From the Ground-Up: Role of Usability and Aesthetics Evaluation in Creating a Knowledge-Based Website for the U.S. Army Corps of Engineers

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Abstract. Government agency websites are places where both tacit and implicit organizational knowledge is managed. To maximize benefits to the organization, these websites must be tailored not only to meet immediate employee needs, but they should also be aesthetically pleasing enough to keep workers engaged and interested in exploring and sharing information. Usability testing allows users to interact with websites and give vital feedback. Knowledge acquired during the usability testing process can be used to improve the information architecture of the website and its content. Preferences for aesthetic features can be gauged simultaneously. This study included usability and aesthetics tests with federal employees who interact with the Natural Resources Management Gateway, a complex information-rich website, on a regular basis. The study clarified the relative importance of both usability and aesthetic features on employee satisfaction and identified the most preferred home page design. Involvement of employees in early design stages of knowledge management systems is strongly advised.

Keywords: Usability, aesthetics, knowledge management, public website, outdoor recreation website, home page design.

1   Introduction

Organizations, including government agencies, increasingly rely on the Internet for internal communications, research, planning, reporting, daily management activities, and knowledge management. Turnover, downsizing and other changes in an organization create gaps in institutional knowledge and skills that may be lost if they are not captured, stored, and made available to new employees. Information technology (IT) and knowledge management (KM) are two ways of preserving and generating an organization's knowledge assets. There has been little research on the best way to

design these systems as usable and attractive bodies of information for public sector personnel. To optimize benefits to organizations and employees, we propose that both usability and aesthetics are fundamental design factors.

The current study is part of a research program focused on the KM process for employees of the Army Corps of Engineers' Natural Resources Management (NRM) branch. Since 2001, the Corps of Engineers has been developing a knowledge management system, the NRM Gateway (http://corpslakes.usace.army.mil). A component of the NRM Gateway, Lake Discovery, will be developed as a knowledge-based website for outdoor recreation management professionals. The study goal was to assess perceptions of usability and aesthetics of three prototypes of the Lake Discovery website in order to make recommendations to the Corps regarding design features.

2   Literature Review

As our research stems from the nexus of three areas of inquiry – knowledge management, usability and environmental cognition -- we will briefly review key points relevant to this study. Our thesis is that effective KM systems must incorporate principles from website usability and human cognition research and practice. There is great variety in the definitions of knowledge management. Two points of agreement are that knowledge management is more than IT (information technology) and that it is a never ending process that involves human interaction ([1], [2]). Knowledge management includes creating databases, establishing libraries, building intranets, sharing best practices, installing groupware, providing training programs, fostering collaboration, and creating virtual organizations. What makes it a never ending process is the constant challenge of determining what knowledge to manage and toward what end [3]. In concluding their review of the research, Wang and Noe [4] summarize the factors that lead to successful knowledge management and knowledge sharing initiatives. The major factors are a culture of trust and innovation, fairness and transparency in decision making, alignment of knowledge management initiatives with existing work habits and organizational goals, management and supervisor support, increased employee self-efficacy and satisfaction in sharing knowledge, and consideration of cross-cultural differences. In a review of the knowledge management potential of Web 2.0 technologies, Schneckenberg [5] concludes that the degree of openness, freedom, and employee empowerment in corporate environments influences the outcomes.

Large government websites, such as the NRM Gateway, have become a major channel of information and communication, making it critical to ensure that the sites are designed to optimize the interaction between the system and users in an efficient and cost effective manner ([6], [7]). Usability refers to how easily a specific task can be accomplished with a specific tool. A product is usable and useful only if it helps users find what they need, understand what they find, and helps them to use it to meet their goals. The International Organization for Standardization [8] defines usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." Effectiveness refers to how well a system does what it is supposed to do. Efficiency is

the degree to which a knowledge management system supports users in carrying out their tasks. Satisfaction pertains to the subjective responses users have to the system. Including usability research in the website design process can save time and costs associated with development, maintenance, training, support, documentation, and litigation. It may also increase sales, traffic, revenue, user satisfaction, market share, productivity, and trust ([9], [10]). The return on investment for usability efforts is high ([11], [12], [13], [14]). From a best design practices standpoint, usability is fundamental to creating and maintaining a successful, useful website. Website usability significantly affects navigation and search success ([15], [16], [17]) and user satisfaction ([18], [19], [20]). Usable websites also increase customer trust and loyalty and reduce perceptions of risk ([21], [22], [23]). Reducing design complexity increases usability ([24], [25]), as does a sound information architecture ([17], [26]).

For the purposes of this study, we use aesthetics in its scientific context to mean the study of judgments of sensory stimuli, specifically Internet web pages. Since websites are primarily visual stimuli, it is reasonable to assume that the determinants of preference for other visual stimuli also influence website preference [27]. This assumption is borne out in the human-computer interface literature. In an application of the Kaplan and Kaplan information model ([28], [29]), Singh et al. [27] found that home pages perceived to be high in involvement (i.e., rich in complexity and mystery) and understanding (i.e., coherence) influence attitudes toward the site, which in turn affect behavioral intentions to explore and use the website further. Some researchers have found it useful to divide aesthetic elements into two types: classical elements, which correspond to the understanding dimension of the Kaplan and Kaplan information model (i.e., clarity, orderliness, and ease of comprehension) and expressive elements which correspond to the involvement dimension (i.e., originality, visual richness, and promise of further information). Classical aesthetics and coherence have been found to contribute to website usability ([30], [27], [31]). Expressive aesthetics has been found to influence "playfulness", which in turn influences usability ([32], [33], [34]). The term playfulness was defined by Moon and Kim [35] as "the strength of one's belief that interacting with a WWW site will fulfill his or her intrinsic motives." In their study, the playfulness measure was tied to enjoyment, motivation to explore, imagination, and decreased awareness of outside distractions and the passing of time. Similarly, Lavie and Tractinsky [30] defined playfulness as "a state characterized by perceptions of pleasure and involvement." Mystery is enhanced if the setting gives the person exploration possibilities or the feeling that there is more to see or more to learn if that person keeps going [28].

3   Method

This study employed a three-group within-subjects research design, where design layout (i.e., home page) of the menu organization was manipulated at three levels, each representing an increasing level of graphical aesthetics for the website (Figure 1). The Word prototype organized menus with text only. The Bubble prototype organized menus by bubble shapes. The Metaphor prototype presented graphics corresponding to the

main menus. For each of the three layouts, the three primary content categories and all secondary subcategories were included. For example, a primary category on the prototype home page is "facilities"; clicking on "facilities" leads the user to another page listing subcategories, such as "beaches" and "trails". The category structure, or knowledge hierarchy, had been established in previous research by the authors ([36], [37]).

| Word | Bubble | Metaphor |

Fig. 1. The Three Lake Discovery Home Page Designs

We utilized an Internet survey in which participants were asked to search for information pertinent to typical job duties in outdoor recreation management (e.g., find information on accessibility standards for your recreation facilities). In keeping with the title of this study ("From the Ground Up…"), Corps employees verified the realism of these tasks for the researchers before data collection began. The sampling frame consisted of 703 Corps of Engineers full time permanent employees with job titles of "Natural Resource Specialist" or "Park Ranger". Participants were asked to complete three job-related tasks, one per prototype. After completing the tasks, participants were asked to rate their experience by responding to seven standardized scales for Effectiveness and Efficiency [8], Classical and Expressive Aesthetics [30], Coherence [27], Playfulness [38] and Satisfaction [39]. The eighth scale, Mystery, was developed by the authors based on a literature review and prior experience. All scales employed a 7-point Likert format (Table 1).

4   Participants

The response rate was 47% (328/703). Missing data can produce misleading confirmatory factor analysis (CFA) results and potentially erroneous implications [40]. Therefore, duplicate entries and individuals who did not respond to all scale items were removed, leaving a total of 240 individuals for the statistical analyses.

Respondents were 73% male; 70% graduated from a four-year college or university. Eighty percent were 30-59 years old, and most (66%) had worked in the natural resource management field for more than ten years. Typical job duties included daily management of outdoor recreation areas and visitor safety and enjoyment.

Table 1. Scale Items for Variables

Scales and Subscales		Scale Items
		"Thinking about my impressions of this website, it is…"
Aesthetics	Classical	…Clean, …Clear, …Aesthetic, …Pleasant, …Symmetrical
	Expressive	…Original, …Sophisticated, …Creative, …Fascinating, …Uses special effects
Usability	Effectiveness	Given the tasks, I could find the sought after information
		I was able to complete all website tasks successfully
	Efficiency	Learning how to use the website was easy
		Using the website is easy
		The website is user friendly
		Using the website is fast
	Satisfaction	*"Thinking about my experience with this website, I feel..."*
		(1) Terrible...Delighted (7)
		(1) Frustrated...Contented (7)
		(1) Unhappy...Gratified (7)
		(1) Sad...Joyful (7)
Cohernce		It is easy to make sense of this website
		This website is easy to comprehend
		I can easily create a map of the website in my head
		The website is orderly
Mystery		The website that this prototype represents promises a lot of information
		Based on the home page, it appears there may be a lot more to see in the underlying website
		There seems to be a lot to explore in the website represented by this home page
		I doubt that I will learn anything new by visiting the website beyond what I have learned from the home page
		I believe there is not much to discover by visiting the under-lying website
Playfulness		*"Thinking about my experience with this website, I feel..."*
		…Spontaneous, …Imaginative, …Happiness, …Original, …Innovative

5   Results

All scales, excluding Mystery, displayed high inter-item reliability (Cronbach Alphas above 0.90), exceeding the recommended standard of 0.70 [41].   While there is a theoretical basis for including Mystery as a contributor to user satisfaction, the scale

items had not been verified in previous studies. Two of the five Mystery scale items ("I doubt that I will learn anything new by visiting the website beyond what I have learned from the home page" and "I believe there is not much to discover by visiting the underlying website"), were inconsistently worded with respect to all other items (higher ratings being negative rather than positive). This inconsistent wording led to ambiguous interpretation of results and possible respondent confusion. Furthermore, three of the five items in the Mystery scale had Cronbach Alpha reliability coefficients below recommended standards of 0.70 [41]. Finally, exploratory factor analysis revealed that three items loaded higher on other factors than Mystery. For these reasons, the Mystery scale was eliminated from the confirmatory factor analyses.

Using AMOS 18.0, confirmatory factor analysis (CFA) was performed to examine construct validity and evaluate the psychometric properties of the scales ([40], [42]). CFA also confirms the theoretical structure of the measurement model through the results of recommended goodness-of-fit indices [40]. Three CFA goodness-of-fit indices, CMIN/DF (2.846), CFI (0.930), and TLI (0.919) were within the acceptable range while GFI (0.776), AGFI (0.721), and RMSEA (0.078) were in the tolerable range (Kline, 2005). After eliminating Mystery, the measurement model constructs and items used in this study showed an acceptable degree of validity ([43], [41]).

One sample T-tests revealed preference for the Bubble prototype (Table 2). All scale means for the Bubble prototype, including Satisfaction, were significantly positive (i.e., above neutral point of 4.0 on Likert scale, range 1-7). The means for all but two of the scales for the Metaphor prototype (Satisfaction and Playfulness) were significantly positive. The means for all but three of the scales for the Word prototype (Satisfaction, Expressive Aesthetics and Playfulness) were significantly positive.

Table 2. One-Sample T-Test Results for Scale Means Compared to Neutral Value of 4.0 (n=240)

	Bubble (n=74)	Metaphor (n=79)	Word (n=87)
Aesthetics	5.36 (+)***	4.78 (+)***	4.60 (+)***
Classical	5.77 (+)***	4.88 (+)***	5.34 (+)***
Expressive	4.96 (+)***	4.67 (+)***	3.87 (-) *ns*
Usability	5.43 (+)***	4.38 (+)**	5.24 (+)***
Efficiency	5.96 (+)***	4.77 (+)***	5.67 (+)***
Effectiveness	5.99 (+)***	4.48 (+)*	5.85 (+)***
Satisfaction	4.33 (+)*	3.90 (-) *ns*	4.20 (+) *ns*
Coherence	5.77 (+)***	4.69 (+-)***	5.50 (+)***
Mystery	5.55 (+)***	4.86 (+)***	5.31 (+)***
Playfulness	4.55 (+)***	4.24 (+) *ns*	3.75 (-) *ns*

*p < 0.05; **p < 0.01; ***p < 0.001; *ns* = not significant

One-Way ANOVAs with post hoc Tukey tests revealed that the Metaphor prototype scored lower than Bubble and Word in Usability, Efficiency, Effectiveness, Mystery, and Coherence (*p*<0.001 for all comparisons), and lower than Bubble in

Classical Aesthetics (Table 3). Using the same test, the Word prototype scored lower than the Bubble and Metaphor prototypes in Expressive Aesthetics, and lower than Bubble in Playfulness. The Metaphor and Word prototypes scored lower than the Bubble prototype in Aesthetics. There was no significant difference in Satisfaction across the three prototypes, and in no case did the Bubble prototype perform significantly lower than the other two.

Table 3. One-Way ANOVA Results for the Three Prototypes (n=240)

Scale	$F(2,237)$	p	Group Differences
Aesthetics	8.200	0.000***	Bubble > Metaphor, Word
Classical	9.158	0.000***	Bubble > Metaphor
Expressive	14.316	0.000***	Bubble, Metaphor > Word
Usability	21.696	0.000***	Bubble, Word > Metaphor
Efficiency	18.427	0.000***	Bubble, Word > Metaphor
Effectiveness	25.828	0.000***	Bubble, Word > Metaphor
Satisfaction	2.597	0.077	No significant difference
Coherence	14.854	0.000***	Bubble, Word > Metaphor
Mystery	9.519	0.000***	Bubble, Word > Metaphor
Playfulness	7.552	0.001**	Bubble > Word

*p<0.05, **p<0.01, *** p<0.001

6   Discussion and Recommendations

The home page designs and knowledge content categories (i.e., prototypes) evaluated in this study were generated 'from the ground up". Personal interviews with a small sample of end users in their actual work locations assessed initial prototype designs [36]. This step narrowed the scope to the three prototypes (Figure 1) that were evaluated in this study with a large sample, Internet survey. By involving end users in all steps, we were able to identify both usable and aesthetically-pleasing prototypes. The Bubble and Word prototypes were superior in terms of usability and aesthetics with an edge going to the Bubble design. These findings are not too surprising given that the Word prototype home page was the least original of the three, consisting primarily of lists of words and phrases. Although the Word prototype may not appeal as much to users who are more attracted to interesting and rich visual displays, it still possesses meaningful usability components and should not be abandoned entirely. Our findings have high confirmability as they are consistent with studies where different methods were employed with employees from the same study population [36] and where different methods were employed with a sample of college students [37].

These findings will be used to improve the information architecture, usability, and aesthetics of the Lake Discovery website and its content, increasing its usefulness for outdoor recreation managers in government agencies. Such improvements will move the agency toward development of a user-based knowledge management system. Our

ground-up approach of involving end users in the very beginning stages of development and evaluation can be applied to similar governmental efforts.

Theoretically, our findings support the principality of aesthetics, coherence, efficiency, effectiveness, playfulness in home page design. All factors were significantly related to user satisfaction. Optimal amounts of both usability and aesthetic features are preferred in terms of home page design; too much or too little of either are least favored. Both should be given due consideration in website design for public sector websites and knowledge management systems.

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