ICT Adoption and Organizational Change
An Innovative Training System on Industrial Automation Systems for Enhancing Competitiveness of SMEs

Nunzio Casalino[1], Marisa Ciarlo[2], Marco De Marco[1] and Mauro Gatti[3]
[1]*Università degli studi Gugliemo Marconi, Via Plinio 44, 00193, Rome, Italy*
[2]*KPMG Advisory, Via E. Petrolini 2, 00197, Rome, Italy*
[3]*Università La Sapienza, Via del Castro Laurenziano 9, 00161, Rome, Italy*

Keywords: e-Learning, Automation and Innovation in SME, Change Management, Learning Organization, ICT Adoption.

Abstract: The purpose of this paper is to introduce and discuss the benefits of on-line training on automation and innovation fields and try to explain their organizational impact on small and medium-sized enterprises (SME). Besides it tries to understand what are the main barriers for SMEs with respect to the realisation of their innovative potential and their capacity to improve internal processes by ICT adoption and organizational change. They are becoming particularly important for achieving greater productivity, lower operational costs, and higher revenues (usually characterized by reduced access to external finance, unavailability of wider distribution channels, low internationalization, etc.). The purpose of the paper is also to synthetize the experience done and the benefits of e-learning and of a specific online environment in the training process in this field. The project provides training contents to enhance participants background and some innovative simulations to improve knowledge of employees on industrial automation systems.

1 INTRODUCTION

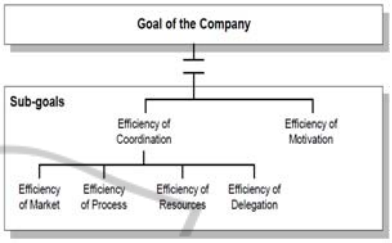
Information and communication technologies, automation and robotics have changed and are changing processes in industry. In parallel also on the scientific and vocational education level the integration of different fields like mechanics, electronics and information technologies (mechatronics) is practiced since years. Nevertheless many, especially small, enterprises have rather conservative approaches to new technologies and thereby miss many opportunities by utilizing improved technologies. SMEs need highly qualified staff, competent in operating with new machines and in managing sophisticated production processes. AutoMatic project addresses the problem of low or missing overview about possibilities offered by industrial automation systems. It adapts and develops an innovative approach and learning contents targeted specifically to SMEs to basically qualify staff on industrial automation systems. There have been significant debates about the impact of new ICTs on economic performance and competitiveness in general, and on productivity, efficiency, and innovation in particular. The diffusion of automation can produce new opportunities for SMEs. It overcomes the concept of traditional organization, emphasizes the interdependence between the organization of jobs and technology. Notably, in seeking an explanation for the acceleration in productivity and economic growth experienced in many industrialized countries, many economists have looked at the development, application, and utilization of ICT as a critical factor. Hence, at the firm level, the expectations are of greater efficiency, lower costs, and access to larger and new markets, while governments see the application and use of ICT as generating higher productivity, and competitiveness. This paper provides an analysis of automation and innovation fields and try to explain their organizational impact on Small and Medium-sized Enterprises (SME). Besides it try to understand what are the main barriers for SMEs with respect to the realisation of their innovative potential and their capacity to create employment (reduced access to external finance, unavailability of wider distribution channels, low internationalisation, etc.). Moreover, as first argued by New Growth Theory (Romer, 1986), the capacity of continuous innovation has

Casalino N., Ciarlo M., De Marco M. and Gatti M..
ICT Adoption and Organizational Change - An Innovative Training System on Industrial Automation Systems for Enhancing Competitiveness of SMEs.
DOI: 10.5220/0004116002830288
In *Proceedings of the 14th International Conference on Enterprise Information Systems* (ICEIS-2012), pages 283-288
ISBN: 978-989-8565-11-2

become a key factor in the global competition of high-income regions in order to acquire the additional factors of production and the new value adding processes which are necessary to keep an economy on a sustainable growth path. SMEs seem to be the ideal vehicle to promote both goals – sustainable innovation-based economic growth and employment creation – without trade-offs, given, as frequently assumed, the high flexibility as well as the relatively labour-intensive mode of production in SMEs. However, the issue as to how realistic these expectations are is anything but resolved. Despite experience with a different number of SME promotion programmes, it is also still debated as to which specific policy measures are really suitable to guarantee undistorted competition by compensating firm-size specific disadvantages, such as the SME's restricted access to public resources.

2 ORGANIZATIONAL IMPACT OF ICT AND AUTOMATION

ICT adoption and organizational change are becoming essential for achieving greater industry productivity, lower operational costs, and higher revenues. The close correlation between these dimensions of improved economic performance from ICT and organizational change corresponds well with findings from other studies on the impact of ICT on firm performance. It has thus often been argued that the effective utilization of ICT requires more horizontal organizational structures with greater levels of responsibility for the overall coordination of work placed on the individual employee. It also requires the implementation of clearer functional descriptions of tasks. All this often requires a complete reshaping of the organizational structure of the firm where all aspects of the organizational development are consequently given attention. Hence, it is important to note that the firms are going through a period of rapid modernization, emphasizing improved production processes and flexible organizations that can address the needs of the market, as part of transformations of the socio-economic fabric to a market-driven economy. This may in part explain why ICT is combined with other factors, such as new marketing strategies and organizational change. Today there is a strong need to collect more revealing data on ICT utilization and its impact on SMEs, the need for more rigorous analysis of how ICT investment and use affects innovation, and the need for better understanding how this can translate into productivity increasing and enhancing competitiveness. How to correlate SMEs in the internationalisation processes or whether they only function as suppliers in global value chains, dominated by large-scale transnational enterprises, is an open question. Without doubt, the current wave of internationalisation is accelerating the diffusion of innovation across industries. Yet it is unclear whether SMEs are driven by globalisation or whether they are a driving force in this process.



It is clear from this study that ICT utilization is already having an impact on economic performance among firms. This is reflected in the findings on the impact of ICT on economic performance, where it is evident that ICT is a substantial contributor to productivity, profitability, and growth. Accordingly, a new marketing strategy is particularly relevant for translating the introduction and use of ICT into the improvement of profitability. This is mainly because the use of ICT together with new marketing initiatives enables firms to strengthen their position in existing markets or enter new markets, thereby improve profitability. ICT is particularly important for lowering operational costs and increasing revenue. In addition to identifying the immediate impact of ICT on the economic performance of SMEs, it is possible to identify how firms use ICT to improve their future performance, namely through innovation. ICT is only a minor facilitator of innovation; it only becomes powerful in combination with a number of other complementary factors. The main factors contributing to innovation in SMEs are:

- changes in salary structure;
- training of staff;
- capital investment in equipment;
- organizational change;
- new market strategy.

In most of the sectors surveyed, ICT contributes more to process innovation than to product and relational innovation. The use of ICT is thus mainly for changes in production processes within the organization, rather than the development of new products or the furthering of relationships especially with suppliers. It was found that relatively fewer firms report decreasing costs as a result of ICT. Automation is the adoption of control systems and ICT to reduce

the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Automation plays an increasingly important role in the world economy and in daily experience. Automation has had a notable impact in a wide range of industries beyond manufacturing (where it began). In general, automation has been responsible for the shift in the world economy from industrial jobs to service jobs in the 20th and 21st centuries. The result has been a rapidly expanding range of applications and human activities. Design and manufacturing of products are important for information technology industry and can assist design, implementation, and monitoring of control systems.

3 INNOVATION AND TECHNOLOGY TRANSFER

Joseph Schumpeter is often mentioned as the first economist having drawn attention to the importance of innovation, defining five types of innovation ranging from introducing a new product to changes in industrial organization. The Oslo Manual clarified the definition of the two more technical definitions but still it appears that "innovation" is not easy to define precisely. In 1999 in his key note speech Mills gave some simple definitions:

1. Science: how to understand things;
2. Technology: how to do things;
3. Management: how to get things done;
4. Creation: bringing into existence;
5. Invention: devising something new or a new way to do things;
6. Innovation: turning an idea into income.

According to David Archibald the innovation is a science and explains what innovation and creativity means by these simple formulas:

1. Creativity = Idea + Action

By this, Archibald means that the "idea" is just the beginning to create something. People must do something to bring the idea and create something.

2. Innovation = Creativity + Productivity

In reality the sequence is: get an idea, test or prototype it, produce a finished item and bring it into use. In the case of artists this corresponds to: get inspiration, sketch it, put it down on canvas, and finally exhibit the work. For many businesses the ultimate goal is the idea to produce profit. In this case innovation must come from ideas that lead to sales.

3. Profitable Innovation = Innovation + Marketing

The innovation process is a combination of various activities starting from research but including design, market investigation, process development and may also include organizational restructuring, employee development, etc. Innovation implies creativity and dynamism that will benefit the company and result in an higher standard of living. However, as a conclusion it must be kept in mind that measurement of innovation is very difficult. Technology transfer is the process by which existing knowledge and capabilities developed under public R&D funding are used to fulfil public and private needs. Besides an organization must become a learning organization and there must be a constant and unstinting market focus. Market and learning orientation are less formal, less structured, and less sequential in SMEs (Gibb, 1997; Meziou, 1991). According to Baker and Sinkula (1999), learning-orientation "is a mechanism that directly affects a firm's ability to challenge old assumptions about market and how a firm should be organized to address it". SMEs have a natural advantage in that it is easier to create a learning environment in smaller organizations. Specifically, organizational learning is a workplace learning, which is a lower-level learning style involving the use of existing knowledge to enhance operation efficiency in SMEs (Badger et al., 2001; Chaston et al., 2001). To expand, a learning organization can be described as possessing:

1. commitment to learning: the degree to which an organization values that which promotes a learning culture by believing that learning is key to improvement and competitive advantage;
2. shared vision: an organization-wide focus on learning, or direction of learning that is evident across all levels of an organization;
3. open-mindedness: willingness to critically evaluate the organization's operational routine and to accept new ideas by continually judging the quality of decisions and activities taken and perceptions about marketplace;
4. intra-organizational knowledge sharing: collective beliefs or behavioural routines related to the spread of learning among different units within the organization by having mechanisms for sharing lessons learned in organizational activities from department to department (unit to unit, team to team).

4 ORGANIZATIONAL STRUCTURE AND HUMAN RESOURCES

A new flexible production system involves a lot of changes into firm's organization chart with the increasing use of automation, often pointing out the problem of the lack of trained staff. Indeed, very few workers were able to actively practice with new technology. This structure has to be modern and efficient and its staff have to be extremely skilled. Staff has to use the best technology available at the moment in the market (PLC, systems control, numerical controls, systems of automation distributed, industrial PC, barriers of protection). The business structure must integrate and elaborate information coming from different sources. As it regards the different business functions, they must be shaped so that results are accessible from this information. It is necessary to improve competences to allow solutions of personalized automation. We analyse in the detail the main competences. The technical person must also take care of the management of the cars related to specific phases of the production trial and must verify the conformity of the result in comparison to the standards, affecting the necessary regulations and intervening on possible anomalies. The technical staff must be able to use the principal programming languages and application, developing the ability to work in team and for objective, using different methodologies, as for instance the project management. The principal occupations are assembled in the technical offices and in the centres of research and development. Some unit profiles:

- the *technician*, in collaboration with administrative personnel, develops experimental researches using all necessary competences for the carrying out of the activities;
- the *engineer of trial* is the person who knows the trial that must be automated. In most cases, he coincides with the planner (mechanic) head;
- the *electric planner* designs the structure of the electric system that the cars and the different uses of the production trial;
- the *expert of field* defines typology, position and technical specifications of several sensors and essential actuators to check and watch the trial;
- the *planner of automatic controls* is traditionally also an expert of measures and covers the necessary competences of an expert of field. They define the control system architecture and the specifications;
- the *person responsible for maintenance* is another figure whose role is increasingly growing;
- the *person of maintenance of automation* must know how to distinguish between corrective maintenance and improved maintenance.

Then the role of management, it is to improve the quality of the products, the flexibility, to reduce the times of production, to adjust laws and rules and to improve the use of the available resources. This is possible by means of suitable choices of investment, actions of marketing and naturally through an adjusted plan of production. This last phase must be managed through a fit allocation of human resources and with the control of the productive trials making use of automation. As it regards the control of the production trials, the principal problem is the quick obsolescence of the firm's products. The solution is therefore the use of flexible systems of production that develop, in an automatic way, different products. Therefore we can distinguish three types of competences to recognize industrial automation:

- *Methodological Competences*. The figures have technical competences, tied to the routine of automation;
- *Technological Competences*. Methodological competences are realized in solutions implemented through technologies therefore technological competencies are necessary for those who are working with industrial automation;
- *Competences of Trial*. Automation requires knowledge on the trials to automatize. Rather, experience shows that the automation of a productive trial often induces to find formal and general descriptions of the same process;
- *Technological Complexity*. Technological complexity should not be too far ahead of scientific understanding as it would limit the commercial viability of the innovation by being too sophisticated for the end-user.

5 THE RESEARCH PROJECT

SMEs are generally resistant not only to training but also to other forms of wider participation. Generally, SMEs also engage in less management development activities than larger firms. Managers in SMEs are much less likely to have formal appraisals or discussions on their training needs. SMEs must still provide the ability for managers to learn by experience, bringing their knowledge, skills and values into the workplace and putting them into practice. Inevitably, these resources are limited and sometimes inadequate. This

can be potentially harmful for an organization, sacrificing the strength and consistency of its culture to achieve short-term gain. AutoMatic project, titled "Development of curriculum and innovative training tools for industrial automation systems for people employed in SMEs" addresses the problem of low or missing overview about possibilities offered by industrial automation systems. It develops approaches and learning materials directed specifically to SMEs to basically qualify staff in terms of industrial automation systems. AutoMatic has been selected for co-financing under the Lifelong Learning Programme, Leonardo da Vinci, Transfer of innovation projects (2009-1BG1-LEO05-01640 - October, 1st, 2009 . September, 30th, 2011, 24 months. The project web page is: www.automatic-project.eu.

During the project has been developed an innovative training approach e-learning platform, several learning contents and specific simulation tools in the field of industrial automation systems which are applicable in European SMEs. AutoMatic builds upon an existing approach developed in the pilot project "International Curricula of Mechatronics and Training Materials for Initial Vocational Training" for vocational schools developed by Tallinn Technical University, Estonia. The project consortium is composed by:

- Gabrovo Technical University, Bulgaria www.tugab.bg (project promoter);
- ECQ - European Centre for Quality, Sofia, Bulgaria www.ecq-bg.com (project coordinator);
- Tallinn University of Technology, Estonia www.ttu.ee;
- CeRSI - LUISS Guido Carli University, Rome, Italy www.luiss.it;
- Multidisciplinary European Research Institute Graz, Austria www.merig.org.

Target groups are practitioners in SMEs who intend to get an introduction and overview about industrial automation processes are the main target group of AutoMatic. The project also addresses students in vocational education as end users as well as teachers and trainers as intermediates. The developed products can support SME employees that want to improve their qualification or re-qualify and need to increase their flexibility with respect to market demands and successful realization on the common labour market. Between the results achieved, interactive training tools for industrial automation systems were developed. More specifically innovative **c**urricula and the following 5 training modules targeted at SME management and staff:

- ICT Based Means for Automation and Innovation;
- Sensors in Industrial Automation;
- Actuators in Industrial Automation;
- Application of PLC in Industrial Automation;
- Industrial Networks and Interfaces in Automation Systems.

In AutoMatic platform was integrated a "virtual teacher" that speaks slowly, with a clear voice and a perfect intonation. Therefore AutoMatic proposes an innovative approach for the training with a virtual teacher that holds the lessons, so that the distance training is combined with a similar direct contact. AutoMatic platform also offers auto-evaluation forms through which the learners can verify the acquired knowledge level. Such forms, at the end of every subject, allow the worker to immediately verify the acquired knowledge through the portal. Four different sections were developed for each training module:

- training courses;
- exercises;
- self-assessment;
- links & references.

The learning tools and materials are available in 5 languages: English, Bulgarian, Estonian, German and Italian. The learning tools and materials are available on-line, on dvd and on traditional booklets. Some main results achieved (Casalino, 2009) are:

- increased flexibility of SME employees who want to improve their qualification;
- increased motivation of target groups and their commitment for life-long learning and career planning;
- a good impact on the quality of vocational training and international co-operation in the area of industrial automation systems by providing time-saving and user-friendly approaches.

6 CONCLUSIONS

Studies on the process of information technology acquisition (Davis et al, 1994) clearly show that these systems go through several evolutionary stages. During this development the priority in order to succeed doesn't seem to be tied only to the acquisition process, but mainly to the paths of learning and organizational change. Experience suggests that these paths should be designed and carefully managed in order to allow the acquisition and effective use of ICT applications by the users and the whole enterprise. The traditional methodology for the training, in fact, results incomplete to furnish a suitable medium in the professional training field, because of dynamic and continuous changes in the ICT sector and the increasing demand of knowledge more and more in the quality field (Casalino, D'Atri et al., 2005). AutoMatic can contribute to the success of the SMEs. The strategy is based on the creation of a system for the training that meets the distance learning with the traditional benefits; therefore the two different methodologies are integrated. In fact, on one side the distance statement is a comfortable method for the training of a vast entourage of people within automation but, on the other hand a lot of people doesn't believe in the effectiveness of such method of statement because of the lack of a teacher that mostly involves the trainees. This research project includes the analysis of some indicators and specific key aspects that regard the current situation of automation and innovation culture in the European SMEs. These are:

- what is the current situation of quality aspects dissemination through on-line courses?
- how are the main models used and applied?
- what role can have national agencies or institutions, as the universities, on the diffusion of innovation culture or the implementation of automation for SMEs through both traditional and web-based learning?
- how organizational and cultural specificities affect automation implementation?

The importance of automation is increasing for the reason that lack of quality control and assurance systems, lack of accreditation and certification procedures, poor conformity marks, are still extremely diffused. Such impediments are considered as major potential and unnecessary technical barriers to trade, especially concerning international competitiveness and globalization. It is important to underline that SMEs have to meet the challenges of globalization and the new knowledge-driven economy aims.

REFERENCES

Butler, J., 1999. A practical model for technology and innovation management, *Proceedings of the Portland International Conference on Management of Engineering and Technology, PICMET*, 1, pp.103-105.

Cardinal, L.B., Alessandri, T.M., Turner, S.F., 2001. Knowledge modifiability, resources, and science-based innovation, *Journal of Knowledge Management*, Vol. 5, No. 2, pp.195-204.

Carneiro, A., 2000. How does knowledge management influence innovation and competitiveness?, *Journal of Knowledge Management*, Vol. 4, No. 2, pp.87-98.

Casalino, N., 2009. An Innovative Model of Transnational Learning Environment for European Senior Civil Servants - Organizational Aspects and Governance, *Proceedings 11th International Conference on Enterprise Information Systems - ICEIS*, Milan, Italy, INSTICC, pp.148-153.

Casalino, N., D'Atri, A., Manev, L., 2007. A quality management training system on ISO standards for enhancing competitiveness of SMEs, *Proc. 9th International Conference on Enterprise Information Systems - ICEIS 2007*, June 12-16 2007, Funchal, Madeira - Portogallo, INSTICC, pp. 229-235.

Casalino, N., D'Atri, A., 2005. Quality, usability and economical aspects in a medical web-based training service, *Proceedings of "The 4th IASTED International Conference on web-based education - WBE 2005"*, Grindelwald, Swiss, ACTA Press, Vol., Zurich, pp.304-310.

Casalino, N., Di Persio, F., 2004. Integrating medical services, training and education: the Hermes project platform, in *ATL - Advanced Technology for Learning Journal*, ACTA Press Anaheim - Calgary - Zurich, Vol. 1, Issue 2, pp.71-80.

Chesbrough, H., 2003. The New Business Logic of Open Innovation, Strategy & Innovation, 1, pp.11-15.

De Marco, M., 2004. *Le metodologie di sviluppo dei sistemi informativi*, Franco Angeli, Milan.

Gatti, M., 2000. *I costi nel governo dell'impresa. Strumenti di supporto dei processi decisionali*, Cedam.

Jin, Z., 1999. Organizational innovation and virtual institutes, *Journal of Knowledge Management*, Vol. 3, No. 1, pp.75-83.

Johannessen, J. A., Olsen, B., Olaisen, J., 1999. Aspects of innovation theory based on knowledge-management, *International Journal of Information Management*, Vol. 19, No. 2, April, pp.121-139.

Kaplan, S. M., 1999. Discontinuous innovation and the growth paradox, *Strategy and Leadership*, March-April, pp.16-21.

Kessler, E. H., Chakrabarti, A. K., 1997. Methods for improving the quality of new product innovations, *Proceedings of the Portland International Conference on Management and Technology, PICMET*, pp.405-408.