Requirements Engineering: A User Perspective of Process Quality

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REQUIREMENTS ENGINEERING: A USER PERSPECTIVE OF PROCESS QUALITY

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Abstract

To ensure software quality the factors that impact the quality of the information requirements determination process should be managed. An empirical study was performed to identify and elucidate factors that affect the quality of the information requirements determination process from information systems users that have participated in the IRD process. The results indicate that there exist a set of factors that users from different organizations and systems development experiences agree upon as being critical to the quality of the information requirements determination process.

Introduction

User participation and user involvement in the information systems development process have been suggested as a significant factor in project success (Choe, 1998; Doll and Torkzadeh, 1989; Doll and Torkzadeh, 1991; Ives and Olson, 1984; McKeen and Guimaraes, 1997). The systems development process has been viewed as a series of stages or phases, beginning with a request and feasibility study of a new system’s potential and concluding with the implementation of the system. The broad stages have been defined as definition, design, and implementation (Davis and Olson, 1984). While some research has focused on the definition stage (Chatzoglou and Macaulay, 1996; Doll and Torkzadeh, 1989; Doll and Torkzadeh, 1991), none have identified a comprehensive set of quality factors for information requirements determination (IRD). As the quality of the IRD stage would be expected to impact the quality of the systems development process in later stages (Newman and Noble, 1990) and the quality of the implemented system in terms of the completeness, correctness, and consistency (Yadav, 1985), it is reasonable to propose that efforts to improve the IRD should impact the entire development process and the final system. Recognizing the importance of the users’ input into the IRD, a study was performed to determine the factors that affect the quality of the information requirements determination (IRD) process from the users’ perspective.

Several researchers have investigated factors that influence the requirements determination process (Chatzoglou and Macaulay, 1996), yet none of these researchers have identified a comprehensive set of factors that affect the process quality of the IRD. The primary research question being addressed is stated as: What are the factors that affect the quality of the IRD process? In addition, a secondary objective of the study is to determine if there is any evidence of agreement among users regarding these factors. This research question is stated as: Is there agreement among users with regard to the factors that affect the quality of the IRD process? By addressing these questions several benefits may accrue. First, if factors exist that different user groups identify and there is evidence of agreement among these groups that these factors are important to the IRD process, then these would appear to be likely candidates for managers or researchers to emphasize (or de-emphasize depending on the nature of the factor) to improve the IRD process. Also, there may be factors that are not considered important by users, indicating areas that may allow more flexibility for managers, or perhaps savings in resources dedicated to these factors.

Research Method and Data Gathering

The method used to identify the factors affecting the quality of the IRD process is a nominal group technique (NGT)(Adam, et al., 1986; Delbecq, et al., 1982; Sutton, 1993; Van De Ven and Delbecq, 1974). An underlying assumption of the method is that individuals who perform a task can provide valuable insight into the important factors influencing their ability to achieve a high level of productivity when performing the task (Adam, et al., 1986). This method has been used successfully in several domains
including systems development (Adam, et al., 1986; Havelka, et al., 1998; Sutton, 1993). By using individuals that have had experience in a problem area, the critical factors influencing the problem can be identified. In this study, users that have participated in the IRD process are asked to identify the factors that affect the IRD process. The NGTs are applied to distinct groups of users from different organizations and backgrounds to provide representative and comprehensive results. The NGT was used to identify factors that users believe affect the quality of the IRD process for application level information systems.

This study focuses on users who have participated in the IRD process on a systems development project. According to Simon and Burstein (1985), the value of conclusions drawn from sampled data depends on two aspects: (1) the sampling frame, and (2) the representativeness of the sample within the sample frame. The sampling frame should include all people of interest and exclude people not relevant to the study. The sampling frame for this study includes users who: (1.) have had experience with the information requirements gathering process; (2.) have varied backgrounds, skill levels, etc.; (3.) come from varied industries and functional areas; (4.) have had experience with different information requirements gathering techniques; and (5.) have had experience with different types of information systems. The sampling frame excludes users that have not participated in the IRD process. The practical conditions given for this study restricted the selection of subjects to a nonrandom sample. The key to obtaining effective results when using a nonrandom sampling technique is to capture as varied a collection of individuals in the sample as possible (Simon and Burstein, 1985).

The first user group, User Group 1, was composed of seven information systems users from a manufacturing firm located in Rockdale, Texas. They came from various functional areas of the company including accounting, training and human resource development, quality control, and purchasing. User Group 2 was composed of six participants from different organizations in the Cincinnati, Ohio area. The types of firms represented included distribution, manufacturing, and a public utility. The participants came from various functional areas of their firms including finance, logistics, technical sales support, auditing, and human resources. User Group 3 consisted of six participants from a marketing research firm in the Cincinnati, Ohio area. The participants represented three functional areas; accounting, marketing research, and product development.

The results of these groups were then compared to determine if there were significant differences among these groups with regard to the factors generated. All the participants in the user groups met the conditions to be included in the sampling frame. The user group participants were individuals that use information systems as a routine part of their job and who have recently had a new system developed for their use. The groups included representatives from all levels of employees that use the system. The individuals in the user groups had varying degrees of interaction with IS specialists during information requirements gathering, but all had participated in the process in some manner. The sample of users represented seven different organizations and the participants embodied 13 distinct functional areas. Taking the practical conditions of the research environment into consideration the sample of focus group participants was determined to be adequate; however the nonrandom sampling approach used is a limitation to this work. A discussion of the data analysis and results are presented in the next section.

Data Analysis and Results

The primary objective of this study is to determine a comprehensive set of factors that affect the quality of the IRD process. User focus groups were used to generate these factors. The output of the focus groups can be used to address the research questions presented earlier. The data generated by each focus group consists of a set of factors identified as critical to the IRD process. These factors were then ranked according to importance. Reliance on this data is restricted by the validity of the NGT used. The validity of the NGT to generate valid data depends on two conditions. First, if a set of common factors exists that various users believe are critical to IRD process quality and the NGT process is valid, then there will be agreement among the different user groups with regard to these factors. Secondly, if common identifiable factors exist, then there should be agreement among the groups regarding the relative importance of these factors. In addition to testing the validity of the NGT used, these analyses will also help to address the secondary research question, i.e. is there some agreement among users about the factors that are critical to the quality of the IRD process.

Chi-Square Test for Independence between Groups

The first condition to determine the validity of the NGT is that there exists agreement between the groups. This condition is tested using the chi-square test for independence. The similarities and dissimilarities among the critical factors identified by the three groups of users reflect the perceptions of individuals from different organizations, with different specialties, and different levels of experience. To determine if the groups can be considered independent, chi-square tests for independence between each of the groups were conducted. The chi-square test for independence is based on a two-by-two contingency table. The four cells in the table consist of: (1) the number of factors generated that both groups selected as critical; (2) the number of factors generated that...
are selected as critical by the first group, but not the second; (3) the number of factors generated that are selected as critical by the second group, but not the first; and (4) the number of factors generated that are not selected as critical by either group. The chi-square test compares actual group responses to what would be expected if the two groups were, in fact, independent. A lack of independence between two groups indicates that the groups’ responses are related. These comparisons can be stated in the form of testable hypotheses that are presented below in null form:

\begin{align*}
  \text{H1a:} & \quad \text{The factors selected as critical by U1 and U2 are not related.} \\
  \text{H1b:} & \quad \text{The factors selected as critical by U1 and U3 are not related.} \\
  \text{H1c:} & \quad \text{The factors selected as critical by U2 and U3 are not related.}
\end{align*}

The higher the chi-square value calculated, the stronger the support for rejecting the hypotheses (Conover, 1980). The chi-square values calculated and the critical levels for rejecting the null hypotheses are given in Table 1. The results of the test lead to the rejection of all three hypotheses at a significance level of 0.001. These results suggest that the groups are not independent, lending support to the conclusion that agreement among the groups does exist. This is an indication that the users do agree about which factors are critical to the quality of the IRD process; despite their different organizations, experiences, and backgrounds.

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>CHI-SQUARE</th>
<th>P-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Group 1 v. User Group 2</td>
<td>12.932</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>User Group 1 v. User Group 3</td>
<td>19.629</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>User Group 2 v. User Group 3</td>
<td>25.954</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

**Spearman’s Rank Correlation Coefficient**

To test the second condition of validity for the NGT the agreement between groups of the rankings of the factors are analyzed. The rankings of the factors represent additional information about the factors identified by the users by incorporating the relative importance of each factor into the analysis. If there is agreement among the groups, they will tend to rank the same factors high or low relative to the rest of the factors. Spearman’s rho is a more powerful measure of the relationship between two samples than the chi-square test for independence. The comparisons to be performed can again be represented by testable hypotheses and are presented in null form as follows:

\begin{align*}
  \text{H2a:} & \quad \text{There is no agreement between the ranking of the factors by U1 and the ranking of the factors by U2.} \\
  \text{H2b:} & \quad \text{There is no agreement between the ranking of the factors by U1 and the ranking of the factors by U3.} \\
  \text{H2c:} & \quad \text{There is no agreement between the ranking of the factors by U2 and the ranking of the factors by U3.}
\end{align*}

The null hypotheses of no agreement in rankings is rejected for all three comparisons at less than a 0.001 critical level of significance, see Table 2. This is further evidence that the set of factors generated by the groups may be relevant to the IRD process in general, regardless of the organizational setting or project type, etc.

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>SPEARMAN’S RHO</th>
<th>P-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>User Group 1 v. User Group 2</td>
<td>0.4931</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>User Group 1 v. User Group 3</td>
<td>0.5701</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>User Group 2 v. User Group 3</td>
<td>0.6464</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Kendall's Coefficient of Concordance

To further test the second condition given to validate the nominal group process, i.e. that there is agreement among the focus groups as to the relative importance of the productivity factors, Kendall’s coefficient of concordance was calculated. This measure was used to test the agreement among all three group rankings of the factors. With a small number of rankings Kendall’s coefficient results in a more conservative test using a chi-square distribution (Conover, 1980). Consistent with the Spearman’s rank correlation statistic and the chi-square test for independence, the null hypothesis of no agreement among the rankings of the groups is rejected, at a critical significance level of 0.0291 ($W = 0.4427$, $X^2 = 94.2921$). Based on the results of Kendall’s coefficient of concordance there appears to be strong agreement in the rankings of the critical quality factors among the user groups.

Results

The results of the statistical tests performed provide strong support for the validity of the NGT used. The tests suggest that the set of factors selected as critical by all three of the user groups represent a set of common, relevant factors that affect the quality of the IRD process. Three separate groups of users completed the NGT to generate a set of factors believed to be critical to the quality of IRD process. The aggregate set of factors given by the three user groups addresses the primary research question: What are the factors that affect the quality of the IRD process? The three user groups generated a total of 33 critical quality factors and there appears to be substantial overlap among the groups. All three user groups selected 11 of the 33 factors, two of the three user groups selected another 7 of the 33 factors, and 15 of the 33 critical productivity factors were selected by only one of the user groups. A cursory analysis of the factors generated and selected as being critical to the quality of the IRD process indicates several factors that have received attention, e.g. data gathering techniques, as well as areas that have not received much attention. The factors selected as critical by all three of the focus groups are discussed in more detail in the next section. The comprehensive set of 33 factors is available from the author upon request.

Factors Selected As Critical By All User Groups

The factors selected by all three user groups should represent the most general factors identified, i.e. those that may be most relevant to the requirements gathering process in most organizations for most projects.

Management Commitment

Described as the level of importance that upper level management placed on the successful completion of the project, management commitment refers to the emotional or psychological obligation that upper management demonstrates toward the project. In all the groups, management commitment was selected as the most important factor when all the factors were considered. Not only did the groups feel that management commitment determined whether adequate financial, human, and technology resources would be available, they suggested that the presence of a champion for the project and a sense of urgency to succeed were critical to IRD success.

Budget

The budget for a project was defined by the groups as the financial resources available to complete the project. These resources may include personnel assigned, equipment and software required, and release time for users to sufficiently participate in the project. Despite strong support for some projects from management and users, the lack of adequate human resources due to the shortage of experienced IT professionals and high salaries had caused projects to be abandoned or postponed. The inclusion of the budget as a factor of information requirements gathering success comes as no surprise, many authors have addressed the project management triad of schedule, budget, and requirements (Frame, 1995).

Time Constraints

The time constraint factor was defined as the amount of time allowed for completion of the intermediate tasks and for final completion of the requirements gathering process. Similar to the budget factor, it is not surprising that all the user groups
recognized the importance of scheduling and time constraints on the quality of the information requirements gathering process. Participants indicated that time constraints were most difficult when the users were asked to participate in a project and continue their normal job functions.

**Communication Between Users And IT Professionals**

As would be expected all three of the user groups identified and selected communication with the users, by the IT professionals and the user representatives on the project team as a critical factor (Koh and Heng, 1996). This was defined as the quantity and quality of communication and the amount of group activities performed, including feedback from and to one another during the information requirements gathering process. The participants emphasized that the quality of the communication was much more important than the quantity and that the critical aspect of communication was to get the “true” information requirements documented. Several participants mentioned the experience of “talking at cross purposes” and focusing on minutiae rather than on substantive requirements during interviews and meetings with the IT members of the project team.

**Data Gathering Techniques**

Defined by the groups as the actual procedures used to determine and discover the specific information needs of the users. Several researchers have investigated the effect that various data gathering techniques have on information requirements quality (Chatzoglou and Macaulay, 1996; Darke and Shanks, 1997; Flynn and Jazi, 1998; Koh and Heng, 1996). The focus group participants indicated that they preferred techniques that allowed them to “get it over with” or that “doesn’t interfere with my work.” Consistent with the comments about the communication between users and IT professionals, the participants indicated that they preferred the least intrusive techniques possible that were able to get the requirements documented quickly.

**Team Composition**

Defined by the groups as the composition of the team, their levels of competence, qualifications, skills, and experience for the specific project. The participants indicated that the mix of personalities on the project team was as important as the competence of individual team members. However, they also emphasized the need to have adequate technical expertise from the IT personnel on the team and superior application domain knowledge from the user representatives on the team. As specified in the factor below, the participants also thought it important that the IT personnel have some application domain knowledge also.

**Feasibility Study**

Defined as the complete analysis of the economic, technological, and operational plausibility of the application as defined by the study, the study should indicate the general purpose and limitations of the project. The existence of a completed feasibility study was believed to be a critical factor primarily due to the “scoping” nature of the report, i.e. the requirements would be more easily identified and defined if the project has well defined boundaries and limits. In addition, the fact that a feasibility study has already addressed some of the risks involved, and hopefully lowered their impacts, for the project was believed to increase the project’s likelihood of success.

**IT Domain Knowledge**

Defined as how well the information systems personnel understand the purpose, the tasks, and the outputs of the work processes that the application is to support. The participants indicated that the involvement of IT personnel who had knowledge regarding the application domain for which requirements were being defined greatly increased the ability of the team to correctly and quickly specify the requirements. Specifically, it was mentioned that having IT personnel on the team that had prior experience in the domain area by developing previous applications or doing support work or, best of all, performing some of the users’ job functions would allow the IT personnel to understand terminology and have a deeper understanding of the users’ needs. These observations may have implications for training IT personnel, assigning members to project teams, and the types of data gathering techniques to use during requirements engineering.
User Commitment

Defined as the level of importance the user/clients being affected by the application place on the project’s successful completion, their level of emotional or psychological obligation. The groups indicated that for the requirements engineering process to be successful not only must users participate in the process, but that they must feel that the project is worthwhile and should benefit them. Some participants mentioned that on some projects the goals of the application were not made clear and that they were concerned that the application being developed might have a negative impact on their job. This factor may be similar to the “user involvement” construct developed by other researchers (Barki and Hartwick, 1994; Doll and Torkzadeh, 1989; Doll and Torkzadeh, 1991).

Goal Congruence

Goal Congruence was defined as agreement among IS Specialists, User/Clients, and Management groups on the purpose of the application being considered and the deliverables of the project. All three of the user groups identified goal congruence or agreement among the stakeholders as to the purpose of the project and application to be developed as critical to requirements engineering success. Several participants noted that this was most acute when the disagreement existed between two or more user groups. They suggested that having a project champion or one group having clear “ownership” of the project were solutions. Practically, they all agreed that the user group funding the project was most likely to exert ownership; however, this may mean loss of funding for the project from other areas that might be affected by an application. They also believed that goal congruence was much improved by the existence of a feasibility study with clear objectives laid out.

Systems Integration

Defined as the impact that the application under consideration will have on other systems within the organization. This includes considerations for any integration required with those systems. Related to the goal congruence factor just discussed, the groups indicated that every system and organizational unit that would be affected must either “buy-in” to the new application and be willing to participate in the requirements engineering or that the project must have management commitment at a high enough level to “encourage” the support of key stakeholders. In general, it was agreed that as the number of systems that needed to be integrated increased, the risk level for successful completion decreased.

Conclusion

The results of this study should benefit IS users, IT professionals, project managers, and IS researchers. First, the identification of the factors that affect the quality of the IRD process may give managers guidance in assessing the risk associated with specific development projects. By determining the value of these factors prior to the commitment of resources, managers may increase the likelihood of recognizing problematic projects or alternatively projects with potentially high returns, allowing them to take prescriptive action. Also, by identifying the concerns of users, it may be possible to control and manage the antecedents to the IRD process and thus improve the process quality. In addition, the factors identified may be used to develop metrics to be used to monitor the IRD process or measure its success or quality. Considering the emphasis on total quality management in the workplace today, obtaining and using a set of critical factors for analyzing the systems development process is valuable. For IS researchers, this study offered two primary contributions. The identification of the critical factors suggests that there are many variables that may affect the IRD process that have not received attention and an example of an approach used to generate potential metrics.

References


