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Peter Bennetts
University of Gloucestershire Business School

Trevor Wood-Harper
University of South Australia

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Peter D. C. Bennetts
University of Gloucestershire Business School
pbennetts@glos.ac.uk

Trevor Wood-Harper
School of Accounting and Information Systems
University of South Australia
trevor.wood-harper@unisa.edu.au

Information Systems Institute
University of Salford
a.t.wood-harper@salford.ac.uk

Abstract

Despite the "espoused theory" that the development of MIS should be overtly rational, the "theory in practice" recognises that system development was prone to failures if various interpretative issues were avoided. This paper considers two concerns relating to Churchman's examination of Design Issues. For Churchman's device of a hierarchy of Inquiring Systems there is a mechanism to allow the performance of the system to be measured against some goals. The key point here is that measurement may need to be qualitative. In that situation the development of MIS cannot be a Singerian inquiring system.

The paper presents a list of conditions which Churchman claims need to be true before an entity can be considered to be a system. These conditions are written in terms of three generic idealised roles, which in turn, define how the roles are expected to function. However, the first nine conditions are seen to be necessary and sufficient and they define how the measurement of performance is expected to function. The conditions are not supported by an explicit argument, so this paper uses a case study to examine these conditions and clarify their significance and in particular, whether they are coherent. The insight gained depends on the component measures and total systems measurement, as defined by Churchman. In the context of the case study, it would appear that the organisational goals need to be aligned with IT goals (for the total system and component system, respectively). The idealised role play types are examined similarly, by considering how the conditions need to be interpreted in order for them to describe a potential reality based on the case study. The case study is used as an example of a hierarchical, bureaucratic organisation.

The conclusions suggest that there are unexpected constraints on the measurement of performance and that the Designer uses two modes of thought – one internally focused on the organisation as a system; together with its component subsystems and an externally focused mode which examines the external world. If this last observation is applied to IT as a component system, then we can map the internal mode on to rational approaches and mark the interpretative items of office politics.

Introduction

Software engineers argue strongly that the methods of information systems development (ISD) should reflect the attitudes and approaches of an applied science (Boehm, 1976; Hoare, 1982; Younessi, 1998, for example). In particular, they wish to ignore all issues, which do not reflect this overtly rational process (Goguen, 1993). Similarly, Churchman's (1971) framework for inquiring systems and their design is based on approaches such as systems engineering and developed in the context of the cause-

effect model of physical science. However, as Avison and Fitzgerald (1999) show, perceptions of what constitutes a relevant paradigm for ISD have changed over time. In the UK, Mumford (1983, 1995) (with ETHICS) and Checkland (1981), Checkland and Scholes (1999) (with SSM) were among the first to recognise the need for a wider more interpretative viewpoint.

One purpose of this paper is to examine Churchman's perception of the measurement of performance for systems and their components. A case study will be used to assist the argument. The paper presents a list of conditions which Churchman claims need to be true before an entity can be considered to be a system. These conditions are written in terms of three generic idealised role, which in turn, define how the roles are expected to function. The conditions are not supported by an explicit argument, so this paper uses a case study to examine these conditions and clarify their significance and in particular, whether they are coherent. Subsequently, the idealised role models will be considered.

After this general introduction, the next section develops Churchman's characterisation of design. The primary result of this is a table of conditions for something to be a design system. The nature of the measurement of performance is considered in Section 3. In order to gain insight by looking at an actual example, Section 4 introduces the bare bones of a case study, which is used in Section 5 to look at measurements of performance and again in the following section to examine the role play set up by the conditions. In both these last two sections Churchman's concepts are examined in such a way as to make them appear as successful as possible. Some conclusions are then offered.

Introduction to Churchman's Theory of Design

Design for Churchman (1971) requires the designer to identify the system and its components. Alternative designs are considered, questions asked and hence knowledge gained. Consequently, as a means of gaining insight about design, he examines the nature of some generic modes of inquiry. He develops these ideas by referring to an appropriate set of philosophers. The corresponding inquiring system represents "a reconstruction of [that philosopher's] ideas [about the theory of knowledge] in the language of the design of an inquiring system." (*ibid*.). Churchman does not give a rationale for choosing his particular selection of philosophers. His aim is to use those philosophers' ideas to elucidate what is meant by "design" as well as "system". This paper considers the design of one particular class of system - information systems. Further, the "purpose of an inquiring system is to create knowledge which means creating the capability of choosing the right means for one's desired ends". Churchman is interested in "the meaning of a system from the designer's point of view, i.e. in the 'systems approach' to social change" (*ibid*.).

Conditions 1 to 9, in Table 1, are seen by Churchman (1971) to be necessary conditions for "something S [to] be conceived as a system". These necessary conditions will be used in the comments on measurement of performance. In this particular case Churchman implies S is an "inquiring system", as the purpose of that text is to develop the concept of inquiring systems to explore the nature of design. For Churchman's enquiry into the nature of inquiring systems, there are three generic figures whose existence is necessary (*ibid*.) - the designer, the client, and the decision maker. These figures are archetypes or idealised role models whose actions are described by Churchman (1971) through the conditions given in Table 1. Each archetype can be one person or many people or all three can be found in one person (*ibid*.). Further, each archetype is assumed to have a recognised set of interests or values that are to be addressed by any inquiring system.

Churchman is interested in "the meaning of a system from the designer's point of view, i.e. in the 'systems approach' to social change" (*ibid*.). Checkland (1981) notices that Churchman's writing is based implicitly on hard systems thinking. Further, Checkland characterises this approach as goal-oriented (based on the optimisation paradigm). Vickers (1965), argues that this paradigm is "... totally inadequate" to explain what happens in an organisation. However, this "totally inadequate" paradigm represents the traditional approach with the characteristic that users tended to be ignored.

For those taking an interpretative stance, the users are key actors. It is the users who act as organisational agents who interpret and make sense of their surroundings. Also, in this scenario, the systems developer acts as the change agent who helps users make sense of the new system and its environment. In this context, information systems development creates new meaning. Its effectiveness lies in its ability to improve users' understanding of current conventions and meanings. Information systems development proceeds through the application of symbolic interactionism (where organisational actors interpret system objectives and specifications and act according to the meaning their interpretation provides for them). The social environment is under continuous evolution - no particular rational explanation clarifies organisational reality. Consequently, the philosophical assumptions are an anti-positivist epistemology (which considers that the search for causal empirical explanations for social phenomena is misguided and should be replaced by sense-making) and a nominalist ontology (which suggests that reality is not a 'given', but is socially constructed and consequently uses social relativism as its paradigm). Thus, from this approach, the business world is explained from the viewpoint of organisational agents who take part in the social process of reality construction.

Measurement of Performance

Churchman (1971, pg. 184) recognises the subjective foundation of measurement with a Lockean community for measurement. In order for a measure to be meaningful, the community agrees a standard and a unit (*ibid.*, pg 188) In particular, measurements give readings which accurately describe some aspect of reality (*ibid.*, pg. 186) This accuracy is reflected in a hierarchy of measurements and corresponding hierarchy of Inquiring Systems. In this way "inquiring systems commit themselves to be to the idea that every meaningful descriptor of natural objects can be partitioned.

Later in his text, Churchman (1971, p. 186 et seq.) considers some sample measurements, which are used by a Lockean community. If there is disagreement within that community, this needs resolving at a higher level of refinement (ibid, p. 102). Initially, this is addressed by partitioning. Thus a descriptor of a "natural object" (P) is partitioned into descriptors P_1, P_2, …, P_n if the following hold

If X is P_i, (i=1, 2, …, n) is considered to be true by the inquiring system, then so is X is P.
(1) If X is P is considered to be true, then either X is P_1, or X is P_2, … or X is P_n is true.
(2) If X is P_i is true and X is P_j is true, $i \neq j$ is never true.
(3) $n > 2$.

The above partitioning can be created, quite naturally, from an objectivist ontology. Again, Churchman accepts subjective measures will be needed.

The ontological assumption of partitioning is often expressed in terms of quantification, as this is a neat way of satisfying the conditions for partitioning or refinement. Indeed, Churchman explicitly commands that the essence of qualitative requires the contrary ontological assumption that nature is reduced to a set of descriptors which cannot be partitioned. Further, Churchman dismisses the problem for the time being, asserting that Singerian inquiring systems are assumed to be quantitative so that partitioning is meaningful, if perhaps extremely difficult to implement. We notice, however, that Churchman was considering natural objects as inquiring systems. The case study however, reflects a different interest. Thus organisations and information systems not only do not occur in nature, they are effectively abstract. Can they be considered as Systems in Churchman's sense? This issue will be pursued in Section 5. For the moment we consider what will be a key issue – measurement of performance.

In Table 1, Condition 2 says categorically that an entity can only be a system if it has a measure of performance. This measurement is characterised by the following definition (Churchman, 1971, pg. 50/51):

S is a system only if the following three statements are each true.
S1. S is seen as being teleological AND has a measurement of performance, M.
S2. S is seen to have teleological components, each with their individual measurements of performance, m_i.
S3. The designer can conceive how changes in the component measurements $\{m_i\}$ (representing the set or collection, of all the individual m_i), will affect the value of M (the overall measurement of performance).

Churchman identifies three types of relationship between the component measures and the total system measure.

Weakest (a necessary condition): M is at maximum when the system is operating perfectly and this happens if and only if the value of the measurement of performance for each and every component measure, m_i, is also maximised. The designer, in this case does not want to espouse an explicit relationship.

Moderate: M is increased by each and every increase in the measures, $\{m_i\}$. The designer in this case hopes to improve the system part by part. If there is any interaction between parts, another part is addressed.

Strongest: M is a function of $\{m_i\}$, only AND there is a global maximum. The designer, in this case is committed to an explicit mathematical relationship.

It would appear that all these measures (M and $\{m_i\}$), are expected to be real numbers (Churchman, 1971, pg 50/51). ("S is mapped ... onto a bounded real number scale").

Table 1. The Conditions for a Design System (after Churchman, 1971)

The necessary conditions:(Churchman, 1971, pg. 43)

1. "S is teleological" (i.e. defined within a cause-effect model of nature).
2. "S has a measure of performance" (a number (*ibid*., pg. 47)).
3. "There exists a client whose interests (values) are served by S in such a manner that the higher the measure of performance, the better the interests are served, and more generally, the client is the standard of performance."
4. "S has teleological components which coproduce the measure of performance of S."
5. "S has an environment - which also coproduces the measure of performance of S."
6. "There exists a decision maker who - via his resources - can produce changes in the measures of performance of S's components and hence changes in the measure of performance of S."
7. "There exists a designer, who conceptualises the nature of S in such a manner that the designer's concepts potentially produce actions in the decision maker, and hence changes in the measures of performance of S's components, and hence changes in the measure of performance of S."
8. "The designer's intention is to change S so as to maximise S's value to the client."
9. "There is a built-in guarantee that the designer's intentions [are realisable (eventually)]."

The designer:

10. The designer has to identify "the client and the decision maker" (*ibid*., pg. 48).
11. "The designer needs to have a theory about his role as well as a theory about the system." The designer must "learn about the system" and understand the influence that he can and should have on the system changes that will be required (*ibid*., pg. 52).

The designer and client:

12. The designer has a value structure identical to that of the client (*ibid*., pg. 47).
13. As an actor in this scenario, the client is "described only in terms of his value structure" (*ibid*., pg. 47).
14. The designer invokes a world in which the client could change whatever was wished "within the bounds of limited resources" (*ibid*., pg. 47).
15. The designer seeks to describe the underlying principles of the client's choices, using a "measure of performance" (*ibid*., pg. 47).
16. "The designer is successful to the extent that he can accurately measure the client's real preferences" (*ibid*., pg. 47).
17. The designer must analyse possible futures by designing and, in principle implementing each of them. The measure of performance is used to "assign numerical values to these possible futures" and hence rank them against each other (*ibid*., pg. 47).
18. "The designer is moral if he serves a client who has a legal or moral right to expect that the system will serve his (the client's) interests and his interests are themselves legal or moral" (*ibid*., pg. 48).
19. If the decision maker's ideas about a system are not seen as "good" by the client, then "the designer's role [is to] try to change the decision maker's value structure" (*ibid*., pg. 48).

The designer and decision maker:

20. The designer is expected to choose the decision maker in a way that will maximise the measure of performance (*ibid*., pg. 52).
21. The designer's ideas about a system are expected to produce changes in the actions of the decision maker and hence changes in the measure of performance (*ibid*., pg. 48).
22. "The decision maker coproduces the future along with the environment, which he does not control" (*ibid*., pg. 48).
23. The environment is defined by what is not changed by the decision maker. Decisions about what will be changed by a decision maker and what will not be changed depends on the decision maker (*ibid*., pg. 52).
24. The decision maker also has a value structure, but it is not necessarily the same as that of the other two actors (*ibid*., pg. 48).

However, there are some assumptions here that need to be addressed by a short excursion into measurement theory. These concepts of measurement flow from the ideas of science and engineering which support software engineering. Fenton (1991) recognises five scale types; where a scale type is a type of scale or a method of measuring. Table 2 summarises the mathematical description of these scale types. It should be noted that each scale has different mathematical operations available to it. Two concerns arise in particular, the Nominal scale would be appropriate for the qualitative evaluation of entities. This is worthy of note because, for example, if the measure was based on the user perception of a system, then the measure may well be deduced

from a questionnaire. Then the values returned will represent Lickert scales and although these can be written using digits, the digits should not be considered as integers, as, in this case, they are only symbols for a rating level and any set of ordered symbols would do as well. It could be tempting to consider digits as integers and these integers as a subset of the real numbers. However, this would give rise to spurious mathematics. Further, when Churchman, (1971, pg 51) writes, "he [the designer] can estimate the optimal design of each component by mathematical means", he would appear to require the measurement to be with real numbers and to be mathematical. The implication, therefore, is that an Absolute scale type is being invoked.

Table 2. Measurement Scale Types (after Fenton, 1991)

Scale Type	Admissible Transformations	Defining Relations	Mathematical Functions	Examples
Nominal	M' = F(M) (F a 1-1 mapping)	Equivalence	Can not use + or -	Labelling / classifying entities
Ordinal	M' = F(M) (F monotonic increasing)	Equivalence. Greater than	Can not use + or -	Preference, hardness, air quality, intelligence tests - raw scores
Interval	$M' = \alpha M + \beta$ $(\alpha > 0)$	Equivalence. Greater than. Known ratio of any two intervals	Differences matter, unit exists, but not zero. Can use - ; but +, * and ÷ only on intervals	Time (calendar), temperature (°F, °C), intelligence tests - standard scores
Ratio	$M' = \alpha M$ $(\alpha > 0)$	Equivalence. Greater than. Known ratio of any two intervals. Known ratio of any two scale types	Unit and zero exist. Can use +, -, * and ÷	Time interval, length, temperature (°K)
Absolute	M' = M		Unit and zero exist. Can use +, -, * and ÷.	Counting

A Case Study

A small case study is used to characterise the usage of measurement of performance. The study was originally described by Bennetts, Mills and Wood-Harper (1998). The study concerns a large company in the financial services sector with branches across the country (Organisation A). The aim of the case study was to gain insight concerning the actual operation of software quality assurance in a large organisation.

Three goals have been identified which relate to the production of software by this organisation:

a) reduce the cost base by improving processes
b) focus on the customer and give them what they require
c) focus on arrears, possessions, provisions.

Quality, as seen by the customer, is recognised by the absence of post-implementation faults. If present, these faults are examined and backtracked to design. A customer satisfaction survey system exists, but is not yet used by senior management.

The software development process is controlled via quality manuals and reflecting customised systems' life cycles. Risk management is not yet felt to be good enough. The risks for each project are defined by the project leader and embedded into each project's quality plan.

Despite an active quality culture in this organisation, each respondent had different ideas about what the organisation was looking for in software quality. Further, as individual practitioners, their views were different to those they thought the organisation had. In order to identify the goals (or factors) of software quality recognised by both the organisation and its staff the goals identified by Boehm *et al.* (1978); Gillies (1992); Hines and Goerner (1995) and McCall *et al.* (1977) were collated. The eight goals in the organisation's Quality Policy document were ranked in the decreasing sequence of importance (Functionality, Usability, Performance, Security, Reliability, Supportability, Maintainability and Operability). These characteristics were all in the list of 18 possible goals. Unfortunately, this sequence was not given as a response by any respondent.

Observations on Measurement

It would seem obvious, intuitively that any commercial organisation can be considered to be a system. Further, a quick check through the conditions of Table 1, the organisation can be considered as a Design System. Given that organisations can identify specific goals for themselves, can the organisation be considered as an inquiring system? In practical terms, it might be useful to be able to use Checkland's (1981) assertion that his soft systems methodology is supported by a Singerian inquiring system. Treating an organisation as a Human Activity System is one thing, but confirming its supporting philosophy another. If the organisation were to adopt "increased market share" as a goal, for example, then the organisation itself would be acting as an inquiring system. Refining a measure within that, which satisfies Churchman's definition for an individual information system does not appear to be straightforward as other goals come into play, some of which are qualitative.

If Information Systems Development (ISD) is treated as a system with software quality as its focus, rather than economy or profit, together with the practitioners as components, each of whom (conceptually) has their own measure of performance, some of which may be qualitative. For example, lines of good code per calender month (for a COBOL programmer); expertise in this aplication domain (for a systems analyst); level of morale in team (for project leaader), but other measures could be made. Then, reflecting the case study) the following observations can be made:

- Usability, in particular, has many metrics associated with it, but the concept itself is essentially subjective, so there can be no effective quantitative metric for this aspect of quality.
- The overall measurement of performance is undefined as there is no quantitative measure for Usability.
- As the practitioners were after different goals than their organisation, maximising M has no connection with the individual m_i, so the relationship is not "Weakest".
- Again, given that the $\{m_i\}$ were different to the erstwhile overall measure, if there had been one, so the relationship is not "Moderate".
- There is no justification for any equation creation, so the "Strong" relationship is also unavailable.

On the face of it, the results of this study might suggest that this is a counter-example to Churchman's perception of a system. However, this is not the case. All that is needed is a relaxation of the requirement that the measure be a real number. As argued above, performing mathematics on Lickert scale numbers could lead to spurious mathematics, so the expectation that the measure of performance has to be a real number. To achieve a relationship between the overall and component measures is not always easy but if the practitioners' goals could be aligned with those of the organisation, then a Moderate relation would be achieved, because then it could be argued that, if the overall goal was related to quality, and if the component's goals were also quality related, increasing the quality of a component has a positive effect on the quality of the whole. Different quality aims can be connected by techniques such as balanced score card or Kiviat diagram.

Role Play

To explore Churchman's (1971) conditions as given in Table 1, we reuse the case study. In this scenario, there are several layers of manager, from systems analyst/programmer to MD. From an organisational point of view, each layer of management will have its own (partly hidden) agenda. If a new information system is wanted, we have already seen that their software quality goals are individual. At these layers in the hierarchy they have no control over financial goals. The managers have their own goals plus the official software goals and also some idea about finance. The senior managers and MD are on the board and so have control over the financial growth of the company. Consequently, Churchman's presumed measurement of performance only comes into play for top level staff.

The results of positing each condition are drawn together in Table 3. In this Table, the Condition Number is identified in column 1. In column 2 it is noted whether or not an appropriate interpretation could be identified directly. Three levels of agreement are used. Full acceptance is noted by "OK", partial acceptance by "Maybe", concern by "No". Column 3 offers indicative comment on why column 2 has received that particular setting. A "*" in this third column implies that further comment is in the following text. Thus most conditions appear to be satisfied, with conditions 3, 8, 10, 15, 18 and 21 being potentially satisfied and conditions 5, 9, 12, 14 and 20 not satisfied at this initial stage of interpretation.

Table 3. The Conditions Applied Initially to the Case Study

C.No.	Status	Comment
1	OK	The system has purpose and design.
2	OK	Assuming a qualitative and composite measurement of performance.
3	Maybe	Client is staff in all branches. As measurement of performance increases the client *may* gain.
4	OK	Subsystems can be treated as systems. What does "coproduce" mean?
5	Maybe	Why is measurement of performance co produced? *
6	OK	Decision maker = MD/Board/Managers/Staff, as appropriate.
7	OK	Designer = MD/Board/Managers/Staff, as appropriate.
8	Maybe	That is the intention, but it may not happen
9	No	That depends on who is driving the project and the extent of political will and the availability of resources.
10	Maybe	Presumably?
11	OK	Of course.
12	No	Why should I be able to say this is true? *
13	OK	The client's value structure needs to be described.
14	No	Do all organisations offer their clients exactly what they want?
15	Maybe	Presumably?
16	OK	By definition.
17	OK	Presumably.
18	Maybe	The condition defines the moral designer. *
19	OK	Sounds like "office politics".
20	No	How can the designer choose the decision maker who is chosen by the organisation? *
21	Maybe	Provided Conditions 15-20 hold.
22	OK	By definition.
23	OK	By definition.
24	OK	By definition.

Further insight needs to be deduced in order to gain full acceptance. For example, those conditions that are potentially satisfied would be satisfied if it was possible to take an optimistic view. From this it is deduced that the role play is performed not only by *ideal types* but they exist in an *idealised scenario*. In practice that also includes all remaining conditions except Conditions 5 and 20, i.e. Conditions 3, 8, 9, 10, 12, 14, 18 and 21 are now included.

Condition 5 requires the environment of the system to play a part in creating the value of the measurement. Do we take "coproduction" to mean that the goal to be measured is selected from those for which an independent assessment, external to the system, will be available (or createable for a price)? If we consider Condition 5 in the context of the case study, there are both financial and quality goals to satisfy. The financial goals are set at the level of the organisation and so the system, as such, is at the level of the institution. However, the quality goals are addressed by branch staff within that system. However, the Hierarchy Principal tells us that any system is part of a supersystem and consequently acts as a supersystem to a subsystem. Hence, for Organisation A, to achieve the demands of Condition 5, it is posssible to identify a subsystem, the boundary of which follows the system boundary in all respects except that staff are outside the boundary.

If Condition 12 was re-written as "The designer has an intimate knowledge of the client's value structure", it would be closer to actual practice. Also, Condition 5 assumes all clients have the same values, which would be an idealisation.

Condition 18 presumes that both that designer and client wish to be moral. However, one or other of them could be other than they seem.

In the context of information systems in organisations, there is a natural limit on size - the organisation. Beyond that, although the organisational systems are, hierarchically, part of other supersystems, for those in the organisation, they form part of their environment. The designer, therefore, for Condition 20, that the designer acts in two modes. *Mode 1 is focused on the system*

and making it achieve the desired end. *Mode 2 is focused on the environment* as the designer "heroically" tries to change it. This perception is useful, in this context, as the nature of the design moves from the essentially technical to the essentially political (from ISD to social engineering).

Conclusion

The paper has focused on two critical issues in design - "Who does What?" and "How do you know you have achieved your goal?". For the latter issue, the measurement of performance was seen to be potentially more complicated than a single number. The corresponding problem in Software Quality Assurance, could be addressed by techniques such as "balanced scorecard" or "Kiviat diagrams", provided the measures were of at least Ordinal scale type. If component aims were not aligned with those of the organisation, then any improvements for a component do not necessarily get passeed up to the whole and vice versa. Hence

For the initial issue, the archetypical roles being played were observed to work in an idealised environment. Some goals that need to be assessed qualitatively may need to refer to a conceptual subsystem. The Conditions idealise clients to have the same values as well as insisting that both designer and client are moral. Finally, the designer's activities within and external to an organisation are perceived as two different modes.

References

Avison, D.E. and Fitzgerald, G.; "Information Systems Development" *In* Currie, W. and Galliers, B. *Rethinking Management Information Systems - An Interdisciplinary Perspective* Oxford UP; 1999.

Bennetts, P.D.C., Mills, S. and Wood-Harper, A.T.; "A Qualitative Approach to Organisational Goal Setting for Information Systems Development", *In* Hawkins, C., Ross, M. and Staples G. (eds.); *Proceedings of the Sixth International Conference on Software Quality Management*, Amsterdam; Springer-Verlag, London; 1998; p. 38-49.

Boehm B.W., Brown J.R., Kaspar, H., Lipow, M., MacCleod, G.J and Merrit, M.J.; *Characteristics of Software Quality*; Elsevier, North-Holland; 1978.

Boehm, B.W.; "Software Engineering" *IEEE Trans. Computers*; 1976, Dec., pp. 1226-1241.

Checkland, P.B. *Systems Thinking, Systems Practice,* Wiley, Chichester, 1981.

Checkland, P. and Scholes, J. *Soft Systems Methodology: A 30 year Retrospective,* Chichester, Wiley, 1999.

Churchman, C.W. *The Design of Inquiring Systems: Basic Concepts of Systems and Organizations.* Basic Books Inc., 1971.

Fenton, N.E.; *Software Metrics - A rigorous approach*; London, Chapman & Hall; 1991.

Gillies, A.C.; *Software Quality - Theory and Management*; Chapman & Hall, London; 1992.

Goguen, J.A. "Social Issues in Requirements Engineering", *Proceedings IEEE International Symposium on Requirements Engineering (RE93)*, San Diego, Calif.; 1993, p. 194-195.

Hines, M.L. and Goerner, A.A.; "Software quality: attributes and modalities"; *In* Ross, M., Brebbia, C.A., Staples, G. and Stapleton, J. (eds.); *Software Quality Management III Vol. 2: Measuring and Maintaining Quality* (Proceedings of the 3rd International Conference on Software Quality Management, Seville, April, 1995); 1995; p.137-146.

Hoare, C.A.R., *Programming is an Engineering Profession.* Technical Monograph PRG-27; May 1982; Oxford University Computing Lab., Prog. Res. Gp., 1982.

McCall, J.A., Richards, P.K. and Walters, G.F.; *Factors in Software Quality - Vol. 1 -Concepts and Definitions of Software Quality*; Rome Air Development Centre. RADC-TR-77-369; 1977.

Mumford, E. *Designing Human Systems.* Manchester Business School, 1983.

Mumford, E. *Effective Systems Design and Requirements Analysis: The ETHICS Approach*; Macmillan Press Ltd., 1995.

Vickers, Sir G. *The Art of Judgment - A Study of Policy Making.* Harper and Row, London, 1965.

Younessi, H. "Software process improvement: a multi-dimensional perspective"; *In* Rout, T. (ed.) *Software Process Assessment and Improvement* Computational Mechanics Publications, Ashurst, Southampton, 1998.