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From the Editor...

by Tyler Mitchell

Welcome to the first edition of the OSGeo Journal for 2010! As a good kick-off to the new year this volume takes a few different perspectives on software development and design. Naturally the various issues related to typical development projects applies quite well to our open source geospatial specific interests. The articles cover a range of topics from a review of various software to a discussion of user-centered design. Along the way you'll also get to read some more technically meaty articles and some perspective pieces.

Each volume of the Journal takes several months of concerted effort by many individuals. Landon Blake played a lead editorial role in getting this volume pulled together so you can read it - thank you Landon! It's always a pleasure to have more section editors, LaTeX masters and reviewers come to help. Thank you to all the volunteers.

With our new online management system, any potential article can be submitted at anytime by simply filling in a form at http://osgeo.org/ojs. As well, over the next couple of months keep one eye open for the OSGeo 2009 Annual Report. Get your articles in soon if you have not already. Enjoy the articles!

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Peer-review Papers

Usability Trumps Features

User needs and the redesign of a web-based GIS to support community environmental monitoring

Martin J. Bunch and Michael D. MacLennon

Abstract

Web-distributed tools that complement community-based environmental monitoring (CBEM) initiatives can improve processing of and access to information, supporting environmental education and better informing decision-making. To this end a web-based geographic information system known as 'Juturna' was developed to support CBEM in the vicinity of Toronto, Canada. This web-GIS facilitates input, analysis, and reporting of community data. However, use of the system steadily declined in activity since this initiative started in 2004. Lay users reported that the system was complicated and confusing, and so discouraged use. Also, it employed expensive proprietary software, which was a disincentive for the local Conservation Authority and collaborating NGO to adopt the system.

To revitalize use of the website and provide support to the CBEM program, we undertook to redesign the web-GIS using open source software. To understand why the original web-GIS was not well used and to inform redesign of the system, we implemented a user-centered design methodology. Methods included user testing, rapid prototyping and stakeholder interviews. The process was invaluable in prioritizing user tasks, defining characteristics of users of the website, and identifying those components of the web-GIS most confounding to them. Findings were used to inform re-development of the web-GIS through an iterative process that led to the creation of two prototypes that were evaluated by the user audience and so informed the design of a new (more accessible) website.

Keywords: web-GIS, public participation GIS, user-centered design, iterative development, community based environmental monitoring.

Introduction

Community-based environmental monitoring (CBEM) is becoming an important resource for many environmental monitoring programs. For Conservation Authorities these community-based programs help offset the cost of employing trained scientific experts, and allow members of the public to re-connect with the natural environment as stewards. Creating online tools and resources that complement these community-based initiatives can help improve access to information and allow for more informed decisions to be made on issues that affect the health of these monitored ecosystems.

Through one such CBEM initiative, the Toronto and Region Conservation Authority (TRCA) in collaboration with Citizens' Environment Watch (CEW) invited members of the public to participate in the collection of water monitoring data in Toronto's watersheds. Part of this community-based monitoring program was the implementation of a geographic information system, accessible via the world wide web. This system (known as 'Juturna' after the Roman goddess of wells, springs and streams) facilitates the input, analysis, and reporting of community data. However, use of the web-GIS steadily declined in activity since this initiative started in 2004, while at the same time public interest in the community monitoring program remained strong. Lay users reported that the system was complicated and confusing, and so discouraged use. Also, the web-GIS employed expensive proprietary software, which was a disincentive for the conservation authority and collaborating NGO to ultimately adopt the system.

In an effort to revitalize use of the website and provide support to the community-based environmental monitoring program, we undertook to understand why a seemingly excellent and functional tool was not well used by its intended audience, and then to redesign the web-GIS using open source software. In this paper we briefly introduce the community monitoring program so as to present their information and analysis requirements, and we discuss the application of user-centered design (UCD) methodology as a means of understanding the failure of the initial pilot and to guide redevelopment of the web-GIS to make it more usable to its audience. Specifically, we set out to understand:

- What are the business goals and the website functions most important to the stakeholders?
- How can the Juturna 1.0 system be improved with respect to ease of use its overall usefulness to its audience?

This paper presents a case study in which the pursuit of these questions informed the redevelopment of a web-based public participation GIS. While many professionals in the field may take some of the lessons we present for granted, we offer this case study for those not having system design experience and/or training, in the hopes of saving them missed opportunity, time and resources.

Community-based environmental monitoring and the 'Juturna' web-GIS

Environmental monitoring and the gathering of environmental information are important exercises for understanding the impact of human stressors on the environment. In Ontario, Canada such activities are generally carried out by Conservation Authorities, quasi-governmental organizations that act as stewards to ensure that environmentally sensitive areas remain intact and undisturbed by these stresses. However, reductions in funds for environmental monitoring activities that are allocated by provincial and federal governments has led to increasing examples of local communities partnering with conservation groups so as to continue monitoring ecologically sensitive areas [9] and as a means of empowering and educating members of the public. The regional watershed monitoring program (RWMP) conceived by the Toronto and Region Conservation Authority (TRCA) is one such initiative that implements a collaborative approach to monitoring Toronto's watersheds. Part of this approach was the development of a community-based water monitoring program that allowed members of the community to take part in monitoring the health of the streams and rivers in the Toronto region (Figure 1).

Figure 1: One of the authors (Martin Bunch, right) participating as a volunteer monitor to collect benthic macroinvertebrate samples on a transect in Black Creek near York University, Toronto.

As part of the RWMP the Conservation Authority facilitated annual workshops to train members of the public as volunteers for gathering biological and abiotic data from streams, and to identify the benthic macroinvertebrate (BMI) organisms (mostly bugs and worms but also potentially clams, snails and crayfish) captured in their samples. The purpose of these workshops was not only to educate members of the public about water monitoring and the watershed ecosystem but also to ensure that data is collected as accurately as possibly. TRCA, in cooperation with the environmental NGO Citizen's Environment Watch developed monitoring protocols that use benthic macro-invertebrates and biotic indicators to measure aquatic health. CEW committed to provide education, equipment, and support for community-based ecological monitoring work, to teach annual workshops, and to operate the volunteer monitoring program.

Community volunteers who participated in the program generated data that reported the frequency of various organisms in their samples, geomorphic and vegetative characteristics of monitoring stations, and the station location. This information can be used to construct metrics that indicate whether a stream's health is unimpaired, potentially impaired or impaired, based on the frequency distribution of the organisms collected and their known sensitivities to stressors [1, 4, 5]. TRCA staff involved in BMI monitoring would also generate water chemistry data. While TRCA scientists are practiced at managing and analysing this data, the lay volunteers participating in the monitoring program generally are not.

To address this, TRCA enlisted researchers (our predecessors) at York University's Faculty of Environmental Studies to develop a system to assist in the uploading, storing, reporting and analysis of volunteer data, as well as data generated by TRCA staff. This resulted in the creation of the web-GIS called 'Juturna.' The website itself also served other purposes for different individuals with a variety of interests in environmental monitoring. For instance, the general public could use the website to access TRCA's aquatic monitoring data to perform rapid analysis of watershed and subwatershed data.

In October 2004 the pilot project was implemented. It was one of the first community-based environmental monitoring projects to utilize the internet and rely on a complex web-based Geographic Information System for interacting with the water monitoring data [2]. The web-GIS allowed users to find the location of their monitoring station using postal code searches, aerial photos, street networks, surface water layers, land use, and points of interest. They could then create a point location with which to associate the monitoring station data, upload data and generate reports that included calculation of Benthic indices (indicating stream health).

The pilot project was met with great interest throughout Toronto's environmental conservation community and the initiative was presented at several conferences. The annual water monitoring workshops that were used to train new volunteer water monitors were always filled to capacity. Coming into this project (Martin Bunch inherited the project as a faculty member, and Michael MacLennan was a graduate student at the time), we were very impressed with the system. It was highly functional, allowing users to upload everything from their BMI data to digital photos of their monitoring stations (which were incorporated into the station reports) (Figure 2). It produced extremely descriptive and well organized reports at the monitoring station, subwatershed and watershed level, it had an attractive web interface, sophisticated administrative tools, and most of all it worked consistently and well.

However, we were surprised to discover that there was a steady decline in the number of visitors to the website, despite the ongoing interest in the water monitoring workshops by members of the public. More disturbing was that in the first monitoring season (2005) supported by Juturna, data for only 13 volunteer monitoring stations were uploaded – less than half of what was expected. This suggested that Juturna 1.0 was not effectively supporting the needs of volunteer users. Furthermore, informal feedback suggested that users may have become frustrated with the data upload process and abandoned the process before completing it.

As we looked into modifying the system to deal with this, two other issues arose. First, software needed to be updated and data made current. Our University had licences for the proprietary software to support the update (ArcIMS, ArcSDE Crystal Reports, MS Windows Server) and also access to the needed data (digital air photos, vector layers for roads, surface waters, watersheds, parks and other features) except for proprietary postal code data. However this meant that the program was dependant on the University for software maintenance and support and on the University and/or the TRCA for data updates. Purchasing both the software and data licensing was not feasible for an NGO like CEW whose annual budget for this project was quite small. Second, the back-end systems of this extremely complicated application indicated that maintenance was going to be difficult. There was only very sparse documentation on system architecture and design, and the code was not commented. It was obvious that the design of the original system did not consider maintenance or ongoing development (URLs, for example, were hard coded in the system).

In the winter of 2005–2006, it became clear that the website needed to be redeveloped to alleviate these problems. In early spring of 2006, financial support was provided by the Ontario Ministry of Environment to redevelop the website using Free and Open-Source (FOSS) software. The primary open source applications we used were MapServer, PostgreSQL/PostGIS on a Linux platform with SQL, Ruby, HTML, and Java components. The open

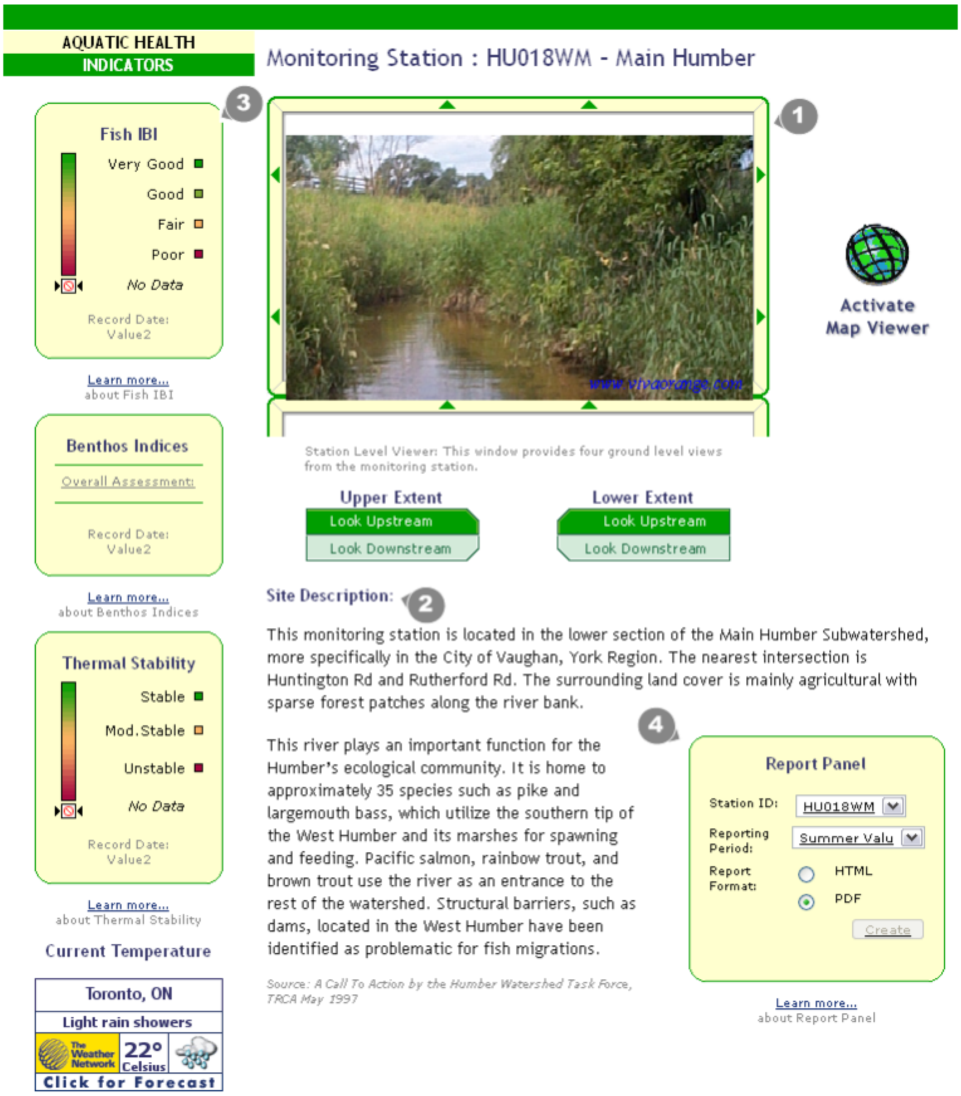

Figure 2: A typical water monitoring station web page in Juturna 1.0, including 1) digital photos of the monitoring station, 2) site description, 3) health indicators and 4) a report generation panel.

source approach provided us with the opportunity to develop the site in a user-centered design paradigm with the users at forefront of design decisions.

User-Centered Design and Iterative Development

Good design of any product (Internet-based, computer based or otherwise) is most successful if the design group understands as much as they can about the users' intended use of the product [3, 7, 8]. User-centered design (UCD) methodology takes this to heart. It is an approach to software development and web design that allows for a deeper understanding of the user. Having observed that there were serious usability problems with Juturna 1.0, we undertook to implement a user-centered design methodology in the re-development process of the Juturna website.

The UCD procedure consisted of a series of development stages that incorporated information gathered from the implementation of several usability methods. [7] defines this kind of approach as an iterative development framework. The idea of iterative development (ID) is founded on the premise of continual refinement through a trial and error process whereby each successive iteration incorporates what is learned from the applied usability methods. The end goal of the project being a product (the Juturna 2.0 web-GIS) that is as usable as possible, meeting the needs of its intended audience.

Usability can be measured on three factors; functionality, desirability and efficiency [7]. Determining how these are achieved depends on how well the development team understands its user audience. In order to do this [3] suggest adopting a 'pervasive usability' approach within an iterative design process. The purpose of this approach is to employ a methodology in which user input is incorporated in every step of the development process. For example, when a change is made to the design of the interface it is tested by users to determine if this change was effective in achieving a usability benchmark. This allows for different usability methods to be implemented at each stage of the development process (Figure 3). In this project the majority of the usability tools were implemented in the first three phases of the project. These tools include stakeholder interviews, use cases, user flows, and user testing.

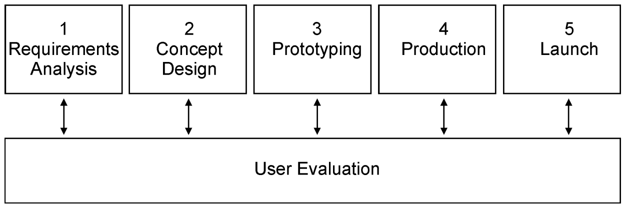

Figure 3: Pervasive Usability process (after [3]).

Methods and the development process

Following the process outlined by [3] and [7] our design process was implemented in five stages: requirements analysis, conceptual design, mockups and prototypes, production and launch. These stages were operated by the application of the techniques presented in Table 1. The process was used both to evaluate the Juturna 1.0 system (to understand its failure), as well as to inform redevelopment of the new open source system.

Stage One: Requirements Analysis

The first stage in the redevelopment of Juturna identified the goals and parameters of the project. Using stakeholder interviews, a baseline evaluation of the existing website in terms of its current functionality as well as its usability was performed. This was followed by stakeholder interviews to explore the purpose of the site from a business perspective, understand the stakeholder organizations' perspectives of the users, and to set the context for the website's future direction. These interviews contributed both to evaluation of the existing Juturna 1.0 system and to determining the target audience, user goals, business goals and technical requirements for the redeveloped website. At this stage user needs and target usability goals were determined as a means of guiding the following stages. This process identified five user groups: volunteers, TRCA staff, system administrators, consultants and partners, and the lay public.

Stage Two: Conceptual design

Analysis and evaluation of the Juturna 1.0 site against data derived from stakeholder interviews was then used to define a concept for the architecture of the initial design of Juturna 2.0. This analysis allowed us to produce flowcharts that summarized how the major user tasks were to be completed in the new system (e.g., Figure 4). These documents

Technique	Description
Semi-structured interviews	Semi-structured Interviews (SSI) occurred over a one hour period in a comfortable setting chosen by the interviewee. A limited set of open-ended questions were used to direct a discussion. More specific questions were asked depending on the responses of the interviewee. Themes explored in the SSI included, for example, history and context of the organization with respect to water monitoring, and the efficacy of the Juturna 1.0 system.
Use cases	User scenarios were developed for each of the identified user groups. Use Case Scenarios are narratives about how a particular type of user of the system would interact with it. These narratives provide some context and "feel" for how the system needs to work. From these scenarios a functional requirements list and user flows may be constructed.
Task analysis	Tasks are expressed as simple flow charts ("user flows") that describe the possible flow of interaction of particular category of user with the website. These assist in developing the information architecture of the system, that is, the design and organization of the navigation structure and consideration of position and placement priority of page components like the log-in form, web-GIS functions, benthic data entry forms and data access rules.
Wireframe mockups	Wireframe mockups are rapid prototype application interfaces. This is a block diagram that illustrates the overall navigation of a website and the blocks of elements (such as content and functionality) that will be present on the screen.
Heuristic evaluation	Heuristic evaluation systematically assesses a user interface design for usability in form and function based on a set of rules. In this case, rules were derived from Nielsen's 10 usability heuristics: visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; help users recognize, diagnose, and recover from errors; help and documentation [11].
User evaluation	For the original Juturna 1.0, for prototypes, and for the re-designed open source system, user testing involving various user groups was undertaken. Five evaluators were used to satisfy the minimum number to catch eighty percent of the usability problems, which is between four and five ([10];[13]. Six tasks exploring four main functionalities were evaluated by participants. These were 60 minute interviews in which evaluators undertook tasks on the system, while the moderator took notes and recorded quantitative metrics about speed of completion and ease of use. Users, sitting at a computer accessing Juturna, responded to questions such as "You would like to generate a report of the Humber watershed for the 2001 year. How would you generate this report?" by undertaking the task on the system, and vocalizing their thoughts as they did so.

Table 1: Primary techniques employed in user-centered design of Juturna 2.0

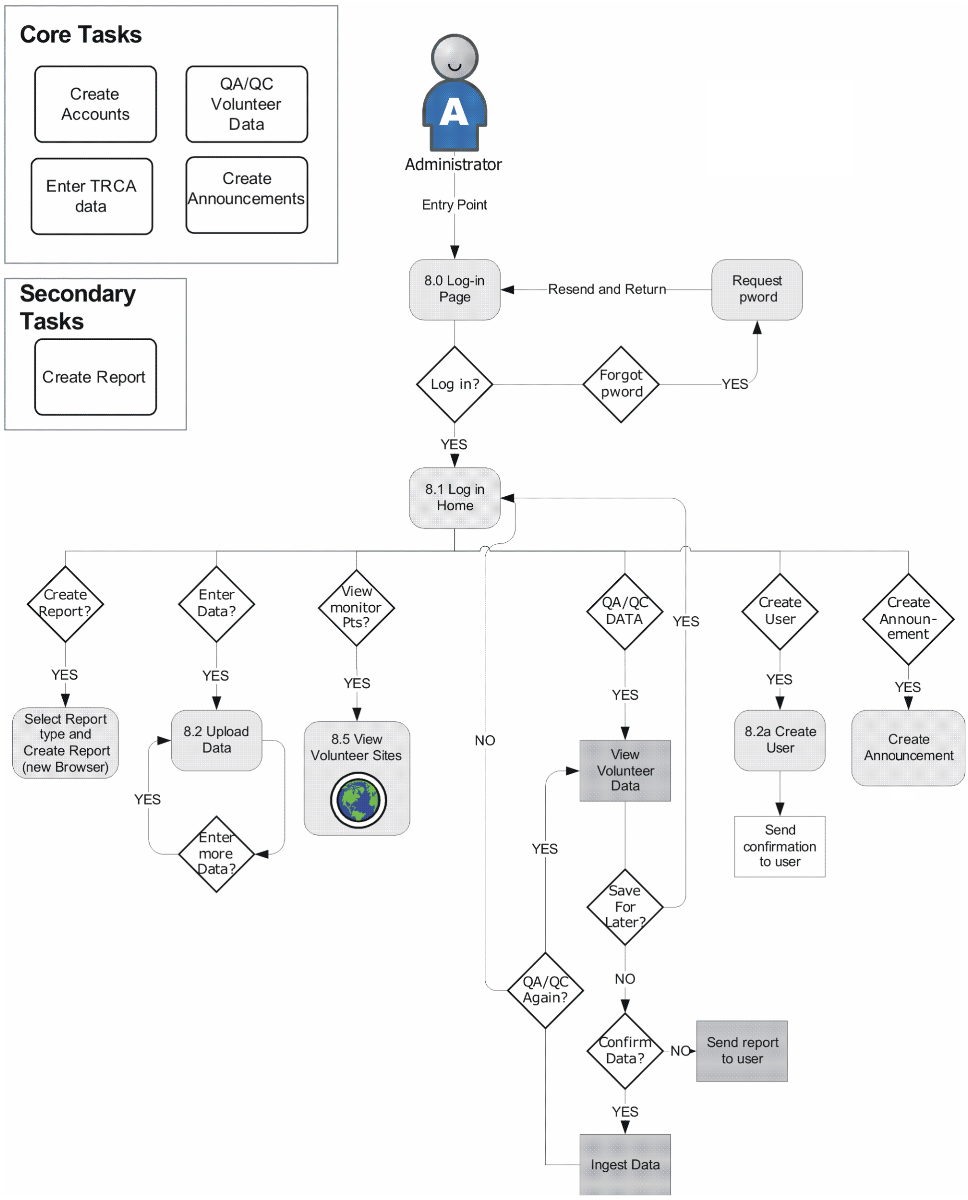

Figure 4: 'User flow' describing possible flows of interaction of the administrator user with the website.

provided a means of sketching the website's organization in a more formal technical document known as a 'use case' that defined user scenarios. These scenarios were developed based on interviews with the major stakeholders and our previous experience with the Juturna 1.0 website.

Stage Three: Mockups and Prototypes

An interim representation of the new website was implemented using mockups and prototypes. This allowed for early evaluation of the new design before the final system was produced. Rapidly producing a prototype of the final website using simple diagrams allows for changes to be implemented easily and quickly, preventing extensive modifications from occurring later in the development process. Figure 5 presents a wireframe prototype used for this purpose. The wireframes lacked content but had operational navigational structure. User testing of these mockups, and consultation with the stakeholders, identified changes to be implemented in the production stage.

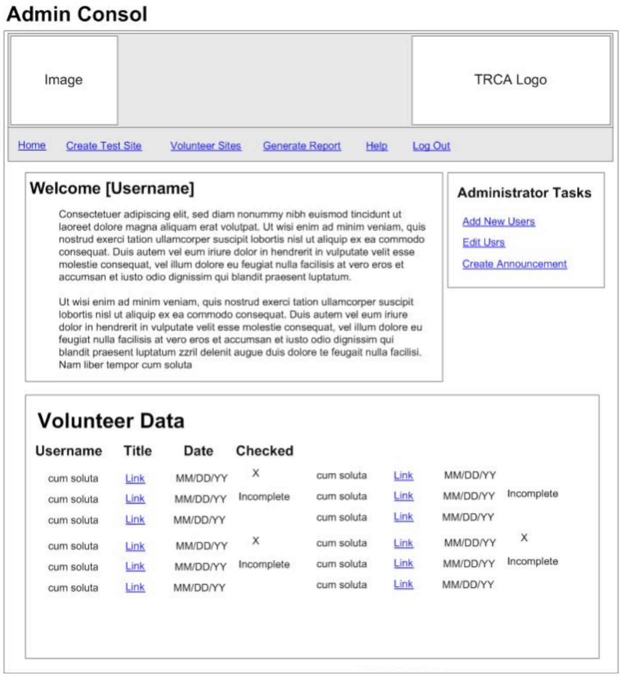

Figure 5: Wireframe prototype of the administrator console.

Stage Four: Production

At the production stage the product was created. Content was added to the website, graphic elements were developed, and coding was produced for the components of the website. Evaluation at this stage occurred in the form of heuristic evaluation to assess the level of usability in comparison to Juturna 1.0. This was a formal comparison of the website with usability rules, so as to predict usability of the system [6, 12]). User testing of the website also occurred to ensure that the website functioned properly.

Stage Five: Launch

At this stage the product was finally launched and made available to the public. Prior to making the website available, a quality assurance test was performed to ensure that all necessary website functions were working properly. This was not an endpoint as the system continues to be refined as further development phases are implemented, new functionality is added, and user needs change.

Assessing Juturna 1.0 and building Juturna 2.0

User testing occurred using the original Juturna 1.0 system (so as to provide insight into its failure and to inform development of the new open source version of Juturna), on a wireframe mockup of the new system, and on a redeveloped version of the system. Primary functions evaluated included: data upload, data download, report creation, user account management, and data assessment functions. These functions were chosen because they were determined through the UCD process as important to the website for all user groups. User groups identified were: Volunteer users (community monitors), consultant users or partners (who may need to access raw data in the system), Administrator users, TRCA users (staff), and Lay users (the general public). Volunteer users and TRCA users were the primary users of the site, and their activity encompassed that of the others. Thus, user testing was undertaken on the basis of these two groups. This process led to four main areas of improvement in the system relating to: task efficiency, topology of navigation structure, reducing users' memory load and bullet proofing against user error.

Improving task efficiency

We were able to improve the efficiency of several tasks in the redevelopment of the website. For example, the action of logging into the website is one of the most frequently performed activities by all but the lay user group. Juturna 1.0 placed the log in function several pages deep within the sub-navigation structure of the site, instead of in an apparent location such as the monitoring sites landing page. In redeveloping the site we placed the log in function on the home page to allow users to easily locate the log in console (similar in location to several popular websites like google.com, gmail.com, msn.com and hotmail.com). This simple modification reduced the total time spent completing these tasks and also saves the user from the frustration of having to search the website for the log in page.

Figure 6 illustrates this point in relation to the number of mouse clicks required by the user to log into the restricted portion of the website. The original website required the user to click four different links on four separate web pages before he or she can start uploading data. The redeveloped website reduced this to one mouse click by placing the log in function on the home page of the website, and also placed data uploading functionality as one of the first tasks a user's log in screen.

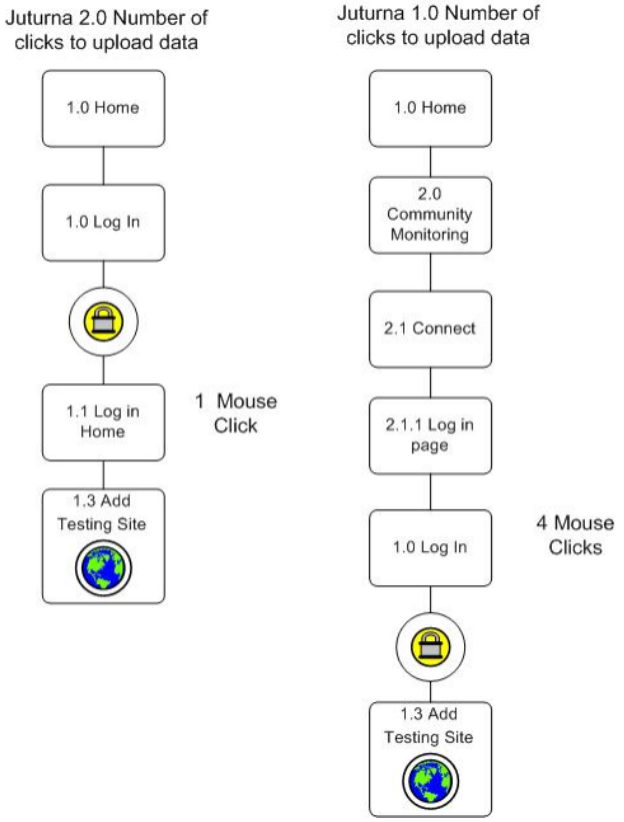

Figure 6: Illustration of click events needed to log in.

The purpose of this approach was to improve the speed at which a user could start a task by reducing the cognitive load required to remember which links to click to get to the data upload screen. Quantitative metrics (Table 2) as well as user vocalization during user-testing interviews was useful in elucidating issues with task efficiency.

Topology of navigation structure

Initial evaluation of the Juturna 1.0 navigation structure found that the navigation was largely inconsistent and arbitrarily defined across the website. For instance, the home page of Juturna 1.0 presented the primary navigation on the left side of the page while all other pages moved the navigation structure to the top of the page. This slight change presents an inconsistent design that has the potential to be highly disorienting to users, giving them the idea that they have moved to another website. To further confuse the design, common names associated with primary navigation on the home page also changed when the user navigated to other pages on the site. For example, the primary navigation on the home page consisted of several links labeled "Administrator Area (secure)", "Community Monitoring" and "Report Generation Area (secure)" while the primary navigation menu found on all other pages labeled these same links as simply "Admin", "Community" and "Report Generator."

Additionally the web pages of Juturna 1.0 tended to be organized in an ordered sequence with certain pages enabled with a sequentially meshed navigation structure. Figure 7 shows the topological structure of Juturna 1.0. Use of an ordered sequence or linear navigation structure works well when users must complete a series of tasks in a specific way (e.g., where a user must upload data in a particular fashion). However, this kind of linear approach is problematic when implemented over an entire website because it prevents the user from exploring a site in a free and open manner, which allows them to decide the order in which information is consumed. The meshed navigation structure implemented in Juturna 2.0 (Figure 8) alleviates this problem by allowing users to navigate to any and every page on the website while still allowing for some areas of the site to adhere to a sequential structure. The downside to this approach is that users have the ability to step in and out of different stages of the linear structure which may break the data uploading process. It is best to monitor for this and communicate this error if a user deviates from the sequential structure.

Task One: Report Generation						
	Craig	Derrick	Samantha	Tanya	Chris	Average
Time to Complete	2	1	2	3	1	1.8
Errors	1	2	2	3	1	1.8
Key	**Time to Complete** 0. Fail 1. Succeed very slowly in a roundabout way 2. Succeed a little slowly 3. Succeed quickly			**Number of Errors** 0. Fail because of errors 1. Many errors 2. Some errors 3. Few or no errors		

Table 2: Task One Quantitative Metrics (names are pseudonyms)

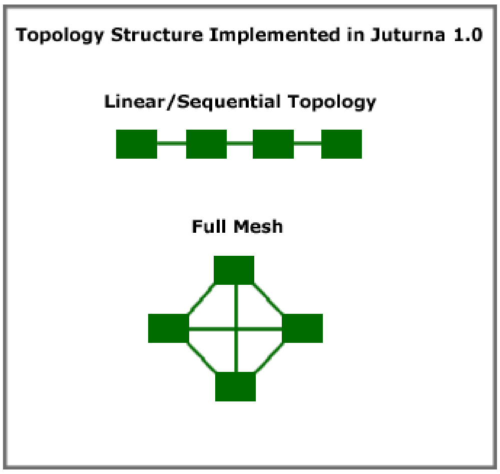

Figure 7: Navigation topology used in Juturna 1.0.

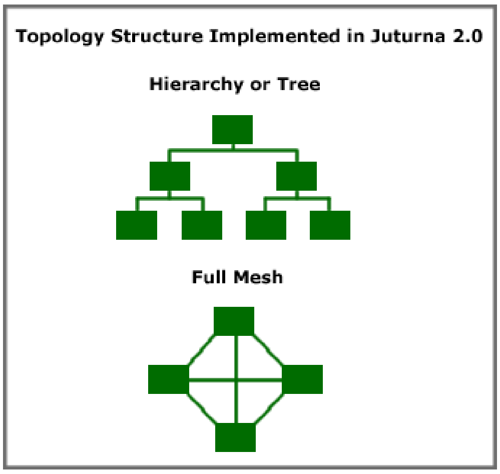

Figure 8: Navigation topology used in Juturna 2.0.

Instead of maintaining a navigation structure that implements both sequential and meshed architectures, we designed the first prototype with a hierarchical and meshed topology that used navigation titles that are task-based. As illustrated in Figure 8, this approach organizes the website around the principle of tasks that a user is able to accomplish on the site allowing them to easily orient themselves and get to the task they want to accomplish. For example, the navigational labels for a user account having permissions to upload data and create reports were changed to 'create test site' and 'generate report' instead of the more general and ambiguous title of 'community monitoring.' Designing the website in this manner created an architecture that will be familiar to the user for two reasons. First, the hierarchical structure is the most commonly used navigation structure on the Internet and is therefore well understood by the user audience. Second, because its organization is task based, there is a greater potential that it appears more intuitive to the user audience because it fits the user's understanding of the purpose of the site.

Reducing users' memory load

Efforts were also made to minimize the user's memory load by making options and links more visible. [3] argue that the user should not have to remember information from one part of the website to another. Instructions for use of the system should also be visible and easily retrievable whenever appropriate. Juturna 1.0 does not minimize the user's memory load because it makes use of a collapsible navigation structure. The system should also always keep users informed about its state. For example, when a user clicks an element on screen, the response from the system should be fast and clearly indicate the navigation path chosen by the user, e.g., by representing visited links by a color change. These are some of the ways websites can inform the user of changes to its state as they interact with the system. Juturna 1.0 did not keep the user informed in an effective manner. Instead it forced users to explore the website through a trial and error process and did not indicate what pages the user has visited. This is particularly relevant in the navigation menu where users must 'discover' what links are available by expanding the hidden menus. Figure 9 shows the Juturna 1.0 navigation menu of the monitoring link as it appeared when the user dragged their mouse over the link. This design reveals a highly complex secondary navigation structure that requires the user to remember the location of sub-navigation items that are always hidden.

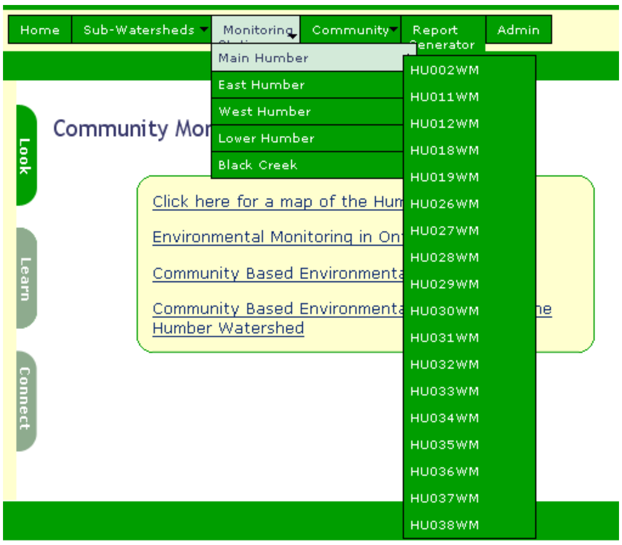

Figure 9: Hidden navigation menu of Juturna 1.0's navigation pane.

Juturna 2.0's interface is more consistent in keeping the user informed and orienting them to the purpose of the website. The navigation menu does not contain any hidden links and there are lots of visual signs in the form of page titles that show the user where they are in the web site. Figure 10 illustrates the title of a web page in Juturna 2.0. Having the title correspond to a link in the navigation bar at left shows the user their location in the navigation structure of the website at all times. This approach reduces the load on the user's memory by utilizing location cues.

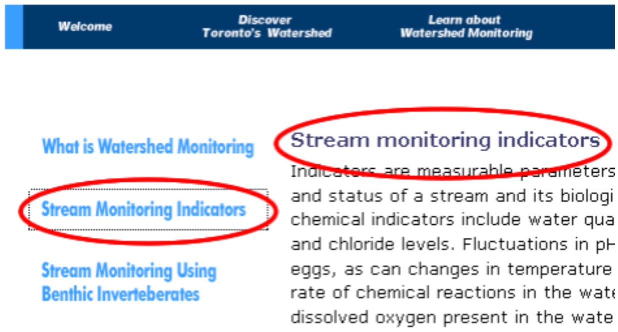

Figure 10: Visual indicators in Juturna 2.0 help users know where they are at all times.

Bullet proofing

It was also determined through the analysis of the Juturna 1.0 system that if improvements were made to the system's ability to prevent and catch user errors the website would be significantly improved. Juturna 1.0, contained many flaws in its ability to catch and prevent user errors in several key functions including data downloading, data uploading and report generation. The inability of the system to catch these errors greatly limited the ability of users to complete tasks. This is particularly apparent in the data downloading function. Initially this function required the user to select several criteria including the geographic extent of their data, the sampling season, the sampling year and the data type, prior to downloading data. However, there was no information present in the selection parameters to let the user know whether they were requesting data that did or did not exist in the database. As a result, the user was faced with the responsibility of discovering what data was present through a trial and error process. The initial redevelopment prototype attempted to alleviate this problem by using a series of selection menus that only listed the parameters present in the database.

Conclusions

Because we were a small team (a professor drawing upon graduate student labour, and contracting out some programming work) with a small amount of funds, the process described above did not demonstrate the rapid response of agile design. However, it did yield responsive development – the new Juturna system is leaps and bounds ahead of the earlier system in terms of usability. Paradoxically, it is also much less impressive. Juturna 2.0 has fewer functions, and is less visually powerful than its predecessor. This is because many of the functions incorporated in the first version were not essential to its mission. Some of those functions and capabilities may return in future iterations of development, but only if users indicate a strong need for them and if they can be implemented without requirements for proprietary software or data.

Currently, Juturna 2.0 resides at `www.juturna.ca` and is a functional web-GIS supporting community volunteer monitoring organized by Citizens' Environment Watch. After the first redevelopment phase of the system was completed in late 2007 there was a delay in implementing Juturna (though it was online and functional) due to a reorganization of the monitoring program by CEW and changing in-house needs at TRCA due collaborative data management initiatives with other CAs. This necessitated another iteration of the design process in 2008. The system is now being populated with volunteer data from the 2009 season and will support a new orientation of the CEW program to operate with schools in the Toronto region in 2010. Future plans for Juturna target interoperability, as well as modifications to make the system easily adaptable to other watersheds outside of the TRCA jurisdiction. Once this is happens we intend to make the system available in a free and open-source manner.

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