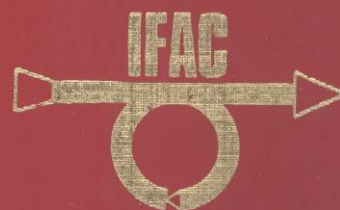


**TRAINING FOR TOMORROW**  
**EDUCATIONAL ASPECTS OF**  
**COMPUTERIZED AUTOMATION**

Edited by  
**J. E. RIJNSDORP and Tj. PLOMP**



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# TRAINING FOR TOMORROW

## EDUCATIONAL ASPECTS OF COMPUTERIZED AUTOMATION

*Proceedings of the IFAC/IFIP Symposium  
Leiden, The Netherlands, 7-10 June 1983*

Edited by

J. E. RIJNSDORP

and

Tj. PLOMP

*Twente University of Technology  
The Netherlands*



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COMPUTERIZED AUTOMATION



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## PREFACE

The introduction of automation and computer technology into all sectors of industry, business and society creates a great need for adequate training. This has motivated the organization of a conference, jointly sponsored by the International Federation of Automatic Control and the International Federation of Information Processing.

The Conference was held in the Holiday Inn, Leiden (the Netherlands), 6 - 10 June 1983. 83 participants from 19 countries, encompassing educationists, computer scientists and control engineers, were engaged in intensive discussions on various aspects of the topic.

These Proceedings contain the text of the opening speech by Mr Pieter van Vollenhoven, a general introduction, conclusions and recommendations, texts of the presented papers, and discussion summaries. Finally, a list of participants has been appended.

The next conference on the same topic is planned to be held in 1987, probably in the United Kingdom.

J E Rijnsdorp  
Tj Plomp  
J M Moller

*Man has three ways of acting wisely:  
Firstly, on meditation, this is the noblest;  
secondly, on imitation, this the easiest;  
and thirdly, on experience, this the bitterest*

Confucius

## OPENING SPEECH

Pieter Van Vollenhoven

*husband to Princess Margriet of the Netherlands*

Mr. Chairman,  
Ladies and Gentleman,

I should first like to express my thanks for the invitation to open this Conference and to say how pleased I was to accept, since I feel that its theme is of vital importance for the future of our society. I should also like to join with professor Plomp in his words of welcome: it gives me a great pleasure to be able to greet an audience comprised of people with such diverse national and scientific backgrounds. As a group you possess a wide variety of knowledge and experience and that alone makes this meeting worthwhile.

In the first place it is worthwhile for you and for those who in the future will benefit from your findings and conclusions. In more general terms, however, it is also of great value for the pursuit and application of science in the Netherlands. Experience shows that this type of international conference often has a beneficial effect on the country in which it is held. We are therefore very gratified that we have been allowed to host the first of the IFAC/IFIP training conferences.

At a conference in London in 1978 Sir Ieuan Maddock, a former Chief Scientist in the British Civil Service, spoke of micro-electronics as 'The most remarkable technology ever to confront mankind'. Indeed micro-electronics and related technology constitute fundamental innovations which, it is commonly expected, will in the long term bring about profound changes in our lives and work comparable to the effects of the invention of printing or the Industrial Revolution.

In 1953 a computer weighed one ton and cost about 8 million guilders. Today a computer of similar capacity weighs 25 kilogrammes and costs less than 20,000 guilders. The number of computers which have been built has also increased dramatically: in 1953 there were 50, thirty years later almost half a million. We are moving towards a society based upon information and information technology which will replace the consumer society.

It sometimes seems that the future is already here. When an aeroplane takes off from Schiphol Airport, the pilot is told by the onboard computer what the arrival time at New York will be. This estimate is based on weather conditions and the route. The pilot himself has been trained by a computer: the flight simulator. The passengers have been booked by a computer and in New York a computer takes over the handling of the luggage. In the Boeing 747 a computer-voice will warn the pilot of emergencies.

However, despite the quite justified attention paid to this subject, I feel that there is one aspect which tends to be ignored and that is the role of the individual. This is unfortunately an omission which is not limited to the literature. As you are only too well aware, the human factor is frequently neglected in the practical application of automation, which can be detrimental to the interests of the people involved, the organisation or the process itself. You are all familiar with the fiascos or near-fiascos which result: according to a recent newspaper article, many of the first generation of robots were installed too hastily and without consultation, and have already been consigned to the scrap-heap or "laid off".

I therefore feel that the organisation of this conference was a very valuable, indeed essential step, since it places the emphasis on the human factor. After all, in the final analysis the crux of the matter is the relationship between science, technology and people, the way in which people can use technology in order to create a pleasant environment. Anyone who bases his thinking on this premise does not ask: what kind of future can we build with the technology available to us?

As I have said, automation and data processing will exercise a growing influence on the nature of our society, and whether we like it or not, we are all going to be involved, in our factories and offices, schools and hospitals, at home and in our daily life. We cannot therefore close our eyes to the disadvantages and hazards these developments may bring in their train. Nevertheless, I am convinced that in princi-

ple at least the advantages outweigh the disadvantages, although if the promises of this new technology are to be fulfilled it will have to be accessible to all. Otherwise there is a real risk of new social inequalities of the type which has frequently been prophesied.

In order to assure such accessibility and to make full use of our technological capabilities, I feel that at least two conditions must be met. In the first place, technology must as far as possible be geared to the needs of the people who make use of it. Secondly, people must learn to live with the new technology. If our society comes to place primary importance on technology instead of people, machines and systems will soon become our masters. Such a situation must at all costs be avoided, if only because it will inevitably arouse opposition. What is important is that people are allowed to retain their own individual responsibility. In other words, the implements produced by homo faber must not affect his dignity as homo sapiens.

The following step, the one with which you are especially concerned, is that people learn to master the new implements. Encouraging this learning process is no easy task, particularly as change is now so rapid that no-one ever completes the process. What is needed is continuous training and retraining, which as your programme points out, discriminates between different situations and levels.

Teaching young people at school how to work with computers is one thing. Familiarizing older generations with new technology is

quite another. Yet the latter is of vital importance, both for those concerned and for society. No organisation and no society can allow the experience and knowledge possessed by older people in particular to go to waste.

I am happy to be able to announce here today the start of a new project in this country. INPUT, a project initiated by the Dutch Savings Banks, aims to introduce micro-electronics and small computers in all Dutch primary schools. Starting with a test phase next September, INPUT will provide 5th grade pupils with an educational package introducing micro-electronics. If the test is successful, it will be possible to introduce a further phase - a real computer and a package on how to use it for 6th grade pupils.

The job you have taken on is to help people to master the implements of their trade. I hope that in the future you will continue to pursue this approach, which places people first, and that others will follow your example. One thing fascinates me about microchips. They seem to be able to do anything. They can translate (perhaps not very well, but they will learn). They can listen and speak and may in the future teach us about themselves. A speaking chip in a watch can even tell a speaker his time is up.

Ladies and gentlemen, my time is up.

May I conclude by wishing you a fruitful conference and a pleasant stay in the Netherlands.

Thank you.

# INTRODUCTION

## PURPOSE AND SCOPE OF THE CONFERENCE

Starting point for this conference was the conviction that computers and automated systems often do not meet expectations due to lack of attention to training of those people which are dealing in one way or another with the process of automation. This also implies poor functioning of system users, resulting in low work satisfaction or even removal from the job.

The conference was intended to bring together computer and automation engineers, training officers and education experts for exchange of experiences, for evaluation of modern developments in training and training design, and for better ways to integrate training into system design and implementation, with the ultimate purpose to attain a better implementation of automated systems within organizations.

It should be emphasized that the conference was focussed on aspects of (re)training of people concerned with the process of automation. General or formal education was only considered as a background or starting point for retraining. Training for automation is needed in all sectors of our society where automation takes place, not only industry and the services, but also the more general public sector, as all of us will be exposed more and more to computerized and automated systems.

## FRAMEWORK OF THE CONFERENCE

The preparatory committees developed a framework for this conference to serve as a structuring principle for the elaboration of the conference theme. The framework consists of three parts:

### a) Training in its environment.

Automation, when introduced in an organization, is an innovative process. It implies changes within the organization, its structure, the jobs available and the relationships between these. Two sectors are relevant within this context:

- automation of production: new developments such as computer assisted manufacturing (CAM) and design (CAD), robotics, etc.
- automation of administration: the broad variety of accounting, data bases, office automation, electronic mail, etc.

Against these backgrounds, the background of social and cultural differences and that of organizational change as a conse-

quence of automation, the place, function and needs for training were discussed.

### b) Training technology.

Knowing the needs for training, it is important to consider the technology of training. Training technology is considered as the knowledge, skills and instruments needed for developing effective training programs. Three main phases are distinguished, which in practice run in an iterative way.

- 1) Needs assessment or the analysis of needs for training. It is important to analyze the need for training within the context of organizational needs and sometimes even within the context of societal needs. Here we are interested in the specific training needs within the process of change of the organization as a consequence of automation. End products of a training needs assessment are at least a description of the training goals, its priorities and criteria, and a description of the context of the training, i.e. the entering behavior (level, attitudes, etc.) of trainees and available resources.

### 2) Training design and development.

Starting from training goals, the actual training program has to be developed. This is an iterative process in which several phases can be distinguished; such as formulating the training objectives, development of the training program and materials, try-out and evaluation, revision, ending up after one or more iterations in the actual implementation of the training program. This evaluation, directed on the improvement of training, is called formative evaluation. Because of our interest in computers, during this conference attention was also paid to the role of the computer within the training for automation.

- 3) Evaluation of training. Evaluation is an essential phase of training technology. A basic characteristic of systematic problem solving is to check whether the training is indeed satisfying the perceived needs. Therefore evaluation is an indispensable part of training development. The effectivity of the training with respect to the goals of the automation innovation process has to be evaluated. This type of evaluation, to test the quality of training, is called summative evaluation, as opposed to formative evalua-

tion we mentioned earlier.

#### c) Related topics.

There are several topics relevant to the conference theme which are not included in the preceding headings. Without being complete the following can be mentioned:

- specific conditions and problems of adult learning;
- computer literacy;
- retraining in automation;
- social and cultural differences;
- automation in the society of the future.

Some other relevant aspects have been touched upon in the discussions.

### THE PROGRAM

The program committee considered it as an honour that Mr. Pieter van Vollenhoven, husband to Princess Margriet of the Netherlands, was willing to open the conference with an address in which he sketched the importance of automation within our present societies and emphasized the role of training as a means to prepare people for their new societal roles.

The remainder of the conference encompassed three types of activities: plenary papers, round table discussions and paper sessions.

The context within which the conference theme was discussed was introduced by experts with experience in development and implementation of production automation, Bessant (UK) and Verstoep (NL), and of administrative automation, Krückeberg (FRG). In their plenary papers they presented automation as an innovative process within an organization and the inherent role of training. In the subsequent round table discussions about these topics and about 'social and cultural differences' and 'new technology and women', the participants have discussed with the speakers and among themselves their experiences with automation and the role of training in this type of environment.

The above-mentioned phases of training development were treated by several well-known educational technologists with great experience in training. Kaufman (USA) discussed the assessment of training needs within an organizational context and Romiszowski (UK) presented his experiences in training design. The topic of evaluation was treated by Keller (USA) and Möller (NL). Gunzenhäuser (FRG) explained how the computer can be a powerful tool in training, also in training for automation.

The majority of the paper sessions were dealing with training design, computer-based training or evaluation. Many of them are case studies, some are more of a technical character, while others are dealing with strategies and tactics. This great variety of papers was very promising for attaining the conference goals, viz. exchange of ex-

perience and discovery of better ways to integrate training into system design and implementation.

It was fortunate that during the conference we could also deal with the related topics. Mrs. Rogers (UK) explained what tools we need to learn 'old dogs new tricks', the title of her paper on adult learning, while Ershov (USSR) gave us a perspective of automation in the society of the future. Three other related topics were treated in the format of round table discussions: retraining in automation, computer literacy and, as mentioned above, social and cultural differences.

The discussions during the conference have resulted in conclusions about and recommendations for improving the innovative process of automation in many respects. During the conference we have collected information, so that at the end of the conference, we were able to formulate as a conference some common conclusions and recommendations, which, after modifications, were approved during the closing session.

### PROCEEDINGS

All papers presented during the conference are topically arranged in this book. The plenary papers, presented by the invited speakers, are the opening papers within the chapters they are belonging to; in the contents they are marked with an \*.

The discussions which took place during the paper sessions, are summarized at the end of the papers. Only in those cases where a topic is also discussed in a round table session, the discussions are put at the end of the chapter.

### ACKNOWLEDGEMENTS

Many people and instances contributed to the success of the conference. Without aiming at completeness, we would like to mention:

- the Committees on Social Effects of Automation and on Education of IFAC.
- the Technical Committees 3 (Education) and 5 (Computer Applications in Technology) of IFIP.
- the Division of Automatic Control of KIVI; the Royal Institution of Engineers in the Netherlands.
- the Directorate General of Science Policy of the Dutch Ministry of Education and Science, which gave a grant for organizing the conference.
- the members of the IPC and the NOC for their contribution to the conference program.
- Jolanda Grob who did, assisted by Paula Achterberg, the bulk of administrative work.

The editors

# CONCLUSIONS AND RECOMMENDATIONS

## 1. DEVELOPMENT OF NEW TECHNOLOGY

Information technology will continue to develop at a rapid pace, leaving knowledge and understanding of social, human, and ethical aspects far behind. In order to close the gap, pilot projects are necessary and interdisciplinary cooperation is to be promoted.

The development of information technology induces growing demands for skills, acceptance, and sensible application. Agencies of all types both private and public, face getting current staff competent, keeping up with development and staying useful. Results of training projects should therefore be broadly disseminated to non-experts.

The conference enabled fruitful comparisons between new technology impacts in manufacturing and in administrative sectors.

## 2. COMPUTER LITERACY

The broad introduction of information technology tends to separate people into two categories, similar to literate and illiterate. In order to prevent this development, computers should play a role in general education, particularly in secondary schools. The following subjects are important:

- what functions do computers perform?
- how does one use computers?
- how to select and use data in a given problem situation
- what are social effects of the information technology?
- the historical development of information technology.

For computer education in schools, a problem solving approach is preferable. This offers possibilities for teaching how to deal with information technology in new situations, which is a basic prerequisite for future job performance.

Computer education is not a matter of transferring only knowledge and skills, but also of encouraging positive and critical attitudes. People need not accept poor technology, even if it is new.

Finally, the word computer (il)literacy carries a negative load. A more neutral term is to be preferred.

## 3. TRAINING REQUIREMENTS

In the manufacturing sectors the pattern is of rising capital intensity: fewer people will be employed, but more will be required of them. As so much is invested in equipment per worker, it is important to match this with investment in human resources, i.e. via training in the broadest sense of the word. Although in the administrative sectors information technology is mainly introduced by isolated substitution of single pieces of equipment, the working environment is changing drastically, resulting in specific needs for training.

The impact of information technology on the organization also creates training requirements for managers and trade unionists.

In general, training is needed on two levels: the development of skills and of problem solving activities.

## 4. INTEGRATED TRAINING

Training can only function if it is well integrated into the organization, taking into account the social environment. This integration pertains to the time axis (the various phases) of projects, to the various functions of the organization, to cooperation between users, experts and suppliers, and to budgeting.

As a consequence, the position of the training function in the organization is not clear. A separate training department need not be the best solution, as integration can probably better be served by situational, user-oriented training than by centralized facilities. This dilemma, of course, is an example of the general problem of centralization versus decentralization in organization development.

#### 5. RETRAINING (Recurrent training)

The term retraining is not very satisfactory, as it covers widely different activities, such as rehearsal, updating (e.g. when equipment is replaced by a newer version) and training for job modifications.

Given that effective training is a creative, heuristic, problem-solving process, it is essential that trainees should have the opportunity to develop their skills, via experiential learning techniques. Regular retraining and recurrent education is not only important for transfer of skills from one job to another, but also for enabling workers to participate in the design process when their work stations are subject to (further) automation.

#### 6. TRAINING METHODS

Contrary to common belief, adults can learn new skills and acquire new knowledge, provided they are well taught.

Manuals are still a weak point in computer systems. Special manuals are required for non-computer experts. Specific attention should be paid to the development of training aids and tools.

Evaluation is relevant to various aspects and phases of training.

#### 7. SYSTEMS APPROACH

Systems theory in its presents form provides a good framework and useful tools for training analysis and design. Relationships between training results, organizational outcomes and societal impacts require more consideration.

#### 8. SOCIAL AND CULTURAL DIFFERENCES

Differences do not only exist between various countries, but also within countries and organizations. Computer technology should be adapted by every culture, not just be transferred to it, in order to preserve dignity and self-respect.

Repetitive training for new tasks, which are rapidly becoming obsolete, again and again, does not make sense.

#### 9. THE PRESENT CONFERENCE

Information technologists participating in the conference showed a great interest in human aspects. Our impression is that this does not seem to be so common with those not present.

There was a gap between information technologists and training experts. The former

were mostly concerned with training at the level of instructional product design and development, but in their papers they often did not refer to relevant literature on training design. The latter talked about relations to organizational policies and factors, but were not always aware of pressing needs and concerns of the former group of people.

In a conference on training the presentation of papers should be of outstanding quality. Unfortunately, many presentations were not above average.

#### 10. NEXT CONFERENCE ON TRAINING

The participants were in favour of a next conference on the same topic. Additional cosponsorship by an international training federation is desirable.

Dr. Cheetham (North East London Polytechnic, Longbridge Road, Dagenham Essex RM8 2AS, United Kingdom) promised to investigate the possibility of an IFIP-sponsored (and IFAC-cosponsored) conference, to be held in the U.K. in 1987, half way between the series of world conferences on Computers in Education.

In organizing this conference, special attention should be paid to paper presentation and to inducing training experts to show their practical experience, which, for instance, can be realized by letting them present workshops on specific training design skills.

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## MAKING THE FUTURE: DEVELOPING THE INDIVIDUAL AND THE ORGANISATION

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**Abstract.** With the emergence of information technology, widespread and sophisticated automation has become a practical option for firms across a wide range of industrial sectors. The skills and responsibilities required at all levels are moving towards the pattern already experienced in the advanced process industries.

In particular there will be a reduction of the direct, day-to-day involvement of those responsible for operation and maintenance: this must be compensated for in the design stage. Automation also raises questions about the adaptiveness of organisations in moving to more integrated forms of operation. It is argued that the training process represents an excellent vehicle for developing this flexibility.

**Keywords.** Automation; training; integration; process control; organisation development.

### INTRODUCTION

The concept of training to support new technology is not new. Ever since man first began to make use of tools there has been a requirement for a training process of some kind to ensure their optimal use. As society moved from simple to more complex forms of technology, so the requirement for training increased and became more specialised. With the trend in the manufacturing sector of increasing capital intensity, a small number of people are becoming responsible for a large amount of plant and equipment, often of considerable sophistication.

This pattern is already clearly established in the large scale process industries where - in oil refineries for example - entire operations are left to the discretionary control of a small group working from a central control room and relying on high levels of automation for the majority of plant operation.

With the emergence of information technology (IT), new possibilities have been opened up in the field of manufacturing technology and we are beginning to see a move towards the process industry pattern across a wide range of industrial sectors.

This paper provides an overview of some of the issues raised by the trend towards sophistication and integration within production automation.

We hope to show, drawing on various case study examples, that training has an important role to play in the process of organisational adaption and that this role goes well beyond that of simple provision of new skills. Training also has an influence on the pattern of work organisation, industrial relation, optimal design of systems, options for change in manning levels and relocation and also the future development of the organisation. We suggest that this range of influence indicates a need to make training a central process within the organisation - rather than something which is "plugged in:" at a late stage to meet specific skill requirements.

### SOME IMPLICATIONS OF ADVANCED MANUFACTURING TECHNOLOGY

Before we examine the implications of new technology for training, it will be useful to look more generally at the type of change taking place within manufacturing industry.

One of the most significant features of this shift is a change in the role of the operator. Increasingly the pattern is moving away from direct involvement and day-to-day experience of the plant.