Re-thinking the curricula for electrical engineering education in Serbia – case of the Autonomy Province of Vojvodina

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Abstract **- In Serbia, universities have to align the new structure of high education studies with and the new structure of economy. Changes in the economy result from transitional processes in Serbia as well as from the new role and achievements of global knowledge-based economy shaping the XXI century. The quantum leap in technology level underway in Serbian economy reveals the deficiencies in the available workforce, and imposes the need for a complete overhaul of the higher education system. The paper elaborates changes which should be done in order to build new curricula for electrical engineering education in Serbia. It is based on surveys organized in the Autonomy Province of Vojvodina, the richest part of Serbia, with economy based on traditional sectors such as agriculture and processing industry, as well as on emerging software industry, telecommunications and pharmaceuticals. Building innovation infrastructure with business incubators all around Vojvodina and a Science and Technology Park in Novi Sad, faces Vojvodina with fast growing economic activities, but with lack of high educated human resources too. We will present the main findings, which are inputs for on-going changes of curricula for electrical engineering education in Faculty of Engineering within University of Novi Sad.**

Index Terms - Electrical Engineering, High Education Reform, Restructuring, Transition, Serbia, Vojvodina.

INTRODUCTION

The Autonomy Province of Vojvodina (APV) lies in the Pannonian plane, ideal for agricultural production. Natural resources of APV, such as oil and gas, provide higher standard of life as compared to other parts of Republic of Serbia (RS). This attractivity enabled the number of inhabitants of the province to be disproportionably higher than necessary for using the aforementioned resources. The surplus of inhabitants is concentrated in larger cities such as Novi Sad, above all, as well as Zrenjanin, Subotica, Sombor, Kikinda, Pančevo, Vršac, Sremska Mitrovica and others. The existence of important educational institutions in these centres, and, above all, the University of Novi Sad as core high education (HE) center in APV, enables the rise of relatively skilled resources. Retention in the country and employment of these high-quality human resources (HR) is thus the priority of the development of APV. The use of the infrastructure of these cities, above all that of Novi Sad, constitutes a chance to attain these goals. In Research and Development (R&D) domain this infrastructure has to be significantly improved by building innovation activity institutions such as Science & Technology (S&T) Park in Novi Sad, business incubators, innovation centers etc. The Information and Communication Technology (ICT) sector, as a generic one, has a key role in this domain. It cannot only employ HR educated to work in the sector, but, because of its inherent multidisciplinarity, enable the employment of specialists in all other sectors.

APV is encountering a multitude of challenges on the road of developing a vivid market economy. Investment and business environment improves as new laws are being introduced, new institutions are being established, and new development policy is implemented. Majority of old industry is subject to radical changes and restructuring, meaning that in foreseeable future it will not be able to contribute to growth and employment. The ICT industry in APV is currently in a phase of fast growth but there are lots of potentials in other sectors which are not used that can make use of ICT advantages for their own development. The ICT industry, thus, constitutes a chance for APV to approach European integrations and standards, and for the economy in APV to realize an outbreak into the global market.

ICT sector, especially software industry, has extremely spread all over the world in the last ten years, and brought many possibilities for business development and entrepreneurship. It is expected that this growth will continue, since technology and communications enable access to global market and new business opportunities to both small and big companies. Globally, this sector usually exhibits the following main characteristics [1]:

- it provides quality employment to computer literate bachelors and technical personnel;
- starting obstacle for market entry, i.e. financial expense, is usually small in regard to the one in other sectors, which facilitates the occurrence of many innovative companies;
- the markets, especially the ones for special purpose software and for computer technology services, are still fragmented and versatile, which allows a wide spectrum of possibilities for small specialized companies in a multitude of subsectors;
- small companies can also export final products, if they have good connections with international markets, since the export canal is simple (Internet connection);

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- International companies are in constant search for cheaper solutions and access to knowledge that can make them competitive; this helps the global spread of technologies to the countries in development and transition.

The following four findings, which are of importance for research presented in this paper, are already a common knowledge.

- **Outsourcing**.
  Outsourcing affects both the involved companies and countries. This process that typically begins as part of a company's cost saving initiatives eventually affects the social structure and economics of the involved countries. Of particular concern for our research is its impact on the engineering practices and education in APV. The more traditional and routine engineering tasks will continue their migration to lower cost countries. Thus, the 'next generation' of engineers in the highly developed countries may need skills different than those from less-developed countries, and in many cases, skills different than what they currently possess [2]. This change implies that ICT professionals should, beyond technical skills and analytical ability, also possess capabilities and knowledge of system integration, communication, organization as well as motivation skills combined with the ability to work across cultures. [2].
- **Team-work and Software engineering**.
  Additional requests for software professionals result from the move from individual software development towards team work. "New graduates know few of the 'best practices' characterizing professional software engineering (SE) (e.g., use of software processes, measurement and analysis, team building, requirements engineering and high-level development methods, quality engineering, software maintenance, and testing). Unfortunately, with the increasing demand for software engineers and other computing professionals, many of these issues are obscured and it is difficult for many computing educators to understand and appreciate the importance of software engineering education. This problem is exacerbated by the fact that employers are so desperate to get graduates with any computer skills that mismatches between curricula and industry needs may be overlooked" [3]. Combination of business skills with computer science and other ICT topics in university curricula became general trend in HE reform [4].
- **Management of technology (MOT)**.
  Fast technological development requires integration of existing, more traditional and obsolete technology, with new, mostly ICT based technologies. There have often been important mismatches between the graduates of universities and the skills needed by technology based organizations. The National Research Council defined MOT as "linking engineering, science, and management disciplines to address the issues involved in planning, development, and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization" [5].
- **High-education reform**.
  Education reforms, under the context of globalization, are dictated by decentralization, privatization and better performance [6]. Growing concern for "value for money" and "public accountability" in a far more competitive global marketplace implies that "modern universities have to expand their commercial and business arms to reach out to the private sector for generating additional funding" [6]. University – industry networking integrates users, producers, entrepreneurs and policy-makers with university staff in knowledge production process, implying that "in an asymmetrical way, the university through these institutional innovations is also co constitutive of its industrial environment" [6]. Also, the HE reform suggessts that "in the Bologna system, the first half of the first cycle … maintains … general un-oriented training. Afterwards, the future bachelor choices a ''major'' orientation, the programme of which is constituted of entrance courses into the elected specialty, preparing the student for the Master degree in the same domain. This is smoothed by the concept of 'minor' orientation, in addition to the major one, which allows certain flexibility to an eventual further re-orientation." [7].

In Serbia and APV, this sector is rising, unlike many others, while the Government of Serbia is preparing the implementation of e-management program on the state and regional level, and the economy and public companies are trying to modernize administration business and the work process. It is encouraging that foreign companies are coming to APV to produce for both domestic and international market [8]. Small private companies earn by export to specialized markets, and universities and institutes have initiated the creation of university innovation centers, incubators, science & technology parks and new innovative (spin-out) companies, focused on international cooperation.

This paper elaborates changes which are being and should be done in order to build new curricula for electrical amd computer engineering education based on surveys organized in APV. Building innovation infrastructure with business incubators all around APV and the Science & Technology Park in Novi Sad, faces APV with fast growing economic activities, but with lack of highly educated human resources too. ICT sector is among leaders in growing sectors, with almost 100% of export of all products and services. During 2006 we were engaged in creation of ICT development strategy in Vojvodina [9]. Visits, interviews and surveys were conducted in order to build information reach foundation for this strategy. Particular attention was paid to knowledge, skills and positions of already employed electrical engineers: how employers evaluate them. The main findings and lessons learned during this research are summarized below.

BACKGROUND

World economy includes processes that change conditions and rules in global competition, and transition towards knowledge-based economy is one of its most prominent features. ICT and software industry sectors are the best representatives of a new technology revolution based on

knowledge. The World Economy Forum defines competitiveness as a blend of factors, policies and institutions determining the level of productivity in the country and thus establishing the level of development that a country can achieve in conditions where knowledge-based economy is being established [10]. By the WEF methodology (2001), the Growth competitiveness index (GCI) encompasses [10]:

1. A component describing quality of macroeconomical environment – represented by the Index of macroeconomical environment (IME),
2. A component describing the state of institutions in a country – represented by the Index of public institutions (IPI),
3. A component describing the importance of technology and innovations, i.e. the level of technological readiness – represented by the Index of technological readiness (ITR), comprising of:
   - Innovativeness index,
   - Technology transfer index,
   - Information-communication technology index.

However, the data for Serbia and Montenegro in this WEF report (it does not contain separate data for Serbia and APV) are not favorable. They are summarized in Table 1, wherein NRI stands for Networked Readiness Index.

TABLE I
SERBIA AND MONTENEGRO RANKING

Year	NRI	GCI	ITR	IME	IPI
2004	79	89	75	102	85
2005	80	80	68	111	69
Source:	[11]	[10]	[10]	[10]	[10]
Countries Surveyed	104	117	117	117	117

The WEF report for 2005/2006 emphasizes the importance of education and acquisition of particular skills, as well as the level of training of employees, in the new conditions of global economy and ICT development. Reduced transportation and communication costs have stimulated large multinational companies to move their production and development facilities into the parts of world where there is a favorable combination of knowledge and abilities of the employees and cost of their work, as well as political and social stability. Such a combination existed during the transition process in most countries of Central and Eastern Europe (CEE) during the nineties, causing twice as fast economical growth as in the rest of Europe [10].

In order to better understand the influence of ICT on the development of economy and the society in general in the countries of CEE, especially in the new EU member states as well as countries candidates for EU membership, several studies of this phenomenon have been conducted in the past years, coordinated on behalf of the EU by the Institute for Prospective Technological Studies (IPTS) in Seville. A synthetic report points at challenges that will influence the development of information society in this decade [12]:

1. A change in conditions of competition pressure – a potential of ICT for economical development;
2. Growing divisions in the society – the influence of ICT on society groups and society segmentation, so called digital division;
3. Appearance of new problems related to economical growth and demography – influence of ICT to transition and reforms in education;
4. ICT can help countries, new EU members, to reach the level of economical development of original EU countries before its expansion (so called EU 15);
5. There is a potential for economical growth based on ICT in sectors that do not use ICT as well.

These findings have stressed the need for more intensive use of ICT in certain branches of industry and public sector as well as creation of economical and industrial environment in which the business sector would invest more in ICT, resulting in faster economical growth and establishment of an information society in CEE countries, in line with the Lisbon strategy for increasing EU competitiveness [13].

Gloomy WEF findings related to the state of competitiveness of Serbian economy are nevertheless encouraging as regards trends (see tble 1). Since ICT is one of the key factors of the Index of technological competitiveness, an analysis of the competitiveness of this particular sector comes as a logical subject of investigation.

METHODOLOGY

The purpose of creation of ICT development strategy in Vojvodina, launched in 2006, was to bring up facts and competitive possibilities for companies of ICT industry in AP Vojvodina, so it could fit to modern market course in an adequate way and compete both at home and on the global market [9]. The authors of this paper were engaged in creation of this strategy, preparing the methodology and conducting research in order to identify main problems and obstacles as well as to propose set-up of priorities (projects and programs) in the field of ICT, crucial for development of economy and society of APV in the next 5-10 years. Methodology consisted of:

- Survey of existing ICT companies in APV, including questionnaires, interviews and on-site analysis of company's performance;
- Set of brainstorming sessions, devoted to analysis of present situation and generation of possible directions for future developments in ICT sector in APV;
- Use of Delphi method for setting-up of priority programs and projects;
- Presentation of achieved results, in order to collect responses from all interested stake-holders, as well as to promote proposed set-up of priorities (projects and programs).

In this survey, primary data comes from statistical research computed in the course of preparation of this document, while the secondary data comes from existing statistical reports. The sample used for the survey was provided by the Chamber of Commerce of Serbia and came from the list of registered companies in ICT area in APV. Checking these data, we identified 43 active companies in the field of software industry with 497 employees, 4 in the field of telecommunication with 71 employees, and 32 companies in the field of hardware industry with 517 employees, which are 79 companies with 1085 employees' total. By direct insight – visits, interviews and analysis of

gathered questionnaires in these companies, we treated a sample of 14 companies with 399 employees, which is 37% of all employees in ICT industry in APV.

For this survey, we developed "A questionnaire for surveying competence, competitiveness, and cooperation and characteristic development trajectories of companies in the ICT sector in AP Vojvodina", which consisted of the following segments [9]:

(1) General company data;
(2) Company profile data – for identification of competence of the company;
(3) Business and company growth data – for identification of competitiveness of the company;
(4) Strategic company partnership data – for identification of cooperativeness of the company;
(5) Company business effects data;
(6) The opinion of the accountable manager of the company about the quality of human resources in the company – current state and trends in the period 1995-2006;
(7) The plan for further development of the company in 2006-2008 (2010), in the following fields:
    - Technology development,
    - Home market,
    - Global market,
    - Development of the company human resources;
(8) What does the company expect from the state to improve business conditions;
(9) Is the company satisfied with available communication infrastructure;
(10) Data of the people who answered the questionnaire.

In the sequel, we shall present findings and results of relevance for analysis of human resource potentials in APV, regarding education and training of electrical engineers.

FINDINGS

I. Software Industry in APV – Survey findings

Analyzed companies of the ICT industry are, regarding the number of employees, in the category of micro/small and just few medium size companies. They have exceptionally good qualification structure, more than 80% of employees have a university degree, among them software developers account for more than 50%. The rise of employment is particularly encouraging. It can be observed that 2006 was the break-out one, with the number of employees more than doubled, and an intention to continue the trend in 2007 as well.

Most of the analyzed companies of the ICT industry are relatively young, founded after year 2000. They are mainly companies in private ownership.

Main activities of the analyzed companies are: (a) selling of own products/services; and (b) outsourcing. 12 products/services were identified for both activities. When the activity of a company is selling their products/services, the predominant are: Real-time system management software; Web applications; Communication software; Production management; ERP (Enterprise Resource Planning). Regarding outsourcing, the predominates are: Web applications, ERP. Note that the analyzed companies are concentrated on lesser number of products/services, when their activity is just their selling. Larger dispersion is noticed concerning outsourcing.

JAVA and C++ are mostly used, showing both the nature of the majority of applications developed and the kind of knowledge graduated experts need to have.

Year after year, revenue of these companies, on home and foreign markets, is observed to grow. Even though these companies are not particularly willing to disclose data about their business, the collected data suggest that the majority as well as the most important buyers/users of products/services of these companies are abroad. Since the average total labor cost in Romania and Bulgaria is two times lower than in Serbia, we can conclude that the main source of competitive advantage is the quality of products/services. This is confirmed by the evaluation of the sources of competitive advantage of the analyzed ICT companies: (a) Regarding the global markets, the predominant source of the competitive advantage is good quality; (b) Regarding the home market, the specialized expertise in the sector is the most important.

Important information for strategic positioning and development of the companies in the ICT sector is the evaluation of competitive disadvantage: (a) Regarding the global market, the most important source of competitive disadvantage is poor marketing; (b) At home, the most important sources of competitive disadvantage are poor marketing and high prices of products/services, implying that the market is still underdeveloped.

The most important type of relationship with foreign partners is R&D outsourcing contracts, with significant presence of license agreements. This finding should influence the institutions assigned with the task of governing the science & technology development, indicating that there exists a significant portion of the innovation system in the APV that is, at least not publicly, a part of R&D system, i.e. is not the beneficiary of regional subvention programs.

ICT companies in APV look for foreign partners in order to solve the problem of finding the customers, stressing the aforementioned conclusion about the poor marketing as the primary source of their competitive disadvantage.

The final finding indicates a large discrepancy between the development of the home and global ICT market. Global market poses more constraints, not only regarding prices and deadlines, but especially regarding quality. Home market, as stated before, is preoccupied more by the price than quality.

II. Human resources in SE

Human resource (HR) **quality** in SW companies in APV (an overview of statements of analyzed companies):

- These are good programmers, dedicated to their work;
- Having in mind the exceedingly complex requirements of the software components used and realized, there is a shortage of very talented programmers, as well as experts in this complex field (digital signal processing, linguistics, math...);
- Regarding skilled managers, it is difficult to find people who are capable of acquiring this fairly complex matter;
- Quality of experts is on a very professional level, with a stress on the personal wish to improve the working environment and continuous professional improvement;
- HR of the ICT companies are their most valued assets;

- Development of human resources has been initiated from the R&D centre at the Faculty of Technical Sciences (FTS) of the University of Novi Sad (UNS);
- Regarding the beginners– junior programmer positions – the engineers coming from the FTS-UNS, are capable of a fast introduction into the work process, with those from the Faculty of Science (FS) from the same university, close second. Recent changes in curricula have enabled the students to acquire practical experience, working on the university projects, which proved to be very useful;
- The shortage of people in the sector is a consequence of huge increase in demand;
- The price of quality experts have significantly grown in the last 12 months;
- Practical cooperation between FTS-UNS, and ICT companies – strategically investment into people during their studies and focusing them on areas that will ease employment after finishing them. Thus, there is a direct correlation between the quality of studies on this faculty and the quality of human resources employed now or in the future at the companies, justifying the intense focus of the companies on the improvement of the studies on the FTS-UNS;
- Some thoughts on theme 'Which are the qualities needed for a Junior Programmer?':
  - *Intelligence* (IQ) is very important; genius is not needed, but high IQ is more than useful;
  - *Perseverance*, will to learn new things (even an extreme IQ is useless if the person is lazy and disinterested);
  - *Ethic/moral values*, sincerity, openness (sounding maybe trivial, this is still of utmost importance);
  - *Communication*: not too many people, especially those that have recently finished their studies, are capable of actively listening, i.e. active participation in the conversation and reasoning (as opposed to just nodding without any understanding what it is about). Asking questions when something is not clear, without fear/shame that the question is stupid - usually there is a more experienced person that will give a helping hand;
  - *Pragmatism*: experience with beginners says that they usually try to solve the problem in highest possible generality. The other usual problem is that people are tied to a certain tool or environment, and tend to neglect any other possibility including more efficient work environments;
  - Excellent knowledge of foreign languages (primarily *English*);
  - Last, but not least, one should acquire the basic knowledge of *project management* during studies.
- Insufficient number of quality programmers for Java and .Net technologies;
- During the period 1995-2006 we observed a declining trend of available high-quality people, which can partly be attributed to increased demand;
- Specificity of the business and long-term projects implore ICT companies to 'build their own personnel', employing new human resources immediately after finishing their studies, and than gradually introducing them into their development teams;

HR **development** strategy in SW companies in APV (review on individual reports of analyzed companies):

- Scholarship for the most talented students, mentoring work, number of international projects and good team organization;
- Doubling the number of HR in the next 2 years using partnership with the biggest companies in the field;
- Growing marketing team, selection end optimization of development team – the goal is to decrease expenses;
- Increasing the number, quality and competence of existing and new employees by improving cooperation with university. Foreign partners provide trainings and education, either in partner's company or in specialized houses. The company knowledge management system provides sustainability and internal education;
- Participation in conferences, postgraduate studies scholarships, mentoring programme for new graduates;
- Training in project management, quality control and managers skills and techniques, and continuous technical and professional improvements;
- Scholarship for students on last years of studying;
- Certification of leading professionals.

III. R&D and Educational Institutions in the ICT sector in APV

The most significant R&D and high education institutions in the ICT sector in APV are located within the University of Novi Sad:

- The Faculty of Technical Sciences (FTS),
- The Faculty of Sciences (FS).

Total number of teaching staff is 158, and number of students is close to 2000. Number of graduates is close to 300 every year.

IV. SWOT analysis of HR in the ICT sector in APV

After the overview, the SWOT analysis was made as:

1. *Strengths*:
- High qualification structure of employees,
- Programmers mostly use JAVA and C++,
- Usage of a very wide array of software tools,
- Programmers are dedicated to their work,
- Quality of human resources at a high professional level,
- Fast absorption of new knowledge, efficient use of the Internet and a logical approach to problem solving are the typical traits of young ICT experts;

2. *Weaknesses*:
- Lack of programmers and other ICT specialists,
- Lack of managers to run ICT business,
- It takes 3-6 month after hiring a recent graduate to enable him/her to perform given tasks with success,
- Lack of quality programmers for JAVA and .Net,
- Lack of inventiveness and innovativeness;

3. *Opportunities*:
- Increase in employment rate since 2005,
- FTS and FS educate high quality ICT specialists,
- FTS has practical collaboration with ICT companies,
- ICT companies organize training of their employees,

- Programs for fast training of the people with medium education for software jobs could be envisaged,
- Including people with lower education or abilities into services via ICT infrastructure is a possibility to explore,
- Awarding scholarships to students of final;

4. *Threats*:

- Cost of quality people has risen significantly since 2005,
- Attitude towards job and absence of professional ethics,
- Lack of interest in studying engineering,
- Underdeveloped infrastructure for specialized training of ICT professionals,
- Lack of specific knowledge and abilities: ICT project management, marketing and PR in ICT etc.

SURVEY'S RECOMMENDATIONS CONCERNING THE CURRICULA FOR ELECTRICAL ENGINEERING EDUCATION

Interviews, on-site visits and written remarks, both from ICT companies and from university staff, lead us to propose the following recommendations [9]:

- Organizing visits of professors from abroad for a period from 6 months to a year (financed by provincial authorities). Priority should be given to our acknowledged experts, due to the language issue;
- Organizing courses of foreign lecturers and exchanging experiences with colleagues from abroad. Participation in organizing thematic courses for enterprises' needs;
- Iintroduction of different management courses within technical studies, such as: project management, marketing management, quality management; business communication; professional ethics; etc.
- Introduce education for entrepreneurship;
- Supporting inventiveness and innovativeness of ICT professionals;
- Supporting the function of an S&T Park as an integrator of companies having a similar but complementary profile, so that they could apply for getting projects of a greater significance;
- Organizing a business incubator in Novi Sad and in other cities in APV, particularly in the field of ICT;
- Founding a Training centre of secondary school pupils in JAVA and C++ tools. This centre would provide an efficient - from 6 to 12-month – training of new programmers, prepared to get involved in development projects of ICT industry in APV immediately. A similar solution gave results in Timisoara (Romania);
- Reforming the secondary education system to encourage team work, creativity, active listening and reasoning;
- Introducing professional responsibility insurance, which is a prerequisite for making some international contracts;
- Simplifying customs regulations on temporary import;
- Including people with lower educational profile or capabilities in providing services through ICT infrastructure, without minimum additional education;
- Encouraging a mathematical way of thinking at the earliest age possible, by organizing mathematical competitions at all levels. The goal is to include as many young people as possible, since competitions develop curiosity and capabilities to be significant in the later work in ICT sector);
- Starting technological foresight programs in ICT field;
- Participation in the expenses of patent protection abroad;
- Building broadband communication infrastructure.

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