

QUESTIONES INFORMATICAÆ

Volume 6 • Number 4

April 1989

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The official journal of the Computer Society of South Africa and of the South African Institute of Computer Scientists

Die amptelike vaktydskrif van die Rekenaarvereniging van Suid-Afrika en van die Suid-Afrikaanse Instituut van Rekenaarwetenskaplikes

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Subscriptions

The annual subscription is

	SA	US	UK
Individuals	R20	\$ 7	£ 5
Institutions	R30	\$14	£10

to be sent to:

*Computer Society of South Africa
Box 1714 Halfway House 1685*

Quæstiones Informaticæ is prepared by the Computer Science Department of the University of the Witwatersrand and printed by Printed Matter, for the Computer Society of South Africa and the South African Institute of Computer Scientists.

Editorial

by

Derrick Kourie

It is my privilege to have been requested by the SAICS executive to take over the post of editor of QI from Professor Judy Bishop. I think it is in order to thank her on behalf of the readership for the fine job she has done in boosting the quality of the journal during her brief but effective term. It is also appropriate to thank the production editor, Quintin Gee, for his substantial role in producing the journal. I am grateful that he is still in the post, and for all the support and work that he continues to do.

My job as editor is directed towards the overall goal of serving the South African academic community in the various computer-related disciplines in particular, and the computer industry in general. A number of objectives which support this goal include

- ensuring that high quality papers are published, thereby providing a display window for computer-related research in South Africa
- boosting local and international circulation of the journal both within the academic community and in the computer industry at large, thereby promoting a fruitful interchange of ideas
- attempting to do this in a cost-effective fashion so that the limited financial resources of SAICS and the CSSA may be released (perhaps even modestly augmented) to promote their various other service-orientated activities.

A number of measures are planned which are intended to meet these objectives. I shall mention some of them below, while others will become manifest with the passage of time.

After much debate it has been decided to change the name of this journal from *Quæstiones Informaticæ* to *The South African Computer Journal/Die Suid-Afrikaanse Rekenaartydskrif*. It will be abbreviated to SACJ in English and SART in Afrikaans. Arguments against this name change include the conciseness and uniformity of reference in both official languages provided by QI, and a certain kind of catchiness to the name. Those in favour of the name change regard the new proposal as being more descriptive for ordinary mortals (i.e. non-Latin scholars), less pretentious, and therefore more inviting for a wider audience. The fact that the new title identifies the journal as South African is also regarded as important. Many readers would, I surmise, be fairly neutral about the name and adopt a philosophical "a rose by any name" position. Perhaps the divide is between those who opt for a high level of abstraction and information hiding, and

those who feel that a measure of refinement is necessary.

Regarding the quality of papers, I shall continually strive to ensure that papers submitted are reviewed by at least two relevant and competent specialists. It is appropriate here to thank all those who have so enthusiastically reviewed papers to date. This is a time-consuming, altruistic, backroom task, with very little explicit reward. To ensure that the burden is spread more equitably, I would like to appeal to readers to suggest additional names of people who could be approached for reviewing. Names of overseas contacts would be particularly useful.

I should also like to invite as much reader-participation in the journal as possible. There are several levels at which this may be done. The most obvious is by way of letters to the editor. Many people out there have strong ideas about a variety of subjects. In the absence of a decent national network facility (perhaps someday!), please feel free to use SACJ as your soapbox.

However, it is also evident that many people read many books for a variety of purposes. Why not share these insights by submitting book reviews to the journal, particularly with respect to books which could be prescribed for courses? If there are any book publishers or distributors out there who perchance may read this editorial, perhaps you should make inspection copies to lecturers contingent on a review being provided to SACJ!

I would also encourage researchers to continue providing a steady stream of research papers to the journal. Clearly, SACJ is in competition with other international journals for your research results. However, this is not a head-on competition. While it would be sheer hubris to pretend that SACJ is precisely equivalent to one of the more prestigious overseas publications, there are considerations which argue in favour of submitting certain kinds of research to SACJ. First, SACJ will be dedicated to providing a quick turnaround in reviewing and publication. Hence, it is an ideal forum for presenting and testing interim research results, and even for quickly assuring your stamp on potentially important ideas which you hope to flesh out later. Secondly, SACJ is the obvious forum to use for locally relevant research. Finally, and quite candidly, the competition for publication in SACJ is obviously not as intense as in a more prestigious international journal. However, I need to be most

explicit on the implications of this latter point.

SACJ should not be seen as a soft option in the sense that quality will be sacrificed. By this I mean that on some arbitrary scale of quality measurement, if CACM contains papers above say the 95% percentile, then SACJ should fall into about a 60% percentile category. Put differently, there is clearly a gap to be filled that lies somewhere between poor, inferior drivel and outstanding research contributions – a gap which SACJ will seek to fill. Papers will therefore be rigorously reviewed, and every effort will be made to ensure that the journal is worthy of international recognition – even if such recognition does not come about immediately. This is not the impossible task that some might consider it to be. There are several South African scientific journals that already enjoy a measure of international recognition (the South African Statistical Journal – to name but one). Furthermore, it is my perception that many of our academics who travel overseas discover – perhaps slightly to their amazement – that they are well able to hold their own with academics at peer institutions. This suggests that there is probably sufficient brain power, research ability and research activity in the country to ensure that the

goal of international recognition is attained.

As for the cost-effective functioning of SACJ, two points need to be made. First, SACJ will be available for a limited amount of advertising at R1000 per page and R500 per half-page. The computer industry and book publishers might wish to avail themselves of this offer, as might universities and employment agencies. Enquiries in this regard should be directed to Quintin Gee. Secondly, a modest charge per page (indicated elsewhere in this edition) will be levied on accepted research papers. This has become standard practice for most journals, the rationale being that the SACJ is one of the journals which counts for state subsidy purposes. However, the editor will have the right to waive such charges in deserving cases, as for example in the case of an author from industry whose company is unwilling to provide the financial support.

Ultimately then, SACJ will critically depend on your support. It will become what you, the reader, researcher and reviewer, make it. In a sense the South African Computer Journal will expose you, the South African Computer Academic, to the outside world without a single Latin phrase to hide behind.

The Application of Scientific Method to Information Systems Analysis

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Abstract

This paper addresses the challenging question of the rigour of the systems analysis process. First of all it discusses the nature of analysis, concluding that, contradictory to current opinion, it can best be described as an art. The processes of research and systems analysis are then mapped onto each other and the similarities are described. Some of the methods used by scientific researchers are then analyzed and a framework is proposed whereby the techniques and procedures for research can be integrated into the systems analysis process, thereby improving its overall rigour.

Received June 1988, Accepted March 1989

1. Introduction

Systems analysis, as a discipline, is approximately forty years old. While it is recognized as a vital task in the building of information systems, the principles upon which it is based, and the underlying philosophies, are in their infancy. An analysis of the literature dealing with systems analysis reveals that it has moved through three distinct stages. The early writings on the topic were fundamentally experiential with authors emphasizing practical methodologies. In the sixties there was a swing towards building a more rigorous approach as authors delved into systems theory and the scientific method to build a stronger foundation. In the third (and current) stage authors have reverted to the practical era, and this despite the emergence of MIS as an academic discipline [5]. Prominent researchers such as Couger and Knapp [4] state categorically that systems analysis has moved from the realm of an art to that of a science. In direct contrast to this the conclusion in this article is that because of the non-repeatability of the solutions and the objects of the analysis, the total analytical function can at best be described as an art. However, this should not be used as an excuse to down-grade the process to the level of witchcraft. Within the individual activities that comprise systems analysis there is scope for the injection of scientific procedures, provided that the philosophy and objectives are clearly understood.

The aim of this paper, therefore, is to revitalize the scientific approach to systems analysis and to draw comparisons between the processes of research and systems analysis, and to provide a basis on which to improve the analytical process. To achieve this end, three main areas will be examined. First, aspects of systems analysis and positivist science will be discussed. Scientific research will then be described and the elements of rigorous research will be superimposed on the

analytical process. Suggestions will then be made relating to specific aspects of the information systems analysis phase of systems development that would improve the rigour of the process.

2. The Scientific Method

The scientific view of the world is basically of a system in which all processes are governed by unchanging laws, and the aim of the pure scientific endeavour is to advance knowledge about those laws and processes - what they are and why they are. In pursuit of this aim, modern science employs three principles: reductionism, repeatability of experimentation, and refutation. Reductionism, which is used to simplify problems, has its foundations in Descartes' view of a problem in terms of parts or levels:

".... to divide each of the difficulties that I was examining into as many parts as might be possible and necessary in order best to solve it." [3]

The second principle of scientific method, repeatability of experimentation, distinguishes it from other disciplines. Proof of a theory is not dependent upon rational argument of why it should be correct, but on physical demonstration. Checkland [3] speaks of science as public knowledge which is demonstrated through experimental happenings. It is a knowledge which is not affected by interpretation, emotions, human bias or irrationality. Connected with the repeatability of experimentation is the measurement of values obtained. Facts expressed as quantitative results have more standing than qualitative findings, and are also more easily repeatable.

The third characteristic, that of refutation, is achieved through sequences of experiments which are used to test hypotheses. Each experiment re-tests and builds on the previous, thus adding to

knowledge (hence this process is also referred to as cumulative progress). The lack of cumulative progress in the information systems field has been written about by prominent IS researchers [5,11].

3. Views of Systems Analysis

A comprehensive scan of the literature on systems analysis indicates that the systems analysis function has moved through three discrete stages. Early writers regarded it as an art form, with the analysis aimed at documenting existing processes only [4]. In the mid-sixties this view changed as authors and researchers looked for a more rigorous approach. Lee, in one of the definitive publications on systems analysis [13] constructed an approach based on the scientific method. He wrote of problem definition (specification of the boundaries of the system), research (an observation of the operation of the systems and a specification of the problems), and the development of models coupled with the formulation of hypotheses. This built on the work of Johnson, Kast and Rosenzweig [12] who refer to the scientific method as a basis for systems analysis. This attempt at a rigorous approach to systems analysis was pursued by others such as Hare [8] who, as early as 1967, advocated a prototyping approach and the use of techniques such as "symptom-cause complex tables" and "differential diagnosis" as methods of understanding relationships and activities within a system. All these efforts were aimed at placing systems analysis on a firmer footing than the art form suggested by earlier authors.

In the third phase there seemed to be a reversion to the earlier approach. For instance, an analysis of books by Hodge and Clements [9], Licker [15], Leslie [16] and Davis [7] to name but a few, reveals almost no reference to the scientific approach with its emphasis on repeatability and rigour. This would force the conclusion that either the original suppositions were false, and that the scientific method had no place in systems analysis, or that authors were ignorant of the work of their predecessors. The latter being the case, MIS researchers are guilty of trying to build the systems analysis foundations in a vacuum instead of building on the works of others - the basis for good research and knowledge development.

4. Positivist Science and Systems Analysis

There are points on which the approaches of positivist science and systems analysis agree, but they vary greatly on the fundamental issues of

methods of observation, confirmation of results and repeatability. Systems analysis is largely based upon subjective enquiry, due to the fact that the systems investigated are of human creation, whereas scientific enquiry must be neutral. Another significant difference between the two can be found in their fundamental aims: the aim of science is the advancement of knowledge (Aristotle's *theoria*) whereas the primary aim of information systems analysis is to improve organizational work or data flows or to provide data to improve or aid decision making. It is therefore fairly obvious that the two are not compatible on major issues and that if the *positivist* definition of science is accepted, information systems analysis cannot be regarded as a science.

Does this mean that systems analysis is therefore relegated to the area of "black (or grey) art" or witchcraft (with the association of unstructured, ill-defined paths)? This would seem an easy solution. A more constructive approach would be to accept the artistic domain but to attempt to superimpose some of the disciplines and techniques of scientific enquiry into the procedure of systems analysis - not with the objective of lifting it into the realms of science but simply of improving its rigour and repeatability and therefore the correctness of the results.

This paper therefore proceeds by investigating the philosophy of research and its relationship to systems analysis. If the relationship holds then aspects of research (or scientific enquiry) could be transferred to analysis and built into the analysis techniques.

5. Systems Analysis and Research

Research is the process of careful search, of systematic investigation. Although there are many forms that research can take, the process aims at understanding a specific problem and building a solution. A research project, according to Howard and Sharp [10] consists of four phases: planning, data collection, analysis of the data and the formulation of conclusions, and the presentation of results. Leedy [14] refers to a cycle of planning, problem analysis, data collection and analysis and result presentation. Now compare this to the systems analysis process. Ahituv and Neumann [1] describe the analysis of a system as three stages: the preliminary analysis - during which the problem is analyzed and data is collected, the feasibility study when conceptual solutions are designed, and information analysis when the final solution is developed and the detailed systems proposal presented. These stages are referred to

by many other authors (eg Davis and Olsen [6], Lucas [17]) and demonstrate that at the macro level there is a close correlation between the processes of research and systems analysis. They both aim at the analysis of a problem and the creation of an appropriate solution (by adapting or inventing). They both aim at documenting the results so as to convey those results to a third party.

If the above argument is accepted then it follows that the systems analyst is a form of researcher and that elements of rigorous procedure should be as applicable to the one as to the other. Since the process of research is far older than that of systems analysis this paper focuses on that aspect - the procedures advocated by prominent philosophers of science.

The **Baconian** method advocates that there is no formal hypothesis, that the researcher should proceed to immediate empirical observation and deduce conclusions based on observations. His rigour is obtained through the nature of his observation. This inductive approach has received significant criticism in recent times by people such as Sir Peter Medawar [18] and Karl Popper [20]. Note, however, that it was fashionable in DP circles a number of years ago to refer to the unbiased nature of the analysis phase and to suggest that the analyst should refrain from formulating a solution (pre-judgement) until he was aware of all the facts (advocating the Baconian approach). This argument (thankfully) has been contested by a number of authors and the studies of Vitalari and Dickson [22] appear to support the contention that not only are hypotheses natural but that good analysts exploit them. An hypothesis can be liberating, leaving the researcher free to let his/her thoughts roam while proving the hypothesis.

Cohen and Nagel were at the other end of the extreme, advocating immediate hypotheses which, they claimed, were research directing. This is followed by inductive reasoning and observation. The problem with this approach is that the researcher formulates an hypothesis when there is insufficient data - much like an analyst suggesting a solution after a user telephones and says: "There is a problem with my system". The danger is that the analyst then protects his hypothesis and makes the facts fit the solution rather than vice versa.

The compromise approach, and the one that seems to have achieved the greatest acceptance by twentieth century researchers, was proposed by Galileo [19]. This has come to be known as the hypothetico-deductive approach and consists of the following steps:

Problem reduction to root forms

Selection of the simplest phenomena relating to the problem

Empirical observation of these phenomena

Projection of hypotheses

Deduction based on the hypotheses

Empirical proof of the hypotheses (relating the problem to the hypotheses)

Generalization

The correctness of each stage is established before proceeding with the next.

There can be no doubt that any researcher is measured in terms of not only the nature and extent of the project (the relevance to the object system), but, as importantly, the rigorous proof of his hypotheses. Failures of research are usually attributed either to an incorrectly specified hypothesis or to this lack of rigour. The many tools and techniques that are available to the researcher aim at improving his ability to understand a problem and to prove the results of his research. The tools and techniques available to the analyst, on the other hand, may help him to describe the object system in terms of flows but do not help him validate hypotheses concerning the true nature of the problems or solutions, ie they are description-orientated, not solution-orientated.

6. Applying a Research Methodology to System Analysis

Assuming that the approach of Galileo is the most rigorous and relevant to systems analysis, how could it be adapted to fit the systems analysis process? A possible methodological statement would consist of the steps shown in Figure 1. The point to note about the sequence is the emphasis on defining and understanding the problem and the focus on proof. The statement of an hypothesis and formulation of a solution is relatively late in the cycle.

7. On the Use of Hypotheses

The hypothesis is probably the most important intellectual instrument in research. Its function is to give direction in experimentation and observation, leading to discoveries even when not correct itself [2]. Analysts should beware of protecting the hypothesis through manipulation of the experimental results. Ideas should be subordinated to the facts, not vice versa. This can, to a certain extent, be overcome by the formulation of multiple, but not conflicting, hypotheses.

SCIENTIFIC METHOD	USE IN SYSTEMS ANALYSIS
Understanding the problem domain.	The boundaries and scope of the problem are defined.
Stating the problem in its simplest form.	The problem situation is reduced to the relevant factual situation.
Empirical observation of the problems in the object system	Observation is against a background of facts, which are either known (experience) or given (user supplied), and prior knowledge. The observation must also be focused using a specific set of objectives.
Problem analysis	This involves data collection concerning the problem to understand the true nature of the problem, and to clarify the requirements.
Hypothesis formulation	The analyst now postulates reasons for the problems and determines possible solutions to each problem based on experience, reading, interaction with other analysts, visits to other sites, and so on.
Solution deduction	The analyst now eliminates the incorrect hypotheses and refines the remainder. A conceptual solution to the system is developed based on those hypotheses.
Empirical testing	The proposed system is simulated to establish its feasibility and to prove that it is valid in terms of problem elimination. A prototype of the proposed solution is developed or it is mathematically simulated.
Generalization	The system is mapped onto the live environment as a final test.

Figure 1 Scientific method and systems analysis equivalents

Analysts are often warned not to "prejudge" a situation, but in many ways a prejudgment is an hypothesis. The fault lies not with the prejudgment, but with an inadequate, non-rigorous and subjective testing of that prejudgment prior to development of that system. As Beveridge so aptly states: "Probably the main characteristic of the trained thinker is that he does not jump to conclusions on insufficient evidence as the untrained man is inclined to do." [2]

8. Conclusion

This paper has attempted to define the relationship between scientific enquiry and

systems analysis. By deduction it has shown that information systems analysis cannot be placed in the scientific domain primarily because of the object being studied and the non-repeatability of the solution. Despite this, elements of the scientific method can be integrated into the systems analysis procedure to improve the rigour of the process and the correctness of the result. The two sections that most easily lend themselves to improvements are problem verification and solution testability. If systems analysis was a science, it could be argued that no solution should be designed and developed until tested conceptually and proved empirically. However, just because it is not, is no excuse to discard the

principles of scientific method and thereby ignore the aspects of conceptual testing and proof. This implies a detailed understanding of prototyping techniques and a very clear definition of experimental objectives (a useful by-product is that this forces modularity on the solution).

If it is accepted that the purpose of analysis (in the main) is to understand a problem, then the tools and techniques used by the analyst must be problem-directed. An examination of those currently used such as Data Flow Diagrams, Structure Charts, and Activity Charts reveals that they are purely descriptive in terms of process or data flow. They are not analytical and do not drive the focus of the analysis at potential problems. Further research into the analytical process should undoubtedly focus on problem analysis and the elimination of problems in system proposals by validating the conceptual solution.

The close relationship between systems analysis and research indicates that an important component in the education of analysts might be the scientific approach to research and even discussion of the philosophical nature of rigour, repeatability, falsifiability and objectivity. A more detailed understanding of these aspects in relation to the systems analysis domain will improve the process and perhaps systems analysts will one day be able to prove scientifically that for any given problem they have developed "the best solution".

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NOTES FOR CONTRIBUTORS

The purpose of the journal will be to publish original papers in any field of computing. These may include research, review and exploratory articles of interest to the journal's readers. The preferred language of the journal will be English, although papers in Afrikaans or other congress languages of IFIP will not be precluded. Typed manuscripts for review should be submitted in triplicate to:

Professor D G Kourie
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Manuscripts for review should be prepared according to the following guidelines.

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- The first page should include:
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 - author's affiliation and address
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 - an appropriate keyword list
 - a list of Computing Review Categories.
- Tables should be typed on separate sheets of A4 paper, and should be numbered and titled.
- Figures should also be supplied on separate sheets of A4 paper, and should be identified on the back in pencil with the author's name and the figure number. Original line drawings, and not photocopies, should be submitted.
- Mathematical and other symbols may be either handwritten or typed. Greek letters and unusual symbols should be identified in the margin. Distinguish clearly between:
 - upper and lower case letters
 - the letter O and figure zero
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 - the letter K and kappa.

References should be listed after the text in alphabetical order of the (first) author's surname, cited in the text in square brackets. References should take the following form:
[1] E Ashcroft and Z Manna, [1972], The translation of 'GOTO' programs to 'WHILE' programs, *Proceedings of IFIP Congress 71*, North-Holland, Amsterdam, 250-255.

[2] C Bohm and G Jacopini, [1966], Flow diagrams, Turing machines and languages with only two formation rules, *Comm.*

ACM, 9 (3), 366-371.

Manuscripts accepted for publication should comply with the above guidelines, but may be in one of the following three formats:

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