QI QUAESTIONES INFORMATICAE

Volume 4 Number 1 January 1986

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	SA	US	UK
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Circulation and Production

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1 Jan Smuts Avenue
Johannesburg 2001

Quaestiones Informaticae 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.

RESEARCH DIRECTIONS IN INFORMATION SYSTEMS

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ABSTRACT

The success of a research project depends upon the inputs and outputs selected by the researcher, a poor choice entailing useless results or wasted efforts.To avoid this one might consider the following alternatives:

1. Our present knowledge in the subject Information Systems largely consists of facts and engineering techniques, scientific principles being few and inadequate. This imbalance suggests that research aimed at extending the *scientific foundations* of the subject should yield more significant results than purely technical research.
2. Structural and functional similarities between information, business and academic systems indicate the existence of general laws that apply accross the interdisciplinary boundaries of the corresponding subject areas. Accordingly it should be possible to *transfer* principles and techniques from Business and Education to Information Systems and vice versa.
3. Economic History predicts that mankind is moving towards an Edensque state in which no one is obliged to work for a living. The information systems necessary in *that state* therefore constitute highly significant problems for research.

THE FOUNTAINHEAD OF PROGRESS

In the dawn of history primitive Man struggled for survival in an inhospitable environment, condemned to toil from dawn to dusk simply to secure the bare necessities of life. "You shall gain your bread by the sweat of your brow" (Genesis, 1974:4)

However, over the ages people made special efforts, beyond the minimum required for subsistence, to establish "fixed capital" - non-consumable machines, systems and education - which facilitate the subsequent production of consumables such as food, clothing, etc. As a result of those efforts, today we achieve a substantially higher standard of living with considerably less effort than our ancestors. And if the process of capital formation continues, Man can aspire one day to evade Adam's curse altogether and satisfy his creature needs virtually without any labour at all (Hohenburg, 1968:3).

Capital formation involves three distinct activities (Mende, 1985):

- routine production of machines, systems and education
- development of the designs of these items and their productive processes
- research to provide a basis for design.

These vary in their potential for diminishing the ratio of work to consumption. Present-day capital items still demand a large proportion of human involvement in their operation, and therefore producing more of them can only marginally diminish the ratio. To effect sizeable reductions demands dramatically improved designs, and so development activities offer much greater opportunities for progress.

However, design is limited by our - still very incomplete - understanding of Nature and Man, and truly revolutionary designs require corresponding advances in the natural and human sciences. Consequently *research* is the most significant of all the capital formation activities: the very fountainhead of progress towards Man's release from Adam's curse.

THE PROCESS OF RESEARCH

Accordingly universities, research institutes and the R & D departments of business corporations throughout the world employ people to carry out the research that is crucial to progress. Like many others, the process of research requires inputs, methods and outputs, success depending on the optimal choice of these three components.

The *output* consists of new knowledge - facts, principles and techniques that were previously unknown. Its significance hinges on the resulting benefits to mankind, in particular the designs of new capital items which can be derived from it: if one selects an aspect of information systems which urgently requires improvement, the chances of a significant research outcome are greater than if one selects an aspect which is quite satisfactory. Consequently to ensure success the researcher should carefully select the problem to be solved, choosing the one whose solution promises maximum benefits to mankind.

Similarily success depends upon careful choice of research *inputs* - empirical observations, readings in the subject literature, ideas in related subjects, original thought, etc. If one chooses an inappropriate input - for example empirical observation when the result can be derived by deduction from established theory, the research may require much more effort than really necessary.

The same applies to the choice of *method* - statistical hypothesis testing, mathematical modelling, logical inference, etc. An inappropriate choice of method can result in outright failure, for example a statistically insignificant result, or an inordinately long project duration.

Consequently if one leaps into a research project without careful preliminary selection of the most appropriate outputs, methods and inputs, a large proportion of the research effort may be wasted. To avoid this risk, one ought to consider various *alternatives* at the commencement of the project.

In identifying such alternatives one may consult existing literature. For example, textbooks on Research Methodology (e.g. Labovitz & Hagedorn, 1976) recommended various methods and inputs; and the " further research" sections of doctoral theses suggest potential outputs. The remainder of this paper presents some further alternatives - the author's favourites - which are particularily applicable in the field of Information Systems.

THE NEED FOR SCIENTIFIC PRINCIPLES

Firstly, it is suggested that the researcher should consider producing outputs in the form of scientific principles (Toulmin, 1953) - concepts and statements of specific relationships that exist between them - as typified by Ohm's Law: "current is proportional to voltage".

Analysis of established subjects such as Physics and Medicine reveals the existence of three distinct kinds of knowledge:

- facts, e.g. the fuction of the heart, the radioactivity of uranium
- principles, e.g. Archimedes' Principle, Ohm's Law of Resistance
- techniques, e.g. open heart surgery, the nuclear reactor.

These are complementary in alleviating the human condition: engineering techniques are based on scientific principles, and principles are based on facts.

Classifying the field of knowledge *Information Systems*, we find for example that the topic:

- Hardware is largely factual, e.g. functions of the disc
- Software is largely factual, e.g. fuctions of IF, sort, IMS
- Programming is largely technical, e.g. structure charting
- System Design is largely technical, e.g. flowcharting
- System Analysis is largely technical, e.g. data flow charting
- Information Systems planning is largely technical, e.g. top-down and bottom-up strategies.

Scientific *principles* are few and far between, e.g.

- a program consists of sequences, selections and iterations (Jackson, 1975:16)
- highly coupled modules are difficult to maintain (Yourdon & Constantine, 1979:85)

Comparing the relatively primitive and failure-prone application systems developed by information systems practioners with the highly sophisticated and succesful hardware devised by our colleagues the electrical engineers, one wonders what causes the disparity in achievement. An explanation of this is that the electrical engineers have much more extensive foundations for their engineering techniques, i.e. the science of Physics. This hypothesis is supported by the success of other subjects such as chemical engineering - based on well developed foundations of Chemistry - and Medicine, which relies heavily on principles of Biology, Biochemistry and Biophysics.

Further evidence is furnished by a classical law of Economics, that if a process employs multiple inputs, their marginal products should be equal. Applying this to the I.S. profession which employs inputs of factual plus scientific and technical knowledge to produce an output of practical systems, a marked deficiency in scientific principles would result in sub-optimal achievement. A similar effect is predicted for the process of research on Information Systems techniques.

Therefore it is to be expected that the lack of science in Information Systems could distinctly impede practical systems development as well as academic systems engineering research. Consequently research outputs that help establish a broad base of *information systems principles* are likely to prove highly significant.

PARALLELS WITH RELATED SUBJECTS

Secondly, there is reason to expect that researchers in the subject Information systems could obtain useful inputs from *related subjects* such as Business and Education.

Simpler information systems typically consist of two subsystems (Mende, 1982):

- a collection subsystem, comprising programs which collect data from sources in the system's environment and store it in a set of files
- an extraction subsystem, comprising programs which extract information from the files and distribute it to the users in the system's environment.

These are similar in function to the two major components of a trading firm:

- purchasing, comprising people who collect goods from suppliers in the firm's environment and store them in a warehouse
- marketing, comprising people who extract goods from the warehouse and distribute them to customers in the firm's environment.

And they in turn are also similar in function to the two major subsystems of academe:

- research, which collects knowledge about the world and stores it in libraries
- teaching, which extracts knowledge from libraries and disseminates it to students.

These functional and structural parallels may well represent particular instances of a *general body of principles* which apply across inter-disciplinary boundaries of Information Systems, Business and Education. General System Theory (Von Bertalanffy, 1972:14) prophesies the existence of many such principles, which "manifest themselves as analogies or logical homologies of laws that are formally identical but pertain to quite different phenomena or even appear in different disciplines". Consequently researchers in Information Systems should consider examining other subjects for potential inputs. And vice versa, they might look for opportunities of transferring Information Systems principles to other subjects. For example, the author has transferred Present Value ideas from Finance to Information Systems (Mende, 1984), and success criteria from Information Systems to Education (Mende, 1981).

FUTURISTIC RESEARCH

Finally The Eden Ideal suggests the need for a "futuristic" as distinct from an "evolutionary" approach to research.

Traditionally research is viewed as a cumulative process of adding new items to the growing stockpile of mans knowledge (Kuhn, 1970:2), each individual researcher building upon a foundation laid by his predecessors. The History of Science has modified that view on empirical grounds, replacing it with a perspective of knowledge successively evolving through turbulent phases of theoretical reconstruction and factual re-interpretation followed by calmer periods of cumulative expansion. Now the Eden Ideal challenges both the previous views on normative grounds.

If Man is ever to attain a state of no obligatory work, then in every decade researchers should provide a knowledge base for the new designs to be developed in the next. Consequently we need a future-oriented view of research, not as a process of extending or reconsructing past knowledge, but as a *deliberate preparation for the future*.

This has subtle implications for the researcher in the field of Information Systems. Rather than examine existing systems, he should investigate those required in Eden; instead of aiming to perfect the theories or methods of the past, he should seek those required to restore Eden. His attention should be firmly directed towards the information systems of the future.

That demands some pre-knowledge of those systems: finer detail in the broad framework of Eden as a state without obligatory work which suggest specific research inputs and outputs.

Such forecasts are obtainable by determining the characteristics of machines and supporting information systems which follow from the premise of no human involvement in their operation, coordination, manufacture or maintenance. For example, suppose a factory's machines are to be repaired without human intervention. Then every machine would need to be equipped with sensors which allow a supporting information system to detect malfunctions and despatch maintenance robots to replace defective parts. This hypothetical information system constitutes an input to the research process, and its problems suggest potential outputs.

As the solutions to such problems are likely to represent "breakthroughs", the researcher may well achieve enormous success by selecting inputs and outputs based upon a *forecast* of the information systems required in Eden.

CONCLUSION

Accordingly when selecting the inputs to a research project, one might consider

- searching other subjects for tranferable ideas
- predicting the information systems requirements of Eden

And when setting research objectives - i.e. the results to be otained from a project - one might choose to

- establish scientific principles
- solve problems relating to Eden's information systems.

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