

Using the End-User Computing Satisfaction (EUCS) Instrument to Measure Satisfaction with a Web Site

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ABSTRACT

The purpose of this study is to revise and revalidate the End-User Computing Satisfaction (EUCS) instrument to measure satisfaction with a Web site from a usability perspective. This study is especially important given the increased significance of the Web and the uniqueness of the Web as a computing environment. A total of 176 students participated in a lab simulation that involved a usability evaluation of the Lands' End Web site (www.landsend.com). Students were asked to complete a set of tasks, record their answers, and then complete the EUCS instrument. Confirmatory factor analysis and invariance analyses were conducted to test the reliability, validity, and generalizability of the revised EUCS. The results show that the EUCS is a valid and robust instrument in the Web environment but that one of the subfactors, *timeliness*, will need further refinement in the future. Usability practitioners can use the EUCS to measure end-user satisfaction with a Web site and use the feedback for improving Web-site design. We describe a case study of an actual usability application that utilized the revised EUCS effectively to support the design of building supply Web sites involving two types of end users, homeowners and contractors. We also propose a typology that researchers can use as a starting point to judge when it is necessary to revalidate an instrument like the EUCS. Finally, we discuss the limitations of our study and present avenues for future research.

Subject Areas: Confirmatory Factor Analysis, End-User Computing, Invariance Analysis, Survey, Usability, and Web-Site Satisfaction.

INTRODUCTION

The growth of the Internet represents one of the most important technological developments of the last half century. The third annual UCLA Internet Project

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(2003) surveyed more than 2,000 households across the United States and compiled the responses of Internet users and nonusers. The results clearly indicate that a large majority of Americans now have access to the Internet, and that hours spent online and home access continue to rise. The top five most popular Internet activities (percentage of users) are: e-mail and instant messaging (87.9%), Web surfing or browsing (76.0%), reading news (51.9%), accessing entertainment information (46.4%), and shopping and buying online (44.5%). The number of Web pages on Web sites is also growing and is projected to grow to 50 billion pages by 2005 (Nielsen, 2000; Palmer, 2002).

Given this growth, the interaction of users with Web sites is becoming an important area of study in a new business environment. This new business environment has been called electronic commerce (EC) or e-business. Straub and Watson (2001) used the alternative term, net enablement or net enhancement (NE) to emphasize the role of networking in linking various parties on the Internet. Straub, Hoffman, Weber, and Steinfield (2002) used the term net enabled or net enhanced organization (NEO) to refer to traditional brick and mortar firms that are using networks to enhance existing channels and become “clicks and bricks” firms.

Straub et al. (2002) described the importance of good metrics for NEOs to the researcher and the practitioner and stated that “the unique characteristics underlying the Web may in some cases require new metrics or at least the careful evaluation of existing ones, to facilitate the development of innovative solutions to emerging problems.” The purpose of our study is to evaluate the appropriateness of a metric to measure satisfaction with a Web site. The metric is the End-User Computing Satisfaction (EUCS) instrument introduced by Doll and Torkzadeh (1988), which has undergone significant testing and development in the literature. Our research objective is to revalidate the EUCS for use in Web-site design. We believe that such a revalidation is necessary for researchers and practitioners. Boudreau, Gefen, and Straub (2001) recommend that researchers “use previously validated instruments whenever possible, being careful not to skirt previous validation controversies or to make significant alterations in validated instruments without revalidating instrument content, constructs, and reliability.” Additionally, a validated instrument will provide usability experts and practitioners with a validated tool to assess end-user satisfaction with a Web site after finishing a usability study. A case study of such an application of the EUCS by usability practitioners will be described later in this article.

It is important to have a useful standard for judging whether a revalidation of the EUCS is needed. Based on our review of the literature, we propose a typology with four dimensions that can be used to judge differences in user- and situation-related context for the EUCS. This typology compares the Web against general application software, software for mobile devices, and game software. This typology may be used as a starting point for assessing the need to revalidate any software-related instrument if there are enough differences on the dimensions described. In the next two sections, we describe the proposed typology, how it applies to the EUCS, and what the current study entails.

The Proposed Typology

Our study of the literature identified four dimensions that make the Web unique as a design environment: competitive environment, marketing environment, usage, and usability. We use these four dimensions to define a typology that compares Web design against design for general application software, software for mobile devices, and game software. Table 1 summarizes the critical issues that arise in these four different environments and how they vary on the four different dimensions. Because of space limitations, we do not completely discuss each cell in this table, but instead highlight some key differences for illustrative purposes. The four dimensions used in the assessment are as follows.

Competitive environment

The need for NE (and NEOs) is most visible in hypercompetitive environments (Wheeler, 2002). Hypercompetitive environments (Zohar & Morgan, 1996) are characterized, among other things, by rapid changes in technology and relative ease of entry and exit by competitors (Bogner & Barr, 2000). This description characterizes the Web quite well, and to a lesser extent mobile devices because of hardware development requirements. General software and games tend to be “slow-rollout” environments because of the extended development time required for large software packages that often have millions of lines of code; this generates extended learning curves for users.

This new environment requires speed and innovation to exploit short-term competitive advantage. The Web is one of the dominant business configurations for NEOs and allows collaboration with alliance partners (Wheeler, 2002). Competition on the Web is not limited to other companies in the same industry. With so many sites present, competition is keen for users’ time and attention (Nielsen, 2000), and begins anew each time Web use is considered. Unlike users of conventional software (e.g., Microsoft WordTM) and to a lesser extent games (e.g., QuakeTM), there is little in the way of sunk costs such as software learning curves or financial investments to deter the user from potentially choosing a different, competing Web site.

Marketing environment

Hoffman and Novak (1997) describe how the Web presents a fundamentally different environment for marketing activities than traditional media, and present a new marketing paradigm for the Web. They state three ways in which the Web is unique: (i) the Web is a many-to-many communication model, as opposed to mass communication, which is one-to-many; (ii) the concept of flow (Csikszentmihalyi, 1990), or engagement, is important for Web-based marketing efforts; and (iii) consumers on the Web engage in behavior that is either goal-directed (consumer is extrinsically motivated) or experiential (consumer is intrinsically motivated). Flow can be described as the sensation people feel when they act with total involvement. In a flow state on the Web, for example, user actions are experienced

Table 1: The proposed typology.

	Critical Issues	Software/Hardware Environment			
		Web ^a	General ^b	Mobile ^c	Games ^d
Competitive environment	Speed of change	Rapid	Moderate	Rapid	Moderate
	Ease of entry and exit	User: high Provider: high Very short	User: low Provider: very low Medium	User: high Provider: low Short	User: medium Provider: very low Medium
	Competitive advantage timeframe	Many to many	One to many	Many to many	Either
	Communication model	Both required Either intrinsic, extrinsic, or both	Functionality required Extrinsic	Both required Either	Both required Intrinsic
Marketing environment	Functionality vs. flow	General Yes	Specific No	Specific Yes	Specific No
	Locus of motivation	High Use, then buy	Low Buy, then use	Moderate Buy, then use	Low Buy, then use
Usage	Scope				
Usability	Location specific				
	Design flexibility				
	Customer experience				

^aWeb refers to Web sites used on the PC (e.g., www.landsend.com).

^bGeneral refers to general application software used on the PC (e.g., productivity software).

^cMobile refers to software used on mobile devices such as PDAs or cell phones (e.g., Documents to Go).

^dGames refers to game software on the PC (e.g., Doom).

as unified flowing from one moment to the next. The user feels in control of his or her actions, and is engaged in the online environment (Csikszentmihalyi, 1990).

Table 1 shows a number of differences between the environments on this dimension. First, both the Web and mobile devices are designed to focus on many-to-many communication, whereas games may or may not have this capability, depending upon whether Internet interactivity is built into the design; most general-use software is not designed to be highly interactive. Second, Koufaris (2002) used a multidisciplinary approach to measure online consumer behavior by using constructs from information systems (Technology Acceptance Model), marketing (Consumer Behavior), and psychology (Flow and Environment). Koufaris (2002) examined how certain emotional and cognitive responses to an initial Web-store visit can influence the consumers' intention to return and their likelihood to make unplanned purchases. From a marketing perspective, mere functionality of a Web site (such as one might find, again, with an in-house application or a purchased one such as Microsoft WordTM) is not enough—the user must be continually engaged. This suggests that the locus of motivation for Web use needs to be intrinsic to retain users, but may also be extrinsic if the purpose of the usage is instrumental (see our points immediately below).

Usage

Sellen, Murphy, and Shaw (2002) used a combined diary and interview methodology, unlike the survey methodology used by the UCLA Internet Project (2003) and Georgia Institute of Technology Graphic, Visualization, and Usability Center (GVU, 1998) studies, to examine in detail the Web activities of 24 people for 2 days. The activities clustered into six categories, each having common characteristics, goals, and purposes. The categories (and their percentages) are: Finding (24%), Information Gathering (35%), Browsing (27%), Transacting (5%), Communicating (4%), and Housekeeping (5%). Even though Housekeeping activities (e.g., checking that the information on the Web is up to date) were not that common, they tended to be the most time consuming, taking over 40 minutes on average. This variation in usages is one of the perceived advantages of the Web: It is an environment or location for many types of usages. On the other hand, the other types of software/hardware environments noted in Table 1 are much more limited in their flexibility, partly because of the speed of change and ease of entry/exit issues noted previously.

The usage of the Web may also be affected by user location. O'Keefe et al. (2000) conducted an experiment with users from the United Kingdom, United States, and Hong Kong. The authors found considerable differences in how the U.S. and Hong Kong subjects were using the Web. While Americans were inclined to use the Web for information search purposes, the Hong Kong users were more inclined to use the Web for social communication purposes. It is evident that the Web continues to change the way people work and live. Unlike traditional software that may have specific usage (e.g., productivity software, accounting software, games, etc.), the end uses of the Web seem to be limited only by the combined creativity of the site creator and the user.

Usability

The usability of Web sites belongs to the broader topic of human computer interaction (Hartson, 1998; Muller & Czerwinski, 1999). Nah and Davis (2002) define Web-site usability in terms of several standard criteria: the ability to find one's way around the Web, to locate desired information, to know what to do next, and to do so with minimal effort. A key advantage of Web-site design is the flexibility it offers usability practitioners to quickly design effective Web sites. Design flexibility tends to be much lower for traditional (general) software and games, largely because of their more limited uses (see above) and more extended development requirements, and somewhat lower for mobile devices because of hardware limitations. At the same time, Web-site design offers its own set of challenges. Nah and Davis (2002) describe the usability challenges on the Web including typical user errors, the problem of disorientation, and the feeling of being "lost in space." Nielsen (2000) describes how usability progressed to assume greater importance in the Internet economy. With products and software, customers generally experience the usability of the product after they buy it and pay for it. Software designers, however, paid more attention to usability to minimize the cost of running a support center. The Web reversed this process, with users experiencing the usability of a Web site first before committing to using it or spending money on any potential purchases. Palmer (2002) reported on a series of three studies that develop and validate Web-site usability metrics. Agarwal and Venkadesh (2002) described a heuristic evaluation procedure (based on Microsoft Usability Guidelines) to examine the usability of Web sites. Clearly, usability is important to the success of a Web site and tools such as the EUCS should be validated to ensure they measure user satisfaction in this domain.

Table 2 applies the proposed typology to the EUCS instrument. The EUCS represents five underlying dimensions of end-user satisfaction: content, accuracy, format, ease of use, and timeliness. Examples of critical issues (scope, functionality, flow, design flexibility, and speed of change) representing the four dimensions of the typology (competitive environment, marketing environment, usage, and usability) are compared for each of the four user environments (Web, general, mobile, and games). Based on the issues sampled in the table, it is clear that the Web design—as applied to the EUCS dimensions—is different enough from the other three design environments to merit revalidation of the EUCS instrument with the Web.

The Current Study

Given the increased importance of the Web today, and the uniqueness of the Web environment, this study focused on end-user satisfaction with Web sites from a usability testing approach. This is a unique approach from previous studies to date, which focused on the general use of the Web (UCLA, GVU) or on users' prior experience with the Web (Lederer, Maupin, Sena, & Zhuang, 2000; Lin & Lu, 2000; Moon & Kim, 2001). Usability testing is one of the tools used to determine if a product or an application is viable (Rubin, 1994). A common way to implement this type of testing is to ask a group of participants, who have a similar profile to the targeted end users of the system, to complete a set of scenarios using the

Table 2: EUCS and the proposed typology.

EUCS Dimension	Critical Issue	Software/Hardware Environment			
		Web	General	Mobile	Games
Content	Scope	Virtually unlimited because of thin client model	Limited to specific release (fat client)	Virtually unlimited because of thin client model	Can be either
Accuracy	Functionality	Potential tradeoff of rapid updating with accuracy loss	Potential tradeoff of slow updating with accuracy gain	Potential tradeoff of rapid updating with accuracy loss	Potential tradeoff of rapid updating with accuracy loss
Format	Flow	Information presentation focus; frequent changes to retain user interest; high site-specific variance, but some consistent design principles	Operation presentation focus (e.g., menus, dialog boxes); changes often avoided due to user learning curve requirements	Both information and operation focus; some design principles shared	Operation focus predominant, information focus often present
Ease of use	Design flexibility	Standard interface/simple usage	Release specific interface; more complex than Web usage	Interface depends on specific hardware/software combination	Release specific interface; more complex than Web usage
Timeliness	Speed of change	Frequent/rapid updates possible	Infrequent updates, must be installed by user	Frequent updates to software only	Real time updating possible

system. The scenarios are usually tasks that are representative of what a typical user may do with the system. The researchers can then test the usability of the system with both objective and subjective variables. Objective measures may include task success rate, task completion time, and number of nodes traversed while performing a task. Subjective measures focus on user satisfaction with the system, which is usually assessed using a survey at the end of the experiment after completing all the assigned tasks. Involving end users in the development process is critical in the design of usable products (Hackos & Redish, 1998). Usability testing is one of many ways to incorporate end users into the design and development process. Other methods include participatory design, focus groups, surveys, structured walk-throughs, expert reviews, and usability audits (Rubin, 1994; Cunliffe, 2000). The advantage of usability testing is that it offers a true end-user perspective (as opposed to a developer's perspective) on the ease of use of a product. Ideally, it is recommended that an organization developing a software application, for example, use several methods of user involvement during the development life cycle to ensure a usable product (Rosenbaum & Chisnell, 2000). While these methods are applicable to many domains (i.e., aerospace, transportation, communications, consumer products, medical systems), they are most commonly used in the design of software. For most large software applications, usability testing has become a standard practice. Web-site design, however, has rapid development cycles and is often done without much user involvement.

There has been no survey instrument to date in the published literature that has been fully psychometrically evaluated to measure the end-user satisfaction with a Web-site based on a usability testing approach. Usability experts and practitioners in the field have been using instruments (created in the past to evaluate software systems and/or other products) to evaluate Web sites, without adequate testing of their validity or reliability. The instruments include Standard Usability Scale Questionnaire (Brooks, 1986), Software Usability Measurement Inventory (Kirakowski & Corbett, 1993), Post-Study System Usability Questionnaire (Lewis, 1995), and Useful Satisfaction and Ease-of-Use Questionnaire (Lund, 2001). One instrument, Website Analysis and Measurement Inventory (Kirakowski & Cierlik, 1998), has been adapted for use with Web sites but is only available for commercial use and for a fee.

The literature on end-user satisfaction with information technology is extensive. Mahmood, Hall, and Swanberg (2000) used a meta-analysis approach to synthesize and validate the construct of IT end-user satisfaction. Satisfaction with information technology has been widely accepted as an indicator of IT usage, which is considered an important driver of IT success. Mahmood, Hall, and Swanberg (2001) state that given the huge spending on IT (estimated at over one trillion dollars), one would hope that better IT usage results in improved organizational performance and productivity. Au, Ngai, and Cheng (2002) summarize the major literature on end-user information system satisfaction. In comparison, the literature on end-user satisfaction with the Web is so far limited (Koufaris, 2002; Devaraj, Fan, & Kohli, 2002; McKinney, Yoon, & Zahedi, 2002). Our study will carefully evaluate the appropriateness of the EUCS (Doll & Torkzadeh, 1988) to measure end-user satisfaction with a Web site. Validating a metric for Web-site

satisfaction is important for both researchers and practitioners working in the area of e-commerce.

RESEARCH METHODS

Sample

One hundred seventy-six students taking either an introductory psychology course or an introductory e-commerce course completed the experiment as part of their coursework. Given the use of a student sample, generalizability to the broader domain of Web users and potential purchasers was a concern. Below, we report sample demographics and background information on Internet use and experience, compared with available results from recent national surveys of Internet users. The most recent survey (UCLA, 2003) shows males and females, who are present in relatively equal proportions in the overall population, to use the Internet in similar proportions (73% and 69% of the surveyed population, respectively). Similarly, our sample was relatively evenly split between male (47.2%) and female (52.3%). The mean age in our sample was 22.73 years. However, the more recent UCLA (2003) survey reports the highest frequency of Internet use is now among younger age groups (24 and below). In our sample, 18.3% of respondents report little or no Internet use, compared to 28.9% of Americans (UCLA, 2003). In addition, 42.6% of respondents reported using the Web between 2 and 6 hours per week, with another 24.3% reporting 7–14 hours of use; UCLA (2003) reported that users averaged 11.1 hours per week online. This figure is somewhat higher than what we report, most likely because it includes time spent on personal and work-related e-mail use, which we did not assess. Over half (50.96%) of our participants reported visiting the Web daily. Education (80%), browsing (58%), entertainment (58%), and personal needs (50%) were cited by respondents as the primary reasons for using the Web. These were also cited by UCLA (2003) as major online activities for both new and experienced Web users. Fifty-three percent of our sample reported never buying anything from the Web in the past year, as compared to national figures of 45.1% in 2000, 50.9% in 2001, and 39.7% in 2002 (UCLA, 2003). Nine percent of respondents reported buying once, 24% reported buying 2–5 times, 9% reported buying 6–15 times, and 4% reported buying 15 or more times in the past year.

These comparisons provide some qualitative evidence that our sample is not dissimilar to Web users in general, and is equally likely to purchase online. Our claim here is mirrored by Han and Ocker (2002). They suggest that, from a marketing perspective, university students are a highly appropriate group to target for online purchasing, because they are extremely active online shoppers (see also Pastore, 2000). While our sample may not represent the entire target market for Lands' End, it does represent an important market segment as evidenced by their online advertising.

In a later section, we will quantitatively examine the generalizability of our results for respondents differing in several demographic and background characteristics.

End-User Computing Satisfaction Instrument

The EUCS has undergone significant testing and development in the last decade and currently uses 12 items to represent five underlying dimensions of end-user satisfaction: content, accuracy, format, ease of use, and timeliness. Recent work on the EUCS has established that it is best represented by a factor structure in which the five underlying first-order dimensions are explained by a single, global second-order construct reflecting overall EUCS (Doll & Torkzadeh, 1988; Doll, Xia, & Torkzadeh, 1994; Doll & Xia, 1997; McHaney & Cronan, 1998). The EUCS has been shown to have adequate internal consistency reliability, test-retest reliability, content validity, construct validity, and external validity (Doll et al., 1994; Doll & Torkzadeh, 1988; Doll & Xia, 1997; Hendrickson, Glorfeld, & Cronan, 1994; Klenke, 1992; McHaney & Cronan, 1998; Torkzadeh & Doll, 1991; Zmud & Boynton, 1991).

To accommodate the specifics of Web-site user satisfaction, minor alterations were made in the wording of the original EUCS items. The alterations involved using past tense for several items, referring to "site" satisfaction (instead of "system" satisfaction) where appropriate, and altering instructions to provide cognitive cueing that would encourage respondents to pay greater attention to the individual items (cf. Graesser, Bommareddy, Swamer, & Golding, 1996). The adapted items appear in Table 3, with the associated dimensions indicated. Coefficient α reliability for the adapted EUCS was .94.

Usability Testing Procedures and Survey Administration

Students were assigned to tasks on a popular e-commerce Web site, Lands' End (www.landsend.com). This site was on a top 50 list of Web sites evaluated by Resource Marketing (Gunderson, 2000) and was chosen because it was (and remains) a popular retail site. The Lands' End site had a deep structure and offered some interactive components such as the "Personal Model" that users could define and view outfits (we do note that the study was conducted in the January to February 2000 timeframe, so the site design may have changed since that time). It was believed that this interactivity of the site added to its complexity to the user. A total of 176 students completed the experiment using this site; those with prior experience on the Web site were excluded.

Students using the Lands' End Web site performed five tasks (see Table 4). The tasks were representative of the type of activities that a user may do when visiting the site. The tasks were written by a usability expert and were pretested in a software usability lab, along with the instrument questions. To avoid order effects, the tasks were sequenced according to one of four preset sequence patterns.

Once the tasks were modified for clarity and time duration, a packet was prepared that included a consent form, instructions, demographic and background information, the tasks, the EUCS, and an item indicating intent to return to the Web sites. Subjects worked through these in order. Students were asked to record the time (using the computer clock) they started a task and the time they ended the task. The difference provided us with estimates for task duration. Students were also asked to write down their answers to each task. A maximum of 10 minutes

Table 3: EUCS items adapted for Web-site satisfaction.

Item	Question	Dimension
EUCS1	Does the site provide the precise information you need?	Content
EUCS2	Does the site information content meet your needs?	Content
EUCS3	Did the site provide help that seemed to be just about exactly what you need?	Content
EUCS4	Did the site provide sufficient information?	Content
EUCS5	Was the site accurate?	Accuracy
EUCS6	Were you satisfied with the accuracy of the site?	Accuracy
EUCS7	Did you think the site information is presented in a useful format?	Format
EUCS8	Was the site information clear?	Format
EUCS9	Was the site user friendly?	Ease of Use
EUCS10	Was the site easy to use?	Ease of Use
EUCS11	Did you get the site information you need quickly?	Timeliness
EUCS12	Did the site provide up-to-date information?	Timeliness

was allowed per task. The answers were scored dichotomously as task failure if incorrect (0) or task success if correct (1). Means for both the time (in minutes) and the task scores (0 or 1) across all tasks provided composite task duration and task success scores for later use in the concurrent validity analyses. Intent to return, also used in the later concurrent validity analysis, was assessed on a 5-point scale by asking “Would you visit this site again?” with answers ranging from *Definitely No* to *Definitely Yes*.

RESULTS

Confirmatory Factor Analyses: Tests of Alternative Factor Structures

Based on the results of previous confirmatory factor analyses (CFAs) on the EUCS in other settings (Doll et al., 1994; Doll & Xia, 1997; Hendrickson et al., 1994; McHaney & Cronan, 1998; McHaney, Hightower, & White, 1999; Torkzadeh & Doll, 1991), three alternative models were assessed: (i) a single first-order factor model, in which all EUCS items load on a single factor; (ii) a correlated five-factor model in which each EUCS item loads on its own factor (content, accuracy, format, ease of use, and timeliness), and the factors are allowed to correlate; and (iii) a second-order model in which the five first-order factors do not intercorrelate, but instead are each explained by a single, higher-order factor.

Absolute goodness of fit for the models was assessed within EQS v6.1 (Bentler, 1995) using the chi-square statistic, the Comparative Fit Index (CFI)

Table 4: Experimental tasks for Lands' End Web site.

Task	Description
1	Every year, you buy your father a short-sleeved polo shirt with a pocket for his birthday. This year you would like to add a monogram to the pocket as well. At the same time, you decide to buy your aunt a new pair of Polartec slippers. Add these gift items to your shopping bag and indicate the price (by item and total) below.
2	Your brother is getting married next spring. He is looking for ideas for gifts for the wedding party. Find two suggested "Bridesmaids gifts" and two suggested "Groomsmen gifts" on the LandsEnd.com site. Write them below.
3	Your spouse has an uncle who has a 50" waist. You want to buy him a new belt. Use the LandsEnd.com sizing chart to find out what size (e.g., S, M, L, XL) to buy him and write it below.
4	As a student, you believe the LandsEnd.com prices seem too high. However, you have heard that they offer great prices on items that they have overstocked and want to sell quickly. Find an item that you would like to purchase and write its Item # and price below.
5	Use the interactive shopping aid, Your Personal Model, to create a model of a female friend or relative. Use the anonymous sign-in and quick-start questionnaire to define the model. Try on a few outfits and select one for your friend or relative. Add the outfit to your shopping bag and write its name and price below.

(Bentler, 1990), and the root mean square error of approximation (RMSEA) (Browne & Cudeck, 1993). The chi-square statistic is reported as a test of the model's reproduced covariance matrix to the covariance matrix found in the data. We supplemented the chi-square statistics with two other measures of absolute model fit. Following the recommendation of several researchers (Jaccard & Wan, 1996; Williams & James, 1994), the CFI (Bentler, 1990) was used as a measure of overall fit. The CFI has an expected value of 1.0 when the estimated model is true in the population and values of .95 or higher indicate close fit (Hu & Bentler, 1999). We also used the RMSEA (Browne & Cudeck, 1993), which assesses overall fit but also includes a penalty function for parsimony. According to Jaccard and Wan (1996), values of RMSEA <.08 are considered reasonable, and values <.05 show a close fit of the model in relation to degrees of freedom. RMSEA includes a confidence interval around its point estimate, allowing hypothesis tests around the .05 and/or .08 values.

Inspection of the normalized Mardia (1970) coefficient in EQS provides a multivariate assessment of skewness and kurtosis, and suggested a significant degree of multivariate non-normality above the .05 level in the data (Mardia's coefficient = 12.81, $p < .001$). Thus, the chi-square, CFI, and standard error estimates reported or used below reflect the robust (i.e., adjusted for non-normality) versions of these provided by EQS.

Table 5 provides goodness of fit statistics and comparisons for the three models. Model 1, the single-factor model, fit the data most poorly on all indices

Table 5: Confirmatory factor analyses results and comparison for alternative models of adapted EUCS factor structure.

Models	χ^2 ^a (df) Sig	χ^2 /df	CFI ^b	RMSEA ^c
Model 1: All EUCS items load on a single factor	201.60 (54) $p < .00$	3.73	.83	.13
Model 2: Five correlated factors	52.47 (44) $p = .18$	1.19	.99	.03
Model 3: Five uncorrelated factors with one second-order factor	61.08 (48) $p = .10$	1.27	.99	.04

^aChi-square reported is scaled chi-square.

^bCFI = robust version of comparative fit index.

^cRMSEA = robust version of root mean square error of approximation.

(chi-square, CFI, and RMSEA). Models 2 and 3 showed good model-data fit, as indicated by the nonsignificant chi-squares and absolute indexes, CFI and RMSEA. The confidence interval for RMSEA in Model 2 ranged from .000 to .064, and for Model 3 it ranged from .000 to .067, indicating both models showed close fit to the actual data. From an empirical perspective, both Models 2 and 3 are satisfactory and provide competing representations of the underlying structure of the adapted EUCS instrument. Our results are consistent with the findings of the two previous confirmatory factor analysis studies on EUCS (Doll et al., 1994; Doll & Xia, 1997). Standardized residuals for Models 2 and 3 were all below .17, indicating good fit (Joreskog, 1993). All EUCS items loaded significantly on their corresponding factors in both models (factor loadings are available upon request). With one exception, the latent first-order factors explained between 57% and 88% of the variation in each individual item, suggesting construct validity for these items commensurate with that found by Doll and Xia (1997). Only 27% of the variation in the item “Did the site provide up-to-date information?” was explained by the timeliness latent factor in Model 2, and only 29% was explained in Model 3.

In our study, there is reasonable evidence of a single second-order factor. The target coefficient was used to test for the existence of a higher-order user satisfaction construct (Doll et al., 1994; Doll & Xia, 1997), finding that 86% of the variation in Model 2 is explained by Model 3’s user satisfaction construct. The second-order factor explained a very high degree of variation in four of the first-order factors (71% in content; 68% in accuracy; 77% in format; 93% ease of use). Variation explained in the timeliness factor was somewhat lower (37%). Zero-order correlations between the five subdimensions ranged from .60 to .76, suggesting a very high degree of empirical overlap. Based on the similarity of our results to previous usage (Doll et al., 1994; Doll & Xia, 1997; Hendrickson et al.,

1994; McHaney & Cronan, 1998; McHaney et al., 1999; Torkzadeh & Doll, 1991), we collapsed the five subdimensions to form a single scale for later analyses.

Criterion-Related (Concurrent) Validity

Establishing concurrent validity depends upon finding a significant relationship between the construct in question and other constructs with which it theoretically ought to be related. The adapted EUCS was significantly and positively correlated with task success ($r = .33, p < .001$), and was significantly and negatively correlated with task duration ($r = -.28, p < .001$). It was also significantly and positively correlated with intention to return to the Web site again ($r = .59, p < .001$). This provides evidence of concurrent validity, since user satisfaction ought to be related to performance, actual usage, and intent to use in the future.

External Validity

To be useful, the adapted EUCS ought to perform similarly for various potential user groups. To assess this, we first correlated EUCS scores with age, gender, the reported number of hours of Web use per week, and the reported number of Web purchases made over the last year. The EUCS was not significantly correlated with any of these, providing initial support for its generalizability. We also used invariance (multisample) analyses to test the significance and invariance of key model parameters across different user groups (Bentler, 1995; Kaplan, 1995). In this study, we defined these differences in two ways: (i) users reporting low Web usage (0–6 hours per week) versus those reporting higher Web usage (more than 6 hours per week), and (ii) users reporting that they made either no Web purchases or purchased only once in the last year versus those purchasing more often. Two analyses, based on these comparisons, were conducted to examine the change in model fit that results from forcing key parameters (factor loadings and factor correlations) across sample groups to be equal. The first model tested is a model that allows key parameters (factor loadings and factor correlations) to vary freely across the two groups being simultaneously assessed. Subsequent models successively force groups of parameters to be equivalent across the two models (for Model 2, factor loadings only; for Model 3, factor loadings and factor correlations).

Table 6 compares these three models on several fit measures for the two comparisons. For users with low versus high hours per week of Web use, chi-square difference tests show no decrement in fit between Model 2 and Model 1, indicating that factor loadings are equivalent across the subsamples. There was a significant decrement in fit for Model 3 versus Model 2, however. Inspection of results showed that the fit decrement was entirely due to a difference between the two groups in the magnitude of the factor correlation for the Accuracy factor on the second-order latent construct, with the correlation being slightly less in the low hours group. All other factor loading and factor correlations were tenable. As a result of this divergence, CFI differences between these two models exceeded the critical threshold of a .10 difference between models that Cheung and Rensvold (2000) specified as being required to reject the invariance hypothesis. However, the RMSEA confidence

Table 6: Invariance analysis for users of LandsEnd.com.

	χ^2	df	Sig.	χ^2 Diff. (df diff.) <i>p</i>	CFI	RMSEA (Conf. Interval)	Comment
Low versus high hours of Web use per week							
Model 1 ^a	119.78	96	.05		.973	.039 (.000–.059)	
Model 2 ^b	127.63	103	.05	7.85 (7) <i>p</i> > .05	.972	.038 (.000–.058)	All restrictions tenable versus previous model
Model 3 ^c	146.73	107	.01	19.10 (4) <i>p</i> < .05	.955	.048 (.026–.065)	Restriction that factor correlations are equal across groups is rejected
Low versus high frequency of Web purchases over last year							
Model 1 ^a	102.30	96	.31		.993	.020 (.000–.046)	
Model 2 ^b	113.94	103	.22	11.14 (7) <i>p</i> > .05	.988	.025 (.000–.049)	All restrictions tenable versus previous model
Model 3 ^c	119.76	107	.19	5.82 (4) <i>p</i> > .05	.986	.027 (.000–.049)	All restrictions tenable versus previous model

^aModel 1 = free estimation.

^bModel 2 = loadings fixed equivalent.

^cModel 3 = loadings + factor correlations fixed equivalent.

intervals for all three models contained the .05 value, suggesting that Model 3, even though a slightly poorer fit to the data relative to the other two, still showed reasonable fit in an absolute sense. Results for users with a low versus high frequency of Web purchases show no chi-square differences for the Model 2—Model 1 and Model 3—Model 2 comparisons. CFI coefficients were nearly equal across the three models, as were RMSEA coefficients and confidence intervals. This indicates that the model restrictions forcing equivalence—that item-factor loadings and factor correlations are equal in the two samples—are reasonable. Considering all these tests together, the adapted EUCS generalized quite well across the different groups tested.

A potential limitation of this last set of analyses is that the sample sizes for the separate groups tested in the invariance analyses were small (ranging from 66 to 107). At small sample sizes, standard errors tend to be underestimated, and fit indices in which sample size enters the calculation may be incorrect. Per the multigroup models we used, overall fit indices ought not to be directly affected by subsample sizes because these indices are calculated for both samples together (i.e., the overall sample size, which was 176). They could be affected indirectly, insofar as various parameter estimates were affected by spuriously small standard errors. However, the robust/scaled standard errors, chi-square statistics, CFI, and

RMSEA we reported here are relatively unaffected by sample size (Bentler, 1995; Kaplan, 1995). As an additional check, the Yuan-Bentler residual-based F statistic was calculated (Yuan & Bentler, 1999). This goodness of fit test is F distributed, is interpreted in the same way as the chi-square goodness of fit test in that a nonsignificant F represents good fit, and has been shown by Yuan and Bentler (1999) to perform better than other GFI statistics with sample sizes as low as 60. The results supported our interpretations in each instance, providing some confidence in their interpretation.

A CASE STUDY

As further evidence of the generalizability of the revised EUCS for Web sites and its usefulness as a tool for usability practitioners, a case study is used to demonstrate a real-world usability study comparing the ease of use, efficiency, and user satisfaction of 13 building-supply Web sites with two different user groups. The usability study was commissioned by one of the building-supply companies to examine their competitors. The names and specifics about the sites will be kept anonymous for confidentiality purposes. The 13 sites were informational sites that provided product information for home building supplies such as roofing materials, siding, windows, decking, and insulation. Forty-six volunteers (23 homeowners, 23 contractors) participated in a usability test evaluating one or more of the sites. Users were asked to complete basic tasks with the sites and report their impressions using the revised EUCS. Satisfaction scores were summarized for each of the five constructs of the EUCS for each site and, along with user performance data, used to make design recommendations.

Table 7 shows EUCS summary scores for three of the sites (A, B, and C). As can be seen, Site A was the least satisfying site for both user groups, especially contractors. This site offered quality pictures of houses but users could not really infer much about the site purpose or to whom the site was targeted from the home page. In addition, this site used a mouse-over navigational technique to display product choices; as the user positioned the mouse over a photograph of a house, the photograph suddenly disappeared and was replaced with a textual link to certain product information (i.e., Siding or Roofing). This method of navigation required the users to spend a significant amount of time searching for a desired product and often resulted in unsuccessful searches. Site B was reported to be more satisfying, especially in Content, to the contractor user group than the homeowner user group primarily because it offered lots of technical product information. In addition, the site used background music, pop-up windows, and advertisements on the pages targeted to homeowners. These features were all reported to be “annoying” and resulted in lower satisfaction ratings of Content and Ease-of-Use ratings by the homeowners. Site C was reported to be the most satisfying across all of the EUCS constructs. This site had a simple navigational structure, attractive colors, and large, detailed product photographs. As shown in Table 7, these features were found to be more influential in overall satisfaction to the homeowners than the contractors. Results from the EUCS along with task performance variables were used to formulate design recommendations for each company site. The EUCS was instrumental in identifying which aspects of the site (Content, Accuracy, Format,

Table 7: Satisfaction summary for homeowners and contractors for three Web sites.

	Site A-HM	Site A-CT	Site B-HM	Site B-CT	Site C-HM	Site C-CT
Content						
Precise information	2.0	2.0	3.0	4.0	5.0	4.0
Meet needs	1.0	1.0	3.0	4.0	5.0	4.0
Help meet needs	2.0	1.0	3.0	4.0	5.0	4.0
Sufficient information	1.0	1.0	3.0	4.5	5.0	4.0
Accuracy						
Accurate	2.0	2.0	4.0	4.0	5.0	4.5
Satisfied	2.0	1.0	3.5	4.5	5.0	4.5
Format						
Useful format	2.0	1.0	3.5	4.5	5.0	4.5
Information clear	2.0	2.0	3.0	4.0	5.0	4.0
Ease of use						
User friendly	2.0	1.0	3.0	4.0	5.0	4.0
Easy to use	1.0	2.0	3.0	4.5	5.0	4.0
Timeliness						
Quick	2.0	2.0	2.5	4.5	4.5	4.0
Up to date	2.5	1.0	4.0	4.0	5.0	4.0

Notations: A, B, C—Web sites; HM = Homeowners; CT = Contractors.

Scaling: 1 = almost never; 2 = some of the time; 3 = about half of the time; 4 = most of the time; 5 = almost always.

Ease of Use, Timeliness) influenced user satisfaction the most across both user groups.

DISCUSSION AND CONCLUSIONS

The need for validated instruments to assess user satisfaction and perceived usability of Web sites has been clearly stated in the literature (McKinney et al., 2002; Straub et al., 2002; Lund, 2001). The unique nature of the Web dictates the need for new metrics or the retesting of scales developed for software applications to determine if they work in the Web environment. This article reports the validation of an adapted EUCS instrument as a measure for end-user satisfaction of a Web site. This study is the first to date to conduct a complete psychometric evaluation of the EUCS in a Web context.

Confirmatory factor analysis was used to study the underlying structure of the adapted EUCS. Consistent with the findings in the literature, end-user satisfaction with a Web site can be viewed as a multifaceted construct consisting of five subscales (content, accuracy, format, ease of use, and timeliness) and a second-order construct. Invariance of key model parameters was tested across user groups defined by (i) the reported frequency of Web usage, and (ii) reported purchasing behavior. The results provide evidence that the adapted EUCS was equivalent across all groups. The EUCS scores were not significantly correlated with age or gender,

supporting the generalizability of the instrument. An important result of our analysis is that the EUCS item "Did the site provide up-to-date information?" did not load well on the timeliness factor. This indicates that the meaning and relevance of this item for the Web is different than the other computing settings, for which the EUCS has been revalidated in the literature so far. In the context of the Lands' End Web Site, it may not be apparent to users if the site is providing up-to-date information or not.

The findings of this study are beneficial to both researchers and practitioners. Researchers can use this new metric when formulating models of Internet behavior, usage patterns, and overall Web-site success. Usability practitioners can now use the EUCS with more confidence in Web-site usability testing. Marketing executives can also use the results of EUCS to discern differences in satisfaction across target user groups. For example, ratings for Content, Format, and Ease of Use may differ based on user experience or search goals, as suggested by the case study findings. Experienced users seeking technical information on a product site may rate a site's content less satisfying if the information is inadequate than an inexperienced user who is satisfied with basic product information. Likewise, less experienced users may rate a site's Format and Content low if product photographs are not of adequate size to detect sufficient detail. The EUCS can also be used to compare user satisfaction of new iterations of a Web site or competitor Web sites. The comparison of sites across the five EUCS dimensions provides valuable information to designers as they experiment with alternative methods of displaying critical information. Usability practitioners in particular will benefit as there is currently no standard instrument to measure Web-site satisfaction.

One important contribution of this study is the presentation of a typology with a set of four dimensions (Competitive Environment, Marketing Environment, Usage, and Usability), which can be used to judge differences in user- and situation-related context for four different computing environments (Web, General application software, software for mobile devices, and game software). When deciding whether the EUCS, or any similar instrument, might or might not generalize to a different technology domain, researchers ought to assess how different the new setting is from previously considered settings, in terms of these dimensions. In doing this for the Web, we found that it has a number of unique differences from domains where the EUCS had been previously validated, supporting the need to validate the instrument in a Web context. Future research may look at using statistical techniques, such as multidimensional scaling, to quantify the different dimensions and assess the degree of similarity/difference for the different user environments. An overall assessment of the information in Table 1 leads us to believe that on a continuum, Web design is more similar to the design of software for mobile devices and general software application design is more similar to game software design.

One limitation of this study is the use of a convenience sample of students from a single university. Our analysis indicated that our sample was similar to general Internet users and purchasers. However, because this study reflects a single sample and one Web site, future research on the EUCS in this context can expand testing to other samples, using field tests and multiple Web sites. Quelch and Klein (1996) present a classification of Web sites into four quadrants based on audience focus (domestic or international) and Web-site content (information &

support/service or transaction based). While the current study utilized sites with a domestic and transaction focus, sites with an international focus and informational content should also be examined with the EUCS. Future research can also evaluate the EUCS across different task types. Our study used *explicit* tasks that instructed users specific items to find (i.e., "... you decide to buy your aunt a new pair of Polartec slippers"). Future studies could examine the EUCS with exploratory searching or implicit search tasks. This type of information gathering has been shown to be more cognitively demanding (Kim & Hirtle, 1995) and results in slower search performance and more disorientation (Norman & Chin, 1988) than directed, explicit searching in hypertext systems.

In addition, future research can refine the subfactor *timeliness*, because one of the items ("Did the site provide up-to-date information?") was not as highly related to the subfactor as it should have been. While this did not substantively affect the overall scale performance, further work should be done to improve this item. This is especially important given the results of a previous study (Sellen et al., 2002), which labeled an activity (e.g., checking that the information on the Web is up-to-date) as a "Housekeeping" activity and showed that such activities tended to be most time consuming for the Web users. *Timeliness* may be redefined as a Web-based construct, based on the phenomenology of the user's actual experience in terms of efficiency (how many steps are required to get information) and time (how much time is required to find the information needed). Users may not readily distinguish whether the speed of acquiring information comes from a fast server or from optimized graphics, or just from a well designed Web site. Research is clearly needed here because it could be any or all of these things.

Finally, future research can also include a comparison of the refined EUCS to alternative usability instruments, which were originally developed for general software, to find which instrument will provide the best metric for measuring satisfaction with a Web site from a usability point of view.

With the explosive growth of computer applications on the Web, researchers and practitioners need to exercise caution in using metrics that were initially created for use in very different domains. The unique characteristics of the Web and the lack of an accepted instrument for measuring Web satisfaction motivated our decision to assess the EUCS in this context. We encourage researchers to continue questioning when, and how, metrics ought to be used in new contexts. [Received: August 2003. Accepted: January 2005.]

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