

IMPLEMENTING AUTOMATION IN MANUFACTURING SYSTEMS: SOME ISSUES REGARDING ENGINEER EDUCATION

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Abstract. In this article we wish to submit our experience in the drawing up of a course directed at neo-graduate Italian engineers for specialization in the Management of Manufacturing Automation Technologies.

The reasons behind the drawing up of the course are described. The professional figure expected to emerge is a manager able to give a real contribution in the transition from traditional technologies to integrated flexible technologies.

The training path is described and we give a short summary of the content of the programme, from which it becomes clear that special emphasis is given to themes regarding the implementation of automation and all its organizational and managerial implications. The most important themes outlined in the programme are: the definition of an automation plan; organizational changes; project management; management of supplier relationships (both traditional suppliers and suppliers of automation products); changes in management systems.

The paper concludes with a description of the present state of progress of the project and with the precise definition of the multinational companies guaranteeing their sponsorship.

Keywords. Education - Automation - Technology oriented MBA - Implementing CIM - Manufacturing processes.

INTRODUCTION

In this paper we wish to submit the experience gained at the CUOA (Consorzio Universitario per gli Studi di Organizzazione Aziendale - Vicenza) in the drawing-up of a course directed at neo-graduate engineers (and/or engineers with brief working experience in the Operations Management field).

The course in question is a "long course", — the type which in Italy is called a Master course — with the aim of providing professional skills needed to implement automation in manufacturing surroundings.

The fundamental basis for the project we are presenting lies in the observation of the type of preparation that engineers have in automation when finishing at Italian Universities. Their preparation is highly technical and the emphasis is on technological knowledge of how particular information systems "work", the hardware and software details of the products themselves, the user interfaces, the local network features etc.

Apart from this type of preparation other essential engineering skills cannot be found: in fact preparation for "implementing" automation in manufacturing environments does not exist. The lack of preparation regarding the implementation of automation with all its consequent organizational, managerial and strategic implications was the main reason for our project aimed at filling this gap. We are supported in this opinion by literature and by our empiric observation of the principal expectations of companies intending to avail themselves of the professional abilities of engineers in facing difficulties in implementing manufacturing automation.

THE COMPANY AND ITS PROBLEMS IN ADOPTING AUTOMATION TECHNOLOGY

The empiric observation of the processes involved in adopting integrated automation technologies — universally known as CIM technologies — on the part of manufacturing companies, allows the description of some "protagonists" present in the reference picture.

A first protagonist corresponds to the "producer" of CIM products — both hardware and software; both plant automation and telematic products — who possesses abilities for the research and development of CIM products to propose to the market. These products represent continual advances of the frontiers of scientific knowledge; they are products able to offer performances that are increasingly better and more user friendly, as well as at lower costs.

A second figure is one we will call the "seller" for simplicity. This is the figure who will interact with the potential user. A feature of this protagonist is that he must possess many different skills; commercial ones as he must succeed in selling; technical ones as he must technically understand the CIM products; organizational ones as a consultant who must demonstrate to his listener that certain organizational or management problems can be resolved through adoption of the technology inherent in the product he is proposing. This multiplicity of roles often has a negative effect on the dynamics of the relationship between the "seller" and the potential client. The third protagonist is the manufacturing company, which must be able to evaluate proposals coming from various sources. It is a question of different proposals at different prices and different fore-

seeable performances.

Ability on the part of the company to sort out the different proposals is rather poor; equally poor is the company's competence in judging its own performance objectives and those effectively obtainable from the different proposals examined. This is due to the following:

- objective difficulty in arriving at technical evaluations of a variety of products, which are extremely complex and sophisticated and in competition with one another;
- the lack of sufficient analytical skills present within the company in developing representative models of the "present situation" to confront with expected "future situations" in terms of processes, capacity and business activity (identifying objectives regarding time-to-market, lead times, work in process and also identifying system interfaces, information exchange models, data base needs, information about technology development tendencies etc.);
- the lack of ability to develop consistent models for evaluating, in terms of cost-benefit, the different possible alternatives.

The reference picture briefly outlined here is at the basis of the CUOA's strategic idea to draw-up a new type of Master course to prepare professionally a figure who will play an essential role in this transition period of Italian industry towards higher automation levels.

THE EXPECTED PROFESSIONAL FIGURE

The aim of the Master is to form company managers able, with further experience in the field, to make a real contribution to companies in the above mentioned transition. The ultimate aim of the Master is that of providing a work method which the student, once within the company, is able to use to realize innovative plans for the company.

Formation of professional skills from the inside is extremely hard in terms of resources and time needed for large companies and is practically impossible for small and medium sized companies due to the complex skills required.

The two professional figures which already can be distinguished are dependent on the size of the company where the student will subsequently work:

- Small and medium sized businesses: the professional figure is that of a technician, in close contact with production direction, able to interact with the outside world and to judge technological possibilities in regard to internal realities and criteria. His task will then be to coordinate external resources following decisions taken in the company about plans for innovation.
- Large businesses: the professional figure is that of a technician working as part of a team towards complex automation planning. His task is to actively participate in product/process innovation while interacting positively with the rest of the team.

Both the figures described lead to a technician with acquired management skills, able to contribute to the development and consolidation of innovations.

Thus management, development and consolidation of innovations are the main tasks which the professional figure must carry out.

A professional figure like the one described requires an adequate basic technical-scientific preparation like that acquired from a technical degree together with:

- a deep knowledge of state of the art of automation in different areas;
- the ability to see company problems from an in-

tegrated or systemic viewpoint;

- the ability to get on with various work teams efficiently;
- the ability to plan integrated production systems.

As a logical consequence of this, training programmes should complete university preparation with a specialist post graduate Master, long enough to develop the knowledge, skills and behaviour necessary to the role dealt with above. Herein lies the validity of the Master, directed at the professional preparation of a "potential manager", able to actively and quickly become part of a company involved in transition plans towards automation.

THE TRAINING PATH

To outline a suitable training path, we must have recourse to the now classic distinction between the areas of knowledge to be conveyed. In other words, the didactic content of the Master can be expressed in a programme able to:

Provide Knowledge

This is at knowledge level. The student will possess the "background knowledge" considered necessary to operate positively in specific environments; as regards:

- the content of single areas of manufacturing automation (not just in descriptive terms, but also through operative experiments);
- the state of the art of automation in terms of existing and alternative technological solutions, also by means of a general view of the network of technology suppliers and a knowledge of methods and criteria to enable the student to evaluate the suppliers;
- a knowledge of the business framework as a real reference, including working logic, rules, critical factors, internal and external interdependences.

Develop Abilities

Ability development is intended in the traditional sense of "know-how" at the level of method and approach to problems. This is especially significant in the context of automation plans due to their particularly complex nature.

The following abilities should be developed:

- systematic approach to the analysis of complex operating systems, based on: particular attention to problem setting, the recursive approach, the ability to build-up interpretative models;
- management of multiple and various interfaces, both internal and external, which are firstly recognised and then clearly defined also in quantitative terms, and suitably managed either alone or above all together;
- planning of new situations, not only in technical terms, but in their managerial and organizational effects.

Develop Skills

We are here, even if it is only simulated, (reinforced however, by initial experiences in the field with project works) at the level of knowing how to be in an organizational situation. It is with many actors, and in the midst of numerous relationships. This is the area of organizational behaviour. The student must acquire sufficient skills to:

- communicate and negotiate in situations having specific objectives, both individual and group;
- integrate in very different work groups both from the specialization point of view and also from the point of view of the actual structure of the groups themselves;

- develop, always both on individual and groups levels, the student's creativity achieved through organizational learning, cross fertilization, learning to learn.

CONTENT

In drawing-up the Master course a series of themes were included which emerged from collaboration with people who were able to verify at first hand the real difficulties to be overcome in implementing plans for automation within the company.

The course, twelve months long and full-time, includes a first part devoted to topics which come under the term of General Management. The second part is devoted to a technological panorama of the three largest areas in the application of manufacturing automation; the area covering manufacturing operations (preautomation activities and JIT, robotics; NC, FMS, AGV etc.); the area of design/industrialization of the products (CAD, CAE, CAPP, NCPP etc.); the area covering the management of manufacturing logistic flows (MRP and MRP II etc.).

The third part of the course is devoted to the topics most closely linked to the implementation of automation plans. The principal arguments can be defined as follows:

- *The definition of automation plan*: the product plan; the integration of the product and process plan; the preautomation activities; the organizational and educational plan; the subdivision of the project into phases and definition of priorities; the identification of the effects of automation on company performances; the cost/benefit analysis; presentation and approval of the innovation project.
- *Organizational changes*: innovation as a form of organizational change; innovation management; communication and organizational learning; creativity development; resistance to change, organizational involvement and negotiation.
- *Project management*: project control methods; the project group; project manager skills; the role of the project manager in the introduction of automation systems; project financing.
- *The management of the relationship between firm and suppliers*: suppliers of different forms of automation technologies; definition of supply specifications; the effect of automation technologies on traditional suppliers.
- *Stipulating contracts*: the formulation of requirement specifications; the connected risks; supply delivery time and supply quality controls.
- *Changes in management systems*: new selection, education, evaluation and incentivization systems; the problem of plant maintenance; costing in automation systems; new problems and new methods in quality control; order entry and the new relationship between sales and production; the need of anticipating the adaptation of management systems.

This third part of the programme will be almost wholly developed using the method of case studies. We must point out that material available concerning the problem of manufacturing automation implementation is not a great deal. For this reason a specific budget for the drawing up of original business cases has been arranged. To this end, the collaboration of both "suppliers" and "users" of CIM products has been assured.

It is easy to see that this third part of the programme is the most important, being devoted to the theme of implementation of automation in all its organizational and managerial aspects, but above all because it is integrated with a project work, or work that the student will carry out within a company. The company chosen must have real problems and concrete plans to invest in manufacturing automation. The project work is an integral part of the third part of the Master course and must last at least 2,5 months.

THE ORGANIZATIONAL STRUCTURE

In order to set up the programme of the Master course, we had to be able to use an organization structure — the CUOA, a consortium of five Italian Universities in the north-east and about seventy public bodies and private firms — which could carry out the necessary synergies between people from the University — where education technologies lie — and people from the two typical environments interested in automation problems: suppliers of automation products and their users.

At the CUOA it was possible to evolve a particular type of collaboration, allowing the integration of different experiences; theoretical ones through University personnel with practical ones, based on the experience of people who operated as automation product suppliers or as a user and so protagonist of the organizational transformation which comes with the implementation of automation in manufacturing environments.

The CUOA considers the new Master course an opportunity to bring together many different experiences in the field of implementation of manufacturing automation, overcoming in this way present limits of individual experiences. We hope thus to contribute to the formation of a professional figure of "System Integrator", someone capable both of designing his own reference model of organisation — in keeping with the firm's strategy — and of carrying out necessary functions of integration between miscellaneous and distributed subsystems.

THE PRESENT STATE OF THE PROJECT

Two large sponsors are currently lending their support to the new course "Master of Integrated Automation Systems Engineering". One is the Digital Equipment Corporation (DEC Italia), a supplier of automation products, and the other is Electrolux/Zanussi, as a user company. Their sponsorship takes three different forms:

- the awarding of a significant number of grants to cover enrolment fees;
- access to the company for university researchers aimed at the collection of case histories;
- use of company personnel as teachers/witnesses for particular specialized topics.

Besides the two sponsors above, other firms have offered grants for young graduates in engineering. These are either manufacturing firms involved in automation projects or suppliers of automation products. Up to now the total number of grants made available by these firms confirms that almost 100% of places available will be covered by grants.

The support which the CUOA has been able to evoke from companies (both suppliers and users) is considered by the CUOA itself a clear indication of the validity of the project and represents a reason for supporting the organizational and financial efforts such a project requires.

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