A Process Capability Approach to Information Systems Effectiveness Evaluation

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Abstract: While defining or measuring the effectiveness of the information systems (IS) function has proven complicated, further effort on refining IS assessment is essential for the effective management and continuous improvement of both the IS function and the organisation. In addition, an effort to investigate the relationships among the established IS assessment tools to better reconcile their existing differences is warranted. This paper aims to clearly differentiate the notions of 'Software' from 'Information Systems'. A new IS assessment model is proposed to provide a more holistic view on how IS quality may be assessed by means of a process capability understanding of evaluating IS effectiveness within the organisational context.

Keywords: Information systems quality, Information systems effectiveness, Assessment, Software process maturity, Process capability.

1. Introduction

This paper aims to clearly differentiate the notions of Software from Information Systems. Within these two different entities, until today Software has attracted the attention on the subjects of quality and assessment of that quality it possesses. Information Systems on the other hand, were not considered as entities that need to be assessed in order their level of quality to be depicted. Moreover, as most researchers referenced in this work point out, considering Software away from its natural context and framework, which is the Organization, is a severe mistake. Software together with the organizational context that it lies within, construct Information Systems. Therefore, the quality of Information Systems is mainly related to the artifact used, the Software, but not less importantly to the organizational context that this artifact is being used within.

Within the Information Systems literature, there are many models proposed to assess the quality of Information Systems. One of the more complete and better known is DeLone and McLean's model of information systems success (2003). This model has been used as a basis for empirical research, and has been refined and extended by many researchers. In this article, two immature models are introduced and elaborated. As concluded, these conceptual models fail to serve as widely accepted models, as they are newly formed, with few experimental and theoretical support and even fewer comments by other researchers. Built on the discussions, a new process capability based model is developed and presented.

Information Systems (IS) and Software (SW) are definitely two different entities. It can be argued that IS are the aim, whereas Software serves for that aim, so that IS tend to be the organizational context where the developed Software is used. IS therefore are built upon Software, and the quality of Software effects, if not determine the quality of the IS. The quality characteristics of Software differ from those of the Information Systems of which it is part of. The quality of Software focuses on the quality of the production of the object or artifact as widely used by many researchers, but the quality of IS focuses on the use of this object or artifact within the organizational environment. The borderline between a Software and an IS may be clear if Software is limited to programs, and IS is seen to be the organizational framework and context in which Software is used. However, this definition may be considered to be to some extent insufficient, inadequate and poor for the discussion about Software quality, as it obviously restricts the consideration to the technical characteristics of Software and leaves out the usage of Software, and the way usersexperience Software, and influence their opinion about its related quality (Von Hellens, 1997).

The Capability Maturity Models (CMMs) have become a de facto standard for assessing and improving Software processes, a model for judging the maturity of the Software processes of an organization and for identifying the key practices that are required to increase the maturity of these processes. It is an interesting and fascinating approach to apply the CMMs on IS in order to assess and improve the overall quality of the processes embodied in the IS. However it is necessary to alter, adjust and modify the maturity levels and key process areas of SW-CMM (or the updated version CMM-Integrated) to better match the needs of a possible IS CMM.

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Definitely, Software quality is an empty statement without some indication of its performance and applicability in the user environment. Therefore, the quality of Software emphasizes the quality of the production of the artifact called Software in an organizational context. These are related closely and largely to the definition of quality, that quality is contingent and resides in the user's perception of the product (Siakas, et al., 1999).

2. Software quality versus Information Systems quality

An IS can be defined technically as a set of interrelated components that collect or retrieve, process, store and distribute information to support decision making, coordination, control, analysis, and visualization in an organization (Laudon and Laudon, 2001). IS are socio-technical systems (Mumford, et al., 1984) of which information technology is one significant feature. They can be thought of as integrating an infrastructure and the various systems, which make use of that infrastructure (Galliers, 1994). IS are meaningful only when they are considered within a context, and the main distinction between a Software system and an IS is that Software is limited to the development process of a Software system, while an IS is seen to be the organizational context in which Software is used (Von Hellens, 1997). If we accept this difference and distinction, then we can argue that Software quality means development process quality not considering the usage of that Software, while IS quality will emphasize product quality assessed by the usage of Software in an organizational background. Due to the multidisciplinary character of IS a discussion about the necessity of a societal viewpoint in these days of globalization of the Software market, virtual global enterprises and cross-cultural teams follows with emphasis on Software quality and process improvement (Siakas, et al., 1999).

There are a number of approaches developed during the 1990's for the achievement of IS quality, however no approach yet provides a solution that is detailed enough in either a scientific or practical sense (Dahlberg and Jarvinen, 1997). Some of the existing approaches that were analyzed and evaluated within the research framework of this paper, have proven that they are mainly limited because they concentrate too much on the technical and control-oriented aspects of IS Quality management.

The movement that began as Quality Control, which refers to the maintenance of a predetermined level of quality, has developed into the notion of continuous Quality Improvement (Dahlberg and Jarvinen, 1997). It can be seen that most Software developers have ISO 9001 certification, yet this alone does not necessarily mean better value for the customer and therefore there is definitely a need for a *multi-perspective* quality model that includes both scientific and practical IS/IT purposes, and is linked directly to the IS practice (Dahlberg and Jarvinen, 1997). The key word in the research of Dahlberg and Jarvinen is definitely the multi-perspective quality model notation, which denotes that IS can not be assessed efficiently and effectively by concentrating on a single perspective but only if all possible viewpoints and perspectives are employed. What these perspectives are or should be, are later discussed in the paper, with respect to the existing IS quality framework.

The concepts, models and measures that work in other fields might be usefully applied to the IS field, but careful analysis and consideration should be given. Furthermore, IS Quality research should be done at real user organizations, so that the results will be both useful and accepted by IS developers. The aim of this study overall is to assess the effectiveness and quality of the Informatics Institute Online Information System, METU, and definitely the results of such an assessment would have been very helpful in better understanding the quality aspects of IS within the organizational context.

3. IS quality within the organizational framework

It is important for the IS developers to recognize that they are primarily engaged in a service-oriented business, rather than being in the business of producing high-quality Software (Von Hellens, 1997). Based on this finding of Von Hellens, organizations using IS, should be aware that the artifacts that they are using are not only Software but a service, and they should be treated as services. Von Hellens continues that, in detail, it has been observed that in many IS development organizations there is either a *covert or overt reluctance* to participate with the user in the requirements elicitation, development or implementation of a new system (Von Hellens, 1997). The absence of user input into this process leads to a decline in use quality (Garvin, 1987) in which users are assumed to have differing needs, and the degree to which a product satisfies those needs determines the quality of the product. This is mainly related to the definitions of quality given by Weinberg and Crosby, as "Quality is conformance to requirements" and "Quality is conforming to some person's requirements" (Weinberg, 1992). The reluctance on the part of

the developer to have sufficient user input is often due to the developer having a different view (i.e. manufacturing-based view) of product quality in which quality is defined in terms of engineering and manufacturing practice—usually 'conformance to specification' (Von Hellens, 1997).

4. Models of IS quality

There are several difficulties of developing a comprehensive model of IS quality. It should be obvious that a definition of IS quality needs to be holistic, one which encompasses all relevant contexts—both technological and organizational—so that the framework to be constructed takes into account the different work contexts and specific organizational needs that should be considered when evaluating an IS quality. The IS quality model therefore takes a broader approach to evaluating quality than does a Software Quality approach which does not take into account the organizational context in which the Software operates. The difficulties of developing a comprehensive model of IS Quality arise from an incapability and inability to settle the varied perspectives taken by the IS stakeholders (management, developer, user) each with their own idea of quality (Andersson and Von Hellens, 1997).

The following subsections introduce two previously developed IS Quality models: the SOLE Quality model and the IS Quality Process View.

5. The SOLE quality model

In an effort to develop a useful, general-purpose definition of IS quality, Andersson and von Hellens have developed the concept of *IS work quality* by using the SOLE (Software Library Evolution) quality model, originally developed by Eriksson and Törn (1991), with consideration of the management functions required to assure evolution quality and user support quality (IS work practices) (Andersson and Von Hellens, 1997).

The SOLE quality model aims to create divisions of quality classes that are consistent with the decisions made by key decision-makers during the Software life-cycle. SOLE identifies three divisions; business quality, use quality, and IS work quality. At each level the listed quality factors relate to individuals who are primarily interested in the quality of the respective quality factor. Therefore, this serves for the previous important notation of 'multi-perspectiveness', and coincides with the basis IS model—DeLone and McLean's (1992, 2003). The following Figure 1 displays the relationship between the three divisions within the overall IS quality framework.

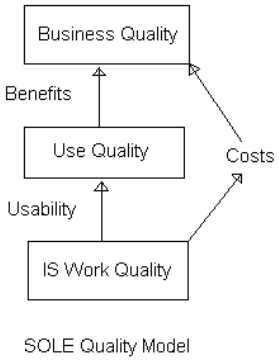

Figure 1: SOLE quality model (Eriksson & Törn, 1991)

The first part as shown in Figure 1, business quality, is the domain of senior and departmental management. It is seen in terms of costs and benefits. If benefits offset cost, then quality is considered to be good. Business quality refers to the quality of the activities that control the IS work all the way through the entire lifecycle of the product and service. The achievement and success criteria include whether deadlines and schedules are met with respect to the scheduled budget. It is the region and under the control of the Chief Information Officer (CIO) who is responsible for the efficient deployment of all types of assets, towards meeting the organization's previously settled information needs and goals. Therefore the project manager must keep continuing projects running efficiently and slickly with no unexpected shockers. Success criteria are the approval and acceptance of the deliverables (Andersson and Von Hellens, 1997).

The second part of the SOLE model, use quality**,** is defined by how well the system does what the user wants it to do. Users can be defined as the people who directly use the system by performing various work practices that prepare data and information for the system. The two main features of use quality in the SOLE model is what does the system do for the user, and how the interface is designed, otherwise called requirement quality and interface quality.

The third part of the SOLE model, IS work quality, is defined by the level of the performance of management, development, maintenance and operation of the IS, and the final products of Software and documentation. IS work quality considers the management tasks required to guarantee fruition and evolution quality and user support quality generally being concerned with all aspects of the way an IS serves the user.

Here it is important to emphasize that the three divisions within the SOLE IS Quality Model coincide with the DeLone and McLean's IS Success Model. 'Business quality' corresponds to the 'Net Benefits' *and* 'Service Quality' dimensions ; 'Use quality' to 'User satisfaction' *and* 'Information use' ; and 'IS work quality' to 'System quality' *and* 'Information quality' dimensions respectively.

The two dimensions of the SOLE model are referred to as the requirements dimension and the user interface dimension The requirement dimension includes such factors as "does the artifact meet the user's needs?", "is it secure?" and "is it easy to change according to new needs?". The user interface dimension is concerned with how easy the artifact is to use, whether effective help is available and that the artifact does not control the user's work performance (Andersson and Von Hellens, 1997).

Therefore based on these divisions and dimensions, the SOLE model shall be designed simply by a graph as:

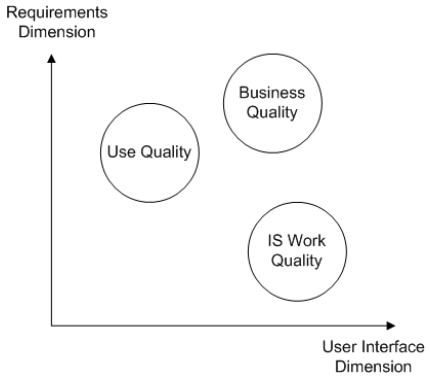

Figure 2: SOLE model

The most important voids of this model can be listed as:

- The model is primarily based on the Software Life Cycle. However the change over time (over the life cycle) can not be depicted or described without the notion of time. Therefore a third dimension can be considered to be the Time dimension.
- The model considers users as a single entity, however, users consists of different groups which view, understand, use and influence IS in different ways. Therefore, users can be considered as an alternative dimension for the model.

6. The IS quality process view by Olayele Adelakun

Another notion of quality as seen from some other point of view is that it is a multi-dimensional concept, which is context-dependent. It differs from the SOLE model and has somehow addressed the drawbacks of SOLE that have been addressed in the previous section. In this model, first of all, the quality of any IS can be said to be a function of three dependent variables (Adelakun, 1991). They are the type of IS, the Stakeholder group, and Time, as shown in Figure 3. The quality of any information system can be determined from this concept. Figure 3 below shows the quality model and how the three variables are related to the information systems quality.

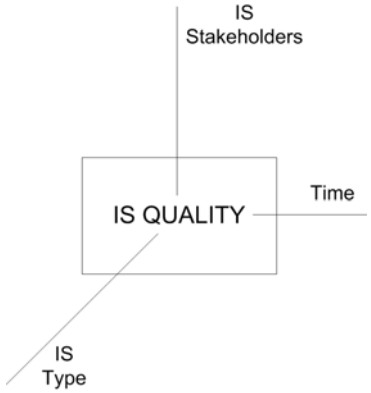

Figure 3: The quality model (Adelakun, 1991)

The IS quality process model was developed by Adelakun in order to operationalize the above framework. The three categories in the process model (IS planning, developers and users) cover the stakeholders' views in Figure 3. IS planning is a process of identifying IS that could be used to maintain and support a business strategy (Adelakun, 1991).

The business dimension of quality is defined as meeting or exceeding the stakeholders' expectations of the business benefits from the IS project (Adelakun, 1991). Examples of this business dimension of IS quality include: increasing productivity, improving customer services, reducing cost, compressing cycle time, and improving the accuracy of the delivery process.

It is even more important to communicate this business quality to the developer as the study by Adeyakun has proven that this activity is one of the most important activities in an IS project. It is not only essential to communicate this business advantage; it is also significant and critical to follow it up.

The IS development phase in Figure 4 usually focuses on the development of the Software object. In this phase of the IS project, as previously noted and justified, the quality focus is primarily technical. Many Software companies apply the Software section in the ISO 9001 quality standard or capability maturity model in the development of the Software product. These standards often view the IS development process as a linear one, starting with the functional requirements, programming, inspection and testing, delivery, and installation. Several researchers note that an unquestionable application of these standards in Software development can lead to serious development drawbacks. Many Software companies are realizing the limitation of these standards and are gradually moving away from them.

The last part of the IS quality process concentrates on the use which is primarily the user's view of quality, where concepts such as usability, quality-in-use etc. are applied here. Usually it is observed that the actual quality of the system can only be determined during its use (Adelakun, 1991).

7. The proposed PB-ISAM

Built on and inspired by the models that have been elaborated, a Process Based Information Systems Assessment Model (PB-ISAM), that would apply only to assessing and evaluating the quality of IS quality in terms of capability, has been proposed.

7.1 PB-ISAM goals

PB-ISAM has three goals:

- To determine the maturity of an IS.
- To improve the IS capability.
- To promote discussion on what it means to be a *mature* and hence an *effective* IS organization.

7.2 PB-ISAM structure:

The PB-ISAM, in accordance to the traditional CMM, should be a maturity growth model, consisting of five maturity levels. Each maturity level should describe a stage in the maturity of an IS organization. The lowest level would be level one, the initial level. Organizations at level one in SW-CMM are characterized by working in an ad hoc manner and by unpredictable performance. This characteristic of level 1 organization can be employed to be used in PB-ISAM, so that the same characteristics are applicable. Therefore, if IS are working or are delivered successfully, it is because of individual heroism. Organizations at level two, the repeatable level, should deliver, and use IS with a repeatable quality, in other words, they should repeat earlier successful performances in similar circumstances. For an organisation to be at level 2, it has to be at level 1 also. At the third level, the defined level, the aim should be the standardization of services. Organizations at level three should employ standard processes to select, develop, deliver and use IS and should have implemented organization-wide processes to train employees who useIS and manage IS related resources and problems. The fourth level, the managed level, should aim attaining quantitative control over the IS processes. And finally at Level five, the optimizing level, continuous process improvement of use and delivery of IS should be aimed.

As in SW-CMM, each maturity level (except for level one) should contain a number of key process areas. To reach a certain maturity level within the PB-ISAM, each of the key process areas of that level and lower levels have to be implemented by the organization whose IS has been assessed. Moreover, for a key process area to be considered implemented each of the goals of the key process area should be reached. As in traditional SW-CMM, a key process area hence should consist of goals and of activities, which are called key practices. An organization that implements all activities from a certain key process area is expected to also reach the goals of that key process area. This relationship between maturity levels, key process areas, common features and key practices is shown in Figure 4.

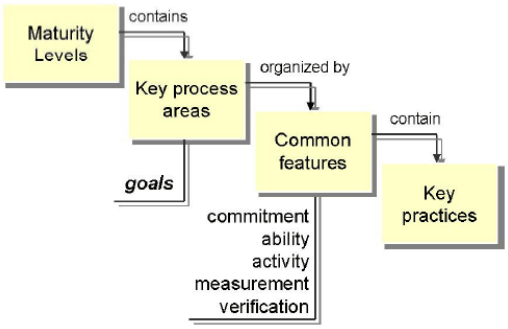

Figure 4: CMM structure

The CMM model distinguishes between five kinds of practices, called common features, which together, these five common features ensure that the goals of the key process area are reached. It is possible and appropriate to suggest such practices for the PB-ISAM. :

- Commitment to Perform: activities aimed at ensuring organizational and management commitment to the key process area activities.
- Ability to Perform: activities aimed at enabling the key process area.

- Activities Performed: the activities needed to get the job done.
- Measurement and Analysis: activities aimed at determining the status of the key process area.
- Verifying Implementation: activities aimed at verification of the implementation of the key process area.

However, in order to define the contents of PB-ISAM, it is important to take into account previously conducted studies in the area, and to use such studies as the guiding frameworks. Therefore, it is suggested that in order to develop a CMM for IS, the studies of Andersson, Von Hellens and Adeyakun, and DeLone & McLean, need to be taken into consideration. Initially, the guiding framework, can be formed by means of merging these studies to better depict and display the multi-dimension and multi-perspective attributes that a IS quality assessment model should embody. It can be a very interesting approach to place the SOLE model structure in the three-dimensional model of Adeyakun. Such an attempt can be simply graphically represented as shown in Figure 6 below. If DeLone and McLean's model were additionally merged into this model, the three quality dimensions would increase up to eight, resulting with a more comprehensive and complete model.

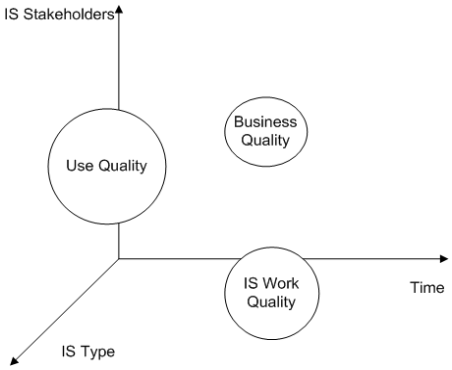

Figure 6: A proposed mixed framework

For a complete assessment of an IS, it is important to take into account all three IS stakeholders' perspectives: (1) IS planner, (2) IS developer, and (3) IS user. These three views are important since, as DeLone and McLean states in their latest paper (2003), different stakeholders in an organisation may validly come to different conclusions about the success of the same information system.

The capability (or maturity) level achieved by the Information System assessed may be presented as in Table 1 below.

Table 1: Information system success capability level ratings for the proposed assessment model (PB-ISAM)

Maturity Level	IS Success Dimensions	Rating
Level 1 PRODUCTION Performed	System Quality	Largely or fully
Level 2 PRODUCT Managed	System Quality Information Quality	Fully Largely or fully
Level 3 RECEIPT Established	System Quality Information Quality Information Use	Fully Fully Largely or fully
Level 4 INFLUENCE ON RECIPIENT Predictable	System Quality Information Quality Information Use User Satisfaction	Fully Fully Fully Largely or fully
Level 5 INFLUENCE ON SYSTEM Optimizing	System Quality Information Quality Information Use User Satisfaction Net Benefits (Organizational & Workgroup Impact) Service Quality	Fully Fully Fully Fully Largely or fully Largely or fully

This capability model is proposed by merging the DeLone and McLean's IS success dimensions; and the SW-CMM and ISO 15504 assessment methods. For instance, as an interpretation of this table, if we take an IS which is found to be at maturity level 3 after assessment by any of the three stakeholders; according to the proposed table, this would mean that the criteria for levels 1 and 2 are fully accomplished by that IS. That is, the indicators for system quality and information quality are achieved at least to the percentage of 86% or higher; *and* the indicators for information use are achieved at least to the percentage of 51% or higher. Being at level 3 also indicates that other success dimensions which belong to higher levels, level 4 and 5, are therefore either not achieved (0% to 15%) or are partially achieved (16% to 50%). The rating scale proposed shall be defined according to the ISO 15504 specification as shown in Table 2.

Table 2: Indicator rating scale adopted from ISO 15504 (1998) specification

Percentage interval	Rating
0%-15%	Not achieved
16%-50%	Partially achieved
51%-85%	Largely achieved
86%-100%	Fully achieved

8. Conclusions

This study overall, aims to distinguish and identify existing models of IS quality assessment ; and

based on these established models to propose a process based model ; and finally to accomplish an assessment based on this model in an organization, the METU Informatics Institute Online Teaching System. In this paper, the first two steps of these total three steps were successfully accomplished in great extent. However, the final step is still to be completed.

Until recently, the practitioners and researchers in the general Software domain have considered and focused primarily to the quality of the artifact being developed, on the Software. This artifact, as a laboratory object, was analyzed and depicted usually away from its natural environment, the organizational context. Merging the organizational context with the artifact, we obtain IS, which are multi-dimensional and entities with multiple perspectives. Considering the quality of Software, is definitely considering only the manufacturing process of that product, leaving out the context within which that product will operate. Of course the manufacturing quality of a product is important, but until recently, in the Software area, all attention was focused only in this "manufacturing" process.

This study has shown that some important awareness is being developed within several areas of influence, on the subject of IS quality. Two models were briefly introduced and discussed in this paper. As it has been elaborated, these two models, lack extensive and detailed consideration and are definitely incomplete with respect to many points. On the other hand, they are compatible within themselves and with other generally accepted evaluation approaches. There are no contradictions or real overlaps, hence they can be complementary in their positive effect on the organization. Information systems, by definition (DeLone and McLean, 1992), are integrated systems for providing information to support operations, processes, management analysis and decision-making functions within an organisation. Therefore IS quality shall comprise the requirements of the business organization, the users, and the IT personnel (Ozkan and Bilgen, 2003). In that regard, the paper in general supports the claim that the use of a systematic IS based performance evaluation approach would improve organizational effectiveness.

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