

8-2010

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Recommended Citation

Islam, A.K.M. Najmul; Koivulahti-Ojala, Mervi; and Käkölä, Timo, "A lightweight, industrially-validated instrument to measure user satisfaction and service quality experienced by the users of a UML modeling tool" (2010). *AMCIS 2010 Proceedings*. 287.
<http://aisel.aisnet.org/amcis2010/287>

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A lightweight, industrially-validated instrument to measure user satisfaction and service quality experienced by the users of a UML modeling tool

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ABSTRACT

The research community has delivered many comprehensive instruments to measure user satisfaction and service quality. However, they may be tedious to deploy in industrial settings, often leading to low response rates. Industrial organizations are thus looking for simpler and more cost effective ways to measure both user satisfaction and service quality. This paper presents and validates a lightweight 8-item instrument to measure the user satisfaction and the quality of service experienced by the users of a Unified Modeling Language tool. The instrument merges ease of use and service-related items. The analysis of the results of two surveys, conducted in a global high-tech corporation, indicates that the instrument has adequate reliability and validity. It is short, easy to use, and appropriate for both practical and research purposes. Future research is needed to validate the instrument in the context of other organizations and other classes of information systems.

Keywords

Service Quality Measurement, User Satisfaction Measurement, UML tools.

INTRODUCTION

Modern business organizations have typically invested ample resources to improve their business processes and Information Technology (IT) infrastructures over the years. During the current economic downturn, most business organizations have continued to increase their IT investments (Kanaracus, 2008) but only in the areas of IT where most business value can be obtained. Organizations thus need to assess the returns of IT investments.

The extant research in information systems (IS) evaluation considers the user satisfaction and the service quality as the central constructs or surrogate measures of the business value of IT. It has produced comprehensive approaches and multi-dimensional instruments (DeLone and McLean, 2003; Petter *et al.*, 2008; Smithson and Hirschheim, 1998; Symons, 1991). However, the instruments are complex and tedious to use in industrial settings. The surveys collect data using so many time-consuming evaluation dimensions that the response rates may deteriorate (Jarrett, 2005; Urbach *et al.*, 2009). For example, the widely adopted instrument End User Computing Satisfaction (EUCS) (Doll and Torkzadeh, 1988) deploys 12 questions to measure user satisfaction. If the management also wants to measure service quality using, for example, the IS ZOT SERVQUAL (Kettinger and Lee, 2005), there are 54 additional questions to be answered.

The situation is worsened by the fact that the IT organizations typically offer large portfolios of applications and evaluate all or most of them regularly. For example, the outsourcing of applications and related services is common and the service qualities and applications of all providers must be surveyed frequently to ensure the fulfillment of service level agreements. Because each user is likely to use a substantial portion of the entire portfolio of applications, the same users need to fill numerous lengthy questionnaires to assess the systems and related services. For example, if each user deploys on average ten applications and the IT organization measures each application and related services biannually using EUCS and IS ZOT SERVQUAL, each user should answer $2 \cdot 10 \cdot (12 + 54) = 1320$ questions annually. In practice, most users are unlikely to answer all surveys, decreasing the reliability of the results. Finally, the analysis of vast amounts of multi-dimensional data is so cumbersome especially in large organizations that IT departments may find the task insurmountable.

Organizations would thus benefit from lightweight instruments to evaluate the systems and services. They also need to plan sampling and other mechanisms carefully to devise the overall structure for measurement. To address these concerns, this paper draws upon the experiences obtained in a global high-tech corporation that wanted to measure user satisfaction and service quality systematically and organization-wide. The corporation could not accomplish this objective effectively because it experienced all the challenges discussed above. This paper presents and applies a new lightweight instrument containing 8 questions to evaluate a Unified Modeling Language (UML) tool used in the corporation and the services supporting tool deployment. The instrument has been designed to be generally applicable for evaluating a variety of systems and services.

The paper proceeds as follows. Section “Evaluation of user satisfaction and service quality” reviews the research on the measurement of user satisfaction and service quality. Section “UML Modeling tools for UML modeling” introduces the basic concepts related to UML modeling and modeling tools. Section “Case organization” describes the case organization and the UML modeling tool used. Section “Research methodology” presents the research methodology and the proposed instrument. Section “Validation of the proposed instrument” presents the preliminary validation. Section “Conclusions and future research” concludes the paper.

EVALUATION OF USER SATISFACTION AND SERVICE QUALITY

User Satisfaction measurement

User satisfaction has received considerable research attention since the 1980s (Bailey and Pearson, 1983; Baroudi *et al.*, 1986; Benson, 1983; DeLone and McLean, 1992; DeLone and McLean, 2002; Ives *et al.*, 1983). It is an important measure of information systems success, often regarded as the easiest and the most useful way to evaluate the IS. Bailey and Pearson (1983, p. 531) define user satisfaction as the “sum of one’s positive and negative reactions to a set of factors.” Doll and Torkzadeh (1988, p. 261) describe it as “the affective attitude toward a specific computer application by someone who interacts with the application directly.” Eagly and Chaiken (1998, p. 296) regard user satisfaction as a “psychological tendency expressed by evaluating a particular entity with some degree of favor and disfavor”. Huang *et al.* (2004) conclude that user satisfaction is the most often used construct to measure the success of information systems.

Bailey and Pearson (1983) developed a 39-item instrument to measure user satisfaction of data processing personnel. Ives *et al.* (1983) developed a 39-item User Information Satisfaction (UIS) instrument and a separate 4-item UIS measure using a sample of 200 production managers. Due to some limitations, these instruments are not used as much as the 12-item EUCS instrument (Doll and Torkzadeh, 1988), comprising content, accuracy, format, ease of use, and timeliness factors. EUCS is very comprehensive and addresses most limitations of the previously developed instruments. After the exploratory study was completed in 1988, confirmatory studies with different samples concluded the instrument was valid (Doll *et al.*, 1994; Doll and Xia, 1997). A test-retest of the reliability of the instrument found the instrument was reliable over time (Torkzadeh and Doll, 1991). Harrison and Rainer (1996) showed that the instrument could be used generically to evaluate computer applications. The instrument has become widely adopted and it has served as the reference model for many user satisfaction measurement instruments. Lewis (1995) developed the 19-item Computer Usability Satisfaction Questionnaires to measure system usefulness, information quality, and interface quality. Other authors have developed user satisfaction models for specific areas (e.g. Bargas-Avila *et al.*, 2009; Huang *et al.*, 2004; Muylle *et al.*, 2004; Ong and Lai, 2007; Palvia, 1996; Wang and Liao, 2007).

Service quality measurement

Marketing researchers developed the 22-item SERVQUAL instrument to assess service quality through the following five dimensions (Parasuraman *et al.*, 1988):

- (1) Tangibles: Physical facilities, equipment, and appearance of personnel;
- (2) Reliability: The ability to perform the promised service dependably and accurately;
- (3) Responsiveness: The willingness to help customers and provide prompt service;
- (4) Assurance: The knowledge and courtesy of employees and their ability to inspire trust and confidence; and
- (5) Empathy: Providing caring and individualized attention to customers.

SERVQUAL has been adopted in a variety of domains such as healthcare, education, banking, financial services and IS (e.g., Jiang *et al.*, 2002; Pitt *et al.*, 1995). Nyeck *et al.* (2002, p. 102) stated the SERVQUAL instrument “remains the most complete attempt to conceptualize and measure service quality.” In the IS field the application of the instrument has garnered a great deal of debate recently (for a review of most debated issues, see (Landrum *et al.*, 2009)). The case organization did not find SERVQUAL attractive for two reasons. First, SERVQUAL includes only one training and documentation related

question: “Useful support materials (such as documentation, training, videos, etc.)”. Yet, the role of documentation is emphasized in the context of open source tools because nobody may be supporting these tools. Second, when the support is centralized, the users may not be able to meet the support personnel face-to-face in order to evaluate physical facilities, equipment, or personnel-related tangibles. Therefore, SERVQUAL may not be attractive when open source tools are used or the support organization is centralized.

UML MODELING TOOLS FOR UML MODELING

Unified Modeling Language™ has become an international standard for systems modeling (ISO, 2005). UML modeling tools offer graphical editors to enable architects, developers, and engineers to model requirements, architectures, data structures, dynamic behaviors, and other characteristics of systems. UML models can be used to support communication between people, document a system, generate test cases, predict the realized system’s quality, and automate code generation. UML tools may generate software from the UML models and UML models from the software (reverse engineering) and may have a built-in knowledge of UML rules to validate the correctness of the models automatically. Table 1 presents high-level features for the UML modeling tools (adapted from Koivulahti-Ojala and Käkölä, 2010).

The use of UML and UML modeling tools do not automatically lead to productivity improvements. Their potential may not be reached, if engineers need to struggle with the problems related to the poor availability or usability of modeling tools or the lack of user support and training. For example, Arisholm *et al.* (2006, p. 365) studied the impact of UML documentation on software maintenance and concluded that “for complex tasks and past a certain learning curve, the availability of UML documentation may result in significant improvements in the functional correctness of changes as well as the quality of their design. However, there does not seem to be any saving of time. For simpler tasks, the time needed to update the UML documentation may be substantial compared with the potential benefits, thus motivating the need for UML tools with better support for software maintenance.” Dzidek *et al.* (2008) found that using the UML could be beneficial when a developer must extend a nontrivial system with which he/she is unfamiliar and that better UML tools and more experience would likely yield even a larger return on investment. These results indicate that when the processes and capabilities are improved through, for example, better UML tools, training, and user support, returns on UML-related investments can be substantial. Measuring user satisfaction and service quality is crucial to focus the required improvement actions appropriately.

CASE ORGANIZATION

This research project was conducted in a global high-technology corporation, developing products in multiple sites with multiple partners. To support product development, a new UML modeling tool was being rolled out globally when the research project started. Most of its users were from the R&D organization. It was supported by a virtual team consisting of personnel from the global IT department and the department responsible for process and information systems development and support for R&D as well as subcontractors working for these departments. The middle management responsible for the tool rollout and support decided to conduct two surveys to evaluate how satisfied the users were with the tool and the quality of service. The tool was intended to gradually replace some existing tools. Numerous users thus adopted the tool between the two conducted surveys. The section “Research methodology” describes the process of study design. The name of the UML tool selected for rollout is not disclosed here. The main functionalities of the tool are presented in Table 1.

RESEARCH METHODOLOGY

Study design

Two surveys were conducted. Table 2 provides their sample details. The email invitations were sent to all the people who had registered as users by the date of each survey. One reminder was sent to the same users.

Instrumentation

The instrumentation of the survey was developed in co-operation with the virtual team responsible for tool support and deployment. The team had three main requirements for the instrumentation: 1) it should measure both the service quality and the user satisfaction with respect to the tool; 2) there should be no more than 10 questions, 3) the survey should be applicable to develop the service and the tool further together with the tool vendor. The first requirement limited the possibility to use a standard survey as to our knowledge there is no standard survey to cover both the service quality and the tool related satisfaction. The authors of this paper created a new instrument, which was accepted by the case organization. The list of questions in the instrument is given in Appendix. Identifiers (Q1-Q11) express the questions in short form. Q8, “Overall, how satisfied are you with <UML Modeling Tool> tool and service” was included for use as the criterion for data analysis because it covers both the service quality and the user satisfaction with respect to the tool. A five scale measure was used from ‘5 =

Very Satisfied' to '1 = Very Dissatisfied' for questions, Q1-Q8. In our data collection, we randomized the questions in the instrument, mostly eliminating the common method bias (Straub *et al.*, 2004).

Feature	Purpose of the feature is to help	Functionalities that the UML modeling tool in the case organization supports:
Modeling & Diagramming	Create, remove, and edit model elements and diagrams; view the models from different perspectives.	Yes. Create, remove and edit of the following UML diagrams: Use Case, Class, Object, Composite Structure, State Machine, Protocol State Machine, Activity, Sequence, Communication, Component, and Deployment Diagrams
Hierarchy Management	Create, update, and delete hierarchies in which model elements are assigned.	Yes. Possible to create a package hierarchy.
Collaboration and Version management	Multiple concurrent users to manage different versions of assets and to resolve conflicts; integrate the UML tool to version control and/or change management systems as necessary.	Yes. Integration to version control which enables multiple users to manage models concurrently.
Publishing	Compose and publish views of the selected models or model elements; provide data in different formats (e.g. JPG); create reports and documents based on the selected model (elements).	Yes. Possibilities such as report generation, publishing in the HTML format, and copying diagrams in different formats. Open Application Programming Interface for accessing models. XML Metadata Interchange and Eclipse Modeling Framework support model interchange.
Traceability	Create, remove, update, and trace relationships between models or model elements.	Yes. Possibility to create relationships between model elements and trace those relationships.
Simulation and Validation	Simulate dynamic behaviors of models or interface or integrate the tool to simulation tools; validate UML model correctness and completeness.	Limited. No simulation possibilities for dynamic behaviors. Validation of UML models is possible (Object Constraint Language or Java).
Model and Code Synchronization	Generate code based on models; create models based on code (reverse engineering); integrate UML tools to source code systems, Eclipse, or Model-driven architecture tools such as AndromDA.	Yes. Code generation/reverse engineering: (e.g., Java 5, EJB 2.0). Integration with Integrated Development Environments.
User Management	Manage access and connectivity to the organization's directory services (e.g., Active Directory).	No. However, integrated version control system may be connected to directory services.

Table 1. Main features of UML modeling tools (adapted from Koivulahti-Ojala and Käkölä, 2010)

Survey	Number of invitations	Number of responses (N)	Percentage of responses
Survey 1	267	42	15.73%
Survey 2	444	62	13.96%

Table 2. Sample data

Actions taken in the case organization

The virtual team supporting the UML Modeling tool analyzed the results of the surveys. As the validation results were not available during that time, the team made decisions based on the means of all questions and the total mean of all questions. Based on the 1st survey, communication and training practices had to be improved because the means of questions related to instructions, user guides, and training were lower than the mean of all questions.

Based on the 1st survey, information sharing with the users was improved in several ways and training sessions were organized. Information letters were emailed to the users, new guides were created, and the Intranet pages providing information about the tool and related support were improved. Tens of users were trained in on-line and face-to-face training sessions before the second survey was organized. Conference calls and virtual meeting tools were used, respectively, to share voice and presentations in on-line training sessions.

The answers to the feedback question Q11 were analyzed together with the tool vendor. In 1st and 2nd surveys, respectively, 20 and 18 users gave feedback. A requirements management process and tool were used to manage the UML tool related requirements sourced from the answers.

The results of the second survey revealed that the improvements related to information sharing and training had raised user satisfaction and that the availability and speed of the tool would be the next areas to improve. Fortunately, the software upgrades had already been planned to increase the reliability and usability of the version management features and to make the features faster to use. No separate action plan was thus necessary.

VALIDATION OF THE PROPOSED INSTRUMENT

This section presents the univariate and bivariate analyses for the two surveys. The PASW 18.0 software was used for data analysis.

Central tendency computation

All the questions in the study are either nominal or ordinal. The central tendency of nominal/ordinal variables can be best explained by the Median and Mode (Bryman and Cramer, 1999). Besides them, the mean, standard deviation, and range of all the questions are presented in Table 3.

Question	Mean	Median	Mode	Std	Range
Q1	3.79 ¹ , 3.52 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.782 ¹ , .880 ²	3 ¹ , 4 ²
Q2	4.00 ¹ , 4.03 ²	4 ¹ , 4 ²	5 ¹ , 4 ²	1.036 ¹ , .849 ²	3 ¹ , 3 ²
Q3	3.79 ¹ , 3.57 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.871 ¹ , .819 ²	3 ¹ , 4 ²
Q4	3.51 ¹ , 3.63 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.746 ¹ , .821 ²	3 ¹ , 3 ²
Q5	3.93 ¹ , 4.02 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.877 ¹ , .833 ²	4 ¹ , 4 ²
Q6	3.30 ¹ , 3.92 ²	3 ¹ , 4 ²	4 ¹ , 4 ²	.966 ¹ , 1.01 ²	4 ¹ , 4 ²
Q7	4.12 ¹ , 4.00 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.803 ¹ , .923 ²	3 ¹ , 4 ²
Q8	3.88 ¹ , 4.00 ²	4 ¹ , 4 ²	4 ¹ , 4 ²	.739 ¹ , .810 ²	3 ¹ , 3 ²

1: Survey 1, 2: Survey 2

Table 3. Central tendency computation

Linear Regression Method

In order to ensure statistical conclusion validity (Straub *et al.*, 2004), we perform regression analysis. The regression analysis assumes Q8 (criterion) is the dependent variable and the others (Q1-Q7) are independent variables. Table 4 provides the results of the regression analysis.

Question	R-Squared	Constant	B
Q1	.142 ¹ , .305 ²	2.533 ¹ , 2.208 ²	.356 ¹ , .508 ²
Q2	.366 ¹ , .128 ²	2.154 ¹ , 2.623 ²	.432 ¹ , .341 ²
Q3	.142 ¹ , .244 ²	2.671 ¹ , 2.253 ²	.320 ¹ , .489 ²
Q4	.268 ¹ , .242 ²	2.053 ¹ , 2.472 ²	.520 ¹ , .440 ²
Q5	.100 ¹ , .305 ²	2.904 ¹ , 2.113 ²	.248 ¹ , .486 ²
Q6	.012 ¹ , .260 ²	4.088 ¹ , 2.623 ²	-0.80 ¹ , .369 ²
Q7	.466 ¹ , .524 ²	1.292 ¹ , 1.462 ²	.628 ¹ , .635 ²

1: Survey 1, 2: Survey 2

Table 4. Regression analysis results

The following rule proposed by Bryman and Cramer (1999) is followed in identifying how well each question fits the data:

- <0.1: poor fit
- 0.11– 0.3: modest fit
- 0.31– 0.5: moderate fit
- > 0.5: strong fit

Table 4 shows there is at least the modest fit for all questions except Q6 in both surveys. The R squared values for Q6 in the 1st and 2nd surveys are, respectively, 0.012 (poor fit) and 0.260 (modest fit). It means that the overall satisfaction is not explained by Q6 in the 1st survey because people were not satisfied with the available training or training had low importance in measuring overall satisfaction. However, the 2nd survey suggests that training impacted the overall satisfaction. People were not satisfied with the training in the first survey and their overall satisfaction level was mainly caused by other areas (Q1-Q5 and Q7). The low satisfaction level of training revealed by the 1st survey is also visible from the mean of Q6 which is 3.30 while in the 2nd survey the mean is 3.92 (Table 3). The difference may be explained by the fact that both on-line and face-to-face training sessions were arranged between the surveys. The strongest fit is observed for Q7.

Item to Criterion correlation

In order to ensure the criteria-related validity (Boudreau *et al.*, 2001), the correlation of each item with the overall criterion is computed. Table 5 shows the correlation coefficients. Some prior studies (e.g., Doll and Torkzadeh, 1988) suggest having a cut-off point as 0.40 for this criteria-related validity check. Table 5 shows most of the correlation results are above the cut-off point. However, the coefficient for Q5 in the first survey is slightly below the cut-off point. On the other hand, the correlation coefficient of Q6 in the first survey is very low (also confirmed by the regression method). The explanation to this was given in the previous subsection.

Question	Correlation Coefficient
Q1	.426 ¹ , .488 ²
Q2	.621 ¹ , .406 ²
Q3	.422 ¹ , .474 ²
Q4	.532 ¹ , .491 ²
Q5	.390 ¹ , .544 ²
Q6	.042 ¹ , .447 ²
Q7	.719 ¹ , .669 ²

1: Survey 1, 2: Survey 2

Table 5. Item to Criterion correlation

Item to total correlation

To ensure higher model reliability, the correlation of each item's score with the total of all items' scores has been computed. A threshold of 0.45 is used for this validity check. Table 6 shows that the correlation values are well above the threshold except the result of Q6 in the 1st survey (see the explanation in 'Linear Regression Method' subsection).

Factor analysis

The factor analysis was performed only for the data from the second survey that had enough responses. The principle component analysis was used as the extraction technique and varimax was used as the method of rotation. Two formative factors (Petter *et al.*, 2007) were revealed with eigenvalues greater than 1.00, explaining about 61% of the total variance: System Use and System & Support Richness. The item loadings are given in Table 7. Some prior studies (Ong and Lai, 2007; Bargas-Avila *et al.*, 2009) suggested using 0.5 as the threshold value for the item loadings. All item loadings are above the threshold, except the Q2 loadings. Q2 represented both factors to some extent, demanding some more validation of the instrument using more data. The Cronbach's alphas for the factors were 0.65 and 0.792 respectively.

Question	Correlation Coefficient
Q1	.458 ¹ , .569 ²
Q2	.549 ¹ , .634 ²
Q3	.683 ¹ , .618 ²
Q4	.600 ¹ , .708 ²
Q5	.544 ¹ , .737 ²
Q6	.372 ¹ , .756 ²
Q7	.734 ¹ , .616 ²

1: Survey 1, 2: Survey 2

Table 6. Item to total correlation

Question/ Item	Factor 1 (System Use)	Factor 2 (System & Support Richness)
Q1	.699	
Q2	.421	.437
Q3	.888	
Q4		.559
Q5		.848
Q6		.808
Q7		.749

Table 7. Rotated Factor Matrix

Test-retest reliability

Based on the central tendency computation and the regression and correlation-based analyses, both surveys provide similar results and relationships, thus confirming the test-retest reliability check. However, there were some exceptions due to a limited number of responses in the first survey and lack of training and communications.

CONCLUSIONS AND FUTURE RESEARCH

The extant literature provides few, if any, methodologies and instruments that could be used effectively to measure user satisfaction with respect to applications and services in industrial contexts where the effective execution of business processes is dependent on the use of tens of application systems. New instruments are thus needed that enable IT organizations on a regular basis (i.e., even several times a year) to measure user satisfaction with respect to all the applications and related services that belong to the portfolios of the IT organizations.

This paper presents a lightweight 8-item instrument, merging ease of use and service-related items, to measure user satisfaction with respect to both an application and related services. Based on the use of the instrument in one organization to assess user satisfaction with respect to one application and the related services, the instrument appears to have adequate reliability and validity. It is easy to use and appropriate for both practical and research purposes. The case organization was able to plan and implement improvements by analyzing the means of all questions. We thus encourage practitioners to adapt and test the instrument in their own application and service contexts and academics to further validate and refine the instrument in different organizations and for a variety of classes of systems.

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APPENDIX

- Q1. How satisfied are you with the speed of <UML Modeling Tool>?
- Q2. How satisfied are you with the availability of <UML Modeling Tool>?
- Q3. How satisfied are you with the ease of use of <UML Modeling Tool>?
- Q4. How satisfied are you with the instructions and user guides available for <UML Modeling Tool>?
- Q5. When needed, I get support fast and in a professional way
- Q6. How satisfied are you with training available for <UML Modeling Tool>?
- Q7. How well does <UML Modeling Tool> tool meet your modeling needs?
- Q8. Overall, how satisfied are you with <UML Modeling Tool> tool and service?
- Q9. How often do you use <UML Modeling Tool> (Weekly, Daily, Monthly, Less than Monthly)?
- Q10. Your area is (EMEA, APAC, Americas)
- Q11. Please give feedback (E.g.Improvements, development ideas)