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ABSTRACT

Developing countries should take immediate steps to avoid some of the serious problems that are now facing the United States in regard to the pool of trained computer professionals. Problem areas which should be reconciled involve a diverse range of topics from general national policy to salary structures and conversions efforts. By using the hypothesis that the relative magnitude of most computing problems facing a country is a function of the degree of computerization (as measured by the number of computers per billion dollars of gross national product) the various stages of computer development can be detected. The evolution of computerization problems, particularly as they pertain to personnel, in advanced countries can be analyzed and suggestions can be made on the policies that developing countries should attempt or avoid. For example, policies concentrating on developing narrowly oriented computer specialists are likely to satisfy near-term needs, but will tend to backfire later as computer applications become a more pervasive part of national society. (MC)

NATIONAL DEGREE OF COMPUTERIZATION: A CONTEXT FOR EVALUATING COMPUTER EDUCATION POLICIES IN DEVELOPING COUNTRIES

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P-4866

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INTRODUCTION

Right now the USA has some serious problems with respect to its trained computer professionals in government and business (G&B). For example, we have:

1. Government agencies with over 1,000 second-generation computer professionals unable to cope with large third-generation computer needs;

2. Business installations serviced by computing specialists with relative unconcern for adverse social impact of their products;

3. Major inefficiencies in G&B due to the relative unconcern of many computing specialists with economic factors;

4. Weak foundations for deciding on computing policies in G&B due to the relative unconcern of many computing specialists with data collection and analysis on their activities.

Developing nations could easily pursue training policies leading to similar national problems with their computing manpower resources by the late 1970s--but not necessarily. This paper attempts to provide a context for evaluating such training policies and to suggest some improvements.

A PRIMARY DETERMINANT: NATIONAL DEGREE OF COMPUTERIZATION

The context provided is based on the hypothesis--supported by personal observations in over a dozen less-developed countries (LDCs) and several European countries, and discussions with representatives or observers of other

*This talk will be presented at the Rio Symposium on Computer Education for Developing Countries in Rio de Janeiro, Brazil, August 6-12, 1972.

countries--that the relative magnitude of most computing problems facing a country are functions primarily of the country's degree of computerization. Under this hypothesis, other factors such as the overall state of the art in computing, the competitiveness of the computer industry in the country, or the type of national economy, are less important determinants of national computing concerns than the overall pervasiveness of computers in the country's daily life.

One measure of this latter attribute is the number of computers in a country per billion dollars of gross national product (GNP). Thus, if the relative magnitude of national computing problems were really independent of time (or computing state-of-the-art), one could chart the trends experienced during the various stages of computerization in advanced nations, and draw conclusions about the type of problems likely to be of future importance in LDCs as they become more computerized. From these one could then infer national recommendations for training and other policies to reduce the adverse social and economic impact of likely future problems.

This is what Figure 1 tries to do. It shows, as a function of the number of computers per billion dollars of GNP in a country, what the relative importance of computer problems has been and is likely to be. "Relative National Concern" is a necessarily subjective estimate of the magnitude of the social and economic costs to the nation caused by shortfalls in the given areas.* More detailed breakdowns

*For example, Colombia in 1969 had about 16 computers per billion dollars of GNP. Its main problem was still a shortage of trained manpower, followed by problems of fractionalization and duplication of effort. Other problems were only moderately significant, with hardware no longer being a problem (being used about 30 percent of the time, on the average) and retraining not yet considered a problem, but about to become one.

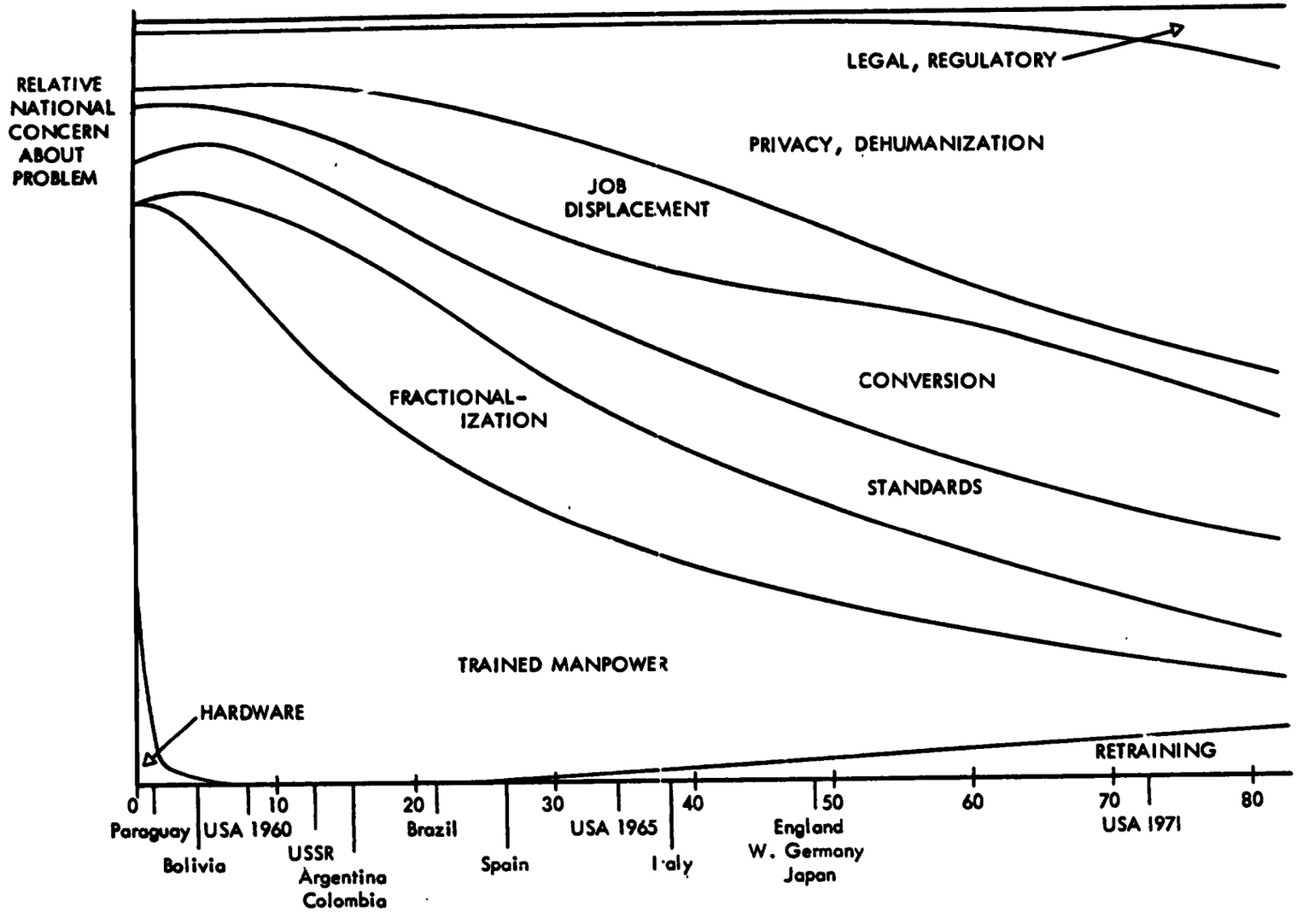

FIG. 1 - RELATIVE MAGNITUDE OF COMPUTING PROBLEMS vs. NATIONAL DEGREE OF COMPUTERIZATION

of these problems are given in Table 1 and its explanatory notes, but first let us consider some additional qualifications to Figure 1.

SOME QUALIFICATIONS

Besides the points raised above, the hypothesis embodied in Figure 1 needs some further qualifications:

1. A country is often too gross an abstraction. For example, in Brazil, Rio and São Paulo have computerized as much as most parts of the US, while other large parts of the country are just getting started. Clearly, technology transfer takes place within countries as well as between countries.

2. Some problems are more sensitive to computer state-of-the-art (or calendar time) than others. For example, conversion problems will probably diminish primarily with time as metacompilers and microprogramming and emulation capabilities are developed.

3. Clearly, the type of society determines the level of concern with information privacy more than the degree of computerization.

4. A country's speed of computerization is clearly going to affect the level of concern with retraining problems.

Still, the general trends of Figure 1 appear to hold for the majority of cases considered.

DETAILED CONSIDERATIONS

Table 1 provides an additional level of detail on the major types of social and economic costs associated with national computer problems, and some measures for improving the situation. Further details on some of the entries are given below; most of the rest are fairly self-explanatory.

TABLE 1--ASPECTS OF NATIONAL COMPUTING PROBLEMS

Problem	Social and Economic Costs	Measures for Improvement	Comments
Hardware Shortage	Missed opportunities in planning and policy analysis (1) Useful people wasted on tedious clerical rote-work	Acquire some computer systems	Generally, LDCs have more hardware capacity than they can productively use
Trained Manpower Shortage	Missed opportunities in planning and policy analysis (1) Adverse impact on applications area (2) Wasted hardware (and personnel) resources	Support university teaching and research programs (3) Establish government training programs Regulate private training schools Establish realistic salary structures (4)	Training shortage generally felt at all levels: operators, programmers, analysts, managers, users, users' managers
Retraining	Missed opportunities in planning and policy analysis (1) Adverse impact on applications area (2) Wasted hardware (and personnel) resources	Establish continuing education programs and incentives (5) Establish sabbatical periods for personnel upgrading and retraining (5)	Armer's "Paul Principle" [1] People trained for a technical job today will have obsolete skills in five years
Fractionalization	Wasted personnel resources Wasted money due to insufficient leverage on vendors	Establish regional and national computing centers (6) Establish users' groups and coordinating offices	See Venezuelan example (7)
Standards	Duplication of effort Escalated implementation costs Missed opportunities for information services (8)	Establish responsibility in a National Bureau of Standards-type agency Develop and enforce standards for input/output equipment, languages, data representation	Should be coordinated with standards efforts in other countries

Conversion	Wasted personnel and hardware resources; slipped schedules (9) Disincentive to innovate	Use higher-order programming languages Incorporate modularity, self-description features in data bases	May be reduced by advanced technology: metacompilers, microprogramming and emulation
Job Displacement	Wasted personnel resources, lowered morale	Carefully analyze side effects of automation projects Establish continuing education programs and incentives (5)	Once considered a much larger problem; often resolved by additional computing manpower needs
Privacy, Dehumanization	Loss of self-determination Inflexible, unresponsive institutions Disincentives to perform useful computing services	Broaden education of computer specialists Establish right of appeal and review of personal data Regulation of data banks	Should be coordinated with efforts in other countries
Legal and Regulatory Problems	Lack of redress for injury (e.g., in automated medical or transportation system; financial losses) Expensive, time-consuming legal procedures favor large organizations	Fix legal responsibilities Educate legal personnel legislators on computing issues and vice versa Design legal transaction-documentation into computer systems (10) Establish certification criteria and procedures for computer personnel and systems	Should be coordinated with efforts in other countries

1. Missed opportunities in planning and policy analysis. Lack of computing capability or trained manpower to use it means that much useful data on national problems such as health, housing, agriculture, and transportation is not thoroughly analyzed, often leading to inappropriate national policy decisions in those areas.

2. Adverse effect on applications area. A shortage of computer-aware personnel in decisionmaking positions can lead to:

a. Establishment of unrealistic software schedules;

b. "Gold-plating" of systems by vendors, if only to protect themselves against ill-defined requirements;

c. Major design retrofits. Some US software systems have had to be 95 percent rewritten to meet operational needs.

3. Support university teaching and research programs. Here is an example of the need to consider the long-term implications of near-term policies in training computer professionals for G&B. For example, at an early stage of national computerization, the major concern is simply for trained manpower, and there are large pressures to meet the needs by quickly training narrow specialists to fill the breach. However, such policies do not meet the needs of later stages in national computerization, as they de-emphasize education in the humanities and social sciences, in economics, in the scientific approach to computing phenomena, and in learning how to adapt to changing technology. Another consideration is the ordering of research priorities to meet national needs. For example, if there is a shortage of computing instructors, an attractive strategy is to emphasize research in computer-aided instruction, using computing as the subject matter. A further consideration is given in Bruce Gilchrist's paper in this Symposium on the need to collect and analyze supply and demand statistics, so that one will not produce an oversupply of trained manpower [2].

4. Establish realistic salary structures. Many organizations lose their most valuable trained computing personnel because of an inability to recognize that their market value and replacement value is considerably greater than most other personnel in the organization with an equivalent level of training (e.g. civil engineers, chemical engineers) and a more direct contribution to the organization's product. Personnel turnover rates of 40 percent per year are not uncommon.

5. Establish continuing education programs and incentives. These should include series of evening University extension classes (which use G&B professionals as well as University people as lecturers), adequate G&B travel budgets for attendance at professional meetings; and a system of incentives, such as certificates, for pursuing continuing education. Further, developing countries have the opportunity to leapfrog the more advanced nations in the area of adapting to rapidly changing technology, by instituting and nationally supporting paid sabbatical periods for G&B professionals in need of upgrading their skills.

6. Establish regional and national computer centers. This can be done by business as well as government, as witness the CICSA cooperative in Cali, Colombia, which provides computing services, keypunch and tab services, system analysis services, and training to about 30 local companies.

7. Fractionalization: Venezuela. In 1967, Venezuela had about 12 computers per billion dollars of GNP, and exhibited the following fairly typical pattern of fractionalization. The computing centers in the various government agencies had sprung up in response to internal agency demands for data processing, with very little centralized coordination. Some were called "computer centers", some "electronic centers", some "data processing centers", some still "mechanical tabulation division". Their places in the organizational structure

were equally diverse; sometimes they reported to the general director of the agency, sometimes to assistants for finance, plans, or administration. Eight of the thirteen Executive Ministries (Agriculture, Communications, Education, etc.) had computers, as did fourteen other government agencies (Social Security, national banks, etc.). Most of these were IBM 1401s, with IBM 360/30s on order or under consideration. The government computer rental budget was about $300,000 a month and was growing about 27 percent per year. But, although this was about 40 percent of the total computer rental budget for Venezuela of about $750,000 a month, the lack of coordination between agencies gave the government very little leverage in dealing with suppliers, influencing training and education policies, or promoting interagency information processing. However, the Council of Ministers had taken a first step toward coordination by the formation of the Consulting Committee on Computation. This Committee made significant improvements in the selection, acquisition, installation, and management of data processing equipment, and on the selection and training of personnel.

8. Missed opportunities for information services. Often, a lack of standards on data formats makes it impossible (in the US as well as elsewhere) to use potentially valuable data collected by one agency (say, health) to meet the needs of another (say, environmental protection). Or even local units of length, like the vara in Latin America, vary sufficiently from place to place to make good statistical analysis of land use very difficult.

9. Conversion: Wasted personnel and hardware resources; slipped schedules. For example, one large current conversion effort in the US will require 200 full-time programmers for three years.

10. Design legal t c. on-documentation into computer systems. Relatively little effort currently goes into providing the equivalent of audit trails for complex computer systems. In some cities in the US, computerization caused a major loss of control over municipal records and transactions, with no way of reconstructing the situation. In general, the area of legal and regulatory problems associated with computer systems appears to be growing most rapidly into an area of major national concern, particularly with the likely emergence in the near future of information utilities providing a wide variety of computer services into the home [5]. As noted in Table 1, this implies a major future requirement to educate legal personnel and legislators on computing issues and to provide some relevant legal training for many computer people.

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