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EMPLOYMENT EFFECTS OF TECHNOLOGICAL CHANGE:

Some Implications for Education

by

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1. INTRODUCTION

The impact of new technologies on the labour market is of great concern to thousands of Canadians. Many Canadian workers contemplate the possibility of job loss or traumatic readjustment. Governments must weigh the economic and political implications of technological unempoyment and income redistribution. And educators must try to anticipate the pedagogical demands of technological change. The views as to the impact of the new technologies are several.

Optimists point out that technology has been changing throughout history and that even the enormous improvements in productivity that accompanied the series of innovations since the Industrial Revolution have not caused significant and persistent unemployment. They point out that the additional output stimulated by the new technologies has tended in the past to require more than enough labour to offset any inherent labour-saving bias. They argue that the current wave of technological change should be seen as just the latest in a long series of technological developments that have contributed to higher output, employment, and living standards.

Pessimists contend that there is something very different about the "Information Revolution". They see the potential for massive displacement of human beings throughout the world of work and have little faith in the ability of the output effect to

stave off job loss. Nobel prize-winner Wassily Leontief points out that man, as a factor of production, has two dimensions: mental and physical. But the computer and the robot are already beginning to replace both mental and physical functions of blue- and white-collar workers. "Human workers", says Leontief, "will go the way of the horse."[1]

A third group acknowledges the potential job loss due to technological displacement but argues nevertheless for rapid adoption of technological advances. In their view the erosion of relative productivity and cost competitiveness through failure to innovate may have employment consequences even more serious than technological displacement effects. That is, if other countries advance technologically and we don't, we stand to lose international markets along with the industries and jobs that supply them.

A fourth and final group is agnostic about the issue of the overall net employment effects of technological change.[2] They contend that, irrespective of the aggregate outcome there will certainly be problems of adjustment and adaptation in particular sectors, occupations and skills, and for particular groups of workers. On this view it is important to attempt to identify particular problem areas and frame appropriate policies of mobility, training, education, and social security to minimize the pain of transition and adjustment.

There are undoubtedly elements of truth in each of the views outlined. Moreover, with the possible exception of the most extreme optimists, most observers would agree that technological change is transforming the labour market in such a way as to complicate considerably the transition from school to work and from job to job. The nature of work and of society is changing and so, too, are our education and training requirements.

In this paper we attempt to raise some issues concerning the impact of technological change on the labour market, and its implications for the education system. In the next section it draws upon work in progress in the Economic Council of Canada's Labour Markets and Technological Change Project to outline some major employment consequences of technological change. Section 3 then raises some issues concerning changing occupations, skills, and their educational implications. Section 4 reviews some questions about the possiblity of collaboration between educators and industrialists to meet the technological challenge. Some concluding comments are offered in Section 5.

We turn first to a brief look at some facts and figures about technological change and employment in Canada.

2. TECHNOLOGICAL CHANGE AND SHIFTS IN THE DISTRIBUTION OF EMPLOYMENT

Technological change is nothing new. The Industrial Revolution which started in the late 18th century brought new

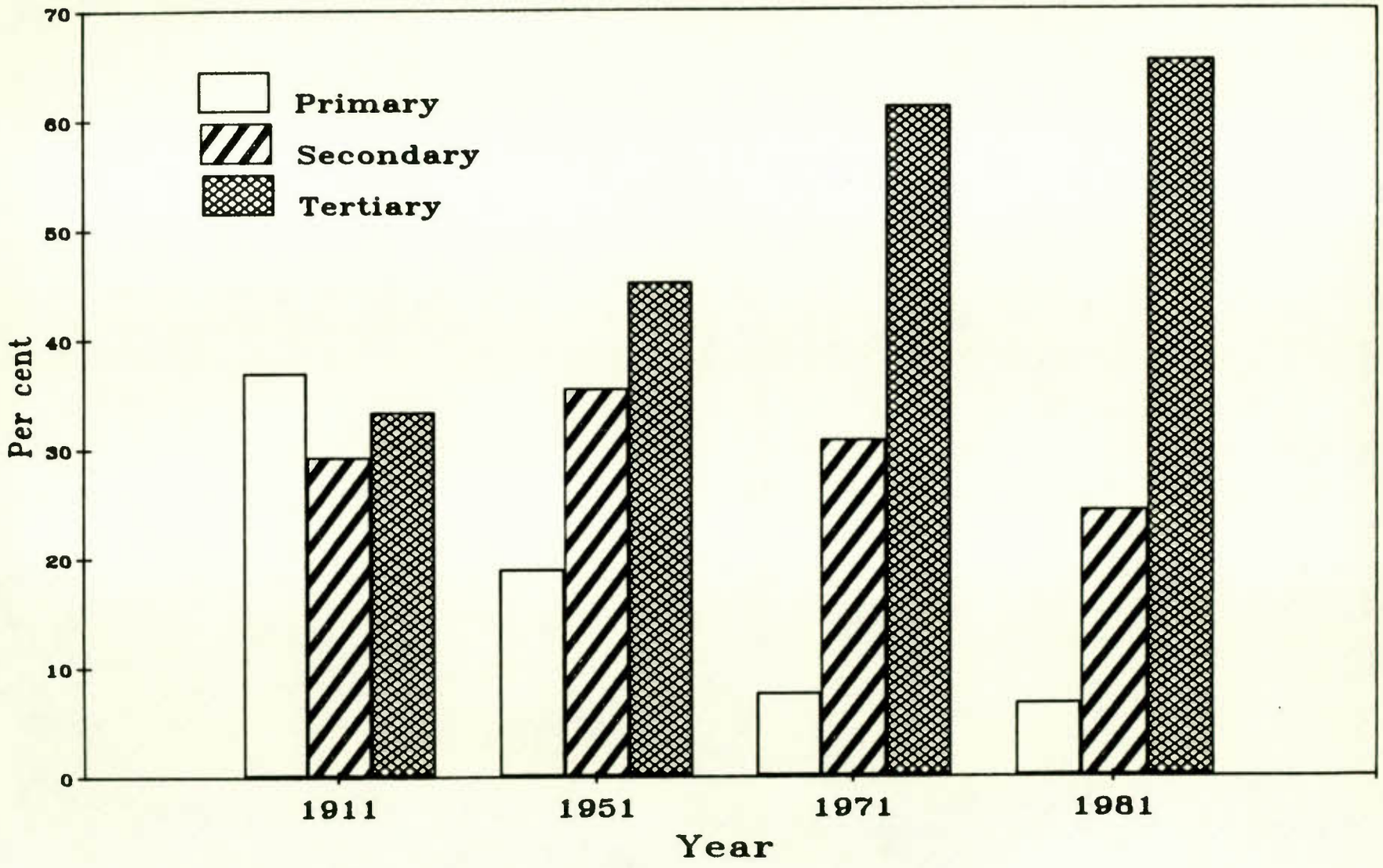
machinery, methods, and organization to the world of work. The factory system radically transformed the meaning of work, its pace, and its rewards, for millions of people. The evolution from largely agrarian to industrial societies was accelerated by the era of railroads, steel, and steam in the second half of the nineteenth century. In the present century the internal combustion engine, the assembly line, and advances in chemistry and electricity have further promoted the transformation. The employment consequences of the enormous shifts in the economic centre of gravity which accompanied the process of change are illustrated in Chart 1.

In 1911 over one-third of Canadian workers were employed in the primary industries (agriculture, forestry, fishing, mining, oil wells). At the time of the 1981 Census, that proportion had dwindled to 7 per cent. The process of industrialization is reflected in the growth of employment in the secondary sector (manufacturing and construction) between 1911 and 1951. Note, however, that while employment in the secondary sector has levelled off, the tertiary sector (which includes transportation, communications and utilities, trade, finance, insurance and real estate, community, business, and personal services, and public administration and defence) has rocketed from about one-third of the jobs in 1911 to two-thirds in 1981. The overall picture is one of massive shifts in the employment structure in a period of 70 years.

CHART 1

Employment Patterns by Industry Sector

Canada



Now, many observers maintain that we are in the midst of a new industrial revolution based on information processing, telecommunications, robotics, and biotechnology. They contend that the pace of change of the new technologies and their diffusion is rapid. Hence, workers' adjustment and adaptation to the new technologies could be more traumatic than in the past. In today's bleak economic climate there are concerns as to whether the emerging technologies can provide enough jobs to offset the erosion of new job opportunities in the more traditional sectors of the economy.

As part of the Council's Labour Market Impacts of Technological Change Project it was decided to examine the employment record of Canada's "high-tech" industries to seek some evidence on this question.

What's High-Tech?

While most people have some intuitive notion of what constitutes a "high-tech" industry, we found it hard to pin down a definition unanimously accepted by researchers. Two definitions do, however, seem most prominent.[3] The first, which might be called the "R&D" definition, accords the "high-tech" label to those industries with above-average ratios of R&D to investment. The second, or "Sci-Tech", definition includes those industries with high levels of scientists, engineers, and technical employees. One might justifiably argue that such

criteria are rather imperfect indicators of "high-techness". Indeed, Council researchers are currently developing a definition that is based more upon the technological sophistication of the products that an industry produces and/or uses. For present purposes, however, we use the R&D and Sci-Tech definitions which at least have the virtue of having been used in a number of U.S. studies to date.

Specifically, we have examined a set of 33 industries identified by Sunder Magun and A.L. Shingadia in a study of employment in high-technology industries undertaken for the Canada Employment and Immigration Commission.[4] As it turns out, the industries identified by the "Sci-Tech" definition (share of sci-tech workers at least 1.5 times the all-industries average) includes all the industries identified by the "R&D" criterion.

How Many Jobs?

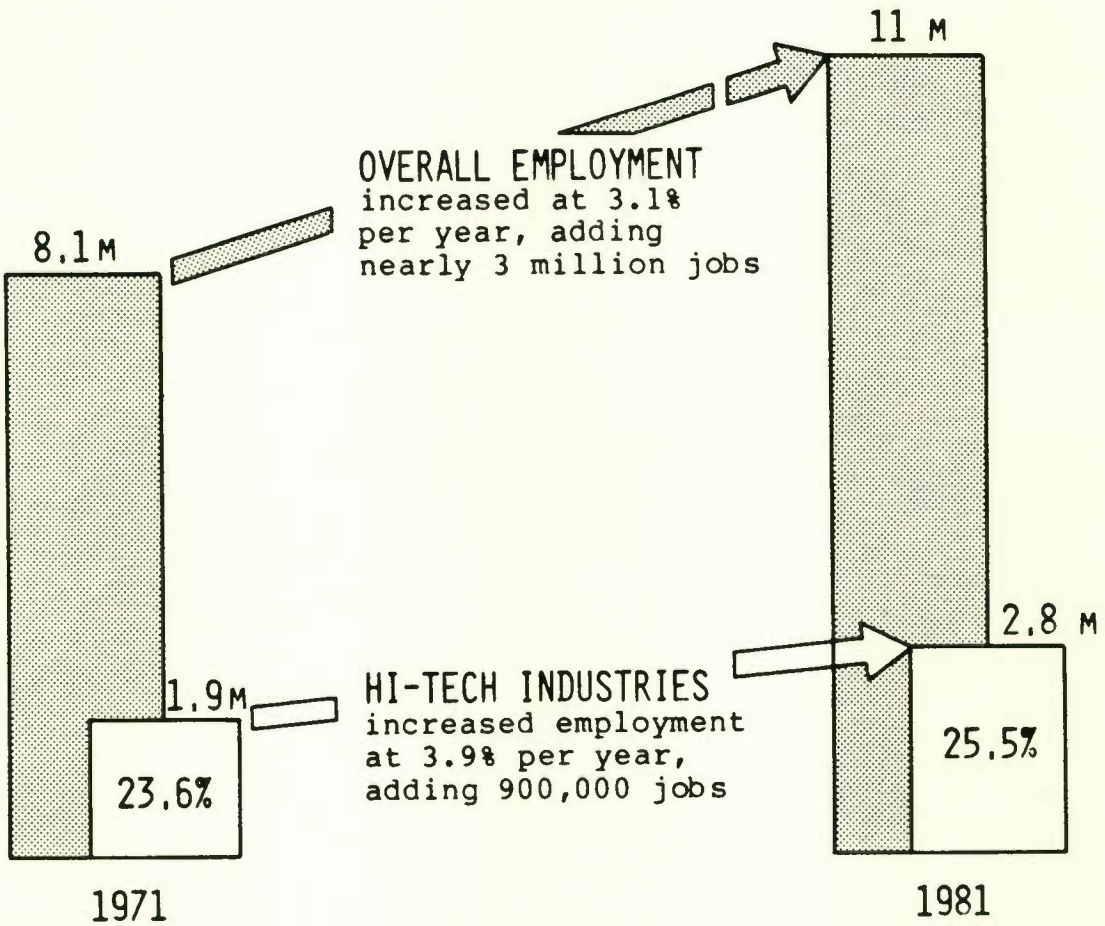
The first major finding is that between the 1971 and 1981 Censuses employment in the high-tech industries grew considerably faster than the 3.1 per cent average annual growth rate for Canadian industry as a whole. Chart 2 shows that the average yearly growth rate for the high-tech industries was 3.9 per cent. This result may be compared to U.S. figures for the period 1969-1979, which show little difference between the employment expansion in the high-tech sector and that in the economy as a whole.

Twenty of the 33 Canadian high-tech industries showed annual employment growth rates in excess of the all-industry average. Compared to the 3.1 per cent annual growth rate for the whole economy, a group of five highly related high-tech industry "stars" stand out. The Computer Services industry, with an annual average job creation record of 21.2 per cent per year, was clearly the leader, followed by Offices Management and Business Consulting at 17.9 per cent, Miscellaneous Services to Business Management at 9.4 per cent, Engineering and Scientific Services at 7.9 per cent, and Offices of Architects at 7.1 per cent. However, these impressive growth rates must be carefully placed in perspective. Inspection of Chart 2 reveals that Canadian high-tech industries as yet account for only a relatively small (one-quarter) slice of the overall employment pie. The high-tech sector accounted for 23.6 per cent of total Canadian jobs in 1971. By contributing proportionately more than its share of the total jobs added in the 1971-81 intercensal decade the high-tech sector increased its slice of the employment pie to 25.5 per cent.

But even the five high-tech industries to which we accorded "star" rating in terms of rapid growth rates accounted for such a small proportion of total employment that their contribution to job creation in 1971-81 was relatively small. Taken together, the five industries (Computer Services, Offices of Management and Business Consultants, Miscellaneous Services to Business Management, Engineering and Scientific Services, and Offices of

CHART 2

THE EMPLOYMENT RECORD OF THE HIGH-TECH INDUSTRIES



SOURCE: STATISTICS CANADA CENSUS DATA.

Architects) constituted only 1.1 per cent of total Canadian employment in 1971. Thus the addition of 145,245 jobs in that group of industries accounted for only 5 per cent of all new jobs created in the decade.

What's in Store?

Since the last Census of Canada the onset of the recession led to massive job loss: 595,000 were lost between September 1981 and November 1982. Though some employment gains have been made recently, staffing levels are still below pre-recession levels in some industries. Can high-tech industries improve the employment outlook? A prudent response would reflect guarded optimism. If the trend of the 1971-1981 period continues, employment in our high-tech sector will continue to grow faster than the overall economy; its share of jobs will thus increase and so, correspondingly, will its total addition to national employment.

Set against this are two disquieting considerations. First, dynamism and flux mean dislocation. The very process of change which creates new vistas for some leaves others stranded and desperate. We are thus compelled to underline the frequent observation that policies must be framed to ease the trauma of workers in transition. Second, there are suggestions that the quality of the unfolding employment structure may be changing in a fundamental way. It is clear that not all the jobs in high-tech industries are high-tech jobs. But many may not even

be "good" jobs. Even in Silicon Valley some production and assembly jobs are poorly paid, and the ergonomics of new technologies are bringing new health and safety problems to the workplace. In particular, however, there are fears about the distribution of occupations. Many American analysts, in particular, maintain that future job growth will come at the top and bottom of the occupational distribution, while job opportunities in the middle are eroded, with obvious consequences for income distribution. The Canadian evidence on this issue is as yet unclear. It remains a major challenge of our research.

3. OCCUPATIONS, SKILLS AND EDUCATION

The Occupational Structure and the De-Skilling Debate

The changing industrial composition of employment outlined in the last section masks important changes in the occupation structure within industries, and in the skill requirements of particular jobs. Such changes have profound implications for the nature of the education and training requirements of the work force.

As far as occupations are concerned, detailed forecasting is, of couse, a hazardous business.[5] One particularly illuminating set of figures, however, is shown in Table 1. This shows the top 30 occupations in terms of projected employment growth in the

Table 1

A scenario[1] showing occupations[2] contributing most to employment growth, Canada, 1983-1992

Rank	Code[2]	Occupational Title	Projected Employment 1983 (000s)	Projected Employment 1992 (000s)	Requirements (1983-92) Total (000s)
1	4111	Secretaries & steno	351.3	438.8	87.5
2	4131	Bookkeepers	368.2	448.5	80.3
3	9175	Truck drivers	238.0	310.0	72.0
4	1171	Financial officers	140.9	180.0	39.1
5	6191	Janitors	223.6	261.4	37.8
6	4133	Cashiers & tellers	229.6	263.8	34.2
7	8781	Carpenters	107.3	138.1	30.8
8	4197	Gen. office clerks	136.4	165.3	28.9
9	6125	Waiters	252.4	281.0	28.7
10	6115	Guards & oth. security	76.9	101.5	24.6
11	4113	Typists, clerk/typists	95.7	118.4	22.7
12	4171	Receptionists	90.4	112.0	21.6
13	1137	Sales mgmt. occs.	169.9	191.1	21.2
14	8798	Labourers: other cons.	54.2	74.9	20.7
15	3131	Nurses, grad., nonsuper.	185.5	206.1	20.6
16	8335	Welders	79.8	99.8	20.0
17	8584	Industrial farm mechanics	88.2	108.0	19.8
18	8581	Auto mechanics	140.7	160.0	19.3
19	8563	Sewing machine occs.	88.1	106.6	18.5
20	9171	Bus drivers	49.0	67.4	18.4
21	6121	Chefs & cooks	162.5	180.8	18.3
22	8780	Superv: other constr.	66.5	84.3	17.9
23	1130	Gen. managers	79.2	96.8	17.6
24	7195	Nursery workers	58.8	75.9	17.1
25	4143	E.D.P. equip. operators	71.3	88.1	16.8
26	6112	Police officers: govt.	53.8	69.3	15.5
27	4155	Stock clerks	91.5	106.6	15.1
28	2183	Systems analysts	56.8	71.9	15.1
29	4153	Shipping clerks	84.2	98.5	14.3
30	5133	Commercial traveller	95.9	109.6	13.7

Notes: 1- Based on a COPS reference case scenario developed by Informetrica Ltd., October, 1983 and COPS own computations. Included are all occupations which are not supervisory or residual in nature.
2- According to the Standard Occupational Classification, Statistics Canada, 1980.

Source: Government of Canada Consultation Paper on Training (Ottawa: Supply and Services, 1984).

period (1983-1992). A high technology content does not seem to be the overwhelming feature of this group of occupations, though it is true that secretaries and stenos may use sophisticated word processing equipment, while bookkeepers, financial analysts, systems analysts and clerks, and E.D.P. operators may all require some familiarity with computers. Nor do these occupations, with a few exceptions, appear to be amongst the most highly paid. Finally, the education requirements of most of these jobs appear to be modest: with the exception of nurses, systems analysts and financial officers, none requires a degree.

One of the most complex questions, however, is: what is happening to the skill content of jobs? That is, just as shifts in the structure of employment across industries may mask shifts in employment among occupations, so there may similarly be important shifts in skill requirements within particular occupational classifications. Both developments contribute to the so-called de-skilling hypothesis advanced by Braverman (1974) and further treated by Clegg (1984). For such authors there is an inevitable tendency inherent in the process of technological change that leads to work simplification, fragmentation and de-skilling. The debate is closely related to the popular contention of Kuttner (1983) and others that the middle echelons of the occupational structure are being eroded. On this view technological change has a tendency to polarize workers into the "techno-experts", whose knowledge gives them control over technology, and the "techno-peasants" whose work-lives are controlled by the technology.

The debate about the skill consequences of technological change still rages, and some of the contrasting views are described in Newton (1985) and in Globerman (1984). Research is considerably hampered by the very slipperiness of the concept of skill. For example, the Canadian Classification and Dictionary of Occupations (CCDO) provides the General Educational Development (GED) and Specific Vocational Preparation (SVP) requirements for an extensive list of occupations. Yet such criteria are really only indicators of vocational preparation needs and still beg the question of skill content. More informative research must be based upon detailed micro investigations of specific job evaluation factors such as complexity of tasks, analytical requirements, responsibility, and relationships.

Suffice it to say, for present purposes, that while observers like Clegg see "an overwhelming and apparently inexorable trend towards work simplification" and de-skilling, others like Davis (1983-84) see the need for new skills and responsibilities deriving from the increasingly "stochastic" nature of work. That is, new technologies place increased emphasis on the need to deal with uncertainties and unpredictable events. Human interventions are then stochastic requirements to adjust or correct perturbations of the system or (in the case of Three Mile Island that Davis uses to illustrate his point) to avert disaster. Under the stochastic system individuals are required to exercise

analytical and diagnostic skills, draw upon a wide repertoire of responses, and exercise considerable decision-making responsibility.

Some Educational and Training Implications

An important concern related both to the (dis-)employment and skill issues discussed so far is that of the appropriate education and training demanded by the technology of the future. Views on this question seem to be divided. Some argue that, with the aid of labour market forecasting, we must identify the range of skills that are likely to be in short supply and use our educational and vocational training resources to meet these needs. Others regard forecasting as not just difficult in practice but downright disastrous in its consequences if done incorrectly. They warn against the dangers of being over-specific. Since the future is at best uncertain, they argue, specificity is folly. However, we do know that adaptation and adjustment will be of paramount importance. Therefore we must concentrate on creating a workforce that is highly mobile, flexible, adaptable and versatile. To this end they emphasize the ability to learn. Ehrenholt (1983) puts it neatly:

> "The ability to learn will, in my view, emerge as the premium skill of the future. It is not what you know that will be the key to success in the emerging economy, but what you can learn -- and how fast. And here the college-educated will have the edge: how good a learner you are will more and more determine how good a worker you are." (p. 43)

There are, in any case, numerous suggestions that the introduction of technological change may alter the pattern of educational attributes sought by firms, and may require substantial internal training for its implementation. Moreover, it appears increasingly to be the case that the traditional sequence of formal schooling, on-the-job training, and lifetime practice of one's trade or profession is giving way to a more cylical pattern in which periods of re-education and re-training feature prominently. Such developments will, of course, depend critically upon the rapidity of technological change, the adaptability of workers and the willingness and ability of firms and governments to undertake the necessary institutional changes.

As far as the internal training of business firms is concerned, many writers emphasize the need for a system characterized by continuity and flexibility. In this context, Hedberg's (1984) application of sociotechnical systems (STS) principles to the design of a new steelworks is instructive. Laying stress upon the proposition that dynamism and change are immutable, Hedberg uses the delightful metaphor of "tent" and "palace" organization cultures. Organizational palaces are elaborate edifices that yield only slowly to change. New needs and challenges are typically met through the construction of new wings; the palace takes on a fortress-like character and is ultimately changed only by revolution. In organizational tents the occupants expect to be continually on the move. They watch

out for hostile elements in their environment and carry little baggage. In the tent culture of Hedberg's vision of STS, the organization and its individual members react constantly to environmental factors and technological change by a process of continuous learning. This process is fostered by co-determination, task rotation, and the systematic planning for change that involves anticipatory learning.

4. SHOULD EDUCATION BE THE HANDMAIDEN OF TECH CHANGE?

The material presented in this paper so far -- on employment prospects, occupations, skills, and so on -- might be viewed by some as reflecting an implicit view of education as the handmaiden of the economy. Certainly, educators are interested in the pedagogical implications of technology-driven shifts in the occupational and skill patterns of employment. But views differ not only on the issue of general versus specific education touched upon above. They differ also on the question of how much, and with what speed, the education system may be expected to respond to the perceived needs of industry. Indeed, it appears that the current wave of technological change is the occasion, once again, for one of Canada's periodic bouts of soul-searching on the issue of the role of the education system in the economy and society. One of the persuasive voices in the current debate asserts that

> "...inadequacies are appearing in our education and training systems, just when rapid technological change requires workers to have the ability to acquire new skills quickly."7

This sentiment accords an overwhelming economic rationale for education. Claiming deficiencies in quantity and quality of requisite skills, the proponents of this view urge corporate and academic collaboration as a means of counteracting the adverse effects of reduced academic budgets. Accordingly, they advocate joint research initiatives, cooperative education programs, adult education for corporate employees, personnel exchanges, and conferences, colloquia, and symposia.

A specific illustration of the object of this kind of collaboration is given by a recent paper concerning "the need for Canadian universities to supply students in science and engineering with the education necessary to understand the process involved in bringing scientific or technical ideas to commercialization."[8] Such goals are laudable in themselves, of course, but they tend to reflect a strong (and, perhaps, misplaced) conviction about the ability of education, alone, to solve the complex problems of a particular phase of economic development. Such convictions may, in some circumstances, lead to the identification of the education system as almost a scapegoat for our technological ills. Consider the following challenging words:

> "I would like to conclude by saying that Canadian universities have an important role to play in increasing the public's awareness of the impact of technological innovation on the economy and in improving the quality of management of technological innovation and technical entrepreneurship. If they

> fail to accept this role as part of their educational mandate, if they maintain their aloofness from the business world, then I would predict a very gloomy future for Canada. Universities must face the realities of the 1980's and not act as if this were still the 1880's. They must be a contributor to the educational needs of tomorrow's industrial scientists and engineers, not yesterday's."9

Not all observers subscribe to so instrumentalist a view of the role of the universities, however. Myers (1984) draws a parallel between perceptions of technological change and perceptions of education, in the following way. He refers to the "unbridled enthusiasm" of some Canadians for the narrowly economic purposes and benefits of technological change and a "marked disinclination to consider seriously any possible broad social, political, or cultural side-effects."10 Similarly, he maintains, there is a disquieting tendency of governments to view the role of education in narrow economic terms (exemplified by such terms as "human capital investment") rather than in broader terms of social, cultural and personal development.

Far from denying the need for the education system to meet the challenges of technological change, Myers endorses such developments as

- the expansion of programs of continuing professional education to meet requirements of upgrading and recertification;
- increasing provision of part-time credit study opportunities;

. greater emphasis on various noncredit learning opportunities and resources for the general public and for particular groups.[11]

On this view, the education system must be prepared to adjust to social and individual needs in an age of rapid change. He warns, however, that this is

> "...not a debate to be abandoned to the human resource technicians, high tech buccaneers and vocational training enthusiasts who have set the pace and tone so far."[12]

5. CONCLUDING REMARKS

What are some of the implications of our observations for young people in transition from school to work? It seems, first of all, that Canada's high-tech sector has performed rather well, in terms of job creation, in the decade of the '70s. If that trend continues, its relative size will continue to grow. In terms of absolute numbers of jobs, however, we can hardly expect the high-tech sector to be the major generator of new jobs in the next few years, far less to cure our unemployment problems. Nor is more rapid growth of the sector a totally unmixed blessing, for rapid change means problems of displacement, dislocation, and readjustment. So overall demand and output behaviour of the economy will be a greater determinant of job opportunities than the performance of the high-tech sector *per se*.

The occupational profile of the employment projections discussed in Section 3 suggests that the great majority of new jobs in the foreseeable future will not require major shifts in educational preparation. For a relatively small number of very specialized jobs, in high-tech occupations, qualifications in mathematics, computer science and related disciplines will be in great demand. But for many jobs, even the recent emphasis on "computer literacy for all" is increasingly questioned. Successive developments in the computer field have rendered the machines increasingly "user friendly" and have reduced, pari passu, the required operating skills. And, in any case, computer literacy, per se, is unlikely to provide an automatic passport to employment. Stephan Peitchinis, among others, worries about "wasting public money and misleading young people to believe that once they can operate these computers they will be assured of jobs."[13]

The public expenditure is, moreover, considerable. A recent newspaper article describes the projected doubling of the number of micro-computers in Canadian elementary and high schools, from 53,600 at the end of the last school year, to 120,000 at the end of the 1985-86 year. The associated expenditures amount to many hundreds of millions of dollars. There are signs, however, that the school system's enthusiasm for the new technology is tempered with a certain caution as to its potential. The approach seems to be more a question of "helping students become comfortable

with computers as a learning aid rather than emphasizing operating skills and programming."[14]

So, computer programming may be no better for the mind than chess; the majority of new jobs in the future will not require advanced scientific and technical training; and the jury is still out on whether the skill content of technology-affected jobs will be enhanced or eroded. Perhaps the major conclusion to be drawn is that, whatever the eventual pattern of occupations, whatever the eventual skill requirements, one characteristic of recent technological changes stands out: its rapidity. The challenge for workers (and thus for the education system) is how to acquire the characteristics of flexibility, adaptability, and versatility that will ease the pain of the various worklife transitions they can expect to face. We must help individuals to learn how to learn.

Footnotes

1 Time magazine, May 30, 1983, p. 62.

2 For an outline of the micro and macro theory of the employment effects of technological change see Newton (1984).

3 See, for example, Tomaskovic-Devey and Miller (1983); Appelbaum (1983); and Riche, Hecker and Burgan (1983).

4 Magun and Shinigadia (1984).

5 See Economic Council of Canada (1982) for a discussion of such hazards, plus the Council's own forecasting efforts.

6 For an overview of STS concepts see Newton (1985).

7 CMA Task Force Report (1984); see also National Workshop on Management and Technology (1985).

8 Clarke and Reavley (1981).

9 Ibid., p. 134.

10 Page 2.

11 Page 6.

12 Page 7.

13 Quoted in Weiner (1984).

14 Fife (1985).

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