Quality Assurance Standards and Survey of IT Industries

Maria Khalid, Isma Yaqoob, Farhana Shahid, Rohma Nayab, Mehreen Sirshar

Fatima Jinnah Women University, The Mall Rawalpindi, Pakistan

Abstract: *Quality of the product depends on customer satisfaction which can be achieved by applying standards. Different standards have been reported in this literature that assist in improving Quality of products. The intent of each standard is to assure Quality in the processes and achieve a standard product. This research is the comprehensive survey of Standards followed by IT industries for assuring Quality in their products. After analysis of Standards, it has been explored that the techniques after adopting these Standards shows improvement in the systems. The IT businesses follow ISO (International Organization for Standardization),CMMI (Capability Maturity Model Integration), PMI (Project Management Institute), ASME (American Society Mechanical Engineers), ANSI (American National Standards Institute), IEC (Internationa Electr technical Commission), DRR(Digitally Reconstructed Radiography), ASQ (American Society of Quality) Quality Standards and some of them also use Quality evaluation tools for Quality Assurance. This research also assesses the improvements of IT businesses after applying Quality Standards.*

Keywords: *ANSI (American National Standards Institute), ASME (American Society Mechanical Engineers), ASQ (American Society of Quality) CMMI (Capability Maturity Model Integration), DRR (Digitally Reconstructed Radiography), follow ISO (International Organization for Standardization).*

I.   Introduction

Quality Assurance is an important phase of quality Management Processes. The market value of the product depends on its Quality which can be achieved by using Quality standard measures. Quality of the product also depends on customer satisfaction which can be attained through applying Quality Standards. Now days, achieving Quality is very important because of customer high demands. For Quality certification of IT industries and companies standards should be followed. By applying standards businesses can also gain value in international market. Quality standard implementation in each phase of product development process produce Quality product at the end. Meyer [1] defines software Quality according to an adapted number of Quality factors as defined by McCall [2], which are; correctness, robustness, extendibility, reusability,compatibility, efficiency, portability, integrity, verifiability, and ease of use etc. Different methods of software Quality Assurance have been used for different conformity assessment procedures in order to validate the software as an essential part of measuring system. By applying Quality Assurance standards, it helps to inspect product Quality, find causes of irregularities and determine improvement plans that can be conducted.

The newest version of the Quality standard created by the International Organization for Standardization (ISO) is ISO 9000:2000 which includes more engagement of top management and continuous improvement. Some broadly proposed standards, such as ISO/IEC (International Electro technical Commission) 9126 or ISO/IEC 25000 suggests a Quality Model for software products. Software Quality models acts as a support for estimation of features of an application that contribute to the software Quality. Quality of the products are key feature of management process related with confirming that system has low number of defects and reaches desired standards. Pfleeger [3] agrees with Garvin who views Quality from five different perspectives namely:

* The transcendental meaning that Quality can be recognized but not defined,
* User view meaning that Quality is fitness for purpose,
* Manufacturing meaning that Quality is conformance to specification,
* Product view meaning that Quality is tied to inherent product characteristics
* The value-based view meaning that
  Quality depends on the amount the customer is willing to pay for the product.

The rest of the paper is as follows: Section 2 discusses the Quality Assurance Standards in different IT industries and organizations. Detailed analysis of reported techniques discussed in Section 3. Section 4 concludes the research.

II.   Quality Assurance Standards In Different It (Information Technology) Industries

Quality Assurance is the most important aspect in any business. To achieve value in global market in IT industry, company must need to produce Quality product. After product s h i p p i n g , it is very costly and difficult to correct errors. To prevent these problems   Quality Assurance   Standards   should   be followed to maintain product Quality. This research is the comprehensive survey of Quality Assurance Standards in IT industries. The IT businesses follow different Quality Standards and some companies   also used Quality evaluation tools for Quality Assurance. A review of Quality Standards   in IT industries is described below.

2.1. Quality evaluation for Model- Driven Web Engineering methodologies (F.J. Domínguez-Mayo et al., 2012) [4]

Many   methodologies adopted for   web application development in MDWE (Model- Driven Web Engineering). It is very important to identify Quality in these approaches and improve it because these methodologies involve processes   and techniques for developing web applications. This research aims at developing Quality characteristics and sub characteristics for MDWE methodologies based on ISO/IEC (International Organization for Standardization/International   Electro technical Commission) standards. These Quality characteristics and sub characteristics improves efficiency and Quality in MDWE   methodologies which also evaluates weaknesses and strengths of approaches.

2.2. Evaluation of Quality Assurance Factors in Agile Methodologies (M.Sirshar, 2012) [5]

It is claimed by agile software development to improve the Quality of software products. Due to this claim it is used in new software industry and information technology but due to its immature nature fewer frameworks for assessment of   Quality exist. Research introduced new tool for assessment of Quality in agile software development but it is not verified for implementation in industries which is its limitation. The proposed tool provides different techniques which can be used for different software Quality features by particular methodology. The proposed tool opened new platform for variety of testing in agile methodologies and it has also opened new perspectives of research in software industry.

2.3. How to improve software Quality Assurance in developing countries (A.Javed et al., 2012) [6]

Quality is an important factor of software industry. Quality of the software depends on customer satisfaction which can be achieved by applying standards. This research identifies the problems which limits improvements in software Quality by higher authorities. The problems which are identified in this research are; "lack of specialists", "developer's attitude", "unrealistic deadlines", and "lack of conformanc to standards", " team formation and compromise on Quality "," internal politics". To solve these issues following solutions are presented in the research; "deploying CMMI model", "certified and specialized SQA team", "grip over domain knowledge", "no compromise on Quality" and   "correct developer's attitude".

2.4. Quality Standard and Specification for Soft-Scape Construction in Malaysia (J.A.Sani et al., 2012) [7]

Soft-Scape Construction Quality Standards and   specification   are   discussed.   Related documents for comparison are collected from government agencies and   selected private companies. Difference between product and process Quality is discussed. "Process Quality" is related to reliability of a procedures and skills of developer where as "Product Quality" deals with product in accordance with design and specification. This research paper basically focused that how similar standards are being applied differently on different organization and thus yield different results for different organizations.

2.5. Evaluating the reliability and impact of a Quality Assurance System for E-learning courseware (Y.T.Sung et al., 2011) [8]

Electronic learning (E-learning) is becoming popular every day. Quality Assurance in E- learning courses is becoming important due to long distances. In Taiwan E-learning courseware Quality Assurance methods adopted by eLQSC (e-Learning Quality Service Centre),   E-learning Quality certification   is evaluated and reliability of certification   process is checked. Using eLCQC (e-Learning Courseware Quality Checklist) evaluation tool sixty–seven E- learning courseware applications are evaluated. The evaluation tool eLCQC showed, item discrimination, item difficulty and adequate reliability. eLCQC is a high Quality tool for evaluation of B2B (Business-to-Business) applications and helps courseware producer's   to   improve

designing and implementing courseware.

2.6. Software Quality Assurance A Study Based on Pakistan's Software Industry (A.Iftikhar et al., 2011) [9]

Quality management practices play important role in software industries. The critical factors of Quality management in software industry are identified by literature review which is validated through experimental study. A comparison of more- experienced and less-experienced firm is done on the basis of critical factors of Qualit Management. The study demonstrates the investigation of the effect of "age of Quality" and "use of software" over software Quality management practices. The results of the study shows that "age of software" and "use of software" have limited effects over software Quality management. Software industries in Pakistan need to improve their software Quality management practices to compete with others in terms of product Quality.

2.7.A Fuzzy Group Analytical Hierarchy Process Approach for Software Quality Assurance Management: Fuzzy Logarithmic Least Squares Method (K.K.F.Yuen et al. 2011) [10]

Fuzzy Group Analytical Hierarchy Process Approach is for measuring the Quality of software. The international standard of software Quality attributes, International Organization for Standardization (ISO/IEC9126-1:2001) which comprises of six criteria with twenty seven sub criteria, is applied as the attributes of software Quality. Regarding the prioritization method, the modified fuzzy Logarithmic Least Squares Method (LLSM) is being applied to derive the importance of weight vectors. The Fuzzy Prioritization Programming for Direct Rating Scales (FPP-DRS) and the rescaling functions are proposed to design rating criteria in fuzzy number. These techniques will help developers, testers and purchasers, to measure the level of the software Quality and to improve process performance.

2.8. Implementation and Configuration Management Model for Quality Enhancement in Higher Education (M.N.Malik et al., 2010) [11]

Quality Education and strengthening education system is the basic need of under developed countries like Pakistan. By introducing the concept of logical inputs from young generation make education system strong. Young students when developing their projects has lack of information about related work done before and need direction for developing innovative projects. There is no platform provided for Higher Education to keep information about students work. This research present Configuration model for the problem, which suggest that when an application is send to Higher Education about a project, the control unit check it in data repository and inform the status of the work, related work done and related documentation managed about the project. Through implementation of configuration model Quality position of the project is increased and helps students to perform innovative work.

2.9. Customizing ISO 9126 Quality model for evaluation of B2B applications (B.Behkamal et al., 2009) [12]

A Software Quality Model contributes in evaluating Web applications. ISO 9126 model is used as basis for evaluating web applications and this model is customized with B2B (Business-to-Business) applications. Web applications are analyzed and Quality factors are extracted. Customization is done by extracting and ranking Quality factors from web applications and B2B applications. These Quality factors are added to ISO 9126 model and weighed from the viewpoints of end user and developer.

Evaluation Parameters	Meaning	Possible values
Reliability	Maintaining level of performance under different conditions for a stated period of time. Also defined as failure-free operation.	Yes, No
Integrity	Resist attacks to its security.	Yes, No
Reusability	Components of the software to be reused in other applications.	Yes, No
Maintainability	How easily system can be corrected and modified.	Yes, No
Ease of use	Friendly to use and learn.	Yes, No
Efficiency	Performance level using minimum resources.	Yes, No
Portability	Transferring from one place to another and run in different environment.	Yes, No
Functionality	Performing according to defined requirements and specifications.	Yes, No
Verification	Comparison with specified requirements	Yes, No
Validation	How easy to test	
Performance	Utilizing low resources, lower response time and mean time of failure and recovery.	Yes, No
Extendibility	Adapting new features.	Yes, No
Effectiveness	Completed task under stated conditions.	Yes, No

Table 1: Evaluation Criteria for Quality Assurance Standards

2.10. Integrating RFID with Quality Assurance system – Framework and applications (J.Lyu Jr. et al., 2009) [13]

Quality Assurance system is very important to handle abnormalities, inspect product quality and find improvement plans. Using RFID helps Quality Assurance system identifying and avoiding quality problems. RFID as a Quality Assurance system is very effective in improving product quality than other conventional QAS. A structure is designed for RFID (Radio Frequency Identification) based QAS (Quality Assurance System) which helps on site staff to control changes during production process and handle abnormalities and defects. RFID is proved to be very beneficial in controlling quality and achieving customer services standards.

2.11. An examination of ISO 9000:2000 and supply chain Quality Assurance (R.Sroufe et al., 2008) [14]

International Organization for Standardization (ISO) developed latest ISO 9000:2000 Quality standard. These standards estimate a firm's Quality products and services. ISO 9000:2000 ensure that firm should design, produce and deliver Quality products. ISO 9000:2000 can be viewed as Quality Management System (QMS) and paper driven process. ISO notice that if a firm can be put within Miles and Snow strategic topology. Miles and Snow structure differentiates between plants that only want ISO registration because of demands of customers and plants that improve certain aspects of Quality Assurance further than ISO registration. Effective supply chains consider ISO registration as a chance to increase Quality Assurance and Quality Standards integration of supply chain. Plants who integrate QMS (Quality Management System) gain important benefits. Different Quality Standards integration and supply chains Quality Assurance of firms with ISO 9000:2000 registrationis the basis of comparison between firms.

2.12. Quality Assurance of 3D- CRT: Indications and difficulties in their applications (L.Begnozzi et al., 2008) [15]

3D Conformal Radio Therapy (3D-CRT) is standard for handling many diseases although many new methods are introduced. For Quality Assurance of 3D-CRT treatments many points are raised. Clinical

signs standards such as Digitally Reconstructed Radiography (DRR), and possible clinical advantages and disadvantages of 3D-CRT skill are discussed. Medical physics support activities are also considered, including suggestions concerning Quality control protocols.

2.13. Quality Standards and Applicability to DOE (D.Faulkner,2008) [16]

Misconceptions about Quality Assurance and Quality Assurance Standards are discussed. Basic purpose is to understand the difference between Quality Assurance and Quality Control. Different standards are used for QA measurement such as American Society Mechanical Engineers (ASME), Nuclear Quality Assurance 1(NQA-1), American National Standards Institute (ANSI), International Organization for Standardization (ISO), American Society of Quality (ASQ) Q 9001:2000. Different Quality Standards are discussed to show that how some Quality Standards differ in their approach while others have strong similarities.

2.14. Quality Assurance and Control in the Construction of Infrastructure Services in Developing Countries – A Case Study of Pakistan (A.H. Khan et al., 2008) [17]

Project Success usually based on achieving satisfaction of the participants involved. Industries of Pakistan have been struggling with Quality issues for years. To decrease development costs QA concepts have to be applied on industrial work. In order to achieve QA, software processes are continuously monitored. Problems related to performance are solved by using National Drainage Consultants (NDC) and Project Monitoring Organization (PMO) standards. The Taunsa Barrage Project has been considered as an achievement in the construction of infrastructure growth projects in developing countries. This research paper is basically focused on the Quality Assurance and control using Quality concept, Quality management system (QMS) and Quality management system standards.

2.15. Quality Assurance Methods for Model-based Development: A Survey and Assessment (I.Fey et al., 2007) [18]

Quality of Automotive embedded software development processes isimprovedby Model-Based development. Software development process support tester and developer to use different QA techniques and tools to achieve Quality Standards. An Auto Code Review (ACR) is discussed which is used for software modeling. GQM table is used which consists information of automation abilities, estimated efficiency and supportive tools. To achieve model- Based development process relatively high efforts are needed. Basic purpose is how to use different tool and techniques to achieve efficiency.

2.16. Improving Software Quality – a benchmarking approach (A.Imam et al., 2007) [19]

Software Quality cannot be achieved by relying on conformance to standards of industries. It is also difficult for companies to continuously update standards. Many multinational companies have built their own standards which are military based, and when software development processes get matured they try to improve their standard to achieve maintainability. These internal and commercial standards are proved to improve the Quality of systems. This research paper provide guidance about 'Quality Manuals' and 'Templates', which will help in improving software Quality by using different standards like Cost Maturity Model Integrity CMMI (SW) and ISO 9000-3:1997.

2.17. Development and Quality Assurance of Computer-Based Assessment Batteries (R. E. Schlegel et al., 2007) [20]

Critical but informative discussion about QA assessment and standards is done between user and developer. During conversation many factors which are supposed to improve Quality and usability are lightened. In addition, detailed over view of the critical elements that constitute competent Quality assessment are discussed. Different standards such as Advisory Group for Aerospace Research and Development Standardized Tests for Research with Environmental Stressors (AGARD STRES) are followed. Overall focus is to improve Quality.

2.18. Software testing and preventive Quality Assurance for metrology (N.Greif, 2006) [21]

Different methods of software Quality Assurance have been used for different conformity assessment procedures in order to validate the software as an essential part of measuring system. Testing and certification of products, processes and producer's declaration are the major components of conformity assessment. Software Quality Assurance includes two categories which are important for metrology; one is the analytical testing of the software product and second is preventive action applied for software development processes for evaluation and improvement of software processes. Testable requirements are defined for software products and processes for estimating Quality of

metrological software. Problem of refining and defining testable requirements can be solved through international software standards. PTB (Physikalisch-Technische Bundesanstalt) testing center prop up Quality of metrological software.

2.19. A Review of Standardising SOFC Measurement and Quality Assurance at FZJ (V.A.C. Haanappel et al., 2006) [22]

Quality Assurance (QA)/ is considered as mentioning existing problems with data uniformity and reliability. In this research paper QA systems following the standards of the ISO 9000 series are discussed. Amount of standard cell test parameters are explained with examples. Testing parameters defined are generally leading to increase in performance. Maintainability of QA systems and standardization in testing are suggested to improve measurement processes.

2.20. ISO 9000 Quality Standards in Construction (A.A. Bubshait *et al.,* 2000) [23]

Complexity of system varies from test system to a registered International Organization for Standardization (ISO 9002) quality system. Convincing points for registration are that high level managements are usually interested in increasing quality of project quality and meeting demand of customers. ISO 9000 important points which are focused are (1) Inspection and test status (2) Inspection and testing (3) Control of nonconformance product (4) Handling, storage, and preservation. Misunderstandings during implementation of techniques are observed. By applying methods it is also checked that which contractors are not performing.

III. Analysis

For Quality Assurance different standards are being followed to assure Quality in their processes and to achieve a Quality product. F.J. Domínguez-Mayo et al. [4], K.K.F.Yuen et al. [10] follow ISO/IEC (International Organization for Standardization/International Electro technical Commission) standard. M.Sirshar [5] showed concern about integrity and tool support for Quality assessment but it is not concerned about reliability. Y.T.Sung et al. [8] also showed concern for tool support for evaluation but this technique also considers reliability along with integrity. B.Behkamal et al.[12],R.Sroufeet al.[14], V.A.C. Haanappel et al.[22], A.A. Bubshait et al. [23] follow ISO (International Organization for Standardization) series of standards. A.Javed et al. [6], A.Imam et al. [19] adopted CMMI (Capability Maturity Model Integration) for improving Quality of their systems. J.A.Sani et al. [7] follow reliability to improve their procedures Quality for Soft- Scape Construction. A.Iftikhar et al. [9] is focused towards maintainability to improve their software Quality management practices. M.N.Malik et al. [11] presented Configuration Model to improve Quality in Higher Education. J.Lyu Jr. et al. [13] used RFID (Radio Frequency Identification) for Quality Assurance. L.Begnozzi et al. [17] presented 3D Conformal Radio Therapy standard for improving quality in the process of various disease handling.

Table 2: Analysis of Quality Assurance Standards Parameters

S#	Techniques	Reliability	Integrity	Reusability	Maintainability	Ease of use	Efficiency
20	A.Javed et al., 2012	No	Yes	No	Yes	No	No
19	M.Sirshar, 2012	No	Yes	Yes	Yes	Yes	Design simplicity
18	F.J. Domínguez-Mayo et al., 2012	Yes	No	No	Yes	Yes	No
17	J.A.Sani et al., 2012	Yes	No	No	No	Yes	No
16	A.Iftikhar et al., 2011	No	No	No	Yes	No	No
15	Y.T.Sung et al., 2011	Yes	No	No	Yes	Yes	No
14	K.K.F.Yuen et al., 2011	No	Yes	No	No	No	Yes
13	M.N.Malik et al., 2010	No	No	No	No	No	Triwnphant work in the
12	J.Lyu Jr. et al., 2009	Yes	No	No	Yes	No	Standard operation
11	B.Behkamal et al., 2009	Yes	No	No	Yes	Yes	20%
10	R.Sroufe et al., 2008	Yes	Yes	Yes	Yes	Yes	Yes (percent not
9	L.BegNozzi et al., 2008	No	No	No	Yes	Yes	No
8	D.Faulkner, 2008	Yes	No	Yes	Yes	No	70%
7	A.H. Khan et al., 2008	No	No	No	No	No	No
6	I.Fey et al., 2007	No	No	No	No	No	30%
5	A.Imam et al., 2007	No	No	No	Yes	No	No
4	R. E. Schlegel et al.,2007	No	No	Yes[9]	No	Yes	No
3	N.Greif, 2006	Yes	Yes	No	Yes	Yes	No
2	V.A.C. Haanappel et al., 2006	Yes	Yes	No	Yes	No	No
1	A.A. Bubshait et al., 2000	No	Yes	No	Yes	No	No

S#	Techniques	Portability	Functionality	Verification	Validation	Performance	Extendibility	Effectiveness
20	A.Javed et al., 2012	No	No	No	No	No	No	No
19	M.Sirshar, 2012	Yes	Yes	No	Beta test, regression test and integration test follow	Yes	Yes	Yes
18	F.J. Dominguez-Mayo et al., 2012	Yes	Yes	No	No	Yes	Yes	No
17	J.A.Sani et al., 2012	Yes	No	No	No	No	Yes	No
16	A.Iftikhar et al., 2011	No	No	No	No	No	No	Yes
15	Y.T.Sung et al., 2011	No	No	Yes	Yes	No	Yes	No
14	K.K.F.Yuen et al., 2011	No	Yes	Yes	Yes	Yes	No	Yes
13	M.N.Malik et al., 2010	No	No	No	No	Yes	No	Yes
12	J.Lyu Jr. et al., 2009	Yes	Yes	No	No	No	No	Yes
11	B.Behkamal et al., 2009	Yes	Yes	No	No	No	Yes	No
10	R.Sroufe et al., 2008	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	L.BegNozzi et al., 2008	No	No	Yes	Yes	Yes	No	No
8	D.Faulkner, 2008	No	Yes	No	No	No	Yes	Yes
7	A.H. Khan et al., 2008	No	No	Yes	Yes	Yes	No	No
6	I.Fey et al., 2007	No	No	No	No	No	No	Yes
5	A.Imam et al., 2007	Yes	No	No	No	No	No	No
4	R. E. Schlegal et al., 2007	No	Yes	No	No	No	No	No
3	N.Greif, 2006	No	Yes	Yes	Yes	No	No	Yes
2	V.A.C. Haanappel et al., 2006	No	No	Yes	Yes	No	No	No
1	A.A. Bubshait et al., 2000	No	Yes	No	No	Yes	Yes	No

D.Faulkner, [16] discussed similarities and differences among American Society Mechanical Engineers (ASME), Nuclear Quality Assurance 1(NQA-1), American National Standards Institute (ANSI), International Organization for Standardization (ISO), American Society of Quality (ASQ) Q 9001:2000 standards. A.H. Khan et al. [15] follow National Drainage Consultants (NDC) and Project Monitoring Organization (PMO) standards. I.Fey et al. [20] focused on Model-Based development to improve automotive embedded software development processes. R. E. Schlegel et al. [18] follow Advisory Group for Aerospace Research and Development Standardized Tests for Research with Environmental Stressors (AGARD STRES) to improve Quality and usability. N.Greif [21] presented testable requirements for software products and processes for estimating Quality of metrological software.

IV. Conclusion

Quality Assurance Standards are very important to handle irregularities and inspect product Quality and find improvement plans. For customer satisfaction and for Quality certification of IT industries these Standards plays vital role. In this research, different Quality Assurance Standards are considered which are followed by different IT industries. These industries adopted these Quality Standards to assure Quality in their processes and to achieve a Quality product fulfilling all Standard characteristics. Most of the techniques use ISO 9000 series (International Organization for Standardization) for resolving their Quality issues. Other techniques use CMMI (Capability Maturity Model Integration), PMI (Project Management Institute), ASME (American Society Mechanical Engineers), ANSI (American National Standards Institute), ISO/IEC (International Electro technical Commission), DRR (Digitally Reconstructed Radiography), and ASQ (American Society of Quality). All IT industries that are more focused about achieving Quality follow the standards according their system requirements. Some of the techniques also use Quality evaluation tools for Quality Assurance like RFID (Radio-frequency identification) tool based QAS which helps on site staff to control changes during production process and handle abnormalities and defects, eLCQC (e-Learning Courseware Quality Checklist) tool used for E-learning courseware applications Quality evaluation. In this research, different Quality Standards are surveyed with respect to different IT industries adopting these standards and after implementing these standards into their systems IT industries shows improvement in their systems. Some IT industries found it difficult to follow Quality Standards for assuring Quality because they are restricted by financial problems. According to specific domain of IT industries and businesses they use standards which fulfill their Quality requirements. Some multinational companies also build their own standards which are services based initially. Now days, achieving Quality is very important because of customer high demands. Therefore, it is suggested that IT industries should follow Quality Assurance activities in order to fulfill Quality Standards for improving their product Quality because most of the industries not consider Quality an important factor which leads to their early decline and which is one of their major drawback. Industries that are standard certified make value in national and international market and fulfill their customer requirements.

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