USING THE WOSP MODEL TO IMPROVE END-USER PRODUCTIVITY OF INFORMATION SYSTEMS[1]

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Abstract

Organizations increasingly depend on information systems for business success. However many applications do not meet user needs, and may be used by only a minority of the initially expected user group. By involving end-users in the development process, their preferences can better define "what users want" before product implementation. There is a need for an easy-to-use tool to help end-users express their software needs clearly. The Web of System Performance (WOSP) model adds reliability, flexibility, security, extendibility, connectivity, and privacy to the functionality and ease-of-use of the Technology Acceptance Model (TAM), which introduces a social dimension. Each WOSP factor has a clear system design implication. This study develops an IS performance review questionnaire, based on the WOSP model, and evaluates its factors using conjoint analysis. The results suggest the WOSP model is more comprehensive, and that security and privacy rate above functionality and usability in browser selection.

Key Words: reliability, flexibility, security, extendibility, connectivity, privacy, functionality, usability

1. Introduction

The use of information technology (IT) in today's organizations has increased in recent years because IT is now a primary survival factor for organizations. In recent years IT has become a critical success factor for business organizations in a global competitive environment. The benefits that can be derived from IT investment give ample reason for the interest, and can broadly be classified into four purpose categories:

- Increasing productivity and the performance of operating processes
- Facilitating support for management
- Gaining competitive advantage
- Providing a good framework for the restructuring or transformation of business

For this among other reasons, organizations are increasingly dependent on information technology to accomplish their basic activities, and cannot afford information systems that hinder the processes they were intended to support (Davenport et al, 1994). It is estimated that in the last two decades, approximately 50% of all new capital investments in organizations have been in information technology (Westland et al, 2000). Further, the total worldwide expenditure on IT exceeded one trillion US dollars per annum in 2001, with a 10% annual compounded growth rate (Seddon et al, 2000). This

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notwithstanding, organizations today have less financial resources available for information technology than previously (Rivard et al, 1997).

The result has been an increasing desire by organizations to control IT related spending, including end-user computing. One way to achieve this is better information system evaluation, i.e. "buying smarter". This helps firms enhance overall performance (Taylor et al, 1995), and provides the information senior executives need to justify huge IT investments (Hitt et al, 1996; Brynjolfsson, 1993).

2. User preference in IS development

The impetus for systems development is typically an organizational problem or opportunity (Browne et al, 2001). However, most system development projects are abandoned before completion, after completion, or fail to meet user expectations, resulting in an annual costs in excess of $100 billion to organizations in the US alone (Ewusi-Mensah, 1997; Standish, 1996).

Gause et al (1993) distinguish customers who pay for the system from those who actually work with it, and observe that most software tools purchased are not used, and if they are, are used only by a minority in the organization. They suggest the main reason for this is a lack of end user involvement in development and purchasing processes (Vassey et al, 1994). Particularly important is the evaluation of IS performance by non-IS employees, who are the primary users of IT-related products and services (Chang et al, 2000). The end-user needs a way to influence IS development and purchase, so his or her inherent needs and characteristics are incorporated in the product (Isomaki et al, 2005). This in turn requires a way to comprehensively analyze how users interact with information, technologies and tasks (Isomaki, 2002).

Requirements engineering is the process of specifying requirements by studying stakeholder needs, and systematically analyzing and refining them into a specification (Hoffman, 2000), which states the requirements the software must satisfy to fulfill a contract or standard (IEEE, 1998;Loucopoulos et al, 1995). The bottom line in systems development work is to extract from users their knowledge, ideas, and needs about whether an information system will meet his or her needs (Burch et al, 1983). The role of end users is to provide input for the design, and then sign off on the end product. This raises two issues:

- A requirements specification process that involves end-users in system development.
- Tools and techniques to facilitate end-users' involvement in the process

Communication problems in requirements elicitation are a major factor in software project delay and failure, especially for social-technical software in complex organizational settings (Al-Rawas et al, 1996). The humanization of information systems has a social aspect. If information systems are also social systems, designers must connect their social and the technical aspects (Isomaki et al, 2005). Such social requirements are much easier to include if they are incorporated before the design is finalized.

The following section discusses the WOSP model which might help users gain a better understanding of an information systems' performance, as a critical first step in indicating their application preferences for development or acquisition.

3. IS performance constructs

The dominant model for explaining technology acceptance by users is the Technology Acceptance Model (TAM) (Hu et al, 1999). It suggests two factors, perceived ease of use and perceived usefulness, influence application attitudes, which in turn influence the intention to use it. The model has considerable empirical support over a wide range of technologies, users and organizational contexts. TAM is parsimonious, has a theoretical basis, has significant empirical support, and most important, is IT specific.

Nevertheless, this model appears to exclude other critical system performance factors like flexibility (Knoll et al, 1994), security (OECD, 1995), reliability (Jonsson, 1998), extendibility (McCarty et al, 1999), privacy (Benassi, 1999), scalability, (Berners-Lee, 2000) and conformance to standards (Alter, 1999). An investigation on the acceptance by physicians of telemedicine using the TAM model found perceived ease of use and perceived usefulness explained only 37% of the variances in attitude towards the technology, and perceived usefulness and attitude together only explained 44% of the variances in the intention to use the technology (Hu et al, 1999). These considerations suggest that the TAM is valid but incomplete.

The Web of System Performance (WOSP) model derives its criteria from a systems theory approach, equally applicable to biological and mechanical systems (Whitworth et al, 2003). In this model, information systems, like other natural systems, are subject to environment pressures (David et al, 2003). They can be represented on four levels (hardware, software, cognitive and social). The performance at each level is how successfully it interacts with its environment.

This system is proposed to have four basic elements: *boundary, internal structure, effectors, and receptors*. Each interacts with the system environment to gain opportunity or avoid loss. The boundary controls what enters the system, and can be designed to repel threats or to use opportunities. The internal structure which manages and supports the system can be designed to maintain operations despite internal changes, or change them to suit external changes. Effectors change the external environment, and can be designed for maximum effect or minimum cost. Finally, receptors allow communication, and can enhance or limit information exchange. Each of these elements has a dual role in system performance, to maximize opportunity or minimize risk, giving the eight system performance goals defined below. They are illustrated in Figure 1:

- **Effectors:**
  - *Functionality* – a system's ability to change its environment relative to itself
  - *Usability* – a system's ability to minimize the resource cost of actions
- **Boundary:**
  - *Security – a system's ability to protect against unauthorized entry, misuse or takeover*
  - *Extendibility – a system's ability to use outside elements in its performance*
- **Structure:**
  - *Reliability* – a system's ability to continue operating despite internal changes like part failure
  - *Flexibility* – a system's ability to perform in new environments
- **Receptors:**
  - *Connectivity* – a system's ability to exchange information with other same type systems
  - *Privacy* – a system's ability to control the release of information about itself

The sum of these eight criteria is proposed to be *system performance*. The model ignores system creation costs – it is assumed users naturally weigh higher performance against higher cost.

The WOSP factors are all known in the systems requirements literature, but their combination in a single system model is new. The WOSP model further proposes that these system performance dimensions exist in a natural state of tension, and can be visualized as the corners of a "web" of performance. Hence pulling one corner can give "bite back effects" (Tenner, 1997).

WOSP extends TAM's two factors to include other aspects of system performance known to system design. It particularly applies to social-technical systems such as email, browsers, bulletin boards and chat rooms (Whitworth et al, 2004).Which factors most affect system performance will vary with the environment.

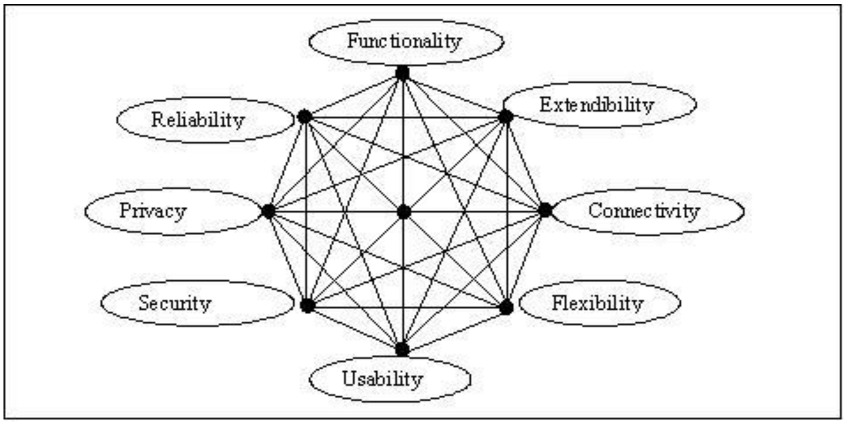

Figure 1. The WOSP model

4 Evaluating the WOSP model

This paper investigates whether users take into account the eight WOSP factors when evaluating software performance, and the degree to which this affects technology acceptance.

Browsers are rapidly becoming the universal platform on which end users launch information searches, email, multimedia file transfer, discussion groups, and many other Internet, intranet, and extranet applications. Their importance and online use will likely increase, as such transactions become even more common. There are many browsers available, and even with a particular browser (like Netscape), there can be many variants. Companies may select particular browsers for better compatibility and a better online interaction platform. An Internet browser seemed a good example of the sort of social-technical software that requires a user evaluation and choice.

4.1. Analysis Method

Conjoint Analysis is widely used in the marketing and agricultural disciplines to gauge the importance to consumers of the various attributes of a product or service. It assumes people evaluate the value of a product or service by adding up the separate amounts of utility provided by each of the attributes of the product or service (Hair et al, 1995). Conjoint analysis decomposes these preferences to determine how much is due to each factor. A product or service with a particular set of levels or values of the various attributes or factors is referred to as a treatment or a stimulus.

This analysis method shows the relative importance of each factor by part worth estimates. Conjoint analysis is also unique in that it allows for the generation of a preference model for each subject. To provide a consistent basis for comparison across different individuals, the range of values for each model is standardized. It calculates relative importance values for each factor from their part worths such that the total for all factors comes to 100%, making it possible to compare the significance of the various factors. The individual preference models can then be aggregated for a group. Thus analysis can be either at the individual or at the group level. Conjoint analysis was selected as the method for investigating the suitability of the WOSP model for eliciting user preferences for software performance.

4.2. Experimental design

The additive model of conjoint analysis was used for this analysis. A fractional factorial design was chosen in order to avoid cognitive overload of the subjects, given that there were 8 factors, each with 3 possible levels (high, medium, and low). The conjoint module of the SPSS statistical software package was used to create an orthogonal fractional factorial design of 27 stimuli. In addition, 6 "holdout" stimuli were generated for checking subject evaluation consistency. Subjects had to evaluate a total of 33 stimuli, i.e. 33 different browsers. The full-profile method was used, where each stimulus in the set has all the eight factors that a user must consider, each having a level defined, and is presented separately.

For the dependent variable (the selected company browser), ranking, rather than rating, was used as a measure of user preference, because it is generally more reliable, as subjects are forced to be more discriminative. The independent variables were the eight WOSP dimensions.

4.3. Subjects

The subjects were 28 graduate students comprising 43% female and 57% male, and representing a diverse cultural background. They had been using a browser for over 8 years on average, and in the 6 months prior to the experiment had used a browser for 23 hours each week, on average. Reasons for using the browsers varied, including general information searches, online financial transactions, online purchases, emailing, and taking courses online. Generally, the subjects were very familiar with browser software.

4.4. Method

The participants assumed the role of a senior IT manager evaluating 33 different web browser types and versions to make a recommendation for adoption by their organization. The treatment was to present to each subject the results of a previous technical analysis that gave each browser a different set of WOSP performance factor ratings. Given these ratings, the participants then had to rank the browsers according to preference.

As a preliminary "priming" phase, subjects were presented with 10-15 illustrative statements for each factor, and asked to rate them on a scale of 1-5 for:

- **Clarity (C)** *of meaning*
- **Validity (V)** *relative to the factor definition*.
- **Importance (I)** *In assessing browser software*

The factor presentation order was randomized, so no two subjects received the statements in the same order, to control for order effects.

For the second stage, the statements for each factor were sorted in order by importance, then clarity, then validity. The six highest ranked statements were taken as the most useful, and used to anchor the factor in the second phase of the experiment (see Table 1: three statements are given for each factor due to brevity of space)

Table1. Anchor statements for WOSP performance factors

Connectivity	**C**	**V**	**I**
When downloading it gives useful information, like the estimated time to complete the download.			
If a download is stopped, or fails for any reason, it can be restarted again later from where it left off, saving a lot of time.			
It gives access to other ways of communicating, like Telnet, Ftp, email and chat.			
Functionality			
The Favorites list lets me jump directly to my favorite sites			
This browser gets me where I want to go quickly			
The browser has everything I need to search, navigate and display the Internet.			

Flexibility			
It runs on all our computers and operating systems.			
It is easily changed to fit disability needs e.g. larger text or graphics for those with poor vision.			
It has a preferences "control panel" to change browser settings.			
Openness			
It works with all third party multimedia tools, like real-media player and flash.			
It follows all World Wide Web source code and data standards, e.g. Unicode.			
It can handle graphics, sound and video in a wide variety of different formats.			
Privacy			
Any sensitive information I give the browser, like logon passwords, is encrypted, so others can't see it.			
Password information always shows as asterisks, so others cannot look over my shoulder to see them.			
It stops web sites from getting my name or email from my computer's data.			
Reliability			
It never breaks down or "hangs" (fails to respond), even if I use it for a long time.			
If one part of the browser fails, like a plug-in, the entire browser does not crash.			
Even if I multi-task, and do many things at once, it still works well.			
Security			
When a file is downloaded to the hard drive, it is checked for viruses before use.			
It can detect and prevent spyware from installing.			
It can detect and prevent popup ads.			
Usability			
The user interface is consistent and easy to learn.			
I did not need training to use it the first time.			
I accomplish my tasks easier and quicker with this browser.			

In the second phase, subjects were asked to evaluate each browser as follows:

- Grade the browsers as Strong, Good, Adequate, Limited or Weak
- Score the browsers 1 – 100. Score the worst browser as 1, and the best browser as 100
- Rank the browsers from 1 to 33, with 1 the best and 33 the worst.
- Explain the reasoning behind ther decisions.

The entire experimental procedure was carried out via email. This standardized the subject procedure, reduced researcher variability and cut down on experiment administration time.

4.5.Results

The results were assessed for the accuracy of the estimated models at both the individual and the aggregate levels to ascertain how consistently the model predicts across the set of preference evaluations given by each individual. The lowest Spearman's rho correlation in the data was 0.85, and the lowest Kendall's tau was 0.65. The significance for all correlations was less than 0.01. To ensure extreme individual values did not bias the aggregate results, a boxplot analysis was done on the part worths of each of the eight factors generated by the 28 subjects. Three data sets did not have consistent internal validity, taken as a Kendall's tau of at least 0.4, and one data set had an extreme outlier for the performance factor usability. These four data sets were excluded from any further analysis.

Ideally, if the performance factors are equally important to users, they should each have an average relative importance of 12.5%, as there are 8 of them. However, since the confidence interval of the means is given as a better estimate of the true value of the parameter than the mean, the 99% confidence interval is given for the average relative importance (Vining, 1998). For the purposes of evaluating the results, it is assumed that if the expected average importance value of 12.5% is at least contained within the confidence interval of a factor, that factor is significant in the subject's performance evaluation model.

The second metric is the percentage of subjects who gave a relative importance equal to or greater than the expected 12.5%. It takes account of the possibility that the relative importance values could be biased by the extreme values of some subjects in the sample (Bajaj, 2000). The results of the experiment are summarized in Table 2. A graph of the average importance values for the factors, and the lower and upper confidence limits, is in Figure 2.

Table 2. Summary of Results

Performance Factor	**Avg. Importance.**	**Std Dev.**	**99% Confidence**	**above12.5%**
Security	22.78	12.78	16.07-29.50	70.83
Privacy	15.47	9.19	20.30-10.64	58.33
Usability	14.16	9.88	19.36-8.97	50.00
Functionality	12.02	8.21	16.33-7.70	29.17
Reliability	11.64	8.15	15.93-7.36	33.33
Connectivity	9.24	6.54	12.68-5.80	33.33
Extendibility	7.69	4.56	10.09-5.30	16.67
Flexibility	6.99	6.46	10.39-3.59	16.67
Correlation with Avg. Importance				0.95

5. Conclusions

As can be seen from Table 2, security, usability, privacy, functionality, reliability and connectivity seem significant factors when subjects assess web browser performance. Extendibility and flexibility have some effect on the evaluative process, but not a major one. The correlation between the average importance of a factor and the percentage of individuals who gave a part worth greater than 12.5% for that factor is 0.95, which is very high. This means the relative importance of a factor was also reflected by the number of individuals who gave it a high part worth. These results support the WOSP model view that factors additional to those suggested by TAM affect user technology acceptance. In particular, security and privacy were judged as more important by subjects than TAM’s usability and functionality. However, the experimental software of this study was a browser. Browsers are complex organizational level applications, but are not the only example. It would be useful to repeat this experiment with other software (Venkatesh et al, 2003).

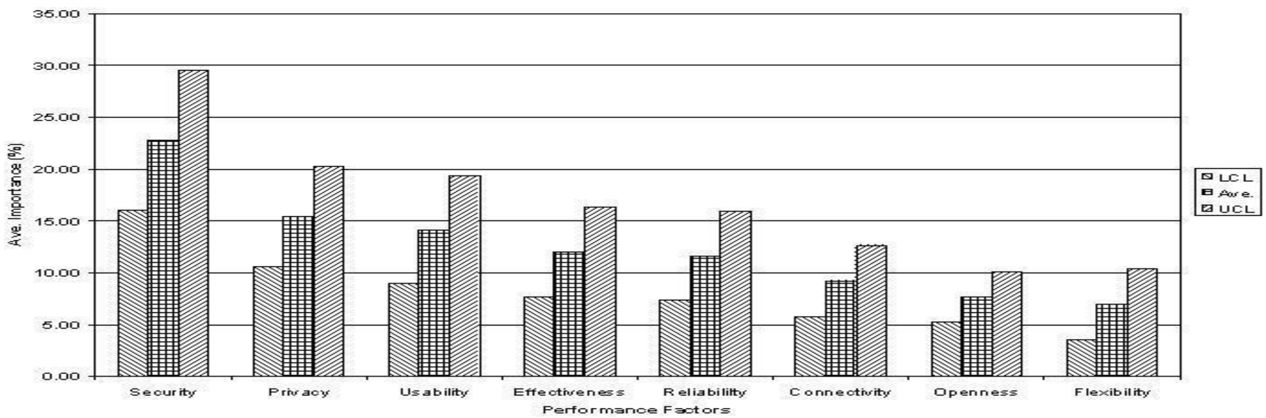

Figure 2. Graph of lower confidence limit, average factor importance, and upper confidence limit

6. Discussion

Of the eight WOSP factors, extendibility, flexibility and connectivity are probably the least known. More familiar factors like security, usability and reliability may be rated as more important, following the availability heuristic (Kahneman et al, 1982). As users become more educated, their rating of software acceptance factors may change. This study found flexibility had the lowest relative importance. This may have been because it is not of value, or because many users do not fully understand or appreciate its value. Its importance may be apparent to system designers but not to users.

Product development is by its nature complicated because the information concerning what the customer needs resides with the customer, while the information concerning the solution or how to satisfy those needs lies with manufacturer (Thomke, 2002). This is especially so in a combination of information systems development and the new product development aspect of marketing (Bragge et al, 2005). While the needs and preferences of the end users should be the key issue, these users, who are not usually technical experts in the application, are often not involved in the application development process. A proposed solution is to tighten the relationship between developers and their customers, and foster collective creation and sharing of knowledge (Fuller et al, 2004; Franz et al, 2003)

The WOSP model gives a straightforward way for users to indicate their software preferences to system designers. In conjunction with an analysis method such as Conjoint Analysis, which analyses at the individual and aggregate level, the WOSP model can facilitate the following product development functions (Hair et al, 1995):

- **Segmentation:** The analysis could be used to segment application users according to the importance they attach to each of the eight performance factors. This could help with resistance to application adoption by individuals who perceive the application as lacking essential qualities. So it would be easier to match users with systems of their preference.
- **Marketing information:** For developers and vendors of applications, information obtained on the relative importance of the performance factors by various groups could be combined with the information on the cost of providing the various factors, and the various levels of each, at the development stage. This could give useful insight on the profitability margin of providing various groups with their ideal applications.
- **Simulation:** Conjoint models can be used in simulation. This would involve 3 steps:

- Estimation and validation of conjoint models for subjects from a population of interest
- Selection of stimuli for testing, based on an issue for research in the software of interest
- Simulation of subject's choices for selected stimuli to predict application evaluations.

Overall, this study suggests the WOSP model is more inclusive, as it adds to TAM factors well recognized in the system requirements literature. Further studies may define different factors configurations for other types of software. We intend to generalize the statements used to anchor this browser evaluation to create an eight factor equivalent of the TAM questions.

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