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Globalization Prospect of Credit Transfer System in Educating Control Engineers: A Developing Country Experience

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Abstract: More that ever before nowadays is extremely important to consider the impact of high technologies on the sustainable economical and society development of the country. One of the main reasons is the high technologies and the underlining sophisticated knowledge themselves, whereas the other is the fact human resource mobility hence high education and training are an intrinsic part of the ongoing globalization processes. In turn, the actual run of high education and training as well as the associated recognition, evaluation and verification of degrees and diplomas acquired in various countries is to become more and more a global issue. The very same issues concern high education and degrees oriented towards automation, control and systems engineering. These issues are explored more closely through the case study of the actual ongoing practice in a small developing country.

1. INTRODUCTION

In the contemporary age of globalization the mobility not only of the capital and material and energy resources but also of human resources is an essential feature, as a matter of fact is a sine-qua-non precondition. In the case of highly educated and skilled labour it also does involve the aspect of the actual compatibility study curricula and syllabuses as well as recognition and verification of university degrees. As currently the globalization processes have gained full momentum, the above pointed aspects concerning highly-educated human resources and labour become also global and affect more and more countries at larger scale. The notorious evidence is found in such process within Europe, which in turn had become known as the fame of Bologna process after the *Bologna Declaration on European Space for Higher Education* and the respective accord document (1999).

Indeed the high education is very important for economical development of any country, big or small and developed or developing one. Well structured and contents rich high education produces a successful engineers and mangers, which make up one of the fundamental preconditions for prosperity and good life of people in any country on a long run. Yet, so deep and many considerable changes have taken place during the last couple of decades within the high education in general, and that in automation and control in particular (e.g. see References cited, a selected short list, in particular see: Dimirovski, 2004; Dormido and Morilla, 2002; Gentil, 2004; Ilyasov, 2000; Kopacek, 2004; Lindfors, 2004; Mishau et al, 2001; Romanovsky et al, 2004; Stinchombe, 1990; and Vlacic and Brisk, 2001).

These processes are especially affecting hence important for small countries with transitional economies as the Republic of Macedonia (the RM) is, and for other developing and countries alike. High education as a part of all the society as a whole is also affected by the overall transition requirements. For this reason our Republic of Macedonia is one of the countries that signed to Bologna Convention for European Education (EC of the EU, 1999) albeit is not a member country of the European Union as yet. It is not so simple matter to transform one education system to another one, because the transformation means not only to get certain subject credits, but also to satisfy certain conditions: student work space, laboratory equipment, education staff, administration staff, and other requirements due to the existing laws.

2. GENERAL FEATURES EDUCATONAL MODELS: A CASE EXAMPLE

As a rule, the countries with transitional economies are ether developing under-developed hence with low gross-national income and level of poor living. Keeping in mind that countries in transition are typically rather poor, it is difficult to properly ensure the pre-conditions needed for a successful process of high education and training. Additionally, since the high education process is long-term process it is impossible to obtain quickly the results of any changes and modifications introduced. At least it is necessary minimum four or five years to carry out one generation of engineers. Therefore the problem is much complex than it seems at a first glance and a considerable deep insight is necessary in order to infer proper conclusions. Albeit Macedonian high education is formally transformed according to these new trends in Europe, in reality it does not work so well and essential changes are moving slowly.

1.1. Outline of an Education Model

The largest university in Rep. of Macedonia is “SS Cyril and Methodius” University, which is also a national university and

located in capital Skopje. It is consisted of many separate units working as faculties from technical and non-technical profile. In the past almost all undergraduate studies at (College) of Electrical Engineering and Information Technologies (FEIT).

In the course of transition process we had to decide about the two education models: 3+2 or 4+1. The Faculty of Electrical Engineering and Information Technologies has indeed accepted the model 4+1, four years undergraduate and plus one year of postgraduate studies for MSc degree. It was not easy to transform all class lectures at undergraduate study from 9 to 8 semesters. This required an effort to change all curriculums in the means of a new philosophy using the European Credit Transfer System.

The principles of the European CTS include the following item features:

- Credit is allocated to course units according to the principle that an academic year equals 60 credits;

- Universities present the full range of courses to incoming students in an information package in which the credit value for each course is clearly indicated;

- There is a formal learning agreement signed prior to departure by the home university, the host university and the student, describing the student's program of study abroad, and accompanied by a transcript of record that lists the student's past academic achievements;

- The sending university recognizes the credits received by students from partner institutions in such a way that the credits for the passed courses replace the credits which would otherwise have been obtained from the home university during a comparable period of study.

At this moment only the first two item points have been fully applied in the undergraduate studies. For the time being there is not an exchange of students and lectures between FEIT and other similar institutions abroad in the wider sense, e.g. across Europe. Thus for the time being we have no experience with the last two item features.

Still, these are oriented at meeting the principles of high education in countries of European Union. It should be noted, the principles of the European CTS also include the following requirements:

- Five year studies equal to 300 credits;

- One credit equals to 16 hours institutional study plus 10 hours home study;

- Credits are applied to all subjects and other relevant student activities;

- Recognition of credits is not set up in conjunction with the evaluation;

- Students do receive their credits, respectively, only after recognition of the subject.

From these five requirements the evaluation of the credits for each subject were the most difficult to satisfy. All courses are technical faculties had time duration of five years: 9 semesters lectures of teaching and 10-th semester was used to prepare a final diploma examination. So was the case with our Faculty organized in 3 class-hours lectures plus 2 class-hours exercises per week, and divided in two groups: specialization elective courses and compulsory courses. To evaluate a subject credit we take into account class-hours lectures, class-hours auditory exercises, class-hours laboratory exercises and seminar works. The formula is:

Number of Class-hours Lecture $\times$ 1,5 credits + Number of Class-hours Laboratory exercises $\times$ 1,0 credit + Laboratory Exercises $\times$ 0,5 credits

Therefore the maximum credits per subject that can be earned is 7.5 credits, and the minimum – 4.5 credits. It may well be that this formula is not the best solution. Nonetheless, it is better than to evaluate each subject with equal number of credits. In this way whole student's effort and engagement about certain subject should be properly weighted.

1.2. Curriculum of Computer System Engineering Module

Department of Automation and System Engineering (ASE) is one of the 11 departments at the Faculty of Electrical Engineering and Information Technologies (FEIT). It provides lecturing on 20 course subjects during all study semesters. The 11 of them are elective, and another 10 are compulsory. With the selection of elective subjects the student can choose her/his orientation to one of the following three majors:

- Process automation;

- Robotics and expert systems;

- Computer hardware engineering.

As the number of elective subjects increase towards higher semesters the student has a larger freedom to build its own profile of engineering education according to personal preferences and wish. In principle, the developmental policy at FEIT adopted evolves along the lines of enabling the students to a large extent to shape themselves their own professional education and training within a framework that has to be compatible with the principles and constraints of Bologna Declaration. It should be noted, however, that the current stage of the transformation developments is still the early stage. The real-life lessons are yet to be learned in the near future.

2. CTS AT FEIT AND THE STUDY MODULE ON COMPUTER SYSTEM ENGINEERING AND AUTOMATION

Taking into account the requirements specified in the Bologna Convention, academic studies will provide highest automation and system engineering education to students who have completed 300 credits. Beginning with the academic year 2004/2005 the novel approach and the ECTS was applied to the undergraduate study program of FEIT (Law of H.E.,

2000).The FEIT is operating with 8 study curricula according to principles of ECTS. The undergraduate studies take 8 semesters including 14 working weeks each. In each semester two midterm exams are carried out; though several mini-tests and home works may be implemented. The CTS of the FEIT for control engineers of computer system engineering and automation module is shown in Table 1 further bellow. The undergraduate as well as graduate studies at FEIT (and at other colleges and universities too) in our country operate under the supervision of the Ministry of Education and Science. Any changes to the programs and the organization of studies must be compatible with the Law for High Education and must be officially examined and approved by the Ministry before made legal by the Government.

The syllabus of module computer system engineering and automation is largely focused on courses in Automation and Control Engineering. However, a considerable number of courses are dedicated to technical application of information technologies, electronics and measurement and processing of signals. All these courses are organized in 3 class-hours lectures plus 2 class-hours exercises per week. During five years of study, students pass trough program that provide them with the following grades of competence:

- First year: introductory level is common for all modules;
- Next three years: professional level (subjects specific and related to control engineering) leading to BSc Eng;
- Last year: Master of Science degree.

In authors' opinions, the credit system is appropriate for studies of computer system and automation engineering as these programs need to meet a number of externally determined constraints and requirements. Namely, these may be summarized as follows:
- National requirements for engineering diploma or master of science;
- Bologna Convention requirements including specialized courses;
- Quality standards specified separately for education and for different courses and training programs.

These measures can involve partner universities from participating countries educating control engineers and working together to modify or to adapt existing programs, or to establish new, jointly devised programs of study. Thus, the programs of studies in area of computer system engineering and automation at different colleges and faculties should essentially be very similar or equivalent, which means that implementing the CTS across institutions in different countries should not be too difficult.

In the meantime, in reality it doesn't work in such a way. We have not information about the strategy of government for need of this kind of engineers and masters (the strategy of our government is focused on a project of an open informatics based society). Because of lack of many other necessary conditions (work space, education staff and so on) we have included only one specialized course for Programmable Logic Controller (PLC). Almost there do not exist quality standards for education valid for a long time period, because the law for high education was changed many times in this transition period of 16 years in our country. Nonetheless, to the best of our knowledge, the proposed syllabus for module of computer system engineering and automation is compatible with the syllabuses created at engineering colleges of the same kind across Europe and indeed on a larger world-wide scale.

3. THE EXCHANGE OF STUDENTS AND THEACHERS

At the current age of globalization processes world-vide, one of the aims of implementing the CTS should be to enable the exchange of students and lecturers with other foreign universities and polytechnics that operate under similar programs on a global scale. For the time being we have established the co-operation with the "Jozef Stefan" Institute in Ljubljana, Republic of Slovenia. This is merely a bilateral international project currently going on for a second three-year period. But both sides see it only as the beginning and both sides are gathering pragmatic experiences needed. These should be put through a jointly conducted re-appraisal process by the end of this second three-year period.

In the future, our intention is to establish new partnerships with other foreign institutions. On the grounds of the intentions of and by the means of the principles of Bologna Convention, the following benefits are expected to be gained:

- Staff and student exchange will improve the level of teaching in English;
- Students will be able to choose where they would like to complete some courses;
- Exchanging lecturers will allow comparison and exchange of teaching methods and programs;
- The exchange of experiences allows faculties to ensure that a minimum level of education has been attained;
- A consequence of such co-operation is better preparedness of students to undertake the future employment.

Table 1 The CTS of the FEIT for control engineers of computer system engineering and automation module

Semester I

Compulsory courses		
Course	Class hours	Credits
Mathematics 1	3+3+0+0	7.5
Physics 1	3+1+1+0	6
Fundamentals of Electrical Engineering 1	3+2+1+1	7.5
Structured Programming	2+2+2+0	6
Foreign Language	2+0+0+0	3

Semester II

Compulsory courses		
Course	Class hours	Credits
Mathematics 2	3+3+0+0	7.5
Physics 2	3+1+1+0	6
Fundamentals of Electrical Engineering 2	3+2+1+1	7.5

Object-Oriented Programming	2+2+2+0	6
Foreign Language	2+0+0+0	3

Semester III

Compulsory courses		
Course	Class hours	Credits
Linear Transforms	3+3+0+0	7.5
Basic of Measurement Techniques	3+1+1+0	6
Electronics	3+1+1+0	6
Theory of Systems	3+2+0+1	7
Specialisation Elective Courses		
Principles of Logic Design	3+1+1+0	6
Algorithms and Data Structures	2+2+1+0	5.5
Internet Programming	2+1+2+1	5.5

Semester IV

Compulsory courses		
Course	Class hours	Credits
Elements of Numerical Mathematics	3+2+0+0	6.5
Linear Dynamic Systems	3+1+1+0	6
Electronics 2	3+1+1+0	6
Digital Signal Processing	3+1+1+0	6
Specialization Elective Courses		
Computer Architectures	3+1+1+0	6.0
Electric-power devices	3+0+1+0	5.0

Semester V

Compulsory courses		
Course	Class hours	Credits
Nonlinear Control Systems	3+2+0+1	7
Modeling, Identification and Simulation	3+0+2+0	5.5
Specialization Elective Courses		
Fuzzy Logic Control	3+2+0+1	7.0
Probability and statistics	3+2+1+0	7.0
Basic of Machine Intelligence	3+2+0+1	7.0
Introduction in Robotics and Intelligent Systems	3+0+2+0	5.5

Semester VI

Compulsory courses		
Course	Class hours	Credits
Computer Process Control	3+2+0+1	7.0
Microprocessor Systems	3+1+1+0	6.0
Elements for Automation and Robotics	2+2+1+1	6.0
Specialization Elective Courses		
Process and Robots System Design	3+2+0+0	6.5
Automated Production Line Design	3+2+0+0	6.5
Linear Optimal Controllers and State Estimators	3+2+0+1	7.0
Production Process and Plants Control	3+2+0+0	6.5
Electromotor Drives	3+1+1+0	6.0

Semester VII

Compulsory courses		
Course	Class hours	Credits
Digital Transmission of Information	3+1+1+0	6.0
Programmable Logic Controllers	3+2+0+1	7.0
Computer Integrated Production	3+2+0+0	6.5
Specialization Elective Courses		
Tele-control and Distributed System Control	2+2+1+0	5.5
Process measurements and electronic materials	3+1+0+0	5.5
Security System Design	3+2+0+0	6.5
Project Management	3+2+0+0	6.5

Semester VIII

Compulsory courses		
Course	Class hours	Credits
Operational Researches	2+2+1+0	5.5
Flexible Manufacturing System Control	3+2+0+0	6.5
Specialization Elective Courses		
Intelligent Robots and Knowledge Representation	3+2+0+0	6.5
Industrial Networks	3+1+1+0	6.0
Wireless Computer Networks	2+2+1+0	5.5
Principles of Quality Control	3+2+0+0	6.5
Process Computers	2+2+1+0	5.5

4. CONCLUSION

To the best of the understanding of the contemporary trends in educational adjustments and changes, this process of modifications is going to be a continuing one for a number of years to come. Moreover, this process is likely to spread out world-wide one way or another to a considerable part of the globe if not throughout the whole of it.

The actual run of high education and training as well as the associated recognition, evaluation and verification of degrees and diplomas acquired in various countries is already an issue of the globalization phenomena, and it is bound to become *more and more a global issue of concern.* The very same issues concern high education and degrees that are oriented

towards automation, control and systems engineering. We, the control engineers and educators are responsible in the first place these issues of concern to be correctly defined and resolved on a world-wide scale.

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