E-Commerce Websites: a Qualitative Evaluation

Adriano Bessa Albuquerque
Mestrado de Informática Aplicada, UNIFOR
Av. Washington Soares, 1321 CEP 60.811-341 Fortaleza – CE – Brazil
adrianoba@banconordeste.gov.br

Arnaldo Dias Belchior
Mestrado de Informática Aplicada, UNIFOR
Av. Washington Soares, 1321 CEP 60.811-341 Fortaleza – CE – Brazil
belchior@unifor.br

ABSTRACT

E-commerce is considered an excellent alternative for companies to reach new customers. However, many e-commerce websites have a short life because they don't meet the minimal software quality requirements. To help the development of quality e-commerce websites, this work identifies and ranks the main quality attributes to this application domain. The survey of the attributes was based on the specialized literature and on the analysis of significant websites.

Keywords: E-commerce, metrics, quality evaluation.

1. INTRODUCTION

Today's world, becoming more competitive every day, is demanding from companies the flexibility to adjust themselves to the permanent situations of market change, readiness for constant innovation and warranty of the quality of products and services.

At the same time, Internet, after being used initially as a great source of trade information, gradually came to be used as an important environment for trading values (e-commerce). According to Jupiter Research, e-commerce transactions: business-to-business and business-to-consumer, could exceed US$7 trillion per annum by 2005 [3]. However, the sites do not completely satisfy their customers in several aspects and those deficiencies can eventually threaten the very existence of many of those companies in the market.

This paper is intended to collaborate in the effort to produce e-commerce sites of quality, through the identification and ranking of their main quality characteristics, as well as a survey of the different developers' and users' points of view.

2. ELETRONIC COMMERCE WEBSITE QUALITY

To attain the desired quality of software products, it is necessary to produce models that enable evaluation of those products' quality. According to ISO [5], the main purpose of software quality evaluation is to supply referential quantitative results to the software products that are reliable, understandable and acceptable to anyone interested. User satisfaction and economic return are also important considerations.

The quality characteristics were organized using the *Fuzzy Model to Software Quality Evaluation* [2] that was already used with satisfactory results in several application domains. That model ranks a set of software quality attributes, organizing them into three objectives. Each objective is composed of quality factors. Those factors can be subdivided into sub-factors.

Usability is a quality objective that refers to the characteristics that allow use of the e-commerce site in the most diverse situations, not only during its development process, but also during its operation and maintenance. Conceptual Reliability concerns the e-commerce site's capacity to implement, satisfactorily, what was specified and designed. The Reliability of the Representation refers to the e-commerce site's representation characteristics that affect its understanding and manipulation along its life cycle.

The fuzzy model stages used for the evaluation of e-commerce website quality are described below [2]:

- **First Stage**: *establishment of the evaluation object and the set of items to be evaluated.*

For the three quality objectives, hundred and sixteen sub-factors for e-commerce website developers were found and appraised, contained in eighteen quality factors. For e-commerce website users, seventy-eight sub-factors were found, constituting a subset of the specialists' sub-factors, contained in nine quality factors.

The evaluators gave grades from 0 to 4 to each sub-factor, which underwent fuzzification, that is, the transformation of those grades into normal triangular fuzzy numbers according to *Table 1*. Its pertinence functions graph is presented in *Figure 1* below.

A normal triangular fuzzy number can be represented by $\tilde{N}(a, m, b)$, where the values "a" and "b" identify, respectively, the inferior and superior limits of the triangle base, where $\mu_{\tilde{A}}(x) = 0$. The value of "m" corresponds to the triangle height, where $\mu_{\tilde{A}}(x) = 1$ [14].

The set of items to be appraised, that is, the quality attributes found in this paper, were based mainly upon [1, 5, 6, 7, 8, 9, 10, 11, 12, 13].

Table 1: Normal triangular fuzzy numbers for the e-commerce website quality evaluation [2]

Scale	Fuzzy Number	Linguistic Term	Interpretation
0	$\tilde{N}$ = (0.0; 0.0; 1.0)	Not Important	Quality attribute doesn't have importance
1	$\tilde{N}$ = (0.0; 1.0; 2.0)	Little Importance	Quality attribute has little importance
2	$\tilde{N}$ = (1.0; 2.0; 3.0)	Desirable	Quality attribute is desirable
3	$\tilde{N}$ = (2.0; 3.0; 4.0)	Very Important	Quality attribute is very important
4	$\tilde{N}$ = (3.0; 4.0; 4.0)	Indispensable	Quality attribute is indispensable

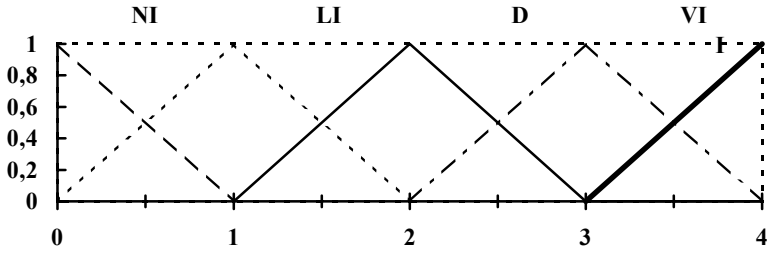

Figure 1: Pertinence functions of fuzzy numbers, for linguistic terms [2]

- **Second Stage***: obtaining specialists' and users' profiles*.

The specialists' and users' profiles were obtained through the completion of the, *Specialist Identification Questionnaire* and the *User Identification Questionnaire* respectively, generating a weighting measured by each evaluator, which will influence in the final result.

- **Third Stage**: *determining items identified in the first stage (degree of importance)*.

Field research provided opinions from thirty specialists and thirty users in four important Brazilian States, according to the questionnaire defined in the first stage. The evaluators were guided in the sense that they had to evaluate each of the quality sub-factors surveyed, according to its importance for the e-commerce website application domain.

- **Fourth Stage**: *fuzzy treatment of specialists' collected data, in the evaluation of each collected item*.

In that stage, the fuzzy treatment of data collected was performed in the evaluation of the developers, users, and consolidated (developers plus users), using similar matrix, considering each specialist's and each user's weighting, obtained in the second Stage, as determined by the model.

- **Fifth Stage**: *fuzzy aggregation of software quality attributes, in each quality model hierarchical level.*

In this stage, the results obtained by the sub-factors were put together to calculate the factor results, according to the model. The results obtained by the factors were joined to calculate the objective results. The results obtained reveal the quality standard for e-commerce websites.

3. EVALUATION OF RESULTS

Table 2 displays the complete set of those quality attributes. The sub-factors are organized, inside of the factors, in decreasing order of importance, according to the consolidated evaluation (developers and users), that is, the joint result of the specialists' evaluation and e-commerce site users.

Table 2: Quality Attributes of e-commerce websites

QUALITY SUB-FACTORS	Consolidated ($\tilde{N}$)	QUALITY SUB-FACTORS	Consolidated ($\tilde{N}$)
1. USABILITY	**(2.00, 2.98, 3.75)**	1.2.6 Interactivity	(2.23, 3.21, 3.88)
1.1 Efficiency	**(2.18, 3.18, 3.85)**	1.2.7 Learnability	(2.13, 3.06, 3.85)
1.1.1 Time behavior	(2.62, 3.62, 3.98)	1.2.8 Information localizability	(1.94, 2.94, 3.74)
1.1.2 Purchase process performance	(2.45, 3.45, 3.98)	1.2.9 Response time uniformity	(1.91, 2.91, 3.75)
1.1.3 Page generation speed	(2.19, 3.19, 3.96)	1.2.10 Communication facilities	(1.90, 2.90, 3.77)
1.1.4 Resource behavior	(1.99, 2.99, 3.77)	1.2.11 Forms of payment availability	(1.82, 2.82, 3.58)
1.1.5 Graphics generation speed	(1.66, 2.66, 3.57)	1.2.12 Storage of purchase list	(1.47, 2.47, 3.43)
1.2 User friendliness	**(1.86, 2.85, 3.61)**	1.2.13 Help availability	(1.40, 2.40, 3.43)
1.2.1 Understandability	(2.67, 3.67, 3.97)	1.2.14 Products comparison	(1.35, 2.35, 3.31)
1.2.2 Undo facilities	(2.63, 3.63, 3.96)	1.2.15 Multilingual communication	(1.32, 2.32, 3.28)
1.2.3 Business rules availability	(2.63, 3.60, 3.93)	1.2.16 "Shopping cart" metaphor	(1.30, 2.30, 3.20)
1.2.4 Products information availability	(2.52, 3.52, 3.92)	1.2.17 Printing facilities	(1.07, 2.07, 3.07)
1.2.5 Accessibility	(2.25, 3.25, 3.93)	1.2.18 Download facilities	(0.94, 1.94, 2.94)

1.3 Navigability	**(1.75, 2.75, 3.55)**
1.3.1 Absence of navigation errors	(2.66, 3.66, 3.97)
1.3.2 Browsers independence	(2.55, 3.55, 3.89)
1.3.3 Browsers version independence	(2.39, 3.39, 3.85)
1.3.4 Products taxonomy suitability	(2.20, 3.20, 3.92)
1.3.5 Security information availability	(2.14, 3.14, 3.73)
1.3.6 Hardware independence	(2.13, 3.13, 3.71)
1.3.7 Minimal path	(2.02, 3.02, 3.85)
1.3.8 Drawback	(1.99, 2.99, 3.80)
1.3.9 Navigation structure taxonomy	(1.96, 2.96, 3.81)
1.3.10 Links visibility	(1.83, 2.83, 3.70)
1.3.11 Links visualization consistence	(1.79, 2.79, 3.65)
1.3.12 Shortcuts availability	(1.64, 2.64, 3.57)
1.3.13 Alternative paths	(1.58, 2.60, 3.55)
1.3.14 Access device adaptability	(1.57, 2.55, 3.41)
1.3.15 Contextualization	(1.42, 2.42, 3.35)
1.3.16 Disabilities users interface	(1.28, 2.28, 3.25)
1.3.17 Navigational prediction	(1.22, 2.25, 3.22)
1.3.18 User class adaptability	(1.13, 2.13, 3.11)
1.3.19 User level adaptability	(1.12, 2.12, 3.08)
1.3.20 Interaction storage capacity	(1.06, 2.06, 3.06)
1.3.21 Mobile devices accessibility	(1.04, 2.04, 3.02)
1.4 Maintainability	**(2.00, 3.00, 3.82)**
1.4.1 Extensibility	(2.24, 3.24, 3.93)
1.4.2 Stability	(2.09, 3.09, 3.85)
1.4.3 Testability	(1.96, 2.96, 3.84)
1.4.4 Analyzability	(1.90, 2.90, 3.70)
1.4.5 Changeability	(1.83, 2.83, 3.78)
1.5 Technology suitability	**(2.14, 3.14, 3.88)**
1.5.1 Appropriateness environment	(2.36, 3.36, 3.96)
1.5.2 Tech infrastructure suitability	(1.92, 2.92, 3.80)
1.6 Reusability	**(2.07, 3.10, 3.81)**
1.6.1 Component based development	(2.10, 3.19, 3.79)
1.6.2 Modularity	(2.13, 3.13, 3.80)
1.6.3 Applicability	(1.97, 2.97, 3.85)
1.7 Implementation feasibility	**(2.12, 3.12, 3.76)**
1.7.1 Legal feasibility	(2.64, 3.64, 3.90)
1.7.2 Market feasibility	(2.21, 3.21, 3.89)
1.7.3 Economic feasibility	(2.18, 3.18, 3.80)
1.7.4 Human resources feasibility	(2.13, 3.13, 3.78)
1.7.5 Financial feasibility	(2.12, 3.12, 3.77)
1.7.6 Technology feasibility	(1.97, 2.93, 3.65)
1.7.7 Social feasibility	(1.63, 2.63, 3.51)
1.8 Profitability	**(2.07, 3.07, 3.89)**
1.8.1 Lucrative	(2.25, 3.25, 3.87)
1.8.2 Market harmony	(2.07, 3.07, 3.88)
1.8.3 Competitiveness	(2.06, 3.06, 3.99)
1.8.4 Marketing value	(2.05, 3.05, 3.93)
1.8.5 Trust	(1.90, 2.90, 3.77)
1.9 Involvement Capacity	**(1.83, 2.84, 3.63)**
1.9.1 Attractiveness	(2.35, 3.35, 3.97)
1.9.2 Aesthetic attributes	(2.20, 3.20, 3.95)
1.9.3 Client profile identification	(1.84, 2.84, 3.61)
1.9.4 Simulation	(1.57, 2.57, 3.46)
1.9.5 Additional services availability	(1.23, 2.23, 3.19)

2. CONCEPTUAL RELIABILITY	**(2.31, 3.31, 3.84)**
2.1 Functionality	**(2.14, 3.14, 3.79)**
2.1.1 Accuracy	(2.58, 3.58,3.98)
2.1.2 Client support	(2.56, 3.56, 3.96)
2.1.3 Information on product delivery	(2.44, 3.44, 3.92)
2.1.4 Suitability	(1.99, 2.99, 3.82)
2.1.5 Flexibility	(1.82, 2.82, 3.69)
2.1.6 Interoperability	(1.45, 2.45, 3.39)
2.2 Security	**(2.77, 3.78, 3.96)**
2.2.1 Payment systems security	(2.96, 3.96, 4.00)
2.2.2 Vulnerability	(2.96, 3.96, 4.00)
2.2.3 Site authentication	(2.92, 3.92, 3.99)
2.2.4 Access control	(2.87, 3.87, 3.98)
2.2.5 Confidentiality	(2.78, 3.78, 3.97)
2.2.6 Privacy	(2.77, 3.77, 3.97)
2.2.7 Clients authentication	(2.67, 3.67, 3.93)
2.2.8 Imputability	(2.26, 3.26, 3.83)
2.3 Reliability	**(2.18, 3.18, 3.87)**
2.3.1 Recoverability	(2.20, 3.20, 3.95)
2.3.2 Maturity	(2.19, 3.19, 3.83)
2.3.3 Fault tolerance	(2.16, 3.16, 3.85)
2.4 Integrity	**(2.36, 3.36, 3.82)**
2.4.1 Data Integrity	(2.92, 3.92, 3.98)
2.4.2 Data entry signalizing	(2.27, 3.27, 3.79)
2.4.3 Robustness	(2.23, 3.23, 3.82)
2.4.4 Audit trail	(2.02, 3.02, 3.67)
2.5 Trustworthiness	**(2.25, 3.25, 3.83)**
2.5.1 Correctness	(2.61, 3.61, 3.92)
2.5.2 Completeness	(2.39, 3.39, 3.88)
2.5.3 Necessity	(1.74, 2.74, 3.68)
2.6 Content adequacy	**(2.18, 3.15, 3.81)**
2.6.1 Updated content	(2.74, 3.74, 3.97)
2.6.2 Correctness	(2.61, 3.61, 3.98)
2.6.3 Intelligibility	(2.64, 3.39, 3.90)
2.6.4 User oriented	(2.03, 3.03, 3.81)
2.6.5 Respectability	(1.99, 2.99, 3.75)
2.6.6 Concise content	(1.97, 2.97, 3.78)
2.6.7 Completeness	(1.87, 2.87, 3.74)
2.6.8 Compatibility with real store	(1.63, 2.63, 3.54)
3. REPRESENTATION RELIABILITY	**(1.96, 2.96, 3.63)**
3.1 Readability	**(2.12, 3.12, 3.82)**
3.1.1 Language correctness	(2.75, 3.75, 3.94)
3.1.2 Style uniformity	(2.22, 3.22, 3.95)
3.1.3 Clarity	(2.17, 3.17, 3.96)
3.1.4 Conciseness	(2.01, 3.01, 3.73)
3.1.5 Terminology uniformity	(1.82, 2.82, 3.70)
3.1.6 Abstraction uniformity	(1.74, 2.74, 3.65)
3.2 Standards conformance	**(2.04, 3.04, 3.54)**
3.2.1 Interface standards	(2.29, 3.29,3.83)
3.2.2 Programming standards	(1.91, 2.91, 3.79)
3.2.3 Navigation standards	(1.91, 2.91, 3.76)
3.3 Easy of manipulation	**(1.73, 2.73, 3.53)**
3.3.1 Up-to-date	(1.89, 2.89, 3.57)
3.3.2 Ability to trace	(1.70, 2.70, 3.55)
3.3.3 Documentation availability	(1.67, 2.67, 3.46)
3.3.4 Structure	(1.65, 2.65, 3.52)

The Security factor was considered the most important. The result obtained indicates that, in e-commerce websites, security is fundamental, especially when it comes to electronic payments, which cannot be vulnerable to any kind of attack, and when it comes to the subject of site authentication itself. This factor obtained the defuzzification value of 3.78, that is 22% very important and 78% indispensable.

The Integrity factor was rated second in consolidated evaluation, reinforcing that an e-commerce website has to manage and control its stored data correctly and appropriately. The consolidated value obtained was 3.36, indicating 64% very important and 36% indispensable. The result shows that of the twenty consolidated quality sub-factors with the best ranking, seven are sub-factors related to Security, thus showing the importance of aspects such as authentication, access control, privacy, vulnerability, electronic payment security, and others.

4. CONCLUSION

All factors obtained a good final evaluation, however, the factors Security and Integrity obtained the best score of all in the consolidated evaluation. This result portrays the Web context, wherein electronic Commerce is inserted. Because these applications are public, accessed by a vast population of users and it is not hard to find cases of security systems defrauded by hackers who begin to gain access to unauthorized data.

Nowadays, there is a preference for e-commerce websites that have resources against unauthorized access and against interruption of processing, even in abnormal situations, and sites that guarantee data preservation, that is, where modifications may only be made by appropriate parties.

5. REFERENCES

1. Bashir, I. et al., 2001, Securing Network Software Applications, Communications of the ACM, vol. 44, no. 2, February, 29-30.
2. Belchior, A. D., 1997, A Fuzzy Model to Software Quality Evaluation, Thesis of Doctored, UFRJ/COPPE, Rio de Janeiro, May, in Portuguese.
3. Grover, V. et al., 2001, E-Commerce and the Information Market, Communications of the ACM, vol. 44, no. 4, April, 79-86.
4. ISO, 2001, ISO/IEC 9126-1, Software engineering – Product quality – Part 1: Quality model.
5. Ivory, M. Y. et al, 2001, Empirically Validated Web Page Design Metrics, SIGCHI, March 31-April 4, Seattle, WA, USA.
6. Jennings, M., 2000, Theory and Models for Creating Engaging and Immersive E-commerce Websites, SIGCPR, Illinois, USA.
7. Kubilus, N., 2000, Designing an E-Commerce Site for Users, Crossroads, Fall, 23-26.
8. Lima, R. S. et al, 2000, Evaluating Web sites for an educational environment target for cardiology, The 3rd European Software Measurement Conference – FESMA-AEMES, Madrid, September.
9. Lohse, L. G., Spiller, P., 1998, Electronic Shopping, Communications of the ACM, vol. 41, no. 7, July, 81- 88.
10. Nielsen, J., 2000, Designing Web Usability, News Riders.
11. Olsina, L. et al., 1999, Specifying Quality Characteristics for Web Sites, ICSE'99 Web Engineering Workshop, Los Angeles.
12. Summers, K. et al., 2001, Identifying Web Site Requirements, **http://www.intercom.com**.
13. Tilson, Roger et al, 2000, A Comparison of Two Current E-commerce Sites, ACM.
14. Zadeh, L. A., 1998, Fuzzy Logic, IEEE Transaction Compute. vol. 25.