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A SOFT SYSTEMS APPROACH TO INFORMATION SYSTEMS QUALITY

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Abstract

Traditional approaches to Information System (IS) development have concentrated upon a production view of quality associated with a controlled development process and metrics that monitor attributes such as software usability, the number of software errors, and developer productivity. IS quality is also concerned with a use view of quality—how those software artefacts are used within an organisational context, recognising the need for a never-ending learning cycle based on experience of the product in use. Soft Systems Methodology (SSM) is proposed as a framework for considering a relevant notion of IS use quality, enabling discussion to take place about the quality requirements of a technical artefact within the context of an organizational setting. Using the rigour of systemic thinking as a basis, criteria for the assessment of IS quality, labelled the 5Es (efficacy, efficiency, elegance, effectiveness and ethicality), are introduced as a way of identifying the aspects of IS quality that are of concern. A modified form of SSM that incorporates stakeholder analysis and an emphasis on the cultural aspects of quality is proposed for the definition of a relevant (in-context) notion of IS quality.

1 Introduction

Quality, as it applies to Information Systems (IS) and the process of IS development, is a topic currently receiving considerable attention, particularly with respect to software engineering. Much of this effort focuses on achieving more effective control of the IS development process, emphasising the need for improved process control and the introduction, and subsequent enforcement of, standards. The need to establish control over the IS development process has lead to the search for software metrics to monitor attributes such as software errors, software reliability, software usability and software maintainability (Fenton 1991, METKIT 1993). This paper, however, is concerned with developing a broader framework within which to consider the notion of quality (Dahlbom & Mathiassen 1991), concentrating on whether the product of IS development is meeting the needs and expectations of, amongst others, the organisational users of that product.

Traditionally, software quality has been concerned with the design and control of a process such that the product of that process meets, or surpasses, the requirements contained in a specification. This view of software quality can be typified as deterministic, 'means-ends' oriented, and in the rationalistic tradition (Winograd & Flores 1986), being founded upon the assumption that there is some definable, true and real set of requirements which can be elicited and formally specified. The ideal is the production of a software product that conforms to a specification, has zero defects and is produced as efficiently as possible.

To consider what approach is applicable to IS quality it is necessary to define the term 'information system'. If information is considered to be data that have meaning within a specific context, then data can only be said to have meaning when considered by a human being, or a group of human beings, within an organisational context. The information system is thus concerned with giving people access to data, assisting them in interpreting that data (i.e., transforming it into information), and assisting them in their organisational activity (Checkland 1988, Wilson 1991). The technical artefacts produced by software engineering become part of a larger information system that incorporates formal and informal mechanisms for creating and communicating information. IS quality is concerned with how well those software artefacts perform in the organisational setting (Miles 1985).

The traditional approach to IS quality focuses on software quality (see Figure 1) and a *production* view of IS development. However, the production view of quality is often context-free, paying inadequate attention to the *use* (organizational) context of the artefact (a similar approach has been proposed by (Floyd 1987) who defines product and production views of systems development). The software artefact may address data management, but it is the software artefact within an organizational context that forms part of information management. To be effective, the IS development process must consider both the organizational context and the engineering of the software artefacts. In Figure 1, IS quality

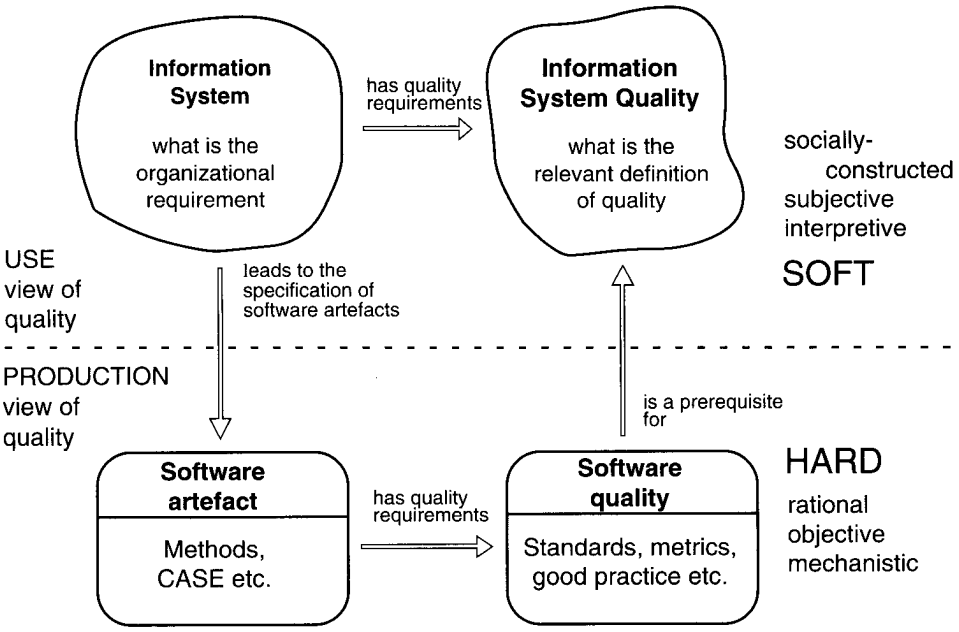

Figure 1: *Information System quality and software quality*

is contrasted with software quality; software quality is likely to be necessary to secure IS quality, but by itself is not sufficient.

Although one might argue that it is possible for software engineering to be a value-free and objective activity, the context in which the product of software engineering (the technical artefact) is used is organizational and unpredictable. In our opinion, the objective rationality of software engineering is embedded in a soft and interpretive context in which reality can be said to be socially-constructed (Floyd 1992, Dahlbom 1992). In this paper we are concerned with how a relevant notion of use quality might be established. Use quality must reflect the different perspectives of those involved in, or affected by, the IS.

To develop further a framework for IS quality, we will consider briefly in Section 2 what is meant by quality as defined in the quality literature and in Section 3 reflect further upon how quality practices have been applied to IS development. The argument that IS use quality is socially constructed and contingent upon the organizational context leads to the need for a way of agreeing upon a relevant notion of use quality. In Section 4 the Soft Systems Methodology (Checkland 1981, Checkland & Scholes 1990) is proposed as the basis of a framework for defining use quality and in Section 5 a tentative approach to defining IS use quality is outlined.

2 Quality and Quality Management

We consider firstly the notion of quality. A widely used definition has been supplied by the International Standards Organization (ISO 1986):

> "The totality of features and characteristics of a product or service that bear on its ability to satisfy specified or implied needs."

In a similar vein, another definition of quality is (Gitlow *et al.* 1989):

> "Quality is a judgement by customers or users of a product or service; it is the extent to which the customers or users believe the product or service surpasses their needs and expectations"

Quality has also been defined as 'fitness for purpose' (Juran 1979). The above definitions of quality require one to consider whose needs are being satisfied, and through the medium of what product. For the purposes of this paper, product is considered to be a generic term that encompasses both goods and services. The presence or absence of quality is made manifest in the use of the product, not in the production process (although it may be possible to predict use quality, to a limited extent, on the basis of characteristics of the production process).

The traditional school of quality emphasises the need for measurement and statistical analysis, although mass inspection is not considered effective or viable. Deming's fourteen points (Deming 1986) for managing the never-ending extended process of organisational activity are a mix of positivist science, relying on measurement and statistics, and social/psychological considerations such as the breaking down of organisational barriers and the driving out of fear. However, the final touchstone is the need to measure and perform statistical analyses. The Total Quality Management (TQM) approach (Deming 1986, Thorn 1988) emphasises the customer/supplier relationship, regardless of whether that relationship involves internal departments or other (external) organisations. The need for communication and control is stressed, identifying three types of communication; down-the-line (hierarchical, process-based), lateral (cross-department, often project-based), and consultation (e.g. encouraging managers to listen to their staff). Control is achieved through the setting of clear targets and the monitoring of performance. Some cultural aspects are addressed in TQM by encouraging employees to take 'ownership' of the quality culture, thereby promoting a sense of belonging and co-operation.

Traditional quality management recognises the need for measurement that supports feedback and control, together with some, limited, attention to social and cultural factors. The basis of traditional quality management seems largely to be consensual, with limited recognition of conflict; it is 'objective' in that metrics are the preferred method of assessing quality. But, the 'hard' techniques that specify how to measure are underpinned by what is essentially a 'soft' definition of quality that determines what to measure. Definitions of quality that are concerned with the extent to which customers *believe* that their *expectations*

are met can hardly be said to be objective. We argue that the superficially objective nature of metrification in quality management is built upon a notion of quality that is interpretative and situation dependent. A deeper understanding of the notion of quality is needed if the relevance of traditional quality management techniques to IS development, or any other discipline, is to be understood (Dahlbom & Mathiassen 1991).

3 Quality and Information Systems Development

Much of the work concerned with the quality of the IS development process addresses process improvement and a production view of quality rather than IS use quality. Within that narrow view of quality the results have not been encouraging. A model of software development maturity has been suggested (Humphrey 1989) in which the capability of a software development process is categorized according to one of five levels: *initial* (level 1), *repeatable* (level 2), *defined process* (level 3), *managed process* (level 4), and *optimized* (level 5). Humphrey considered the majority of organisations to be at levels 1 and 2 (Humphrey *et al.* 1989), with some having attained level 3. Although individual software teams were found to be working at levels 4 and 5, no complete organisations could be found working at these levels. The process capability model is concerned primarily with a production view of quality and can only improve use quality indirectly. Also, the process capability model does not provide guidance, from an organizational perspective, concerning how the change process might be effected.

On the above evidence we might conclude that IS development is lacking a quality process for the construction of software artefacts and that IS use quality will not be addressed with any real enthusiasm until the process of IS development is under tighter control. But, perhaps the difficulties of IS use quality go rather deeper than a historical emphasis on a production view of quality. The production view of quality enables developers to espouse an objective rationality in which the solution to the problems of IS development will be found in 'better' ways of eliciting user requirements and 'improvements' to the process of IS development. Where use quality is addressed, the situation is assumed to be unitary, i.e., typified by common interests, and compatible values and beliefs (Flood & Jackson 1991). This leads to generalized quality models such as those proposed by (McCall *et al.* 1977, Boehm *et al.* 1978, Bowen *et al.* 1985). Tackling IS use quality is not an appealing endeavour for the technologist—use quality is soft and interpretive (Figure 1) and likely to be very messy when situations are complex and pluralistic and even more problematic in coercive situations (Flood & Jackson 1991).

The production and use views of quality cannot be separated as neatly as might be suggested by Figure 1, they are intertwined with one influencing the form of the other. Thus, one might expect considerable problems to arise if a 'hard' approach is taken to a production view of IS quality and a 'soft' approach

Production View	Use View
IS development produces a product — the software artefact	IS development supplies a service to assist the organization in constructing information systems
IS development is complete once the artefact is delivered to the user	The IS development task proper is about to begin once the artefact is delivered
Artefact use is predictable	Artefact use is unpredictable
The emphasis is on controlling the process—the production view	The emphasis is on how technical artefacts are used—the use view
Quantitative techniques (metrics) are the preferred method of quality assessment	Qualitative judgements are needed in making an assessment of quality
Quality becomes perceived as intrinsic to products (reinforced through standards)	Quality is contingent and resides in the user's perception of the product
The IS development process is based on an engineering paradigm, where the means-ends approach can lead to a preference for the waterfall model of development	The ends (purpose) of an information system are considered to be problematical, leading to a preference for incremental and evolutionary development
The notion of quality is objectively given	The notion of quality is socially-constructed (inter-subjective)
The notion of quality endures	The notion of quality is continually changing
Quality is dependent upon the deep aspects of the product (e.g., the technical design)	Quality is dependent upon the user's view of the product (the superficial aspects)

Table 1: *Production and use views of IS quality*

is taken to a use view of IS quality. The purpose of Table 1 is to illustrate the difficulties of combining production and use views of IS quality by contrasting some stereotypical characteristics.

To the extent that IS quality requires a production view (robust technical artefacts are needed if the IS is to function effectively) and a use view (those technical artefacts are used in an organizational setting), IS quality can be seen to be a result of the tension between the use and production views of quality. But how is an appropriate balance and a relevant notion of quality to be arrived at? How does the notion of quality change and unfold over time? The next section proposes the use of soft systems thinking as a basis for the definition of a relevant notion of IS use quality.

4 Quality and Soft Systems Thinking

Soft Systems Methodology (SSM) (Checkland 1981, Checkland & Scholes 1990) has been used as part of the process of IS development in the Multiview methodology (Avison & Wood-Harper 1990, 1991, Wood-Harper & Avison 1992, Wood 1992) and we consider it to be applicable as a framework for exploring quality, particularly given the emphasis on multiple perspectives, cultural constraints, and a continuous process of learning. We wish to address the questions: whose IS use quality requirement are we attempting to satisfy? Why is it important? What constitutes a relevant notion of IS use quality?

The aspect of SSM that seems particularly significant with respect to defining a use view of quality is the recognition of logic-based and cultural streams of analysis (Figure 2). The logic-based analysis may result in changes that are systemically desirable, but those changes must be perceived as meaningful (culturally feasible). A brief description of SSM follows, together with a justification of why we should apply SSM to IS quality.

SSM involves systems thinking, where systems are characterised by emergent properties (those that relate to the system as a whole) and communication and control. The system is seen as an adaptive whole that has the potential for survival in a changing environment. In SSM systems ideas are not used in an ontological sense; the models created through systems thinking are systemic, but the problem situation ('real world') is considered to be problematical. The systemic models of purposeful activity are based upon an explicit recognition of the Weltanschauung, or worldview, of some interested party. It is the Weltanschauung that makes the transformation performed by the system meaningful. Potentially, there are as many systemic models of human activity as there are modellers and interested parties. The logic-based stream of analysis, which is concerned with the building of relevant models of human activity systems, is complemented by a cultural stream that allows social and political factors to be investigated.

The relevance of SSM to a use view of quality is summarized as follows:

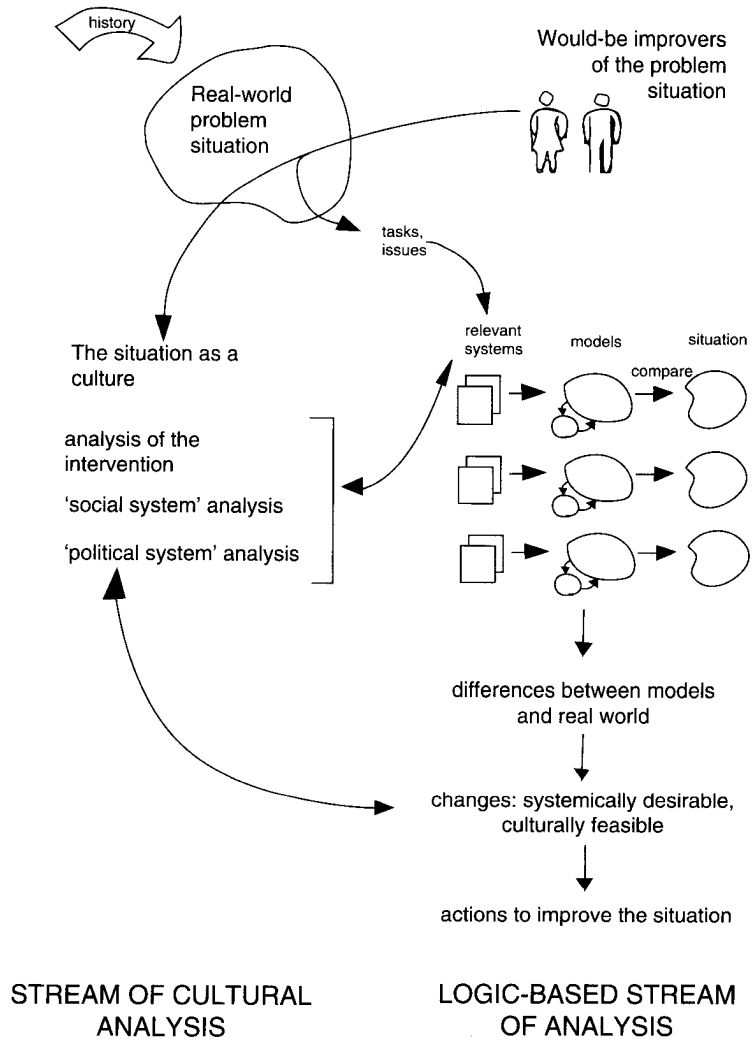

Figure 2: *The process of SSM (Checkland & Scholes 1990)*

- The rigour of systemic thinking can be introduced into complex situations, providing a basis for the definition of a relevant notion of use quality leading to, for example, a rationale for the choice of which metrics are to be adopted to predict and evaluate IS quality.
- The cultural aspects of quality improvement are recognized (the proposed changes that result from the rigour of the logic-based analysis are subject to social and political constraints).
- Participation is essential, requiring one to consider whose quality is being considered and why it is important (Weltanschauung).
- The paucity of the 'means-ends' approach in complex organizational situations is recognized. An SSM approach to quality recognizes that defining a relevant notion of use quality (the 'ends') is itself problematical.
- There is an emphasis on a continuous cycle of purposeful action and learning.

In the next section we consider how SSM might be used as the basis of a framework for defining IS use quality.

5 A Framework for Defining a Relevant Notion of IS Use Quality

5.1 Logic-Based Analysis

Having built a systemic model of a human activity system a judgement is made concerning how successful the system might be in accomplishing the specified transformation. It is the success of the transformation that is the concern of use quality. Within SSM, five criteria for judging the success of a transformation are identified: efficacy, efficiency, effectiveness, elegance, and ethicality (Forbes & Checkland 1987, Checkland & Scholes 1990). From a logic-based perspective, these '5Es' constitute a framework for defining and evaluating quality. The 5Es are defined as:

Efficacy does the transformation work; will it actually produce the required output.

Efficiency is the transformation being carried out with the minimum resources (i.e., the amount of output divided by the amount of resource used).

Elegance is the transformation well designed; is it aesthetically pleasing; is it over complicated; is it over or under engineered. Such judgements are undoubtedly (inter-) subjective, but their inclusion allows professional experience and competence to be drawn upon when assessing quality.

Effectiveness is the transformation process performed by the system meeting the longer term aim (it is possible to be efficient without being effective).

Ethicality is the transformation acceptable from a value judgement perspective, where value judgements concern 'good' and 'bad' and are subject to change over time (Vickers 1965, 1984).

One might, quite reasonably, be suspicious of categories that are as neat as the 5Es—can the metrics that are used in practice be catalogued sensibly under one or more of the 5Es and is the partitioning complete? Perhaps the category that at first sight appears to be missing is 'Economics' (luckily, even this begins with an 'E'). With respect to economics, all attempts to improve the quality of a transformation are bounded by the availability of resources and the willingness to commit those resources to improving quality in any given area of organizational activity. By convention, these resources are quantified using a financial unit of measure, which is a metric rather than a quality factor per se. Thus, quality is always constrained by resource availability, and we consider economic considerations to be an instance of the efficiency criterion.

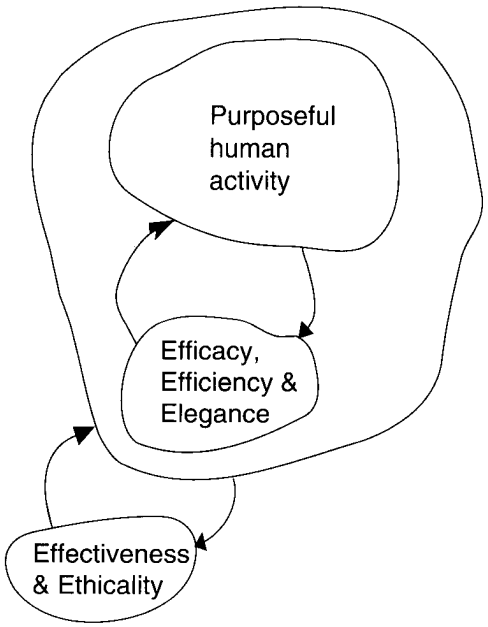

Figure 3: *A general form of a human activity system with the 5Es*

The 5Es allow identification of those quality factors that might be used to judge the success or otherwise of the transformation. However, the 5Es need not necessarily operate at the same level in the systemic model. The transformation

can be accomplished efficiently, but this does not ensure that it is effective or ethical. The systemic model should involve different levels of control as shown in Figure 3, where efficacy, efficiency, and elegance are part of an inner control loop, with effectiveness and ethicality being addressed in an outer control loop.

5.2 Cultural Aspects of Quality

Although the logic-based stream of enquiry may result in systemically desirable models and the identification of associated quality factors, action taken to improve the problem situation will not necessarily be culturally feasible. The action taken as a result of the intervention must be perceived to be meaningful if it is to be successful. Advocates of Total Quality Management (TQM) emphasize the need to establish a quality culture and consider cultural change a necessary prerequisite to the successful introduction of TQM. The philosophy of SSM would support this view, that change must be culturally feasible.

The cultural stream of analysis leads to a different perspective on quality. The objective of introducing a quality management system is not necessarily the direct improvement of quality; the aim might be to change the culture in such a way that the introduction of a quality management system becomes culturally feasible. For example, Quality Assurance (QA) is concerned principally with a production view of quality and thus can only improve use quality indirectly, but the introduction of QA might be a catalyst that instigates organizational change enabling the creation of a quality culture.

5.3 Defining a Relevant Notion of Use Quality

The systemic models of purposeful human activity are compared to the 'real' world and form the basis for intervention in the problem situation. The use of the 5Es allows debate to focus on what constitutes quality (a successful transformation) in the human activity system and to then talk about what quality factors and metrics might reflect the notion of use quality in the 'real world'. This process is shown in Figure 4, where the definition of quality involves two streams of analysis: logic-based and cultural.

Logic-based analysis involves the stages:

1. Exploration of quality.
2. Identification of quality factors.
3. Trade-off of quality factors.
4. Identification of quality prediction and quality assessment metrics.

The central position of learning in the logic-based analysis of use quality reflects the need for a continuous cycle of purposeful action ('improvement') and reminds us that the notion of use quality will change over time, reflecting the changes in

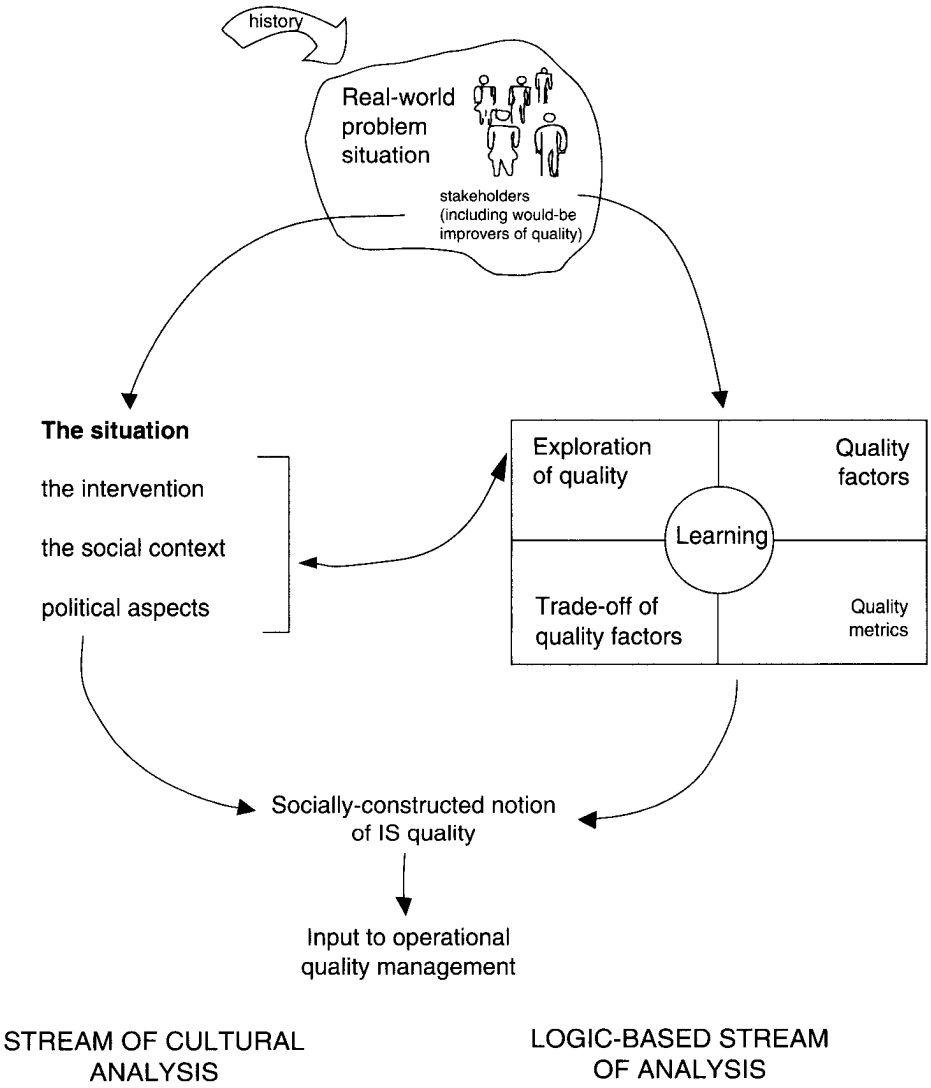

Figure 4: *A framework for defining a relevant notion of IS use quality (adapted from Checkland & Scholes 1990, Wood-Harper & Avison 1992)*

6 Conclusions

6.1 Summary

Software quality may often be a prerequisite to IS quality, but is not in itself sufficient. IS quality requires the consideration of the software artefact in use within an organisational context. There is unpredictability associated with the use of software artefacts which means that however well a software artefact satisfies a requirement specification prepared at a given point in time the use of the artefact will change as the organizational context changes. IS quality is made manifest in use and cannot be attained through a perspective that is wholly production-oriented. A production view of quality may lead to software artefacts that are considered by the supplier to have quality, but does not guarantee that those software artefacts will be effective in an organisational context.

But, whose use quality is it that is to be satisfied? The presence of multiple stake-holders with different perspectives means that the definition of use quality (the 'ends') is just as problematical as the management of quality (the 'means'). Given the social nature of use quality, we have argued that the principles of SSM provide a firm basis for defining use quality. The construction of systemic models and the application of the 5Es criteria (efficacy, efficiency, elegance, effectiveness and ethicality) leads to the identification of quality factors, which can be assessed using quantitative techniques. However, despite the appearance of objectivity, software metrics only have meaning within an organizational context and should be considered to be 'value-full' rather than 'value-free' (Ackoff 1974). Equally importantly, an SSM-based investigation leads one to consider and reflect upon the cultural constraints that may prevent the systemically desirable notion of use quality from being implemented successfully.

6.2 Future Direction

Current research plans include working with organizations in developing relevant notions of IS use quality. The management of quality is being addressed through a quality management framework that identifies those activities we expect an organization to be involved in if it is concerned with the use quality of its products (Vidgen & Wood-Harper 1993).

The use of stakeholder analysis and SSM would seem to be appropriate to situations characterized as 'complex/pluralist', while traditional approaches to quality typically assume 'unitary' situations. Whether the stakeholder analysis/SSM approach would be suitable in situations that are 'complex/coercive' is questionable. The recognition of different value systems may lead to the need to introduce techniques that address conflict and the role of power in a more rigorous fashion, such as critical systems heuristics (Ulrich 1983, Flood & Jackson 1991).

With respect to the investigation of use quality, we are particularly concerned with the notion of systemic desirability and cultural feasibility. Much of the effort

in the practical application of SSM seems to focus on the logic-based stream of analysis, to the possible detriment of cultural analysis. We see the metaphor of production and use views of IS development as a useful epistemological device, but recognize that they also need to be seen as inter-dependent. Similarly, systemic desirability and cultural feasibility can be seen as a duality; the culture constrains what changes are perceived to be meaningful, but any action will recreate/create the culture (i.e., will change or reinforce ideas about what is considered to be meaningful). We consider that the perception of the problem situation as a duality of agency and structure, as expressed in structuration theory (Giddens 1984, Walsham 1993), will provide a richer scheme for the interpretation of IS quality in particular and SSM in general.

Acknowledgments

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