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EDUCATION FOR INFORMATION SYSTEMS DEVELOPMENT

J G Krishnayya*
(at that time, at the Indian Institute of Management, Ahmedabad-380 015)

Now Executive Director, Systems Research Institute
17-A Gultekdi
Pune – 411 037
GeoConcept@vsnl.com
Website: www.sripune.org

O U T L I N E

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0. Summary

Some professionalisation of management is already noticeable today both in business and in government. Correspondingly, more demands are being placed on the existing 'information systems' of organisations, to provide the data basic to decision and policy-making. Increasingly it is being recognised that traditional concepts of financial "accounting" and descriptive "statistics" require updating, broadening, and integration with the purposes of organizations. The new technologies for information storage and processing must be assessed and used. A new profession - that of the information analyst and systems designer - is coming into being.

This profession will see very rapid growth in the immediate future with the coming into use of large, IIIrd generation computers to implement logistical and planning information systems in governmental administrative and planning agencies, businesses, municipalities, the military and so on. Applications oriented educational programs for such specialists are essential if computer-based information systems are to be more useful than their predecessors.

An international consensus is evolving that such programs should provide integrated insights to organisation behaviour, systems theory and computer technology. Much existing education for management deals with making decisions on the basis of available data and does not prepare the student for clinically analysing information needs in a systematic fashion. Similarly, existing computer science education, usually emphasising algorithmic problem solving rather than system dynamics, does not prepare the student for the discipline of evolving system specifications. The course proposed to be run at IIMA is described.

1.0 Professionalisation of Management

One of the most striking changes since independence in the Indian scene has been the increasing professionalisation of management processes both in government and in business. This has meant a greater concern for efficiency in operations, for relevant and pro else management decisions, and for the formulation of quantified plans for action. At the tactical, managerial control, and strategic levels this has meant greater need for information to support these activities.

In the case of smaller organisations, public or private, this additional information is coming from improved accounting methods, from the introduction of cost accounting and from greater attention to keeping of descriptive statistics.

1.1 Problems of Large Institutions

In the case of larger institutions, however, the demands for information are very often outside the scope of existing data patterns (e.g. Parliament asks for employment data about a public sector steel plant by domicile and length of service; but 30,000 employees' data is not available in that form and must be hand compiled.) By virtue of their size, such institutions also require larger stores of information, faster processing of information, and interactions with a wider variety of outside agencies, each with their own fields of interest, as well as among a wider variety of internal cells. Unfortunately, it would be premature to claim that computers have been of

great help in this situation.

Previous to World War II, the only such large institutions were the Indian Army, the Railways and the Post Office and perhaps Tata Iron and Steel Company. All of these functioned in essentially stable rind predictable environments; hence the sinews of their information systems were never under great stress. Today we have hundreds of large organisations and enormous tasks of coordination and planning in the central and state governments and in the headquarters of large enterprises, all interacting under considerable time pressure and subject to a rapidly changing social and techno-economic environment.

1.2 Information Systems Management in large institutions.

The need for complex information flow and storage systems is vary clear. These systems must be responsive to the changing economic and technological environment and to the growing expertise in the use of data on the part of managers in government and industry, who have to be prepared to respond to an over-broadening range of internal and external situations subject to ever-narrowing time constraints. With the advent of computer techniques as well as advanced optical and mechanical information devices, the management of information system has become a highly technical subject, (2), (3) the matching of organisational needs and technical feasibility requires experience and professional skills.

Nevertheless, since the evolution of existing information systems is gradual, their maintenance and operation do not pose problems beyond the learning capabilities of the professional and technical persons already in the field.

1.3 New Information Systems

Illustrative of the new type of management and planning situation, however, which requires the application of professional information system design skills is the one related to management and planning of the country' s science effort. Today more than twenty panels covering most sectors of science have each developed dozens of project recommendations. Many hundreds of research, development and pilot projects are already in progress. How are financial and manpower resources to be allocated among those projects? How are the projects to be evaluated and monitored? How are the production linkages and needs to be tied up on time? How are these decisions and processes to be modified as the external environment -national priorities, foreign exchange and know-how availability - changes? Providing answers to these questions requires the design and development of information storage-and-flow systems which are broader than the existing ones, quicker in their response, and more adaptable.

1.3.1 The Development & Planning Function

As information systems increase in importance, the costs of rnodifying them and of introducing now ones become significant. Therefore the development of information systems becomes a specialised organisation function distinct from their administration or operation - a function sensitive not only to existing organisational needs and contemporary technology but also to the trends in institutional purpose, in organisation structure and in information processing and storage equipment (i). In the information systems development function, questions of competitive efficiency replace earlier ones of feasibility; more coordination with line managers is required to

assure long term viability for the design. Investments in information systems are seen as investments in management capacity. In short, an information systems planning function is needed.

1.4 Overseas Experience

It is understandable that the industrially advanced countries have already faced these needs and the skill-bottleneck. In the Working Papers for the **IBI-ICC World Conference on Informatics in Government** (Florence, October 16-20, 1972) there were many indications of the efforts being made to provide professional training for informatics workers (see 4.1 - 4.7).

The United States, where management education has deepest roots, and where information technology including computers is most developed and widely used, has already a wide variety of short courses to upgrade existing skills, developed in response to market demand. Their attention has now moved to the development of new cadres from the Universities who will specialise in the system development function. They have looked at Management education **(MBA courses)** and found them stressing decision making techniques to use existing accounting information flows; they have looked at Computer Science education and found them concerned with computer hardware and software to the exclusion of the questions of application utility and economics which face the user. Their conclusion has been to push towards a now interdisciplinary curriculum (3) aimed at producing professionals who are not only user-oriented and application-wise, but also conscious of changing hardware limits and system potentialities.

European countries tend to be more hierarchical and elitist in their approach, reserving University type training for a very few specialists and attempting to provide graded work-a-day skills instead through a series of short courses, starting with programming, which can be taken and be certified as the person gains experience. This reflects the ancient 'guild' system of professional training where a person learns existing practices first, comes up to the state-of-the-art through years of experience, and then is considered ready for innovating work. However, the modular package of courses developed for the Netherlands (4.7) has much to recommend itself in a situation where a large number of informatics workers must be put through on- the-job training. Indian institutions like the military might find it relevant as one element in their manpower development strategy.

1.5 Different emphasis in Developing Countries

The relative emphasis to be given on the one hand to short term courses - which can impart techniques but cannot be multi-disciplinary and therefore do not offer a sufficiently broad understanding of context nor much perspective - and on the other hand to longer tern post-graduate courses of upto 2-3 Years, depends upon the employment structure of the country. In industralised countries 'informatique' is growing so fast that it is not possible to keep people out of the market for a long full-time course even though it provides a better basis for a professional career. In Chile, on the other hand (4.8) the University at Santiago has successfully offered a 2-year Informatics course because the country has a proportionately larger University stream then Europe. Not entirely paradoxically, since there are fewer informatics workers and because the design and development of large information systems is a new activity, developing countries need better trained and more multidisciplinary information system designers.

We feel that developing countries which come later on the scene have the load time in which to design longer, full-time, integrated courses for both new entrants and for managers with previous working experience as users of information. Such courses could run for 6 months, a year or two years, depending upon the background of the participants and the urgency of placing them in the field. (We note that four times as many 6-month graduates can be produced by the same group of instructors as 2-years graduates).

A comprehensive approach to the training problem should include the provision of modular short courses for managers and informatics practitioners who will need to know and support the information system development process. The courses being spoken of hero are quite apart from those required to train computer programrners and operators, etc. which can be conducted by a variety of agencies. Germany expects, for example, that whereas today 72.5% of EDP staff are programmers or operators, this will drop to 55% in five years, indicating an explosive increase in requirement for information analysts, systems designers and managers for whom professional education is required.

Existing training for management emphasises decision making on the basis of existing information, and does not prepare the student for analysing information needs in a systematic fashion. On the other hand, computer science education tends to be concerned with the algorithmic and problem-solving capabilities of computers without reference to the users or to the cost-efficiency of alternative systems and configurations. Library science, documentation or classification education is unfortunately never included with the other two, and separately it has a very narrow frame of' reference with an archival rather than a flow emphasis.

The problem then is to make up for these deficiencies and to offer an integrated approach to information analysis and system design.

2. Skills required in the field

Information analysis and systems development can be compared respectively to product design and manufacturing system design in an industrial operation (3). The former looks to the question of purpose and function for potential users of the product, and the latter looks to the question of what machines are needed to manufacture the product and how they should be organised.

A person functioning in either of these roles must have an understanding of systems relationships and of human behaviour. Information analysis requires that the organization be viewed in systematic terms, making it possible to formulate means and ends effectively. It also requires a mature understanding of the limitations imposed by human behaviour on formal organizational functioning so that feasible information system specifications may be produced. System design requires an understanding not only of computer system technology but also of human behaviour, since systems are used, operated and maintained by people.

2.1 Specific skills to be imparted*

The knowledge and abilities necessary to work effectively in this field may be characterised as obtainable by integrating concepts relating to people, models, and systems for the application of computer technology in the context of organizations and society.

*This section is abstracted from Reference (3), which may be read for greater detail.

Thus the requisite knowledge and abilities are conveniently grouped in six categories: (a) people; (b) models; (e) systems; (d) computers; (e) organisations (f) society. The first three categories are fundamental, and may be looked upon as providing tools for applications in the last three categories.

We may list here a few of the specific attributes required in reference to people, systems, computers and oganisations.

(a) **People**

- Ability to hear others, as well as listen to them;
- Ability to describe individual and group behaviour and to predict likely alternative future behaviour in terms of commonly used variables of psychology and economics;
- Ability to describe and predict task-oriented, time-constrained behaviour in an organizational setting.

(b) **Systems**

- Ability to view, describe, define any situation as a system - specifying components, boundaries, and so forth;
- ability to apply this “systems viewpoint” in depth to some class of organisations - manufacturing firms, government bureaus, universities, planning and service agencies etc;
- Ability to perform an economic analysis of proposed resource commitments (includes ability to specify needs for additional information and to make a set of conditional evaluations if information is unavailable);
- Ability to present in writing a detailed description of part of a project, for use in completing or maintaining same.

(c) **Computers**

- Knowledge of basic hardware / Software components of computer systems, and their pattern of configuration;
- Ability to develop several logical structures for a specified problem;
- Ability to develop several different implementations of a specified logical structure;
- Ability to develop specifications for a major programming project, in terms of functions, modules and interfaces;
- Knowledge of sources for updating knowledge of technology;
- Ability to make “rough-cut” feasibility evaluations (in terms of economic and behavioral variables) of proposed new techniques or applications of current

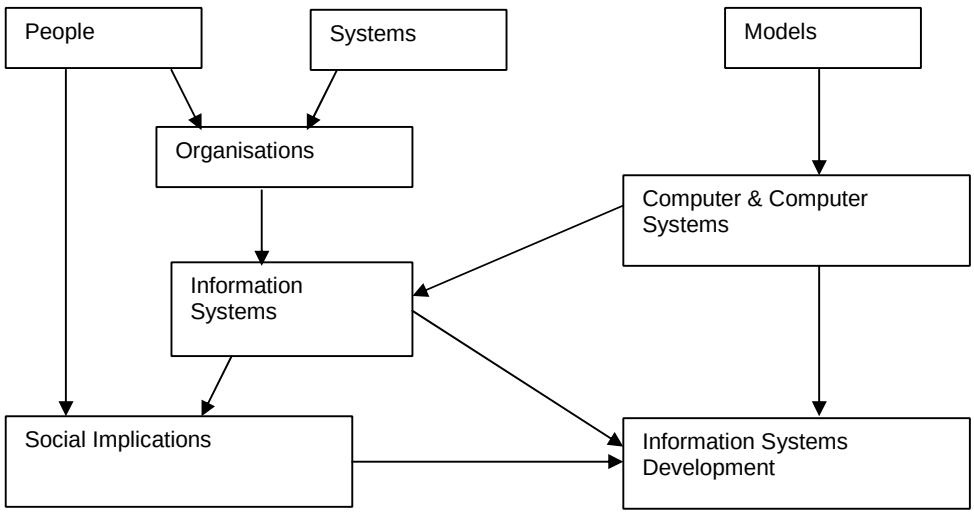
technology, identifying critical variables and making estimates and extrapolations;

(d) **Organisations**

- Knowledge of the function of purposeful organizational structure; and of the major alternatives for that structure;
- Ability to identify, in an ongoing organizational situation, the key issues and problems of each functional area;
- Ability to identify possible short-term and long-term effects of a specified action on organizational goals;
- Knowledge of how information systems are superimposed on organizational patterns, on the operational, control, and planning levels;
- Ability to specify, given information needs and sources, several alternative sets of information transfers and processings to meet needs;
- Ability to make "rough-cut" feasibility evaluations of such alternatives;
- ability to develop specifications for a major information system, addressing a given organizational need, and determine the breakdown into manual and computer-based parts.

The ability to analyse alternatives and to make 'rough-cut' designs is particularly critical in todays working environment where both management styles and information technology are changing rapidly.

2.2 Sequencing of the course elements



The rather crude diagram above illustrates how the three basic 'disciplines' come together to prepare the trainee for work as an information analyst and systems. designer. It also makes clear why a set of independent short courses might not achieve the desired level of cross-disciplinary integration required of' the students, even though they may cover the technical subject matter to the same extent.

3. Proposed Post-graduate Training Course.

It has been seen in Sec. 2.2 that there is a sequence in which course material ought to be presented which seems to imply at least 4 time periods.

A two-year sequence therefore seems best. However, initially, it seems that there would, on balance, be an advantage to offering a one year (three trimesters) version of the course.

The disadvantages of a one-year course are the lack of time for the student to digest and thoroughly integrate his learning, the need to condense much of the material, and tho difficulty of making possible the initial levelling out of diverse backgrounds at course entry and, at the other end of the program, of enabling some degree **of** spocialisation. The advantages are the earlier corrective feedback to instructors both from the candidates and from their employers, and the broadening of the class of candidates who would like to take up the course, since many who could benefit, might not want to commit themselves for two years. A one year course also makes it possible for companies and government organisations to depute an officer to the course, something virtually impossible on a two year course.

The prerequisites are set at those which should be available in a graduate of a good engineering college. They are - elementary probability & statistics, finite mathematics or OR, elementary computer prorramming (i.e. FORTRAN), and elementary economics and psychology.

3.1 FIRST TERM

During the first term the spread of organizational needs caused by the different functional purpose and pace of activity in different parts of organisations is studied as are the individual and group aspects of organisational behaviour. Simultaneously we introduce the use of models as test-vehiclea and for generating alternatives. On the computer side a feel for the hardware/software alternatives and econoimics is given.

Organisational Functions (Introduction to the process of running an enterprise with its various specialised functional divisions. A similar taxonomy of government agencies.)

Operational Analysis and Modelling (Analytical and simulation tools useful in system design. Models as guides for data collection and for testing assumptions and examining alternatives.)

Human & Organisational Behaviour (Principles of human behaviour and group behaviour, effects of organizational structure; impact of information systems; process of organizational change.)

Computer Systems (Providing experience in programming and a working view of hardware/software configurations and operating systems. Modular software systems.)

3.2 **SECOND TERM**

During the second term both the system being designed and the methodologies of system design and. information analysis are covered. Understanding of the data structure dimensions of computer systems is carried further. In addition the initial

contacts are made with the institutions which will host the Systems Design Project.

Organisational Systems & Information Requirements (To establish the purpose of an Information System in different types of organisations, based on the decision requirements for the management of that organisation, whether commercial, planning or service.)

Information Analysis (To analyse in detail the concept of an information system. Approaches to evaluate the working & utility of information systems. The data base concept. Non-computer Information systems technology.

Systems Design (Knowledge & tools for hardware/software selection and evaluation. Design and engineering of software. Technological & Managerial aspects of system design and implementations methods of estimating and evaluating system performance)

Information Structures & Files

Structures for representing logical relationships between elements of information & techniques for operating on information structures. File systems and Data management systems.)

System Design Project (Making the initial personal contacts and analysis of the decision making processes and purposes of the target organisation. Conducted during the last one-third of the term.)

3.3 **THIRD TERM**

The major educational activity in the III term is, of course, the System Design project & the seminars associated with it.

The course work will cover the three major applications we visualise over the next 6 years for complex computer systems in India, viz. large scale logistics control systems, large scale administrative management and information retrieval systems, and real time on-line systems.

Systems Design Project (equivalent to two courses)

(Information Analysis based on organisation goals: Systems design and description. Framework for implementation.)

Logistical Systems (Purposes of material flow systems. Decision making points and information requirements. Interface between manual, mechanical, and computerised systems.)

Administrative Systems (Special considerations in administrative systems: current & future accountability. File design for communication among systems. Information Retrieval from administrative recording systems.)

Real-time and Online Systems (Methodology of evaluating and specifying real-time and on-line systems including data communications. Detailed study of online information retrieval OR reservations type system.)

3.4 Curriculum Extensions

Since such a curriculum has not been utilized before in India, it is likely that there may be many changes required before it precisely meets the needs of the country. Corrections & modifications are therefore expected. However, it must be read in the light of the fact it is meant to train professional information system designers for fairly large organizations whose careers will cover the years 1975-90. Therefore the approach is pitched somewhat ahead of the state-of-the-art in India today. It is not just a question of II generation computers hobbling today's MIS worker but also of the fact the many managements have still to formally recognise the information systems development function. The situation is changing rapidly, however, and the relatively modest number of graduates of this one year course is thought to be certain of useful employment.

Short Refresher courses for senior information system professionals as well *as* for Accountants and Statisticians fulfilling the Information Systems management function are likely to be required as well, in addition to briefing sessions for top level managers in government and industry.

3.5 Recruitment for the Course

It is proposed initially to invite applications from engineering degree holders and to give preference to those with experience who are seconded by their employer - whether a government agency or a firm. Special consideration will be given to members of a government cadre, in India or other developing countries, who are deputed to specialise in Information services for government.

B I B L I O G R A P H Y

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2. J. G. Krishnayya — Information Services in Administrative Agencies,
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3. ACM Curriculum Report (CAGM, May 1972) — Curriculum Recommendations for Graduate Professional Education in Information Systems.

4. The following were published by the IBI-ICC as Working Papers for the World Conference on Informatics in Government, Florence, October 1972, and bear on the manpower aspects.

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4.2 A. Caracciolo di Forino (Italy) — Governmental Policy for Manpower in Informatics.

4.3 A. Ireland (Ghana) — Creation of a Central System Development Unit for Government

		Informatics Systems in Ghana.
4.4	R. Van Hooland (Belgium)	Education & Training in Informatics in the Belgian Civil Service.
4.5	P. Gerken & F. Mueller (West Germany)	The Activities of the “Informatik-Kolleg”.
4.6	P. Gerken & F Mueller (FRG)	A Curriculum for D.P. Professionals in Government.
4.7	J. D. Roosingh & T. J. Hagen (Netherlands)	A Modular Set of Courses in Informatics
4.8	H. Barros (Chile)	A Working Curriculum in Informatics.

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