DEVELOPMENT OF PLC COURSES FOR PRACTICING CONTROL ENGINEERS IN MACEDONIAN INDUSTRY

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Abstract: The ASE Institute Skopje, Institute of Automation and Computer Based Systems Engineering at EE Faculty of SS Cyril and Methodius University, has had a close collaboration with the respective company of Siemens in Macedonia. In Skopje, for some time the GTZ Centre aimed at enhancing technology transfer has been established. Within its scope and program of activities, we have created a dedicated centre within ASE Institute and developed special courses on PLC based automation in cooperation with the Siemens in Macedonia. In this paper we present our results and the current state of the matters on our special endeavours to contribute to combined knowledge and technology as well as training skills transfer to practicing control engineers in our country. Also, we put forward some recommendations on this trend in the conclusion.

Keywords: Technology transfer; Programmable Logic Controller, education, course development, knowledge transfer

1. INTRODUCTION

The last century, as a termination of the Millennium, was a period in which began one of the biggest process of human development and innovation. Simultaneously, the last Century presents a time period of the biggest human clashes and disappointments, also contributing to the humanity urge for the continuous progress without any radical and short-term variations.

After facing the consequences of the destructions of the two World Wars, the normal process for reconstruction and re-constitution began, which divided the World into two spheres each contributing to the general development in specific way. So, humanity witnessed the first steps of the Space conquering, the peaceful use of nuclear energy, explosive industrialization and development of some parts of the Globe (USA, Europe, Japan, ..), computerization and maybe the most popular invention – the Internet.

This process created by itself several nucleuses of the knowledge, know-how, innovations and ideas, mainly concentrated in few zones. Initially, the output, expressing the idea of the invention as a confidential and private way to success, was strictly towards users not too distant from these nucleuses. But, this process contributed to another division of the World: *developed*, covering very small area, and *underdeveloped*, covering the rest of the world. As the humanity began to realize its undivided destiny, it began to think that the process of development must be global instead of local. Also, another process started, the process of the markets unification and growth, avoiding the saturation and self-destruction. However, the need to spread the development must not be understood only as a process of moving between the developed and the non-developed. The spreading of development has to be considered as s dialectic process, establishing the relation within the developed and native surrounding.

These two opposed, but goal-oriented processes, shared the idea that, in order to develop, one must *disseminate*. Therefore, one of the first things to share was the *knowledge*, the *ideas*, the *innovations* and the **technology** as a “path from the input to the output”.

Then, the question arisen was “How”? How to disseminate knowledge, ideas, innovations, and technology in a most effective way?

Let as now define the topic ***technology transfer***. According to several sources, it can be defined as following:
Technology transfer is a process of taking innovations from one domain and applying them to another (Lennon, 2001). Also ***technology transfer*** is the process by which technology, knowledge, or information developed in one organization, in one area, or for one purpose is applied or used in another organization, or area, or for another purpose (Popovska 2003).

During the last twenty years, industrial companies have realised that they can (and must) improve the efficiency by which they introduce new technologies into their products. By actively managing technology transfer, companies reduce the time scale and cost for introducing the new technology, which leads to more competitive products. Technology transfer takes the form of a commercial agreement between two companies - the *donor* and the *recipient*.

From the European perspective (Bessant 2000), *technology transfer* reduces duplicated research. It cuts the long-term cost of research by re-applying the results elsewhere. In addition, technology transfer exposes the technology to outside commercial markets, thereby allowing the companies to inject their own expertise back into the system. However, the major reason for Europe to support this process is the expected 'spin-off' into terrestrial applications. For a relatively small investment incremental, this spin-off can be significantly enhanced, that is what the industries in the Member States expect.

2. TECHNOLOGY TRANSFER IN SMALL AND MEDIUM SIZE ENTERPRISES

Small and medium-size enterprises (SME) account for a substantial share of current employment and future growth prospects worldwide. Depending on the country, these firms provide up to 60 percent of total national exports. Small and medium sized enterprises are impacted by globalisation, which is the growing interdependence of national economies, supports the rise to market turbulence, increased competition, loss of protected markets, and the emergence of international marketing opportunities. But, in this environment, most of the SME are disadvantaged, because they lack the resources of larger multinational firms (Zarezankova-Potevska 2002).

Despite the importance of SME to international marketing, very little is known about their prosperity under the globalisation conditions, or about the globalisation's moderating role on entrepreneurship and marketing strategy.

What is the role of entrepreneurship on SME-operations under globalisation? In such an environment, are the SME with an entrepreneurial orientation more likely to formulate and activate marketing strategies than the non-entrepreneurial SME, and is the marketing strategy associated with the initiation of tactics and other activities, which enhance performance?

Findings reveal that among SME affected by globalisation, entrepreneurial orientation is associated with the development of useful strategies, which are in turn associated with performance-enhancing tactics. Specifically, entrepreneurial orientation is strongly associated with the activation of innovative marketing strategies, product and product-service quality, and product specialization for niche markets. Superior corporate performance is associated with management action for modifying marketing and other strategies, in order to respond to the globalisation and preparation for internationalisation, which involves market research, resource commitment, and product adaptation. Managers appear to attach importance to the tactics of technology acquisition, globalisation responsiveness, and preparation for internationalisation.

In general, in the face of environmental turbulence caused by the globalisation, entrepreneurship is the key orientation that appears to support SME-managers in developing appropriate marketing strategies. These strategies in turn are associated with key tactics, such as technology acquisition, responsiveness, and preparation for internationalisation, which themselves is positively related to the financial performance in the firm. In order to improve their technical and managerial technologies, SME need to access practical applications in a time-efficient manner. For example, *partnership* and *collaboration* between large and small enterprises provide a time-efficient approach to technology transfer. Pairing large and small companies encourages technical cooperation, secondment of administrative personnel in coaching roles, and sponsorship of smaller firms' membership in trade and industry associations, thus benefiting SME. The *network* should initiate and coordinate actions to promote policies that encourage such mentoring relationships between large business and SME. In addition, the network is supposed to initiate similar projects within and across economies.

It is worth to mention the following:
Regarding SME, *technology transfer* has two main issues:
a) **Transfer** of technologies, developed within scientific programs, universities, scientific institutions etc;
b) **Training** and re-qualification of the SME staff with the support of a donor organization.
In that sense, the *technology transfer is a continuation of the invention* with other means, but no less creative.

Inventions compete with one another. If the inventions are poorly managed, they go "sour" in the desk drawer. They age from the day of creation and forfeit their potential for innovation. In this process, the *time* plays a very important role.

Quick profit cannot be made with technology transfer. On average, it takes five to ten years for an invention to become a marketable product and for the first licence income to flow.
Technology transfer requires a high degree of freedom and flexibility and flourishes best without bureaucratic constraints.
Technology transfer is a permanent process, which does not end with the licence agreement. The *technology transfer* requires continuous care and devotion.
Technology transfer has a good prospect if it is centrally organised – especially by SME-, when it is managed by a "lean organisation" and when all the parties participate through financial incentive in the economic success.

3. TECHNOLOGY TRANSFER AND THE UNIVERSITIES

During the support of its own mission, the technology transfer has developed a set of four primary goals:

1. *Encourage and assist faculty members, staff and students* to consider alternate applications of technology developed as a part of their research activities;
2. *Develop an effective and efficient technology transfer program and assess*, document and communicate the full value of technology transfer activities;
3. *Increase R&D income to faculties*, from public and private sources, by utilizing various technology licensing and research funding strategies; and finally
4. *Enhance economic development in the region and in the State* by building strong ties between the public and the private sectors.

In the last few years, the university (faculty) staff and the students are more interested to see their research results having reached the marketplace through starting a new, private company, rather than the traditional way of licensing the technology to an existing company. The technology transfer staffs are prepared to assist in this process by offering the following services (Matkin 2004):

1. **Identification of commercialisation options**. Through an initial meeting and follow-up, the *technology transfer office* staffs learn about the business opportunity and discuss various ways to move it forward. *Technology transfer office* staff present and discuss the attached Checklist of issues for a start-up company at FSU.
2. **Business opportunity analysis.** Following an agreement to work together, *technology transfer office* staff will work with the researcher in order to understand the research background and its applicability to particular markets. A *Business Opportunity Document* will be prepared, which (in 1-2 pages) describes: a) the opportunity (how the products will make money); b) the technology; c) the intellectual property situation; d) the products/services arising from the technology; e) the markets; f) the commercialisation process; g) and the next steps.
3. **Preparation of a Commercialisation Plan.** A brief document outlining the reason why a start-up company is appropriate, how the ownership might be apportioned, the legal incorporation of the company, the company site, the financing of the company, the *Business Plan* preparation, and the company management.
4. **Dealing with the university:** The *technology transfer office* staff can assist researchers to address and resolve the following issues:
   - Internal FSU sign-off/information to appropriate administrators;
   - How to provide a portion of commercialisation proceeds to all parties who have such an expectation - students, other faculty, the university;
   - FSU may have an interest in the intellectual property through policy or prior funding. This needs to be resolved and documented in an agreement;
   - Structural relationships with FSU - is FSU going to hold equity, is the company going to launch initial activities, while housed at the university, technology transfer into the company, etc.?

1. **Preparation of the Business Plan:** A plan is required to run the company, and provide performance milestones for any license. *Technology transfer office* staff is able to assist researchers in the preparation of the Business Plan. The *Plan* normally discusses how the necessary human and financial resources can be gathered in order to create a product flow, which is put into the market for satisfying the need and for creating a cash flow that, from the other side, allows the company to survive and grow. This *Plan* is an expansion of the *Business Opportunity Document*, but provides more description, details the financial projections including cash flow, and finally describes the investment opportunities. Such a plan has a series of *action plans* for product development; market development including sales and marketing, obtaining investments, strategic partnering, etc. There must be specific information about the governance (Board of Directors) and the advisory services (business mentors and advisors). The individuals who are going to manage the company are supposed to prepare the Plan. The technology

transfer staff can provide comments on a *draft plan*.

2. **Launching Company Activities:** As the company activities increase, hands-on involvement by the *technology transfer office* will decrease. The sooner the company has its own employees and advisors, the better it will survive in the marketplace. The *technology transfer office* will monitor company activities in a manner, which is negotiated, and can continue to provide advice and assistance as mutually agreed upon.

4. TECHNOLOGY TRANSFER CENTRES

4.1 General for Technology Transfer Centres

The new technologies, fast IT-communications, opening of the European market, the structural and economic changes, the effects of international and global competition etc. are some of the factors which leaded to the need of establishing *Centers for Technology Transfer (TTC)* (or Technology Transfer Centers).

Historically, departments and structures of some governmental and non-governmental Institutes or Organizations were responsible for activities, which are now belonging to the portfolio of the modern technology transfer centers. Today, the implementation of new technologies in practice is the main goal of the technology transfer centers.

Usually, the TTCs are founded as a part of the structure of Universities, with the main goal to strengthen the links of University with the industry, *in order to support the economical development of the region.*

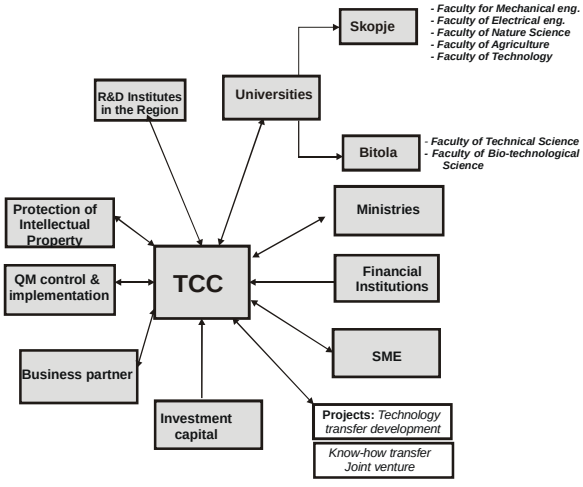

Fig.1: Organization scheme and Plan for Communication activities of the TTC in Skopje

As already mentioned forehead, one of the main reasons to establish a *technology transfer center* is to support the economical development of the region, which includes: new start-up companies, new employments, introduction of new technology, increasing of investments etc.

Organization scheme and plan for communication of TTC in Skopje are presented on fig.I.

4.2 Technology Transfer Centre on the Faculty of Electrical Engineering in Skopje

One of GTZ activities was the organization of Center for Technology Transfer at the Faculty of Electrical Engineering in Skopje. The tasks of this centre were to coordinate the collaboration between faculty and small and medium enterprises defining common projects. During this period of time the center has financed eight projects in the domain of training and education, electronics, wireless LAN, industrial management systems, which leaders were the employment from the faculty. Those projects were:

1. Testbed implementation and transfer of knowledge for e-applications development
2. Development of Switch-Mode Power Supplies for Industrial Applications
3. Substation Supervision and Control (SSC)
4. Production and Implementation of Telecommunication DC Supply System
5. Development of PLC education courses for control engineers in Macedonian industry
6. Industrial Energy Management System (IEMS)
7. Wireless LAN design and performance evaluation
8. Training and Education for Implementation of New Preventive Electric Drives Maintenance Technologies

All projects finished successfully in defined time.

5. IASE PROJECT: DEVELOPMENT OF PLC EDUCATION COURSES FOR CONTROL ENGINEERS IN MACEDONIAN INDUSTRY

Macedonian industry in the last few years has introduced an advanced technology in their production plants. New industrial plants consist of equipments with high level of automation. **Programmable Logic Controllers (PLCs)** are the most used units in process automation. The old control equipment installed in Macedonian process industry is based mostly on relay's logic, and so it has to be substituted with a new technology, that is a PLC, a control component with very high performances.

Engineer's knowledge about a PLC based process control is on the very low level. For this reason we think that a project of this kind will be of interest as well as for the professor's staff from the faculty also for the enterprise as Siskon, which deal with PLC especially with Siemens PLC SIMATIC S7.

5.1. Project objectives

The main objective of this project is*:* ***Development of Training centre for PLC Education.***
Owner of the centre is the small enterprise SISKON which main activities are on the field of industrial automatic control. Centre was developed by the Faculty of Electrical Engineering-Skopje.
For this purpose we designee all steps of the course and make training of the people from SISKON. With achievement of these objectives, in the future, SISKON is be able to organize itself advanced courses for engineers from Macedonian industry for implementation and maintained of PLCs in industrial applications.
The realization of this objective depends on the realization of the following tasks:

1. Adaptation of the space for centre (class, working places)
2. Providing an equipment for centre (hardware and software)
3. Issuing of course literature (one book for PLC and manual guides for exercises)

Other goals and achievements with realization of this project will be:

1. Increasing of the level of collaboration between Faculty of Electrical Engineering, as a high education institution in Macedonia, and enterprise Siskon, which work on the field of automatic control in Macedonian industry.
2. With realization of this project a possibilities for continual education of engineers from Macedonian industry is masked on the field of PLC based control through a courses organized by Siskon;
3. Increasing of the engineer's knowledge about PLC applications in industrial plants; as a perspective, the realization of this project can provide a continual education for the new generations of PLCs.

5.*2. Main activities*

The project consists of creation the training centre for education in programming, installing and maintenance of PL-Controllers. To achieve this goal we need to make some activities, divided into two steps:

Step 1:

1. Providing a class with necessary equipment: furniture, blackboard, computers, PL-Controllers, working desks, video projector
2. Designing and constructions of working desks for simulation a real automation industrial plant using PLC.

Step 2:

1. Creation and development of respective literature and manual guides, in Macedonian language, for programming, installing and maintenance of PLC controllers.
2. Teaching the staff from Siskon to carry out successfully a PLC course for applications in industrial processes.

To carry out these activities 4 person from the FEE and 6 persons from Siskon will be engaged 5 months. The necessary equipment will be provided from the partners, FEE-TTC and Siskon.
Time period of the project realization was 5 months.

5.3. Equipment: hardware and software for education centre

We established three working station which consist one educational simulation panel with one modular SIMATIC S7 312 Siemens PLC with one input, one output and one analogue I/O module. Also all three stations have the educational simulation panels with sets of switches, signalisations lights, several sensors, actuators, transducers and connecting elements. CPU module is S7 312 version, Input module is with 16, 24VDC opt couplers inputs, and output module is also with 16 relay outputs. Analogue module is with 2 12bit inputs analogue inputs and 2 analogue outputs.
Programming device is P4 PC with STEP 7 Light software package. Figure 2 present educational station with simulation panel with SIMATIC S7 PLC, connected with PC and demonstration plants (conveyer).

5.4. Course literature

We prepare literature for the course: one book for PLC and manual guides for exercises. Book: Programmable Logic Controllers (PLC) and its Application, is a book with more than 130 pages, and explain basics of PLC, logic functions, sensors and actuators, and PLC programming, especially Ladder logic programming. The book consist numerous exemplars from industry.

Fig. II. One working centre with PLC SIEMATIC S7-300, Simulation station, simulating process and computer with software STEP 7

Course manual consist material for complete course, hardware and software aspects of PLC with special aspect on SIMATIC S7-300 PLC and STEP 7 software package. Manual consists 14 Section and many exercises starting from very simple to the complete industrial processes.

5. CONCLUSION

In this paper we tried to present the experience of technology transfer centre GTZ in Macedonia, especially their engagement in the field of collaboration between universities and small and medium enterprises. In that manner we explain one of the project financed from GTZ, which was collaboration between Institute of Automatic and System Engineering from Faculty of Electrical Engineering in Skopje, Republic of Macedonia and one enterprise from Skopje which work on the field of Automatics in industry, especially with Siemens Programmable logic controllers. The project was Development ***of Training centre for PLC Education*** the engineers of Macedonian industry. The project successfully finished and to this time Siskon practiced few sessions with engineer from Thermal Power Station "REK" in Bitola.

Our opinion is that this kind of technology and knowledge transfer is a good possibility for help developing countries to practice new technology and reduce gap between the rich and developing countries.

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