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Software Quality Assurance
A Study Based on Pakistan's Software Industry

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ABSTRACT

This paper investigates the role of quality management practices in software industry of Pakistan. We present a comparison between the more-experienced and less-experienced firms with respect to the critical factors of quality management. The critical factors of quality management practices in the software industry are first identified from the literature survey and validated through an empirical study. The study attempts to probe the influence of "age of quality" and "use of software" over software quality management practices and programs. The results of the study shows that the 'age of quality" and "use of software" have partial influence over the software quality management.

Keywords:

Software quality, Capability Maturity Model (CMM), Software Quality Assurance (SQA), International Standard Organization (ISO) 9000 series

1. INTRODUCTION

Software development has been one of the fastest growing businesses over the last two decades. The global competition has become even more severe as the number of software development firms increased at a much faster pace. To survive in this intense competitive environment, software vendors need to differentiate their products in ways that are meaningful to their customers. Quality is a proven way to achieve this differentiation. Quality in software industry is derived from three important sources namely people, technology and management (Owe and Yaacob, 1996). Wikipedia add link defines quality assurance as "a planned and systematic

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pattern of all actions necessary to provide adequate confidence that the item or product conforms to established technical requirements". Software Quality Assurance (SQA) provides means for monitoring the software engineering processes and procedures used to ensure quality. Software firms pay less attention to quality assurance as it is frequently the first area that is cut back when deadlines are missed (Miller, 2007). Software firms develop quality programs which include reviews, inspections and audits detecting faults/defects at early stages of the software development process and therefore, prevent wastage of project resources and diversion from user requirements. Companies also use automated tools for software quality assurance that helps the quality assurance professionals to perform their activities (see eg., Sneed and Merey, 1985). The most commonly used quality assurance standards are ISO 9000 series, Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMMI). ISO 9001 is well established quality framework, currently being used by organizations in almost 170 countries worldwide (Yoo et. al., 2004).

Coleman (2005) discussed The Chaos Report of 1994 published by the Standish Group International Inc. The report found that 31% of software projects ended in cancellation and more than 76% of remaining projects experience significant delays or significant cost overages or significantly reduced functionality or some combination of the three. There is a lack of published studies on software development in South Asia, which is fast becoming an IT outsourcing hub (Sison et. al., 2006).

In this paper, a study of software industry is carried out to find out the SQA trends and to investigate the influence of "age of quality" and "use of software" over SQA with respect to the critical factors of quality. In section 3, literature review is given. Research Methodology is explained in section 4. In section 5 and section 6, results and discussion are given respectively. Finally, conclusion is given in section 7.

This paper aims to address three primary questions,

1. Are software companies in Pakistan aware of the quality management requirements?
2. Are more-experienced and less-experienced companies equally conscious of quality when it comes to software development?

3. Do software companies believe in the fact that investment in SQA will improve the quality of their product and performance?

2. LITERATURE SURVEY

A number of studies have been carried out in different countries including India, Malaysia, Philippines and Singapore to find out SQA trends. There are very few research studies carried out in Pakistan to find the SQA investment trends. Following literature has been reviewed:

Sneed and Merey (1985) studied a family of tools which not only supports software development but also assures the quality of each software product from the requirement definition to integrated system. Further Owe and Yaacob (1996) extended the previous study and conducted a survey in Malaysian software industry to encompass the trends of SQA investments, quality assurance problems encountered, the tools being used in SQA and their weaknesses and people involved in SQA activities.

Ahire (1996) investigated the effect of Total Quality Management (TQM), Age on Quality in case of a manufacturing industry and concluded that manufacturing firms can observe the effects of their TQM implementation efforts within few years.
Issac. et. al. (2004) used Comparative Fit Index (CFI), Bentler-Bonett Normated Fit Index (BFI) and ANOVA to find relationship between age of quality and operational performance in Software Industry in India.

Yoo et. al. (2004) presented an integrated model of ISO 9001:2000 and CMMI to resolve the problems that exist in these models. Further Miller (2007) studied the empirical results of CMMI and Team Software Process (TSP) and assessed these software improvement approaches on the basis of Cost, Schedule, Productivity, Quality, Satisfaction and Return on Investment.

Coleman (2005) used grounded theory to investigate what processes software companies are using and examined why these companies are rejecting best practices. Further Sison et. al. (2006) extended the previous study and conducted a survey to study the software practices in five

ASEAN countries (Malaysia, Philippines, Singapore, Thailand and Vietnam) and provided direction for further research in these countries.

3. RESEARCH METHODOLOGY

Personal interviews and mailed questionnaires are the two main methods of survey. Critical factors of quality management identified from a thorough survey of literature are percentage investment of research and development (R&D) on SQA, number of employees working in quality control department, use of automated testing tools, training given to quality control engineers and ownership of quality certification (Owe and Yaacob, 1996). Ahire (1996) reported that in order to implement a quality management system, on the average, a software firm requires a three-year period of time. Therefore, a three-year time period has been adopted in this research to distinguish between the "more-experienced" firms and "less-experienced" firm. Owe and Yacoob (1996) found a significant difference between the firm that develop software for internal use and firms that develop software for commercial use and reported that "use of software" has an influence over SQA investment decisions.

The survey questionnaire is based on the critical factors of quality management identified from the reviewed literature. Sample of this survey is based on non-probability convenience sampling due to the fact that most of the companies were reluctant to share their investment data.A random sample of 100 software firms in Karachi were selected and questionnaires were sent to each firm. A response rate of 70% was noted. The questionnaires were filled by Quality Control Engineers/Managers and Project Managers. The questionnaire was comprised of 25 different questions based on the factors of quality management identified from the reviewed literature as given in Appendix A.

Following hypotheses were developed to test the relationships:

Research Question 1:

It has been observed that experienced firms are more aware of adapting quality practices in software industry. As this assumption plays an important role in this global scenario we have developed the following hypothesis. To investigate whether there is a significant difference

between “more experienced” firms and “less experienced” firms with respect to the critical factors of quality.

As the time progresses, there is a continuous improvement in company’s operations and quality. Age of quality means number of years since SQA department was founded and SQA practices have been following by the companies (Issac et. al, 2004). This hypothesis will simply test whether the companies in Pakistan are improving their quality with the passage of time or not.

H_{01}: There is no significant difference between “more-experienced” firms and “less-experienced” firms with respect to the critical factors of quality. (Ref. Q4, Q9, Q13, Q15, Q16 and Q20)
H_{11}: There is significant difference between “more-experienced” firms and “less-experienced” firms with respect to the critical factors of quality.

Research Question 2:

Companies develop software for different purpose. Some companies develop software to support their internal operations; others develop software commercially and sell. Some companies develop software internally as well as commercially (Owe and Yaacob, 1996). It is a perception that companies which develop software commercially invest more on software quality assurance than the companies that develop software for internal use. The reason is that commercial users pay for the software and hence they are more quality conscious than the internal users. So, companies that develop software commercially pay more attention to quality assurance.

To investigate whether there is a significant difference between the firms that develop software for internal and external purpose with respect to the critical factors of quality, following hypothesis is developed

H_{02}: There is no significant difference between firms that develop software for internal and firms that develop software for external purpose with respect to the critical factors of quality. (Ref. Q4, Q7 and Q8)

H_{12}: There is a significant difference between firms that develop software for internal and firms that develop software for external purpose with respect to the critical factors of quality

4. RESULTS

Prior to formal analysis, questionnaires were carefully checked for completeness, accuracy and conformity. Later, data errors and ambiguities were removed. A confirmatory factor analysis was performed to test the validity and reliability of the instrument as shown in Table1. The value of CFI greater than or equal to 0.9 indicates that there is a strong evidence of uni-dimensionality in the data. Data coding was performed in an excel sheet and the coded data were imported into SPSS 17.0 and AMOS 5.0 for analysis.

Table 1: Baseline Comparisons

Model	NFI Delta 1	RFI Rho 1	IFI Delta 2	TLI Rho 2	CFI
Default Model	0.711	0.423	0.942	0.827	0.914

Out of 70 respondents, 45 are classified as "more-experienced" firms. Out of the "more-experienced" firms, 15 develop software for internal use and 30 for commercial use. Similarly, among 25 "less-experienced" firms, 7 develop software for internal use and 18 for commercial use.

In order to test null hypotheses (H_{01} and H_{02}), ANOVA test was used and results are given in Table 2 and 3 respectively.

Table 2: More experienced Vs. Less Experienced Firms: Difference with respect to the Critical Factors of Quality

Critical Factor	More Experienced		Less Experienced		F-value	Significance
	Mean	S.D	Mean	S.D		
% Investment on SQA	17.14	0.9520	9.0	0.1872	2.24	0.195
Quality Certification	4.24	4.0	3.2	2.25	2.82	0.235
Strength of SQA staff	10.15	4.598	9.71	7.521	0.027	0.872
SQA Training	1.33	0.577	4.5	3.54	12.0	0.179
QA Automated Tools	2.0	1.41	4.5	2.12	0.24	0.676

Table 3: Internal use vs. External use: Differences with respect to the Critical Factors of Quality

Critical Factor	Internal use		Commercial use		F-value	Significance
	Mean	S.D	Mean	S.D		
% Investment on SQA	10.40	3.050	4.56	3.504	4.839	0.264
Quality Certification	1.00	0.00	0.5	0.33	8.058	0.002
Strength of SQA staff	10.40	2.881	8	5.612	1.367	0.276
SQA Training	0.447	0.22	0.49	0.31	2.778	0.084
QA Automated Tools	0.60	0.548	0.56	0.527	0.306	0.739

Table 2 shows the comparison between the more-experienced firms and the less-experienced firms with respect to the critical factors of quality. ANOVA does not show any significant difference has been observed between the more-experienced firms and less- experienced firms with respect to Quality Certification (QC) and Automated Tools (AT), indicating that "age of quality" has no influence over these two critical factors of quality. There is no significant difference between the more-experienced firms and less-experienced firms with respect to Percentage Investment on SQA (PI), Strength of SQA Staff (SS) and SQA Training (ST). Analysis of the mean values shows that the more-experienced and less-experienced firms are same with respect to all the critical factors of quality i.e. PI, QC, SS, ST and AT.

Table 3 shows the difference between the firms that develop software for internal use and firms that develop software for commercial use with respect to the critical factors of quality. The results show no significant difference between the firms that develop software for internal use and firms that develop software for commercial use with respect to Investment on SQA(PI), Strength of SQA Staff (SS), SQA Training (ST) and Automated Tools (AT).

However, a significant difference can be observed between the firms that develop software for internal use and the firms that develop software for commercial use with respect Quality Certification (QC). The mean values shows that the firms that develop software for internal use are better than the firms that develop software for commercial use with respect to the quality certification (QC).

5. DISCUSSION

Refer to Table 2, Percentage Investment on SQA (PI) was found insignificant ($\alpha > 0.05$). According to the questionnaires filled by the practitioners, all companies invest between 5-10

percent of the total research and development (R&D) budget on SQA activities irrespective of the "age of quality". Similarly, the rational of the insignificance of Strength of SQA Staff (SS) is that, according to the survey, on the average 10-12 people are working in SQA department whether it's a "more-experienced" firm or "less-experienced" firm. SQA Training (ST) was also found insignificant because neither the "more-experienced" firms, nor the "less-experienced" firms in Pakistan software industry pay attention to the SQA training programs.

Refer to Table3; the same factors have been focused with respect to the internal and external use, only Quality Certification (QC) is found statistically significant.

6. CONCLUSION

The survey investigated the trends of software quality assurance in Pakistan software industry. The critical factors of quality have been identified through a thorough survey of literature. The firms that participated in the research have been classified into different groups based on the criteria namely "age of quality" and "use of software". The results of the analyses performed in this study indicate that "age of quality" in Pakistan software industry has a very limited influence over Software Quality Assurance. Only 2 out of 6 factors i.e. Quality Certification (QC) and Automated Tools (AT) were found significant between "more-experienced" firms and "less-experienced" firms indicating that there is not much difference present between "more-experienced" and "less-experienced" firms with respect to critical factors of quality. Similarly, use of software is playing a partial role in the improvement of quality management practices. Software firms in Pakistan need to make improvements in their quality management programs so that they can differentiate their products from others in terms of quality.

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