothesis: H_A

H_A: $\mu < 0$

A two-sample t-test was chosen to calculate the probability of obtaining the observed sample data under the assumption that the null hypothesis is true. If the p-value is below the defined α-level (0.05), then this assumption is probably wrong. Therefore, the author could reject the null hypothesis and conclude in favor of the alternative hypothesis.

5.3.2 Two-sample T-test

The t-test was chosen because it is the most commonly used method to evaluate the differences in means *between two groups*. Furthermore, the t-test can be used even if the sample sizes are very small(e.g., as small as 10 per group) and with unequal sample sizes between the two groups.

The formula for the t-test is a ratio. The top part of the ratio is the difference between the two means or averages. The difference between the means is the signal. The bottom part is a measure of the variability or dispersion of the scores, that is essentially noise. The t-value will be positive if the first mean is larger than the second and negative if it is smaller. This equation is only used when the two sample sizes are unequal.

$$\frac{signal}{noise} = \frac{difference\ in\ group\ means}{variability\ of\ groups}$$

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{X}_1 - \bar{X}_2}}$$

where

$$s_{\bar{X}_1 - \bar{X}_2} = \sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

5.3.3 Normality and Variance Test of Testing Data

The t-test requires some constraints to be fulfilled:

- The variances have to be equal;
- The samples have to be independent of each other; and
- The samples have to follow a normal distribution.

Test subjects were randomly assigned into two groups and were independent from each other. In order to qualify for t-test, *Minitab* statistical software was used to perform the normality test and test for equal variance on samples.

The Anderson-Darling (AD) test was used in *Minitab* software to test if the sample data were normal, especially for samples with only two levels. That is, in this study, two versions of *GeoDF*. The hypotheses were – H_0: data follow a normal distribution; H_A: data do not follow a normal distribution. When p-value $\geq$ 0.05 the data is normal.

As shown in Figure 5.29 and 5.30, the vertical scale on the graph resembles the vertical scale found on normal probability distribution. The horizontal axis is a linear scale. The line forms an estimate of the cumulative distribution function for the population from which data are drawn. Numerical estimates of the population parameters, μ and σ, the normality test value, and the associated p-values are displayed with the plot. The test on V1 and V2 yield p-values of 0.321 and 0.069 respectively, both p-values were greater than 0.05, which proved that the two samples were normally distributed.

An F-test was used to determine whether the variances of V1 and V2 were equal. The test for equal variances generated a plot (see Figure 5.31) that displays Bonferroni 95% confidence intervals (refer to Table 5.8) for the response standard deviation at each level. The p-value of the test was 0.217, which was greater than reasonable choices of α, which indicated that these samples have equal variances.

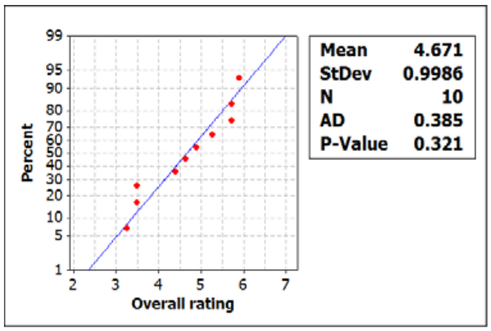


Figure 5.29: Normality test of V1 sample data

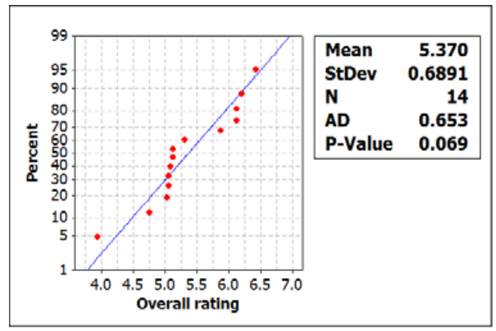


Figure 5.30: Normality test of V2 sample data

Table 5.8: 95% Bonferroni confidence intervals for standard deviations

Version	N	Lower	StDev	Upper
V1	10	0.653238	0.998647	2.01093
V2	14	0.478325	0.689149	1.19763
Test statistic = 2.10, **p-value = 0.217**				

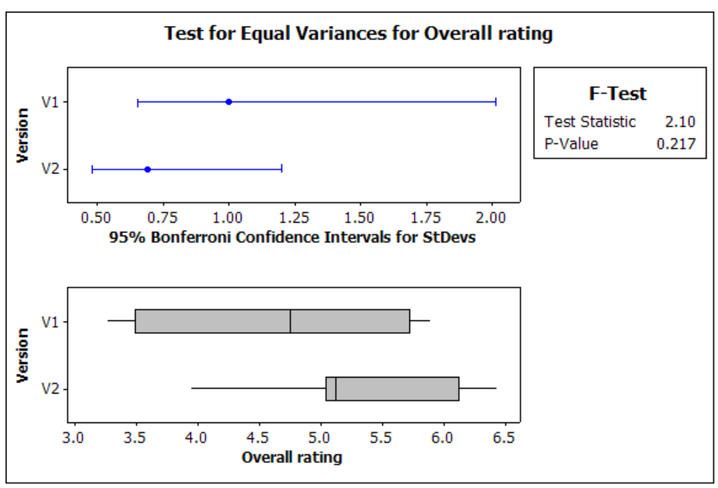


Figure 5.31: Test for equal variances for overall rating

5.3.4 Results of Two-sample T-test

Figures 5.32 and 5.33 give a graphical summary of the distribution of the samples that shows their shape, central tendency, and variability. The median of V1 and V2 are connected by a line to show the increase in overall rating. Sample sizes, sample means, standard deviations, and standard errors (SE) for the V1 and V2 samples were displayed earlier in Table 5.9.

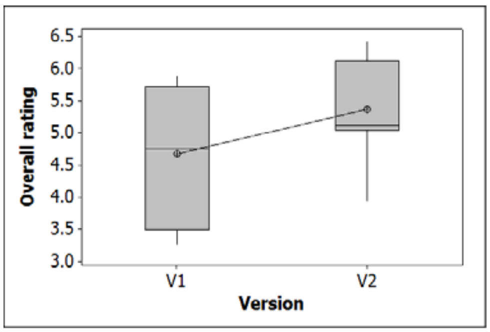


Figure 5.32: Boxplot of overall rating

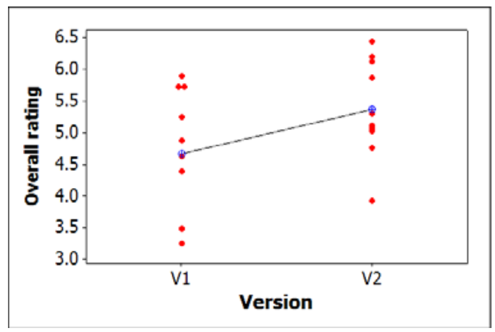


Figure 5.33: Individual value plot of overall rating vs version

Table 5.9: Two-sample T for overall rating

Version	**N**	**Mean**	**StDev**	**SE Mean**
V1	10	4.671	0.999	0.32
V2	14	5.370	0.689	0.18

Difference = mu (V1) - mu (V2)
95% upper bound for difference: -0.109
Estimate for difference: -0.699

T-Test of difference = 0 (vs <):
T-Value = -2.03 **P-Value = 0.027** DF = 22

Descriptive statistics showed clear differences between V1 and V2. Analysis of the post-test questionnaire provided evidence that the subjects generally think it would be easier to get involved in land use planning procedures through the use of the *GeoDF* (mean = 5 (V1), 5.79(V2); seven point scale, refer to Q1 in Appendix D.2). The subjects also rated "Netural" on whether or not *GeoDF* V1 increased their view on the value of public participation (mean = 4.8, Q6). In turn, those who were exposed to *GeoDF* V2 indicated through their ratings that V2 did increase their view on land use related issues greatly(mean = 5.79). If made available, they would use *GeoDF* to participate in future land use planning projects (mean = 5.3(V1), 6.0(V2), refer to Q8). One-sided two-sample t-tests were performed to test whether the results could be shown to a level of proof: *Q1: t = -1.17, p = 0.128; Q6: t = -0.93, p = 0.181; Q8: t = -1.28, p = 0.106.* Negative t-values were obtained which means the first mean is smaller than the second one. Due to the small number of participants, these differences approached but did not reach significance.

The subjects also rated *GeoDF* as a very effective tool in helping to enhance communication among different stakeholders in future land use decision-making procedures (mean = 5.5 (V1); 6.21 (V2), Q4) and they would be more involved in such issues after the experiment (mean = 4.1 (V1), 5.57 (V2)). Results from t-test were: *Q4: t = -1.97, p = 0.031; Q7: t = -2.22, p = 0.018*, with both p-values less than 0.05. These results showed that the *GeoDF* was not only an effective communication tool in land use planning procedures, but was able to encourage participants to be more involved in such processes.

The results shown with the graphs of Figure 5.28, 5.32, and 5.33 proved the hypothesis to be true, that is, enhancing the usability of the *GeoDF* software, lowering the cost of entry, and providing effective communication channels would result in greater participation. The two-sample t-test analysis proved the hypothesis to a higher bar than was needed, namely statistical significance.

5.3.5 Other Findings

The subjects were generally satisfied with the *GeoDF* Web-mapping component (mean = 5.0(V1), 5.14(V2)). Most participants found the discussion forum in V1 not very satisfactory (mean = 4.50), but very satisfactory in V2 (mean = 5.92). This was an unexpected response, as the author did not modify the forum component. This might due to the fact that in earlier evaluation, the way the discussion tree was designed did not effectively show the benefit of the spatial context to the participants (mean = 4.6(V1), Q14), and thus the subjects were confused about how to join a discussion using *GeoDF* V1 and generally felt disoriented in *GeoDF* (mean = 4.9, Q12). With the modifications made to V2, the subjects started to notice the benefits and usefulness of the spatial contexts (mean = 5.36), and thus felt less disoriented (mean = 5.43), which resulted in the higher rating for the forum component in V2.

Table 5.10 illustrates users' preference for different types of maps. The frequency was summarized from answers to the multiple response question - Q22 in Questionnaire 2 (refer to Appendix D.2). 9 out of 10 subjects in V1 and 13 out of 14 subjects had preference for high resolution aerial images of the current zoning. One commented that *"It's cool to have high resolution images. This is why I enjoyed this program. Google Earth incorporation would be great."*

Table 5.10: Results of user preference on types of maps to be used.

	Frequency	
	V1	V2
Overview map of the current zoning and future zoning	7	10
Detailed map of changes in future zoning	3	9
High resolution aerial images of the current zoning	9	13
It depends on the planning issue	1	0

Through a closer examination of the user profiles, the author found that the majority of _novice_ users preferred high resolution images as they could see things better from an aerial point of view. Intermediate and expert GIS users who did not have difficulty understanding vector maps indicated that detailed map of changes of the current/future zoning were more helpful to discuss planning related issues.

Age and computer literacy were also factors in affecting user acceptance of *GeoDF*. Participants involved in the two rounds of usability testing fell into five different age groups. As depicted in Table 5.11, however, due to the small sample sizes, no statistical analysis approach could be used and there was no clear correlation between age group and overall rating.

Table 5.11: Age groups of test subjects

Version	Age	Count	Overall rating
V1	18-24	2	4.18
	25-34	3	4.80
	35-44	1	4.39
	45-54	1	5.72
	55-64	3	4.61
V2	18-24	8	5.44
	25-34	3	5.50
	35-44	1	5.06
	45-54	2	5.06

Different levels of users have different expectations for computer software. By reviewing the videotapes from individual testing, more computer-literate users always expected the system to have certain functions to solve specific problems they encountered, and thus when there was a problem, they tended to look for expected features in the system before jumping to a conclusion. The novice users, however, reacted differently: they felt lost when they could not see a direct solution to their problems.

Nonetheless, based on interviews with the test subjects, the subjects indicated that the acceptance of such PPGIS technology would be largely determined by their motivation and benefits they could gain through the participation.

5.3.6 Limitations of the Evaluation

The sample size of the first round of individual testing was limited to the necessary minimum [Nielsen, 1993; Lewis, 2006; Lumsden, 2007]. Ideally, it will be helpful for larger sample sizes to be recruited for the second round of group testing to verify the results presented in this chapter. However, due to limited time resource, the present evaluation is based on limited number of samples.

Most of the data was collected using the "satisfaction rating" protocols. One known disadvantage of this method is that the participants might misunderstand the questionnaire question, and thus provide a false rating. With the small sample sizes, any false rating could affect the research results significantly.

Measuring the performance time was not always very accurate in this study. The problem related to the time measurement was that the subjects frequently needed to reread parts of the instructions to find out how they should proceed. Therefore, the time spent on each task sometimes included the time spent searching for the right information in the instructions, not just the time spent performing the task. The measurements could be significantly improved if, in future, background software were used that records screen activity, such as mouse movement or keyboard clicking.

The next chapter will sum up the work completed for the research and outline future research opportunities.

Chapter 6

Conclusions

This research is a follow-on to the *GeoDF* research project. The objective of the research is to empirically evaluate the *GeoDF* software in the belief that improved usability and enhanced social collaboration will increase the effectiveness of social cooperation and result in greater participation. This chapter concludes the thesis by summarizing the work completed for achieving the research objective and discussing future research directions. Major contribution and findings of the research will be highlighted in the concluding remarks.

6.1 Work Completed

A literature review on theories and practice of PPGIS and community planning was conducted. Technology cannot be expected to solve societal problems by itself, but it can be used as the platform that is required for the efficient support of communities' activities. The initial *GeoDF* V0 prototype was designed to be an alternative solution to use technology as an additional communication channel to support participatory planning. In order to empirically evaluate user acceptance of *GeoDF* in an experimental participation discussion setting, the significance of a HCI study stood out during the literature review. It is an area that has not been examined extensively in the PPGIS literature.

Before even beginning any testing, the author consulted extensively with City of Fredericton and NB Lung Association staff. The preliminary modifications and improvements made to the early *GeoDF* V0 prototype following these consultations resulted in the *GeoDF* V1 software employed in the first round of testing.

Usability engineering principles were then considered for the evaluation of the *GeoDF* software. The purpose of the evaluation was defined. The *GeoDF* software was intended to help members of the general public participate in the ongoing discussion of spatially-related issues. The usability evaluation aimed to determine whether or not the *GeoDF* software can actually benefit the general public, whether or not the *GeoDF* can enable participants to express their opinions more effectively in a spatially-related discussion situation. Different usability engineering methods were compared, and a series of tests were designed in order to investigate whether or not the *GeoDF* software is usable and acceptable.

After the usability test procedures were established, a two-stage usability experiment was carried out. In the individual meetings, the users were asked to think aloud so that the comments could be recorded and linked together with the user interaction. Observations and findings were summarized and converted to technical solutions and served as rationale for the development and implementation work prior the group testing. Modifications focused on V1 usability defects and resulted in an improved user interface in the *GeoDF* V2 software. The group meetings were then carried out to gather user satisfaction ratings between V1 and V2 in a quick and simplified way so that the study could be completed within a master's thesis project time frame.

The findings and observation from the usability experiment showed that the users were generally satisfied with the functionality. Participants were particularly impressed by the spatially-related discussion that the system supports. The results showed that *GeoDF* tools was not only an effective communication tool in land use planning procedures, but was able to encourage participants to be more involved in such processes. A two-sample t-test analysis proved the hypothesis to a higher bar than was needed, namely statistical significance. Nonetheless, the users' acceptance of PPGIS technology is still largely determined by their motivation and other human factors.

6.2 Opportunities for Future Research

This research proved that enhanced usability, low cost of entry, and effective communication channels would result in greater participation. The following areas are identified for future research or further enhancement of the statistical analyses.

Further analyses could be performed if there were larger sample sizes, such as comparison of the differences between age groups, levels of computer literacy, participation experience, willingness to participate, and on-line chatting experience.

As mentioned in Section 5.1.6, the *GeoDF* V2 still follows the frame layout due to limited time resource and the scope of the present research. AJAX is an emerging development tool being considered for many new Web-based applications – especially Web-mapping. The future trend of PPGIS user experience should be moving towards frameless layout and timely map and information retrieval.

Another direction for future research worth examining is to investigate how open source technologies can contribute to a reusable, timely, and intuitive PPGIS platform. The Web-mapping component of *GeoDF* software was built on proprietary software ArcIMS. As discussed in Section 3.4.1.2, *GeoDF* is hard to reuse for different use cases and the current implementation also limits the spatial data to be stored and displayed in a proprietary format, which is not necessarily an ideal implementation for a long-term public sector application.

As discussed in Section 2.2.2.1, social networks would also influence the adoption of PPGIS applications. People tend to see themselves validated by forming a strong and empowered community. We are already seeing other Web-based examples of location-based social networks, in which participants can share location-information about their neighborhood and connect directly with friends and neighbors. Adopting the concept and technology of location-based social networking in PPGIS research will enable a PPGIS tool to have the capability to organize and geo-reference its participants, which in turn enhances the spirit of public participation.

6.3 Concluding Remarks

This research reinforces the link between the research community and the potential users by documenting collaboration and communication needs of different stakeholders in civic planning and decision-making processes through the usability experiment.

The findings and observations provide evidence of how the public react to the *GeoDF* software. This research also pointed out the significance of usability of the PPGIS tool, and user communication needs and motivations as the most influential factors in the adoption of PPGIS technology in civic planning and decision-making processes.

The PPGIS tools such as the *GeoDF* software are just another means of participation. At the conclusion of the usability testing, the author is specifically interested in real-world planning practises in conjunction with municipalities and assessing the *GeoDF* with real users.

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Appendix A

Usability Test Plan

A.1 User Tasks Link to System Functions

1. Questions to be answered with the Usability Testing:

    Basic questions:

    (a) Does the map download quickly enough?

    (b) Does the website display well (size, color, layout, tool tips) in different browsers?

    (c) Does the website contain too much information?

    Functions:

    (d) Are the map tools easy to use?

    (e) Is the forum easy to explore?

    (f) Does the user complain about any of the functions?

    Layout:

    (g) Do users find the "Three-frame" layout confusing/crowded/inconvenient?

(h) Is the navigation tree on the left panel confusing?

(i) Is the "map layer" not obvious enough?

(j) Do users go over all the discussion threads in a topic before participating?

(k) Do threads at the top/bottom of the discussion get overlooked?

(l) Do the users know how to use the spatial search for arguments? Do they find it useful?

(m) Are the "smilies" intuitive enough?

(n) Do users easily compare the text message and its spatial context on the map?

Instructional design:

(o) Do users better read/understand the master plan?

(p) Do the spatial contexts help users understand other users' perspective?

(q) Will the on-line collaboration draw more attention to planning applications than tradition techniques/tools?

Information architecture:

(r) Are the discussion threads organized in a way that can be understood by users?

(s) Are the category/content names sufficiently descriptive?

(t) What do the users do when they don't know how to continue?

(u) Checklist, Things to do before testing:

- Upload planning context for the forum;
- create different forums/categories - set the scene;
- Create user group/discussion group;

- Clean up forum.

A.2 Test Procedures

Part I: Introductory plenary session

1. Checklist for test day:

2. Lab computer set up

    - Testing Internet bandwidth;
    - Install Firefox;
    - Browser set up (enable Javascript and cookie);

3. Introduction at the beginning of the session

    - Explain the layout of the GeoDF on the white board;
    - Print out the layout of the GeoDF - explain to the test subject;
    - Three frames, forum tab, map layer tab, toolbar;

4. Print out question-based tasks

    - Make participants' copies. One for each test subject, one for Jianfeng;
    - Jianfeng can take notes on her copy;

5. Print out questionnaire and consent form.

6. Time for user to fill out the questionnaire;

7. Debrief at end of session;

8. Test procedure printouts;

9. Pens and clipboards.

Test Protocol

Jianfeng will be the observer and note taker. For each task, determine the following:

1. Time a task requires (server tracks or screen capture);

2. Error rate (observation of users);

3. User's subjective satisfaction (survey after each task);

Test takes about 2 hour start to finish

1. Call day before to remind;

2. Arrive 30 minutes earlier to set up computers;

3. Greet user. Run through pre-test script and set expectations;

4. Has user sign release form and fill out questionnaire;

5. Begins with pre-defined tasks;

6. Jianfeng takes notes and prompts user as necessary;

7. End with user free-form exploring;

8. Thank them for participatin;

9. Follow up with thank you letter.

Part II: Practical "hands-on" session

The "hands-on" session tests both the mapping and collaboration component, including the following main tasks:

1. View discussion threads together with their spatial context
2. Reply to an existing argument
3. Login/register
4. Map exploration
5. Draw sketches
6. Forum exploration
7. Start a new topic
8. Free exploration

Appendix B

Test Participant Release Form

Please read and sign this form.

In this usability test:

- You will be asked to perform certain tasks on a website.
- We will also conduct interview with you.
- You will be asked to fill in a questionnaire.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used to help improve the web site. However, at no time will your name or any other identification be used. You can withdraw your consent to the experiment and stop participation at any time. If you have any questions after today, please contact Jianfeng Zhao at 506-453-5058.

I have read and understood the information on this form and had all of my questions answered.

Subject's signature	________________	Date	________________
Usability consultant	________________	Date	________________

Appendix C

Usability Tasks

C.1 Usability Task 1

First, you might want to explore the discussion forum and familiarize yourself with the GeoDF prototype. View the messages from the discussion tree list on the left hand side. Click on the ones that seem interesting to you.

Question: What had been people's suggestion for placement of the ramp for the Union street area?

Hint: You might also want to switch between Map Layers and Forum tab to get different map themes. Pay attention to the smiley icons, map (top right) and text content (bottom right) for each message in the forum.

C.2 Usability Task 2

This task has several parts. Now choose a topic that seems interesting to you. You want to join an existing discussion.

Task a: Register (first time user) or login to join the discussion.

Hint: If this is the first time you use GeoDF, you will need to have a valid *email account and use that to receive the activation email sent from GeoDF.*

Task b: Explore the map to identify your area of interest.

Hint: Try different tools on the tool bar, try turning on/off different map layers from the Map Layer tab. If you are not sure about what each tool does, hover over a tool, and wait a few seconds for the tool tip to come out.

Task c: Then draw sketches and add annotations as you wish (should be meaningful). *Hint: Erase existing sketches first to avoid confusion.*

Task d: Reply to an existing message in the forum; compose your text message; choose your view point from the "Against, Neutral or For" smiley icons. Finally submit your message.

Hint: Toggle the forum/map view, if there is not enough space for you to view/compose messages. Scroll up/down the forum if you could not find the proper function or feature.

C.3 Usability Task 3

Start a new message about things you concern about. Navigate to your area of interest on the map. Start a poll or add an attachment to support your argument. Submit your message.

Hint: Recall what you did for Task 2.

C.4 Usability Task 4

Free exploration of the map. Try out different map functions, such as "Spatial search for arguments", "Show hottest area of discussion" and different forum functions "Digest", "Invitation", "User group".

Appendix D

Questionnaires

D.1 Questionnaire 1 - Pre-test Questionnaire

Privacy Information

Please note that this questionnaire is completely confidential. The information gathered herein will only be used by our research. Identifying information will never be distributed to parties outside the research.

1. Your age:
   - 18-24
   - 25-34
   - 35-44
   - 45-54
   - 55-64
   - 65+
2. Gender:
   - Male
   - Female
3. Your occupation:

   ____

4. Your education level:
   - High School
   - Some college
   - Bachelors degree
   - Masters Degree
   - Doctorate
5. Your computer experience:
   - less than 1 year
   - 2-3 years
   - 3-5 years
   - 5+ years
6. How often do you use the Internet?
   - Several times a day
   - Once a day
   - Several times a week
   - Once a week
   - Less than above
   - Never
7. How would you rate your knowledge level with the Internet/Web?
   - None
   - Beginner
   - Intermediate
   - Expert
8. Where do you currently have access to Internet? (check all that apply)
   - Home
   - Work
   - Public Library
   - Community Center
   - School
   - Other, please specify:

9. What do you use Internet for? (check all that apply)
    - Work
    - E-mail
    - Information seeking
    - Games
    - Chat
    - Other, please specify
10. How would you rate your knowledge level with GIS?
    - None
    - Beginner
    - Intermediate
    - Expert
11. Which ones of the following web-mapping systems have you used? (check all that apply)
    - Google Maps
    - Google Earth
    - Virtual Earth
    - MapQuest
    - Yahoo! Maps
    - None of the above
    - Other, please specify
12. Do you currently use the Internet to search information about: (check all that apply)
    - City services and programs
    - Government services
    - Community activities
    - None of the above
    - Other, please specify
13. Do you feel a part of the neighborhood you live in?
    - Yes
    - No

14. How important is it for you to feel a part of your local neighborhood?
    - Very important
    - Somewhat important
    - Not really important
    - Not important at all
    - Don't know
15. Have you ever been involved in a neighborhood or community planning activity?

    If yes, how many times in the past 12 months? What role did you play?

    If no, are you interested in participating in the future?
    - Yes
    - No
    - With condition
16. What's your feeling in participating with land use urban planning application?

D.2 Questionnaire 2 - Post-test Questionnaire

Your feedback is important! To help us assess our prototype, we would appreciate you taking a few minutes of your time to complete this questionnaire. Please circle on the scale the one that best represents your views.

1. After using the GeoDF, I think it will be easier to get involved in land use urban planning procedures with the use of the GeoDF.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

2. I gained good overall web-based GIS skills after using the GeoDF.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

3. Assuming the GeoDF would be available for future planning applications, I feel that GeoDF would help to enhance the effectiveness of communication among different stakeholders in future land use decision-making procedures.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

4. Overall, the GeoDF as a means of communication between different stakeholders in land use urban planning procedures is effective.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

5. Overall, it would be comfortable for me to use the GeoDF to communicate with other stakeholders in the planning process.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

6. The GeoDF improved my view on the value of public participation.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

7. My experience with the GeoDF would encourage me to be more involved in land use urban planning procedures.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

8. Assuming the GeoDF would be available on real planning applications, I would use it to participate in future land use urban planning projects.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

9. Overall, it was easy for me to learn how to use the GeoDF.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

10. It was easy for me to remember how to use the GeoDF next time I come back to it.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

11. It was easy for me to recover from a mistake when using the GeoDF.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

12. It didn't take me long to complete the tasks.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

13. The online collaboration forum is organized in a way that can be easily understood.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

14. The maps which are stored together with existing text messages are effective in assisting me understanding the perspective of other participants.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

15. The support information (such as online help, on-screen messages, tool tips) is effective in helping me complete tasks.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

16. Overall, the terminology used in the GeoDF is clear.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

17. Overall, the appearance of the GeoDF is aesthetically pleasing.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

18. I didn't feel disoriented (don't know where I am) when performing the tasks.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

19. Overall, the online collaboration forum component of the GeoDF is satisfactory.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

20. Overall, the web-based GIS component of the GeoDF is satisfactory.

Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
1	2	3	4	5	6	7

21. Which part of this prototype did you have difficulties with? (check all that apply)

    - Registration process
    - Exploring the discussion forum
    - Enter a new discussion contribution
    - Reply to an existing message
    - Understanding the map
    - Understanding the terminology
    - Navigating the maps, including turn on/off layers, zoom in/out of the map, etc.
    - Draw sketches
    - Add Annotations
    - Spatial Search
    - Other, please specify and give the detail of any difficulties

    ____

22. What kind of maps do you like to see? (check all that apply)

    - Overview map of the current zoning and future zoning
    - Detailed map of changes in future zoning
    - High resolution aerial images of the current zoning
    - Other, please specify

    ____

23. Which aspects and features of the GeoDF did you like the best?

24. Is there any issue, aspect or information which you would like to see covered in more detail in GeoDF?

25. Finally, do you have any other comments, suggestions and feedback that you would like us to consider in further developments or application of this prototype?

Appendix E

User Comments and feedback

- S1

  -I like the “AHD”, “Discussion tree”, “Annotation”.

- S2

  - I like the concept of the GeoDF.

  - I became frustrated.

- S3

  - Having get used to the features, I would use it quite a bit to participate. It would be something that I would find it really useful.

- S4

  -It is a little crunchy here, I guess we get spoiled by these million dollars Google package. We can load street names and refresh rate is a lot faster than this. But again, you get spoiled by that, the main hidden thing here is, this is a functional program. I think the issue is to get the city to post some discussion topic as you've done with the topics about the bridge for example, some background documents from the city, and then some arguments and polis, just to build it up, as what you've done here, that would encourage some public comments on this. I guess it's harder for public participants to start a discussion, easier for them to respond to some thing that's put out there. -Registration is an intensive process that people may not be willing to commit the time for. Of course for people who are interested wouldn't have any problems with the process, but I think if people who just wanna have a quick look at it, and give some comments, this may intimidate some of the people. You have to register first, wait for the activation key and login. I guess this is meant for real serious contributor to this process.

- S5

  - The terminology used here is unclear to me.

- S6

  - Color/fonts are good, nice layout. aesthetic to the eyes.

  -It would help if the forum area could be larger and left-side pane could take up less area.

- S7

  - I like its ability to draw and make annotation on the map the best.

  - The screen looks congested. It needs to be streamlines so that common functions are grouped together under a general area.

- S8

  - The discussion forum with each topic described in detail really helps people a lot to know what is new, how many people reply for that topic and how many articles were posted under that topic.

  -This is a nice forum. It was a nice participation experience.

- S9

  - I don't want to participate, all urban planing are temporary, we will have to keep developing it, endlessly, so not interested.

- I like the zoom in and zoom out feature best.

- S10

  - I admire the amount of efforts and work that the designer of this program put into creating this software. It was a great program.

- S11

  - Bravo on what you've done. I think it has great potential. It may be nice if a person could create their map view to put on top of the existing ones and have others comment on - for longer scale projects or planning ideas.

  - The discussion forum worked the best. I found the map feature to be slower and not worth the hassle.

  - I'd like to know when the discussions are being made, and where one can find out more info on planning.

- S12

  - I think this is a great tool.

  - I like the annotative functions best.

  - I thought there was a section for uploading images? If not, this would be useful since people might use a digital camera to help illustrate an argument. - Layers illustrating social-economic data would be interesting, or layer/historical views of urban development or growth.

  - Perhaps a "member profile" could provide space for members to introduce themselves.

- S13

  - The drawing feature is really neat. Easy for people to get involved in the discussion to understand each other.

- I'd like to be able to see the degrees of zooming (like the one used in Google Earth).

- The map layers and the way of showing them can be further developed, it is better if it only has high resolution images and other "normal " maps were only used for illustration purposes, but I guess people have different preferences.

- S14

  - I like the "Show areas of hottest discussion" feature best, for it makes it easier for us to identify hot topics/areas.

  - I think it might be easy for us to move the map with a navigation bar, not just the pan key.

  - It might be helpful if you could put the link of GeoDF on UNB website, so that many more students could take part in the discussion, and make this forum more useful.

- S15

  - It is good and easy to use, nice to have a way to interact with others about land use planning with the added benefit of seeing the areas that are being discussed.

  - Took a few minutes to figure out how to add annotation and create polygons Once it was figured out it was quite simple.

  - I'd like to have some way to interact with City of Fredericton officials. Posting of new information pertaining to developments in the forum.

- S16

  - Chat and forums are well maintained and managed in detail. Good arrange of forum topics: environmental → traffic → housing development.

- I'd like to see perhaps more navigation tool - I understand the limitations of this project.

- Need some aspect of future scenarios or post development planning, etc.

- S17

  - In general, eerything was great! A product that would be useful once implemented.

  - One thing I was trying to do was to resize the map/forum windows but was unable to. Later I found the "Toggle forum/map" tool and this helps to solve the problem, but just a learning curve to realize this button was there and what it does.

  - I don't think there is anything more to be added. The general aspects was great.

  - I thought the layering on the maps was a great feature.

  - The areas of hottest discussion was also a great feature.

  - Distances on map and identification of objects on the map were very useful.

  - The ability to add sketches to the map was a great tool.

  - The forum was well laid out and arranged. Easy to navigate.

  - I found that I was always clicking the zoom in/out. A drag scale similar to other map sites would be a great addition.

  - The erase sketch feature was erasing all lines and annotation that I placed on the map. Frustrating. It is better to just erase the last line that was drawn.

- S18

  - I like the idea of incorporating discussion and drawings with actual satellite images.

  - It's cool to have high resolution images. This is why I enjoyed this program. Google Earth incorporation would be great.

- Possibly larger font and map size and lines would help people with vision problems as well as same fine tuning of the tools would really improve usability.

- Tools seemed to work but I found it difficult not being able to zoom really fast - had to use multiple clicking.

- I'd like to be able to adjust the height of discussion and map easier - easy switching between the two without the button.

• S19

- I like the idea of an informed public forum. I think it is an effective use of the Internet. The site could be a good way to stay informed. I started a discussion about biking in the city and I really do want to know what others think!

- I have seen better maps, the text as it overlaps the maps covers a lot of detail.

- I think the forum could be better organized, and the forum could be displayed more cohesively, i.e., all responses displayed below the original post.

- I found the site rather easy to get lost in - because the organization could be better. I knew I was 'lost' because I would eventually click my way back to the beginning again - but I was going in a circle.

• S20

- Overall, a great program.

- Older people may find it a bit challenging, especially responding to posts, as the "Reply" button is a little bit hard to see. I think make the button bigger and more colorful would make it easier for people to find it.

- The way the forum messages are clearly connected, and the smileys for each entry were great features!

- The idea of digests is good, especiallay, if you can't commit to to logging in very often to read the posts.

- The AHD feature seems to completely blocks out a section of the map if you are zoomed in too close. Perhaps a lighter shade of red or even large points sources of red would be better.

- Saving a map image with a message is only effective if people actively use it. Remind people to add things to the map before clicking the "Submit" may help.

- S21

  - I like the text conversion, especially, everyone is able to participate.

  - The text portion of this software works well, the mapping is too slow and small.

  - I'd like to see a more in-depth explanation of each topic or at lease "Hot topic" that has been identified.

  - The text would be more applicable if the server was quicker, and the screen resolution was better.

- S22

  - Congratulations! The prototype is well designed.

- S23

  Louis - This program expects a rather high degree of computer literacy and forum use. As a person who does not use chat rooms and discussion forums online, I found this aspects difficult to get used to. I wonder how much use this program would be to the average over 30+ person without a lot more interactive help. Unfortunately, most people interested in land use tend to be older - maybe because they are the ones with a rested interest, i.e, they own property.

- S24

  - Overall, well done. The forum topics seem very useful.

  - The map portion of the GeoDF may be a bit confusing for the general public though. Overall a great tool for public input.

  - It would be nice to be able to move the map window up or down so you could better look at the discussion forum topics below.

  - Sketches and annotations were a little confusing. Took a little while to get used to it.

Vita

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Publications:

Zhao, J. and D.J. Coleman (2006). "GeoDF: Towards a SDI-based PPGIS application for E-Governance". Proceedings of the GSDI 9 Conference, Santiago, Chile, November.

Tang, T., J. Zhao and D. J. Coleman (2005). "Design of a GIS-enabled Online Discussion Forum for Participatory Planning". Proceedings of the 4th Annual Public Participation GIS Conference, Cleveland State University, Cleveland, Ohio, USA. Urban and Regional Information Systems Association. August. (CD-ROM)

Conference Presentations:

Presenter, "An empirical assessment of a web-based PPGIS prototype". Presented at the Atlantic Institute Graduate Research Seminar, Maine, USA, June 13-15, 2007.

Presenter, "PPGIS over the web". Present at GeoWeb 2006, Vancouver, BC, Canada, July.