WORKING PAPER

CIM APPLICATION: SOME SOCIO-ECONOMIC ASPECTS
(Labor, Training and Institutional Factors)

Iouri Tchijov

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IIASA
International Institute
for Applied Systems Analysis

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FOREWORD

Many practical case studies have emphasized that managerial and other social aspects are the main issues influencing CIM diffusion.

The paper presented here makes a literature survey of different social impacts so far published. It does not only discuss different effects, but also makes a survey of different measures, such as training, education and organizational solutions, which were applied in various countries to manage the impacts of modern production automation. This review really shows that the social aspects of automation are one of the key issues of a successful implementation.

Prof. Jukka Ranta
Project Leader
Computer Integrated Manufacturing

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1. Introduction

The 20-year history of the application of CIM (Computer Integrated Manufacturing) in industry shows the extreme importance of the social adaptability of these new technologies. Sometimes social resistance or managerial inadequacy is much more difficult to overcome than technical problems in the diffusion processes.

The decisions concerning social problems are not only apparent in traditional economic approaches, but they are also interconnected with the fields of psychology, sociology of teams as well as of the industrial society, ergonomy, etc. When one tries to accelerate or improve the diffusion of CIM technologies and increase their efficiency, the great number of obstacles encountered in the course of their application confirms the importance of the social problems to be taken into consideration.

This is why a person who deals with an economic analysis and forecasting of new technological developments has to use the system approaches, i.e. economic, social and institutional approaches.

2. CIM Technologies

The present CIM technologies, used mainly in metalworking industries (MWI) of developed countries, include the following elements:

- NC-machines (including multifunctional machining centers) for metal-cutting, metal-forming, etc.;
- Industrial robots (IR) and robotized cells for material handling, loading/unloading, welding, painting, coating, assembling and other operations under computer control;
- Flexible manufacturing systems (FMS), combining NC-machines, robots and cells, transportation, storage and control systems for production of complex and sophisticated parts and final goods;
- Computer-aided design (CAD) for computerized drawing, designing and development.[1]

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[1]Here we shall not analyze such CIM elements as CAM, CAP, CAE, CAQ, because of the lack of reliable information on their socio-economic aspects.

The first introduction of CIM at the end of the 1950's and its widespread diffusion starting at the end of the 1970's were caused by the following driving forces [7, 21]:

1. The increasing demand differentiation by quality and specific features of goods and the rapid changes in this process led to a shorter life cycle of the goods and changes in production processes. Batch production was re-established to replace mass production[2]. CIM introduction was a way to higher flexibility of production and led from the economy of scale to the economy of scope.
2. The increasing importance of high-quality goods and the growing demand for sophisticated high-tech products called for the substitution of unreliable human control by computerized control [3]. It also stimulated the introduction of CIM.
3. The necessity of a decrease in control and logistics costs for a highly sophisticated production by cutting the inter-stage control and inventories (including work-in-progress) led to one work-station production instead of world-wide production distribution and high labor division. FMS with computerized control became the most adequate way of the problem solution.
4. The workers' negative attitude (resistance) to monotonous, repetitive jobs under mass production systems led to a relatively high wage rate for unskilled or semi-skilled jobs, and to a decrease of the workers' responsibility for quality. The substitution for an unskilled but highly paid labor force by inflexible automation for mass production and by CIM for batch production responded to this social problem.

The driving forces mentioned above and their interaction were incentives which stimulated the introduction and diffusion of the CIM technologies in MWI. As a result, more than 5% of the machine tools were numerically controlled in the US MWI [18] in

[2]Now 75% of the US MWI production is small or medium batch [24].

the middle of the 1980's. For the other developed countries the corresponding share was between 3 and 5%.

In 1985 the industrial robots population reached 93,000 units in Japan, 20,000 in the United States, and 9,000 in the FRG. Per one thousand employed workers in the manufacturing industries Japan had 7.53 robots, Sweden had 3.57 (in 1984), the FRG had 1.16, and the USA had 1.04 robots [20].

The total number of FMS installed in Western countries, according to our estimates, exceeded 300 systems in 1986 [19, 20]. In the USA the FMS population exceeded 60 in 1986, and in Japan there were more than 100 FMS in 1985 [9].

The shipments of CAD systems grew in the USA between 1976 and 1981 by 70% per year and their market was 4.3 billion $ in 1986 [24]. In the UK 29% of 1,200 observed manufacturing enterprises were to use CAD systems in 1987 [15], and 85 Japanese machine-building firms used 110 systems of this kind [26].

For this intensive diffusion the scale of CIM application has already been described in economic terms (see, for example [12, 19, 26]). But in the field of social impacts, or consequences, there is only little information, usually based on interviews or questionnaires. Below we shall rely on such partial, non-systematic data.

3. Social Aspects of CIM Diffusion

The current wave of technological progress in manufacturing industries, connected with computerization of production control as well as transportation and storage processes, creates a new social environment, and, first of all, it generates a new demand for labor force. The main interrelationships between technological changes and their social consequences are shown in Figure 1.

Thus, CIM diffusion led to a relative employment decrease due to much higher labor productivity under the use of these technologies. The labor cost saving is one of the main stimuli for CIM adoption. For instance, labor costs decrease by a factor of 1.5 - 2.0 when a NC-machine tool is used instead of conventional equipment [12]. If higher-paid specialists work with the NC-machines, the reduction will be even higher.

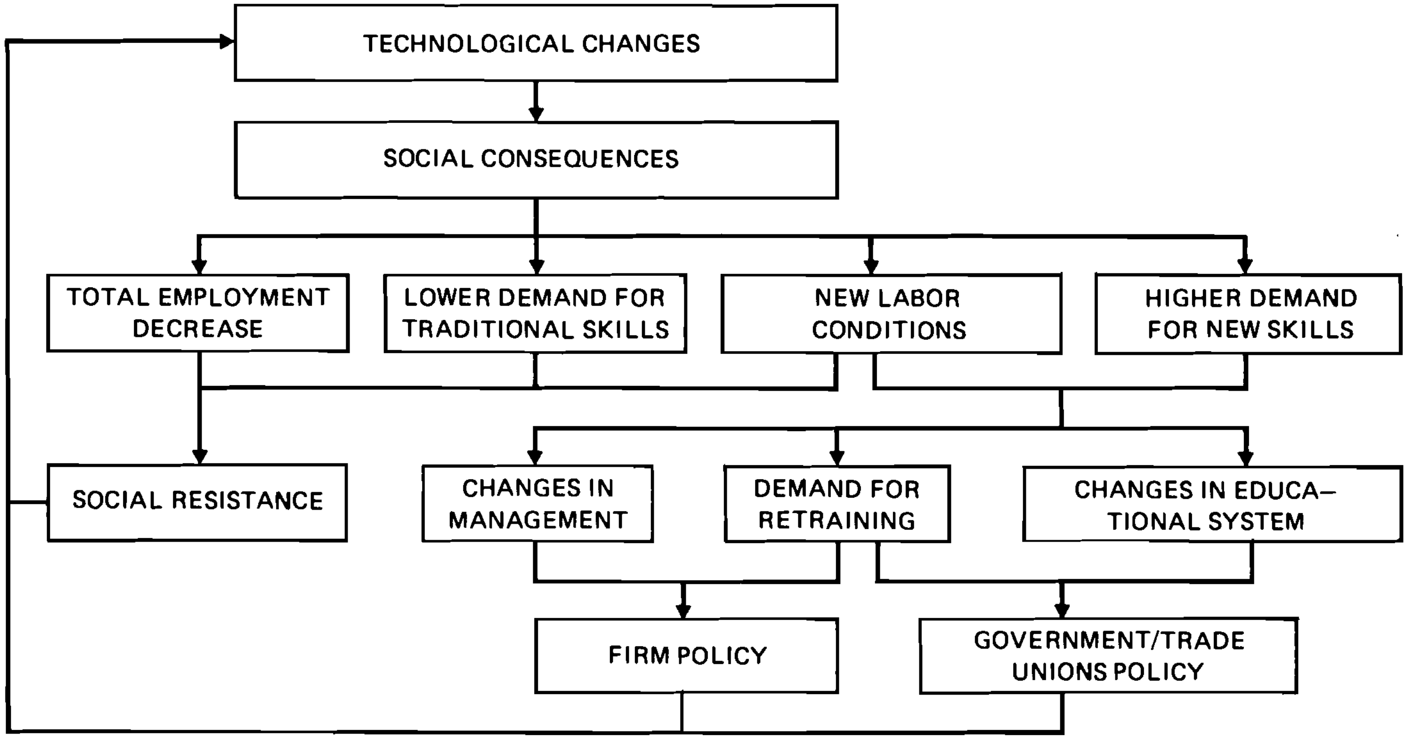


Figure 1. Interactions between technological changes and their social consequences.

Sometimes the use of NC-machines decreases the demand for a highly-skilled labor force and provides a substitution by a cheaper labor force. As one American shop-owner said: "We were very dependent upon skilled labor ... They tended to be prima donnas: "I don't work Saturdays" and "I don't work nights". And this is one of the motivating factors in bringing in NC equipment. That reduced our dependency on skilled labor" [5].

Some MWI firms in the US found a combination of two professions -- the NC-machine operator and the programmer -- very reasonable. The operators were taught the programming elements necessary for reprogramming their machines. This measure not only decreased the number of programmers on a shop floor, but increased the responsibility (and the salary) of the operators and stopped the responsibility exchange between operators and programmers.

According to the JIRA Report [10], the employment cut due to one industrial robot application is 0.9 - 1.0 man per shift. If we take multi-shift use of IR into account, the total reduction will amount to 1.20 - 1.75 men. Potentially (which means that technologically not all the production processes can be robotized) 0.5 million men can be replaced by robots of the first generation, and 1.5 million by IR of the second generation in the US MWI. For manufacturing as a whole, from 14 million employees 1.5 and 4.0 million workers can be replaced by robots of these two generations, respectively [13].

The implementation of a FMS reduces the number of employees by a factor of 4-5. In some exotic cases (Mori Seiki - Japan, and AB SKF - Sweden) the reduction amounted to 20 and 100, respectively [19].

The use of CAD systems for drawing and designing increases labor productivity by a factor of 2-5, the time for drawing declines by 30-70%, and the number of steps of design by 40%. The real employment reduction was 2, even at a growing production, in Japanese enterprises [11, 26].

The total potential reduction in the number of employees can be partly compensated by production growth or increase of duties per worker. This is why the main problems generated by CIM penetration are the drastic changes in the structure of demand for labor force.

Within the main occupational groups in European countries (see Table 1) one can observe a very strong tendency towards an increased share of professional and technical workers as well as administrative and managerial workers. On the other hand, in all countries (except for Finland) the share of production workers, transport operators and laborers decreased.

The forecast for the British manufacturing industry (see Table 2) shows the drastic cut in employment for all occupations, except for a stagnation in the number of managers and a huge growth of the number of technicians. The share of the latter will reach 40% in 1995 and the share of semi- or unskilled workers will drop from 41 to 10%. Partly this will take place due to technological changes in the industry.

In some British firms dealing with new technologies a drastic decrease in the share of apprentices, unskilled and semi-skilled workers and a growth of the share of skilled, technical and professional workers is observed [18].

This means that technological progress lead to a redistribution of employment in favor of higher skilled professionals.

CIM introduction additionally creates the demand for new professions, such as NC-machine operators, CAD draftsmen, programmers, etc. The basic feature of these new professions is the applied use of computer control. On the other hand, some traditional professions, such as turners, drillers, inspectors, draftsmen, are in much lower demand than before.

According to Leontief's and Duchin's estimates [12], 1 million $ (in 1979 prices) invested in the robotization of the iron and steel production will cut the employment by 37 workers, demanding additionally only 4 robot technicians. The same investment in the auto industry will cut employment by 36 workers, including 10 assemblers, 12 conventional machine operators and 8 welders and flame cutters.

In the US MVI robots of the first generation are potentially able to substitute for 16% of the workers in metal-cutting, 26% in metal-forming, and 9% in assembling. The corresponding figures for robots of the second generation are 43%, 55% and 29%, respectively [13].

Table 1. Percentage distribution in some occupational (ISCO) groups [22].

Country	Years	Professional, technical and related workers	Administrative and managerial workers	Production & related workers, transport equipment operators and laborers
Finland	31.12.1960	8.2	1.6	34.2
	1.11.1980	17.0	3.0	34.6
France	1. 3.1968	11.4	2.7	34.6
	4. 3.1982	14.1	0.3	30.9
FRG	6. 6.1961	7.6	3.1	44.6
	6.1984	13.9	3.5	31.8
Italy	1965	5.3	1.2	40.9
	25.10.1981	11.5	16.0	20.7
Sweden	1.11.1970	19.2	2.3	34.1
	1984	27.3	2.3	28.7
UK	4.1966	9.6	3.1	46.8
	25. 4.1971	11.1	3.7	40.0

Table 2. Estimated structural changes in employment in the UK manufacturing industry. Recalculated from [1].

	Structure, %		Ratio
	1980	1995	1995/1980
1. Managers	10	20	1.04
2. Technicians	6	40	3.47
3. Clerical and adminstrative staff	11	15	0.75
4. Craftsmen	32	15	0.24
5. Semi- or unskilled workers	41	10	0.13

In spite of the substantial growth of labor productivity with the use of CAD (sometimes up to 6000%), the employment decrease is usually much less. This is due to production growth and professional retraining to adapt designers and draftsmen to CAD techniques. "Only the employment of parts (detail) draughtsmen (frequently female employees) and tracers seems to be somewhat regressive" [6].

On the other hand, one can observe the growing demand for new skills and professions. Almost all national sources demonstrate a substantial shortage of specialists with new qualifications. For example, the total number of engineers in the field of microelectronics increased between 1983 and 1985 from 26,000 to 47,000 men in the UK manufacturing industry, and from 32,000 to 43,000 men in the FRG. But, nevertheless, 45-50% of the British enterprises need additional engineers and technicians in this field, and 40-48% need retraining courses for their specialists. In the middle of the 1980's 30-40% of the British industrial enterprises sent their engineers and 20-25% their technicians for retraining [14, 15].

In 1984 one out of eight workers in the US economy used computers in their professional activity. Only 5% of the users were those engineers and scientists, who designed and repaired computers, taught computer sciences, and were programmers and system analysts. Another group (10-15%) included engineers and scientists who had to be able to write their own programs for professional purposes. And the majority of the users (80-85%) used a computer as a tool for their jobs, mostly for data and word processing, information storage and retrieval and industrial process control [22]. Naturally, the last group needed moderate special training in computer use (from a few hours to a few weeks), followed by on-the-job training.

The retraining of the older generation of industrial workers is difficult for three reasons. First, they lack any basic knowledge or experience in dealing with computers. The new generations of school-leavers have already gone through some computing courses and have got some experience on this subject to master specific fields more easily. Their adaptability to new computerized technologies is better and faster.

The professionals (conventional machine operators, medium-level managers) of older generations feel a certain idiosyncrasy towards computerized control, because the wide-spread application of computers provides strong advantages to their younger competitors and successors.

This is why the second reason is connected with a fear of losing their professional reputation, of a devaluation of their personal experience, which they have acquired during their whole life. Finally, the educational capabilities of the older generation decrease after a certain age and their propensity to learn is also much lower.

The fear of loosing their jobs as well as the low possibilities of being reeducated for new jobs leads to a strong resistance of some part of the workers and medium-level managers to CIM diffusion.

The strong trade union resistance was a serious obstacle to CIM implementation in 7% of the British firms adopting these technologies, in 17% of the firms in the FRG, and in 16% of the French firms. The resistance of medium-level managers played an important role in 5%, 4%, and 2% of the manufacturing enterprises in these three countries, respectively [14].

The strongest resistance took place in robotization, as robots substitute for workers, and the weakest resistance was observed in CAD implementation, because the union membership rate was relatively low in designing offices.

As a result one can observe the following chronological time-path of robot penetration. First, loading/unloading and material handling operations were robotized in metals and final metal products production as well as in heavy machinery. The psychologically and physiologically unattractive jobs were robotized without a strong workers' resistance. Then, such harmful jobs as coating, welding, painting were robotized. The third wave of robotization was connected with the workers' substitution in highly accurate assembling of microparts (i.e. electronic watches assembling), where the robots liberate workers from very stressful and psychologically unattractive duties.

However, the attempts of some firms in the USA to substitute for (highly skilled and highly paid "elite") machine assemblers by robots met with a strong opposition.

CIM implementation has not only changed the structure of labor demand, but also the job character and its related duties.

As defined in a FAST analysis of 85 FMS/FMC in the FRG [27], the total list of operators' duties is as follows:

(a) programming;
(b) testing and correcting programmes;
(c) responsibility for trouble-free operation of the system;
(d) tasks concerned with the control of the manufacturing process;
(e) pre-setting of tools;
(f) making tools available, charging magazines;
(g) fixing/palletizing of workpieces;
(h) setting/re-setting of fixtures;
(i) monitoring the processing operations;
(j) maintenance tasks;
(k) repairs;
(l) current dimensions control;
(m) final quality inspection.

In 44% of the observed systems there was a low degree of labor division, when the system operators were responsible for (b), (f), (g), (h), (i) and sometimes for (c), (k). In 80% of the FMS/FMC an operator carried out the (b), (c), (f), (g), (h) and (i) duties.

The system with a higher degree of labor division (56%) comprised several different jobs, characterized by setting-up, fixture charging, etc. Only those duties connected with programming, maintenance and final quality control were usually excluded from the operators' responsibility.

According to the Siemens estimates (see Figure 2), the skill differences between mechanics and microelectronics technicians are very high, both with respect to their professional and their psychological background. In order to acquire the new qualifications, a mechanics technician has to be educated from zero level in the fields of electro-technology, electronics, digital and computer techniques. Moreover, he has to become more initiative, innovative and flexible.

The changes in the demand for labor force and in the workers' duties call for a change in their attitudes towards the

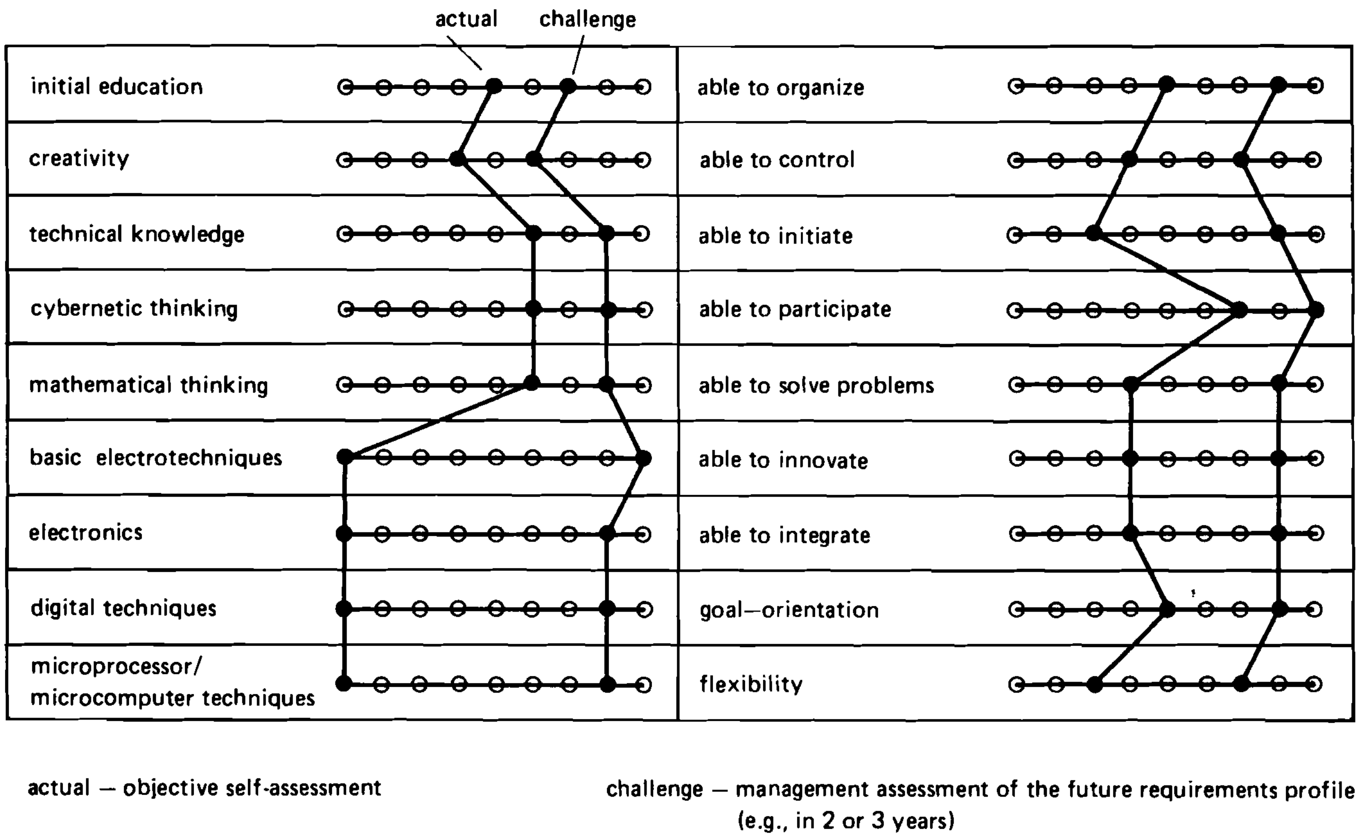


Figure 2. New requirement and qualification profile. Difference between mechanics and microelectronics technician [25].

new working conditions. This is illustrated for the Finnish industry in Table 3 (for the cases of FMS and CNC).

The implementation of these two types of CIM technologies demands higher professional requirements and responsibility as well as a higher general education. In the majority of the observed cases the work with these technologies is considered to be more interesting, meaningful and comfortable. This was true for FMS as well as for CNC-machines and robotized (IR) workplaces.

On the other hand, FMS operators lose, to a certain extent, their independence, the possibility to choose an approriate method or tool, and to control spacing and timing. The outside control increases. In the CNC/IR cases these losses are more moderate.

In spite of the rather high social esteem of the work with FMS, the possibilities of promotion are not estimated to be very high.

The general conclusion is that FMS are attractive for workers despite their high requirements on labor force; a worker considers himself to be a part of the non-human system, where the main decisions are delegated to a computer. The dehumanization of the work is less strongly felt in the CNC/IR cases.

In the case of CAD implementation, the job of designers and draftsmen has been changed in may aspects. They were liberated from routine procedures and their jobs became much more creative. The new technology demanded new knowledge and practical experience in the interaction with displays or personal computers.

At the same time the inter-team competition between the specialists increased. When personal achievements or professional tricks were accumulated in the computer software, their previous owners lost their specific advantages and competitive positions. This is why highly experienced designers tried to monopolize their successful decisions, keeping them secret. This led to multiplicative "bicycle inventions" and decreased the efficiency of CAD systems by a factor of 4 [6].

As all systems with computerized control, the CAD systems also improved performance monitoring, coming close to the "Big Brother" syndrome at the designers' workplaces [6]. This led to

Table 3. Impact of the introduction of FMS (150 respondents) and CNC/IR (60 respondents) on job characteristics: workers' attitudes towards changes, % of replies [28].

	FMS			CNC/IR		
	D	N	I	D	N	I
A. Qualifications						
- planning, problem solving	39	15	46	35	22	43
- responsibility	0	20	80	4	22	74
- professional requirements	15	8	74	9	9	82
- requirements of general knowledge	5	10	85	0	13	87
B. Motivation						
- work is interesting	10	16	74	13	17	70
- work is comfortable	18	20	62	17	13	70
- work is non-monotonous	28	13	59	39	9	52
- work is meaningful	13	23	64	22	13	65
C. Autonomy, control						
- possibilities to choose methods and tools	37	24	39	39	17	44
- possibilities to control spacing and timing	51	26	23	17	31	52
- possibilities to control the amount of work	26	36	36	17	48	30
- outside control	13	26	61	30	35	35
D. Other factors						
- social esteem of the work	5	28	62	9	52	39
- possibilities of promotion	0	54	33	4	52	31

D = decreased

N = no changes

I = increased

unavoidable conflicts between managers and designers. Because of the technical feasibility of current control, the role of medium-level managers decreased. On the other hand, the most creative designers and draftsmen did not want to be under permanent control. Both parties resisted the introduction of computerized control at the work stations.

Thus, all three impacts of CIM implementation (employment decrease, lower demand for traditional skills and new labor conditions) lead to social resistance with regard to CIM penetration, and determined the latter at a high degree.

The fourth impact (higher demand for new skills) presents also a limit to a growing diffusion of CIM. In the Netherlands a report estimates the ratio of the annual requirements for specialists with higher education in computer sciences to actually available graduates as 2.4. In the UK some companies have to pay three times above the normal salary to attract computer and software specialists. In Finland a shortfall of 20,000 university-trained software specialists is forecasted for 1995 [22].

This is why all three parties (firms, trade unions and governments) are actively involved in the development of a policy which would provide an adequate labor force and, at the same time, alleviate social contradictions.

4. Trade Unions and Government Policy

The alleviation of social contradictions and social resistance to the diffusion of new computerized technologies is one of the main elements of union and government policies in the field of technological progress support. Though the majority (85% in Switzerland [17]) of unionized workers in developed Western countries supports technical innovation processes as a measure for higher competitiveness of their firms, the implementation of CIM labor-saving technologies is sometimes met by the unions with a negative reaction, as they are afraid of losses for their members.

Naturally the trade unions try to keep the diffusion of CIM under their control. In 23% of the French firms, adopting CIM for the first time, the trade unions participated in preliminary consultations. In the FRG the respective share was 40% and in the UK it was 50%. The subject of the consultations was to work out those conditions acceptable to the unions [14].

Among the typical demands of trade union collective bargaining in manufacturing industries are the following:

- salary increases linked with training;
- non-admission of employment cuts for the firms introducing CIM technologies;
- promotion routes for personnel;
- restriction of number of objects under simultaneous control;
- limitation of working hours at the screen;
- shorter working week for CAD specialists;
- restrictions on the use of computerized information by non-staff members;
- task rotation among FMS operators.

Now, the new wide-spread forms of cooperation among trade unions, firms and governments are three-party councils. These councils include professionals in computerized technologies, social relationships, education and training, as well as social and economic policies. However, in Western Europe sometimes older representatives in such councils are united on their conservative platform opposing the CIM introduction, while younger representatives support it.

In the FRG, the works council has, according to the Works Constitution Act, a right to be informed on all technical and economic features of a new computerized system which is expected to be introduced. The industrial decision makers and the works council members have to agree on the introduction of such technologies.

In France the 1982 Act makes provision for the works councils to be consulted about any plans on the introduction of technological changes and the councils are entitled to employ experts for the assessment of such projects with regard to their effects on employment, job conditions, retraining possibilities, etc.

The governments of all leading Western countries have adopted a policy of strong support for CIM implementation. This policy is usually realized in two main directions:

- protection of national industrial firms on the new technologies markets (through R&D expenditures, subsidization of private firms, taxation, foreign trade regulations);
- alleviation of social conflicts generated by CIM diffusion (through financial and organizational support for retraining and educational systems).

For example, in the FRG the Ministry of Education and Science finances several pilot training schemes (3.5 years) for CAD draftsmen [6]. In the UK the Application of Computers to Manufacturing Engineering (ACME) Directorate of the Science and Engineering Research Council supports the promotion of highly innovative research and training in advanced manufacturing at Higher Education Institutes. It combines detailed technologies such as new manufacturing processes and their implications with the development of advanced machines using CAD [8]. In 1978 the British government introduced the Microelectronics Applications Project (MAP); among its main tasks there were the following [15]:

- increasing the supply of people trained in microelectronics skills by supporting the establishment of special courses;
- providing grants for the feasibility studies, as well as for part of the development costs of approved applications.

Approximately 50% of British manufacturing firms knew these support systems, but only 20% made use of them; they were mainly used in the fields of CAD and robots adoption and much less in the field of FMS.

This means that in spite of strong governmental activities, the real impact of such a support is relatively limited.

The comparison of the international experience in different approaches to the solution of social problems shows that there are two polar examples -- the USA and Japan. American companies try to overcome the unions' resistance in the field of employment, whereas the Japanese companies usually try to increase the workers' adaptability to new technologies. They increase the duties and the responsibility of the workers without a drastic employment fallout [4].

Japanese firms emphasize the integration of human factors into manufacturing at the factory and production-site levels. This integration of CIM technologies and human resources is referred to as "humanware" within HIM (Human Integrated Manufacturing) systems [2,29].

5. Retraining and Education

The employment support programs as well as the provision of new skills, together with adapting CIM to the human requirements, are the critical bottlenecks in the long-term CIM diffusion process, and this is why the current educational and retraining systems have to be transformed right now in order to meet the future demands on the production side.

Retraining programs and courses are provided by:

- producers of new technologies and equipment;
- users of new technologies;
- trade unions;
- external consultants;
- summer and vocational schools.

Financially these programs are covered by all the parties: users, workers, and governments. The big demand for new skills has led to an active participation of universities and colleges in educational programs, text-book preparation, development of TV and PC programs for retraining courses as well as for individual self-education. Almost all large firms involved in computerization of technological processes and CIM component production have opened special consulting centers.

In order to attract school children to new professions connected with the development and use of CIM technologies, ACME introduced special programs in secondary schools for 13 year-old children and their parents. There are two main types of programs -- for future CIM operators and programmers, and for attracting the best pupils to the respective departments of universities and technical colleges [8].

In almost all developed countries the creation of a new technological culture was delegated to the general education systems. There were three main problems in this approach:

- educational programs were lagging behind the current technological progress;
- crucial shortage of teachers who were able to transmit to the pupils the latest achievements in science and technology;
- lack of adequate technical means and equipment for teaching.

At present 40,000 secondary school children participate in the British pilot projects, however in July 1986 the government announced the extension of the Technical and Vocational Education Initiative to cover all pupils in secondary state schools [22].

According to the Bill adopted by the French National Assembly, technology education is to be provided at all levels of education and training, including the primary schools.

During the Industry Year (1987) in the UK a lot of initiatives were taken to enhance collaboration between business and schools, to familiarize students with technology and its role in economy and society.

Thus, computer familiarization and literacy form the necessary background for the further educational and training process, which has to be provided by the general education system. But the successful fulfillment of this tasks requires the adequate supply of computers and supplementary equipment.

Under the Microcomputers in Schools Scheme in the UK 100,000 computers were installed in British schools and 50% of their costs were covered by the government. In 1985 120,000 computers were used in 46,000 French schools, 80% of them in secondary schools. In Sweden 2/3 of the secondary schools were equipped with an average of 7.3 computers each, and 5,000 teachers attended basic courses in data processing and computer knowledge [16, 23].

Further education and training are at the responsibility of institutions for technical and vocational education. There are a lot of unfilled vacancies in industry due to missing skills. Among them are mechanical design and draftsmen for CAD systems, software programmers, as well as electronics technicians for maintenance, repair, diagnosis and quality control.

To compensate this deficit in the future, almost all developed countries plan to increase the supply of specialists in electronics from post-secondary, non-university education programs, as well as from universities.

For example, in France additional supply of 3,000 computer engineers and 1,500 technicians was provided in 1986 by the computer science training program. At the university level 10,000 engineers will graduate by 1990, 50% more than at present [22].

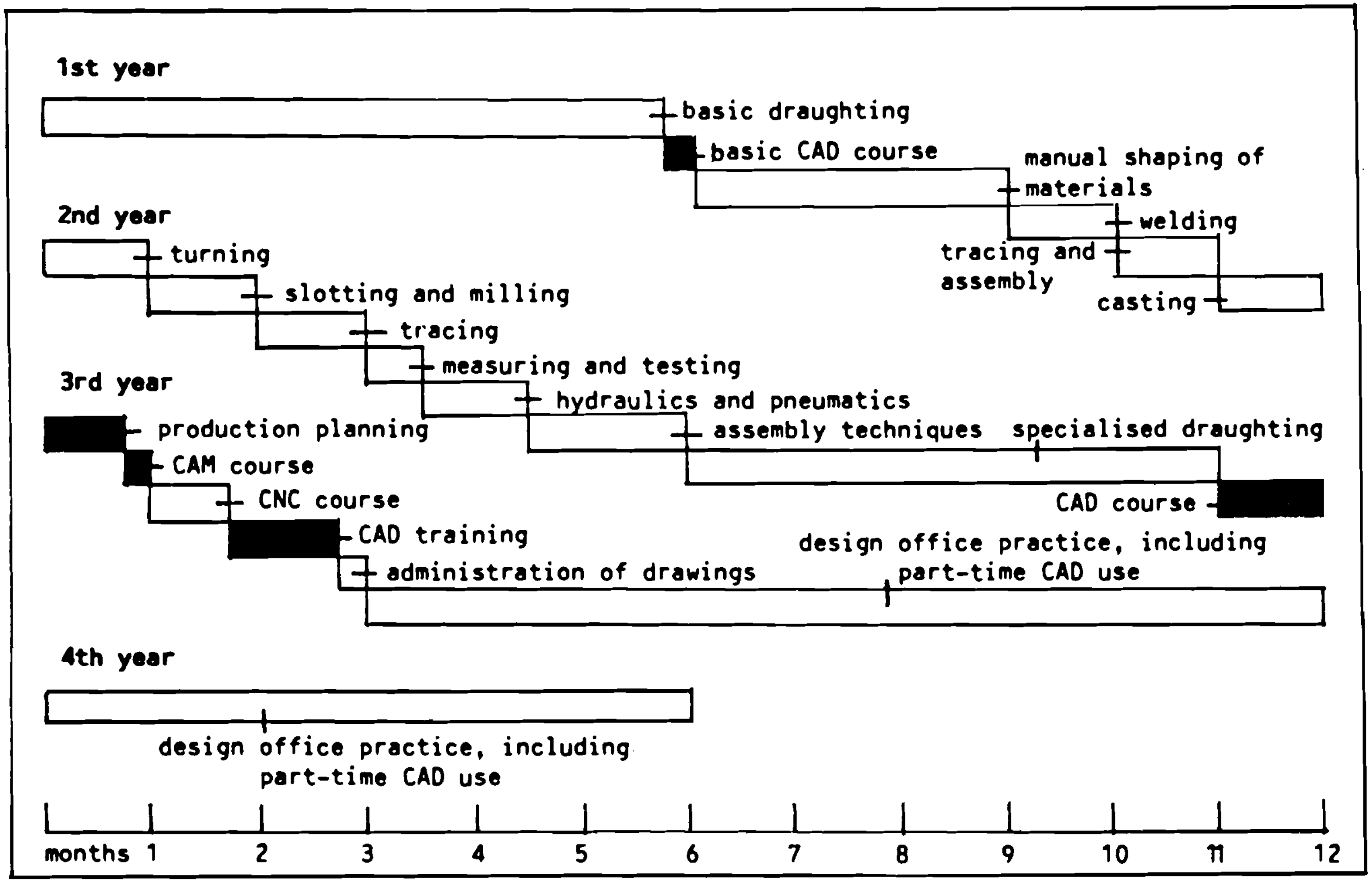
But, according to the estimates of industrial experts, the quantitative expansion does not play the main role today. Users and newcomers suffer from inadequate quality of the training schools and institutions' output. This is especially crucial for small firms, which have no resources for retraining and adaptation of newcomers to their practical needs.

This is why governments usually support skill development for small firms. In the FRG the government provided the capital and running costs for inter-firm training centers. These centers for NC-machine programming and servicing have 75,000 places. The National Employment Office of Belgium is running a program for retraining of job seekers for small and medium-sized firms. Despite the high costs (2700-4400 US$) per trainee, the program is considered cost effective [22].

The combination of basic education with particular training is provided through the collaboration of schools and industrial enterprises. To make this collaboration more effective, consultative tripartite commissions are established in some countries. They usually include representatives of employers and worker organizations as well as representatives of education and training authorities.

The final stage of the labor force preparation for the new skills and duties connected with new CIM technologies is carried out by big industrial firms. In 1985 private firms in the FRG invested 31 billion DM in vocational education and training, of which 1/3 was for further education and 2/3 for newcomers and initial apprenticeship. The pilot project for CAD draftsmen training module is illustrated in Figure 3.

For the 85 flexible manufacturing systems/cells in the FRG [27] 27-38 days of training per machine-tool were provided when the new systems replaced the transfer lines, and only 12-14 days when they replaced stand-alone conventional or NC/CNC machines.



Source: SMS Schloemann-Siemag AG, Modellversuch Technischer Zeichner - Maschinenbau

Figure 3. Pilot project: draftsman training modules and scheduling of instruction [6].

The average number of days per FMS/FMC was 53, 16 per machine-tool or 12 per trained worker.

Machine/system operators were trained more often (84% for 82 systems), pre-setters in 72% of the cases, and programmers in 46%. However, palletizers and tool-setters were trained only in 10% of the cases.

Siemens AG spends over 200 million DM annually on further training for 82,000 employees involved in 8,000 programs. 25 libraries with 380,000 books are available for individual training purposes at the firm. A Siemens program (from a mechanics to a microelectronics technician) is shown in Figure 4. In the European IBM branches about 8% of the total labor cost is spent for education and training. The BMW budget for further training reached 6.5 million DM in 1979 and in that year 1/3 of the total company staff participated in the further training programs [22].

Even for big companies the problem of industrial equipment used in education and training is a serious problem. The situation is less critical if small NC-machine tools as well as CAD displays or PCs are available in training centers and their price at rental payment is relatively low; full-scale FMS are, however, too expensive to be used for training purposes. Some companies designed and began production of special training modules for these purposes.

The cost of a full-scale FMS exceeds several million dollars, while the training module, produced by Denford Company (UK), costs only 100,000 $. It includes 1 NC turning machine, 1 NC milling machine, and 2 robots. They are controlled by a PC. This system simulates almost all production and control operations which are used in a full-scale system. For managing some specific operations even more primitive educational systems are used. They demonstrate 1 or 2 operations in practice and the others are simulated by a PC [8].

This approach does not only permits to improve practical training, but it also helps to overcome an a priori fear of a new technique.

When workers assume more creative and responsible duties, they become more independent of managers, and, moreover, a part of the managerial duties is conveyed to computerized control

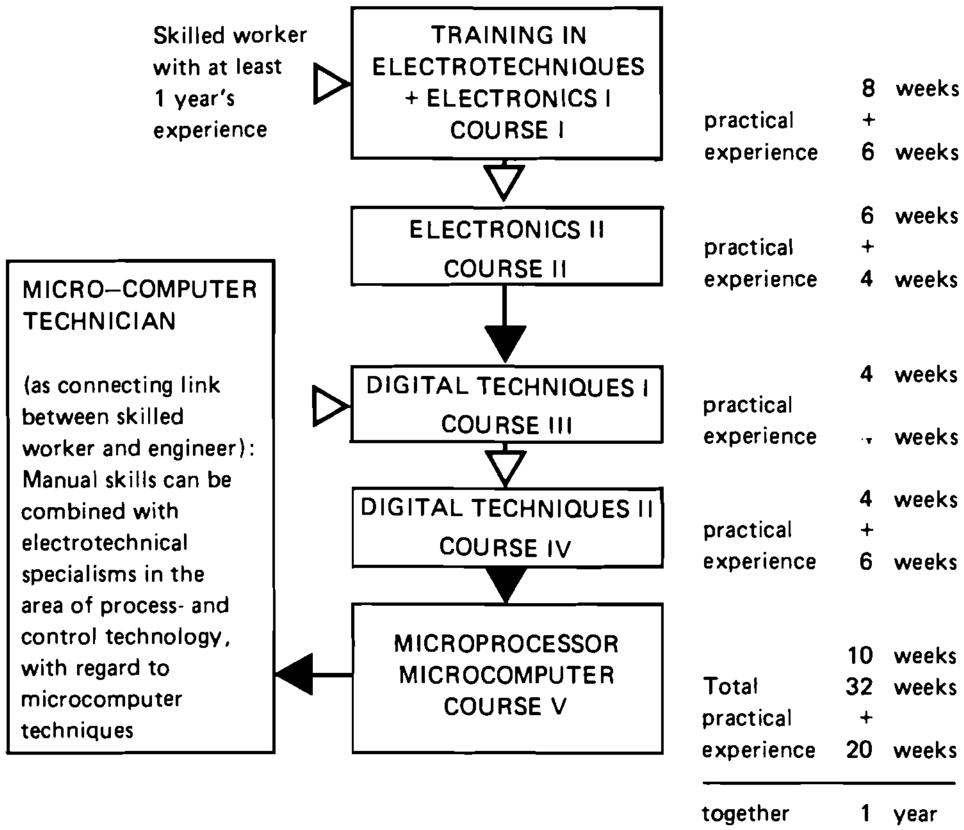


Figure 4. Siemens transfer-training program: from mechanics to microelectronics technicians [25].

within CIM technologies. This transforms the role of managers, especially of medium-level managers, in the production processes. This is why traditional management systems do not satisfy the new requirements, which means retraining courses for management staff become a very important element of the training systems for modern industries.

Retraining for medium-level managers aims at:

- overcoming the fear of a loss of power through the acquisition of experience in all activities under control (technological education);
- acquisition of knowledge for high-level activities to have a chance for professional promotion;
- shift of managerial emphasis from small homogeneous team control to individual workers with completely different duties;
- acquisition of experience in neighboring areas and technologies;
- reorientation from the intermediate control to the final results control.

The current problems in manager training are connected to the problems characteristic of the general situation [7]:

1. Shortage of experienced instructors;
2. selection of the necessary contingent for retraining;
3. development of appropriate teaching methods;
4. lack of the most modern technological and training equipment;
5. difficulties to forecast the future technological development to be able to determine the best ways of retraining.

It is obvious that the future technological development of the economy and society will greatly depend on the resolution of complex, multi-disciplinary social problems.

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