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Software quality revisited

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Abstract

Definitions of software quality have focused on software product quality factors. Quality that focuses on product quality is referred to by Kaoru Ishikawa as a narrow view of quality and he suggests that a broader more embracing and inclusive view is really necessary. The requirements of successful E-Commerce Web sites demonstrate this view. While the site might be considered as the product, Web site producers, owners and visitors also have a "quality" requirement. This broader view gives rises to the need to research and understand quality-of-development, quality-of-ownership, quality-of-engagement as well as quality-of-product. From the quality-of-product perspective, while many of the well established and understood software quality factors of McCall and Boehm still apply in this new domain, they need to be reinterpreted and they are no longer a complete set. Additional quality factors are needed for the WWW. Already identified are quality factors like visibility, intelligibility, credibility, engagibility and differentiation. In this new situation it is also necessary to take a step beyond MIS practice in order to achieve Web site quality and in this regard the paper further considers, proprietor development, engagibility, Software Quality - Metric Ratio Analysis (SQ-MRA) and progressive maintenance. Finally, having revisited software quality definitions and interpretations, it is appropriate to review original thinking regarding software quality factors in order to determine if lessons learned from this revisit apply to the quality of traditional Information Systems.

1. Introduction

The study of software quality has focused on product quality [1] and [2]. However, quality that is limited to product quality is referred to by Kaoru Ishikawa (the founding father of the Japanese Quality movement) as a narrow view of quality and he suggests that a broader view of quality is necessary [3]. The requirements of successful E-Commerce Web sites demonstrate this view and have precipitated a need to cater for the requirements of Web site visitors and owner organizations [4] in addition to product quality. While the site might be considered as the product, Web site owners and visitors also have a "quality" requirement. These E-Commerce sites have a sales focus and their quality is being driven by the sales and marketing professionals whose principal object is to attract and retain customers. The visitors' perspectives are described by [4] in terms of Total Customer Experience (TCE) which addresses the issues involved in attracting and retaining E-commerce customers. A full understanding of the issues involved is also important when determining work effort and cost of Web site development and for complying with the legal requirements of Web sites. The purpose of this paper is to present some of the findings of continuing research which is motivated by the broader view philosophy and seeks to extend that philosophy by going a step beyond it in the context of E-Commerce. The paper also introduces measurement considerations being addressed by the research. The paper will be of interest to academics and professionals who are researching, studying or practicing in areas where quality is a driver of software measurement. Section 2 revisits software quality definitions to reflect E-Commerce requirements. Section 3 addresses software quality drivers and Section 4 outlines quality challenges in E-Commerce. In the context of going a step beyond traditional MIS ownership and use, Section 5 outlines quality considerations that need to be addressed by software quality professionals in order to achieve quality Web sites.

2. Software quality definitions revisited

In a series of definitions relating to quality control, Kaoru Ishikawa [3] refers to products, which can "*satisfy the requirements of consumers*". This, he explains, should be "*Narrowly interpreted to mean quality of products*". He continues "*that broadly interpreted, quality means quality of work, quality of service, quality of information, quality of process, quality of division, quality of people including workers, engineers, managers and executives, quality of system, quality of company, quality of objects etc. To control quality in its every manifestation is our basic approach*". This paper embraces this broader interpretation of quality and adds that in the context of E-Commerce Web sites it is appropriate to add that in addition to quality-of-product and quality-of-production as implied by Ishikawa, quality also means quality-of-ownership and quality of visitor experience, i.e. quality-of-use. While the broader view is the correct view and is a foundation of this research it is inappropriate to use the term quality to describe quality, that is, it is incorrect to say "*that broadly interpreted quality means quality of work…*" and so on. What should we understand by *quality of work*? An opportunity to define quality is missed so, this paper defines quality as a measure of excellence and suggests that measures of excellence apply to all of the perspectives. To control this quality it is necessary to be able to quantify the attributes of excellence of these perspectives and to understand metrics which are appropriate to measuring them.

3. Software quality drivers

In keeping with the broader view philosophy and in relation to software quality, it is appropriate to review strategic considerations that influence software stakeholders in order to determine a broader understanding of what actually contributes to their perspective of software quality. This research has focused on identifying strategic issues that drive quality from the procurer's (owner's) and the software producer's perspectives. The *Software Quality – Strategic Driver Model* (*SQ-SDM*) explains both of these perspectives and both are fully described by [5]. They are illustrated in Figure 1 and definitions for all drivers are set out in Figure 2.

Software Quality – Strategic Driver Model
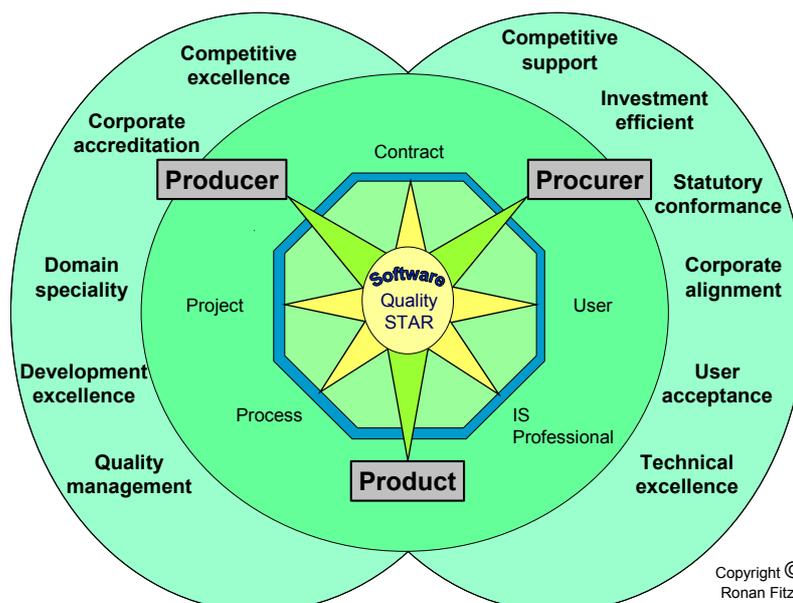
Figure 1: The Software Quality – Strategic Driver Model (SQ-SDM)

Producer's perspective ISO 12207 - Supplier	Procurer's perspective ISO 12207 - Acquirer
• **Competitive excellence** (Domination) The strategic quality driver for selecting a suitable contractor. • **Corporate accreditation** (Certification) The strategic quality driver of contractor maturity. • **Domain speciality** (Qualification) The strategic quality driver for excellent business process understanding. • **Development excellence** (Organisation) The strategic quality driver for excellence during the project life cycle. • **Quality management** (Direction) The strategic quality driver for excellence in assuring software quality.	• **Competitive support** (Superiority) The strategic quality driver for competitive support. • **Investment efficient** (Affordability) The strategic quality driver for excellence in IT Investment. • **Statutory conformance** (Conformability) The strategic quality driver for excellence with legal compliance. • **Corporate alignment** (Alignability) The strategic quality driver for IT excellence in business practice. • **User acceptance** (Acceptability) The strategic quality driver for excellence at the user interface. • **Technical excellence** (Supportability) The strategic quality driver for excellence in software product support.

Figure 2: Producer and procurer strategic drivers of software quality

The growth and demands of E-Commerce are resulting in requests from software acquirers for Web sites that will provide them with competitive support. While explained in the context of traditional IT systems these drivers can be easily interpreted for Web site owners. Additionally, aspects of them (e.g., Technical excellence and User acceptance) are easily interpreted for Web site visitors such that both parties in a B2C contract are considered.

4. Quality Challenges in E-Commerce Web sites

This section considers three significant challenges associated with quality in the domain of the World Wide Web. The first challenge concerns itself with interpreting the strategic driver perspectives in relation to quality Web sites. The second challenge is concerned with the sufficiency of product quality factors when interpreted for the WWW and the third challenge considers the impact of these first two challenges on the measurement metrics and methods that are uses in connection with quality Web sites.

4.1. Strategic driver perspectives

The Software Quality – Strategic Driver Model (*SQ-SDM*) sets out drivers associated with development and ownership, that is, quality-of-development and quality-of-ownership. In the case of quality Web sites, quality-of-development and quality-of-ownership do not address all of the issues and there are significant considerations regarding the quality of the site visitor's experience. Product quality (Kaoru Ishikawa's narrow view of quality) also has to be revisited.

4.1.1. Quality-of-Development

Quality-of-development considers all of the drivers set out in the producer's perspective in Figure 2. In particular, it is important that developers' own website display a quality perspective in terms of all of the aspects of quality discussed here. Indeed, how is a developer going to install confidence in their development capabilities unless they do so? Furthermore, consideration must be given to design and development methodologies for websites and the extent to which developers use and adhere to these.

4.1.2. Quality-of-Ownership

Quality-of-ownership considers all of the drivers set out in the procurer's perspective in Figure 2. The research is now principally focusing on the **User acceptance** driver and in particular its extended meaning in the context of E-Commerce. The research shows that there is a connection between the owner's need to create consumer-centric Web sites and the Visitor's need for an engaging experience [5]. In addition, opportunities and challenges relating to proprietor development exist and these are considered later is Section 5.1. **Technical excellence** (the strategic quality driver for excellence in software product support) also takes on new meaning especially in relation to the on-going maintenance which is essential for a quality Web site. This is also considered further in Section 5.4.

4.1.3. Quality-of-Engagement

Quality-of-engagement is visitor focused and is concerned with the quality of the visit or the quality of the experience and is similar to quality-of-use of traditional MIS applications [5]. However, in the context of the WWW the use has a much more engaging dimension from the visitor's perspective while at the same time is a significant on-going consideration for the Web site owner. The product is no longer an artefact sold by a seller and purchased by a customer. The product is now a core sales and marketing tool of the seller and is designed to attract and retain customers. Quality-of-engagement considers all of the external quality factors as illustrated in Figure 3 while at the same time remaining conscious of the competitive advantage requirements of quality-of-ownership.

4.1.4. Quality-of-Product

In this case the product is a Web site and this research has interpreted acknowledged software quality factors and identified additional factors for the WWW. These additional quality factors are addressed in Section 4.2 which follows.

4.2. Web site quality factors

The continuing research has in the first instance identified a comprehensive set of core software quality factors which extend those published by [1] and embrace requirements of European Community law [7]. In addition, five new domain-specific quality factors for to the WWW have been identified [8].

	External quality factors		Internal quality factors	Strategic quality factors
Core quality factors	suitability installability functionality adaptability ease-of-use learnability	interoperability reliability safety security correctness efficiency	maintainability testability flexibility reusability portability	
Domain-specific quality factors	visibility intelligibility credibility engagibility			differentiation

Figure 3: Combined set of software quality factors for the World Wide Web

These five new quality factors are visibility, intelligibility, credibility, engagibility and differentiation. The combined set of quality factors is illustrated in Figure 3

The taxonomy in which they are presented is similar to traditional External and Internal categorisation of quality factors [9]. In these categories the emphases is on usability (external quality), which is principally of interest to the user, and on technical excellence (internal quality) which is principally of interest to software engineering and IS professionals. The Core quality factors, which are appropriate to all software applications, are shown separate from the Domain-specific quality factors, which are appropriate to the Web. A third category is added in order to reflect owner interest. This category is named Strategic quality factors and differentiation is shown in this category.

The research includes definitions and characteristics for the five new quality factors for the WWW and these are set out in Figure 4 [8]. The first four of these fit with what [4] also refer to as the Total Customer Experience (TCE) and are user focused, while the fifth, differentiation is an issue of primary concern to a quality Web site owner. They clearly reflect quality-of-use and quality-of-ownership.

Quality factor	Characteristics
Visibility The ease with which a user can visit a Web site.	• Tracability • Retrievability • Ease-of-access
Intelligibility The ease with which a user can assimilate and interpret Web site content.	• Legibility • Audibility • Comprehensibility
Credibility The level of user confidence with the content of the Web site.	• Integrity • Accuracy
Engagibility The extent to which a visitor achieves a complete experience at a Web site.	• Navigability • Interactivity • Appeal
Differentiation The extent to which a Web site demonstrates corporate superiority.	• Speciality • Identity

Figure 4: Definitions and characteristics of additional quality factors for the WWW

From a software measurement viewpoint, the Core quality factors when combined with the Domain-specific quality factors (Figure 3) can be used as essential components for a quality accreditation system for Web sites. Furthermore, the research also includes a comprehensive set of ENABLERS for the domain-specific quality factors which can be used by specifiers, designers, developers and evaluators as essential issues which must be addressed in order to estimate, quality assure and evaluate quality Web sites [8].

4.3. Metrics and methods

Within the discipline of software engineering, product quality is assured through testing using well understood and proven processes. Typically, this specifies what must be tested, its timing during the life cycle, the methods to be used and the expected results. This is not the case in the context of the Web sites. The issues of "what has to be tested" include the additional quality factors identified by this research. From research observations, its timing during the life cycle appears to be mainly confined to evaluation after the artefact has been

created. Similarly, the methods might benefit through classification and mapping to the life cycle. However, "the expected results" is a major challenge, as metrics, especially in an E-Commerce context, are not well researched or well understood. While some metrics like Nielsen's less than 10 seconds for WWW response time is an accepted norm, similar types of metrics must be identified and defined especially metrics which relate to the quality-of-use factors per figure 4. In addition to these quality-of-use metrics there is also a need to consider metrics from a quality-of-ownership and quality-of-producer perspective too. The reader will appreciate that these metrics are in addition to quality-of-product metrics. It follows that since new quality factors have been identified for quality Web sites, new metrics associated with these will necessitate revisiting estimation, quality assurance and evaluation methods and techniques.

5. Going a step beyond MIS practice to achieve Web site quality

Having considered the broader perspective of software quality, this section focuses on quality in the domain of the WWW and considers how a step beyond the understood Management Information Systems practice relating to implementation, usability, measurement and maintenance is appropriate in the context of quality Web sites. In the context of the WWW the section addresses the next wave of end-user development, site visitor engagement, assessment by way of software quality Metric Ration Analysis and enhancement by way of progressive maintenance. It outlines quality considerations that need to be addressed by systems professionals whose work is impacted by software quality.

5.1. A development step beyond implementation

Quality Web sites provide an excellent opportunity for the next wave of end-user development. Opportunities abound for professionals in all business sectors to become their own Web site proprietor. Typical of those who are already availing of such opportunities are medical consultants and academics who have large numbers of clients and students who willingly visit their specialist Web site. This approach overcomes the cost of having a solutions provider implement a Web site for them, so, the end-user concept fits well. From the professional's perspective a quality Web site provides an excellent solution to a significant communications problem and from the site visitor's perspective the quality of their requirements is consistent in its delivery and assured by its existence. Respectively, they contribute to quality-of-ownership and quality-of-use. This style of Web site development is proprietor development and is a step beyond implementation. It is successfully achieved by combining development tools with a sound understanding of what constitutes a quality Web site in the area of specialism. And, it need not be limited to the examples already explained. Similar opportunities abound for organisations to support qualified staff to expand their intranets and extranets. In the context of the broader view of quality, definitions of quality Web sites need to be revisited and best practice guidelines need to be formulated.

5.2. An engagement step beyond usability

In the domain of Management Information Systems external software quality (i.e., usability) and its evaluation are well understood by those involved in software measurement. Usability addresses all issues that impact the user of the software [7]. This interaction with software is called quality-of-use by [6]. But usability is the limit of MIS interactivity in that the users' ability to contribute to the software artefact is limited to tailoring the interface to suit their own preference. Beyond that the artefact is static. In the domain of the World Wide Web the artefact is a Web site that can be dynamically created to suit visitors. This type of interaction is

named (by this research) engagibility and is an engagement step beyond usability. It is achieved by the inclusion of communication paths such as visitor contribution to Web site content, moderated mailing list, chat room, support for feedback contribution, comments forum and similar paths, which empower and enable site visitors. It is a significant consideration in E-Commerce and the Total Customer Experience (TCE). The inclusion of this level of engagibility dictates that software quality measurement (methods and metrics) needs to be revisited in relation to productivity, effort and cost estimation, quality assurance and usability evaluation.

5.3. An assessment step beyond system review

The benefits of ownership of Information Systems have been the subject of extensive research for many years and there is a mature understanding of the issues involved. This research advances our understanding and focuses on quality-of-ownership in keeping with the broader view of Ishikawa [4]. In particular the research addresses the owner's perspective in the Software Quality - Strategic Drivers Model (*SQ-SDM*) [5]. In the context of the World Wide Web our understanding of quality-of-ownership of Web sites involves new criteria not found in traditional MIS applications. Measuring these criteria typically addresses analysis of use for competitive advantage and involves measurements associated with page mining, hyperlink excursions, activity usage and a set of similar metrics. This analysis is an assessment step beyond system review and is part of what this research names as *Software Quality - Metric Ratio Analysis* (*SQ-MRA*). In relation to quality Web sites *SQ-MRA* uses a formula to determine a numeric value for individual ratios from a set of strategic quality-of-ownership Web site ratios. These ratios relate to usage considerations. *SQ-MRA* is motivated by the style of ratio analysis which is well understood as a core measure in the principles of financial accounting which are regarded as a simple yet powerful approach to analysing business performance and this research proposes similar analysis for quality Web sites. The concept is similar to the work of [10] who focus on a set of marketing focused metrics which they style E-Metrics. The value of *SQ-MRA* is that it identifies a set of Web site quality metrics which Web site owners can use as a guide in order to specify requirements and performance objectives for the site. Once live, the Web site can be monitored and analysed and then, subject to the findings, can be tuned for optimum usage. Results achieved from this monitoring and analysis give rise to an evolutionary form of maintenance as discussed in Section 5.4 which follows.

5.4. An enhancement step beyond maintenance

A Management Information System, once coded and installed, is maintained by way of adaptive, corrective and perfective maintenance [11]. A significant element which contributes to this form of software maintenance is defect detection and repair. In an MIS system the functionality remains consistent. This is not the case with a Web site. A quality Web site is different because it can continue to evolve (in some instances on a daily basis) and needs to be continuously maintained by way of updating or refreshing general presentation, updating and repairing hyperlinks, adding new content, updating brochureware and responding to visitor communication. This type of maintenance is progressive maintenance (to add to adaptive, corrective and perfective) and is an enhancement step beyond traditional maintenance. It is achieved through a proactive policy of system review which regularly (often daily) revisits the Web site in order to update, upgrade, repair, respond, improve and sometimes delete aspects of the Web site. Progressive maintenance results in crisp, clean, fresh Web sites that impress new visitors, retain existing customers and generally contribute to the overall objective of engagibility. From a Web site owner's

perspective, progressive maintenance typically supports tangible and intangible benefits of quality-of-ownership. Progressive maintenance is an evolving component of software maintainability (an original software quality factor) and so it follows that estimation, quality assurance and usability evaluation need to be reconsidered in order to determine how they are impacted by this new component. Enhancements achieved by a policy of progressive maintenance will contribute to Web site differentiation and support competitive advantage.

All of the considerations in this Section illustrate the need for improved understanding of what constitutes a quality Web site from the owner's and user's perspective. There is also a need for a similar understanding from the developer's perspective. It follows that measurement methods and metrics appropriate to the area of estimation, quality assurance and usability evaluation need to be revisited in order to address the requirements of quality Web sites.

6. Closing observations

Before closing there are two observations worth recording. These are:

- Despite much reworking of Systems Life Cycle models over many years, none of the acknowledged and most cited models (Waterfall, Spiral, V or Star) includes quality in its conceptual model.
- To date few formal computing curricula have focussed on quality. Quality is usually covered within syllabuses on system design and software engineering. Examples of formal benchmarks for computing courses are those offered by the United Kingdom Quality Assurance Agency [12] and by the British Computer Society examinations [13]. Both of these examples do make substantial references to quality within their syllabus guidance. However, it is the belief of the authors that this context would benefit from expansion and more explicit reference to a holistic view of quality.

7. Conclusion

This paper has explained that in the context of E-Commerce the broader view philosophy of quality as referred to by Kaoru Ishikawa is especially relevant. The paper has shown that this broader view addresses quality-of-development, quality-of-ownership, quality-of-engagement and quality-of-product. Driven by sales and marketing professionals, quality-of-ownership and quality-of-engagement have competitive advantage issues that need to be addressed.

The paper also explains that in the context of E-Commerce there is a need to go a step beyond the traditional quality issues of MIS applications. This step beyond addresses proprietor development, engagibility, Software Quality – Metric Ratio Analysis (*SQ-MRA*) and progressive maintenance.

Revisiting software quality also means reviewing current approaches to quality in the system life cycle model, the curriculum, measurement, and evaluation methods and metrics. It follows that standards that are impacted by such considerations also need to be reviewed when software quality is revisited.

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