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From Engineering to Mechatronics Management

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Abstract: International development is critical if we are to stabilise previously unstable regions. The development of new, sustainable education systems in such regions is well known to be an important driver for international development generally, attracting considerable body of literature as well as numerous donor initiatives. Developing economies in the midst of fundamental restructuring of higher education may benefit from radical approaches to engineering education programme design. This paper sets out the case of the development of a BSc and a MSc curriculum in Mechatronics Management in Kosovo. It demonstrates that it is possible to develop higher-education programmes in advanced engineering, which have potential local economic impact in an emerging economy and are designed with that goal specifically in mind. The case demonstrates how it is possible to apply theories of engineering and technology professional competence to develop higher education programmes with the potential to deliver on aggressive economic and educational objectives.

Keywords: International Development, International Stability, Engineering Education

1. INTRODUCTION

Today’s engineering environment is more challenging than ever before. With today’s increased technical complexity and competitive pressures, the breed of managers that has evolved must confront new problems in managing complex tasks. To manage effectively in such a dynamic and often unstructured environment, managers must understand the interaction of technical, organizational and behavioural variables in order to built a productive engineering team. (Thamhain, 1992)

Devereux (2004) described the following key dimensions of educational competence:

1. Administrative Competence: the individual has a range of business knowledge, can follow rules, procedures and guidelines set out by the organisation and can perform to the expected standards set out by the organisation.
2. Ethical Competence: The individual has moral standards which guide them in their decision making activities in the work environment.
3. Productive Competence: The individual is efficient and capable of producing desirable results. Productive competence particularly focuses upon the capability of the professional to continuously develop their knowledge and skills.
4. Personal Competence: The individual can manage time, possesses necessary ‘people skills’, time management, communications and conflict management skills to operate effectively in the working environment.

In the past, the areas of engineering and management were regarded as two very different and unrelated areas. Trained specialists undertook the process and technical aspects of engineering, while a different type of person altogether, often with an unrelated background and experience, oversaw the management of an engineering business or technical processes.

Times have certainly changed; new skills and new approaches are required of a staff that have the responsibility to make the most of their hi-tech processes. The need for a new kind of manager has been heightened by the new international nature of most businesses. There is an increasing demand from customers to deal with people familiar with the technical aspects of a product and who are also experts in business management and customer relationships.

2. ENGINEERING MANAGEMENT

Therefore between 1992 and 1994 an Engineering Management Program as a co-operation between the Vienna University of Technology and Oakland University in Rochester, MI, USA were developed. The participants received a degree Master of Science in Engineering Management from Oakland University as well as an official certificate of Vienna University of Technology. The highlights of the 480 hrs program were:

“Master of Science – MSc.” Degree and an academic record of Oakland University and an official certificate of Vienna University of Technology.

Executive program: 10 (12) 40 hrs. Modules (Friday morning to Tuesday evening) every 3-6 weeks in Austria and a two weeks stay in USA.

Combined American – European faculty (50 : 50).
Two weeks in USA with company visits. At that time this program was unique in Europe.
The program was completely given in English.
Target groups were:
Graduates from technical and other universities with or without practical experience
Graduates from professional training schools (e.g. HTL, FH) with significant practical experience
Postgraduates from continuing education programs and graduates from special training programs with significant practical experience
Persons with similar qualifications
Until 2005 approximately 120 were graduated in this program. More than 60% of these are now in high management positions in industry mostly abroad, 30% founded own successful companies.
In 2006 this program was included in the Department of “Continuous Education” of Vienna University of Technology and currently is running the 14th class.
A similar program, called “International Engineering Management – IEM” started 2002 in Prishtina in cooperation with the “Institute for Enterprise Management and Education – IEME” nowadays “University for Business and Technology - UBT “.
IEM was the first postgraduate program (MSc) in Kosovo. The first program was started with 28 students and has continued successfully for more than six years.
The curriculum of the program almost was made based on the curriculum of the Engineering Program of Vienna University of Technology and Oakland University. Some additional topics are involved to provide information according the region needs: small and medium Enterprise, service industry, etc. 60% of the curriculum consist of Management, Business and Law elements the rest was engineering and technology. All Students who attended the program have become a very good career path.
Fischer (2004) compared 138 Engineering Management Programs worldwide. Firstly, he recognized that the subject domain typically includes a combination of technical and non-technical subjects focussing upon general engineering. Secondly, there is a high demand for graduates with non-technical skills from these programmes, as compared with the skill profiles of graduates. This further suggests an imbalance in the profiles of the programmes as against the demands of the organisations that employ the graduates of the programmes.
Fischer (2004) suggested to design a Mechatronics Management programme targeted at developing future engineering managers.

4. MECHATRONICS MANAGEMENT

4.1 Mechatronics

Mechatronics consists of the integration of mechanical engineering with electronics, computer systems, and advanced controls to design, construct, and operate products and processes. Mechatronics is one of the newest branches of engineering with far-reaching applications. Generally, a mechatronic system can be seen as a mechanism, which is driven by actuators that are controlled via microelectronics and software using feedback from one or more sensors. Mechatronics is therefore the title given to the sub-discipline of engineering which studies the integration of mechanical and electronic technologies to create ‘intelligent’ machines, systems and controllers. Mechatronics is an interdisciplinary field integrating Mechanical Engineering, Electronics, and Computer Science.

Failure of advanced technology projects has often been attributed to non-technical rather than technical problems. Research has postulated that the poor treatment of non-technical issues within advanced engineering programmes has contributed to systems failure, as those charged with designing, developing and implementing the technologies have not been provided with the necessary set of skills and knowledge needed to manage these non-technical issues. As a result, high profile professional bodies have called for a greater balance between technical and non-technical competences of technologists (for example review websites of Just IT Training & Recruitment; JP Morgan and Goldman Sachs International).

4.2. Education in Mechatronics Management

It was clear that mechatronic managers must possess the core skills of mechanical engineers and electrical engineers as well as management and business. Their knowledge enables them to supervise or solve a wide range of mechanical, electrical and software problems, allowing them to participate in and lead multidisciplinary design teams (Ceccarelli et.al., 2006).

Therefore a mechatronics management BSc and MSc program, based on the engineering management program, was developed in the framework of two Tempus grants by " Vienna University of Technology – VUT/IHRT “, "Waterford Institute of Technology – WIT “, “University of Cassino – UNICAS/LARM” and “ University for Business and Technology – UBT “. It provides a broad-based education in the basic principles of electrical, mechanical and computer engineering as well as business. This programme fills a major gap in current mechatronics programmes by focussing, in a balanced way, upon both technical and non-technical aspects of the work of mechatronics engineers. In particular, the focus upon enterprise, systems engineering and mechatronics, as well as the provision of a broad foundation in science, ensures that graduates will be sought after by a wide variety of prospective recruiters. Furthermore, graduates will have the necessary acumen to start-up their own companies (Ceccarelli et.al., 2006).

According to the Bologna Convention the BSc program consists of 180 and the MSc program of 120 ECTS. These programs are the first worldwide to educate “ Mechatronic Managers” and are currently running at UBT in Prishtina.
5. EXPERIENCES

The main goal of the above design was to develop a curricula which would enable graduates to be conversant with business issues, and appreciate these in the context of the implementation of “new” technologies. Therefore the curricula are continuous adapted according to the newest developments and new subjects included. Examples are business and engineering ethics (Stapleton and Hersh, 2004), Internet marketing, medical technologies, End of life (EoL) management; Ressources efficiency, Nano- and Femto technologies, ubiquitous and cloud computing, Complex System Design and Management………………

It is important that the curriculum would be ‘fun’. For many prospective students, science and advanced technology courses are perceived to be extremely difficult and not inspiring. Consequently, it was felt that the programme needed to incorporate ‘edutainment’ i.e. to involve problems set in both an entertaining and educative context. 

A well equipped laboratory for the technologic subjects and an excellent computer infrastructure are absolutely necessary. Therefore at UBT a mechatronics lab was installed and continuous improved (Kopacek, 2006 ).

The staff have to be international and a weighted compromise between academics and industrialists. In fact in the Vienna EM program 20% of the lectures a given by former graduates of this program

The BSc and MSc theses must be supervised by the academic staff because staff members from industry have usually limited time and experience.

Selected MSc theses should be published and/or presented on scientific well recognized conferences. There are some from the Vienna EM program.

To offer the graduates the possibility to finish a PhD work. Until now 6 from the Vienna EM program, 5 (3 already have finished) from the IEM program. For the MM program we have to look.

Teaching material should be available electronically and surprisingly also in hardcopy – preferably textbooks.

Private Universities:

Advantages of these institutions are:
Curricula’s could be very flexible
Newest developments in special courses and seminars – length depends from the subject (2 - 40 hours).
Possibility to hire lecturers familiar with the latest developments from industry as well as from research. The problem is the didactic quality of such lecturers

Disadvantages:
Top education cannot be cheap; most of these programs are too expensive.

Problems:
On a very fast growing education market it’s more and more difficult to attract participants (quality vs quantity).
Usually the pre-knowledge of the participants, coming from different fields e.g IT, mechanical, electrical engineering, physics, economy, financing, social sciences, law,….. are very different and therefore the groups inhomogeneous. This requires that the lecturers have to adapt the contents from program to program.

Attendance of the participants. Many of them are involved in management position in small and medium enterprises and their presence was important at company.

Overwhelming administration

Academic Writing and Research Culture by the participants coming from different areas and have more focus and interest on applied knowledge.

6. SUMMARY

Instability in developing regions such as Kosovo is an important focal point for international-level policies aimed at sustainable development which promotes regional economic convergence. The European Union has already embarked upon processes of convergence together with neighbouring Balkan territories with the explicit aim of accession to the EU of both Serbia and Kosovo. There are mutual interests at work here which are explicitly aimed at continental socio-economic and political stability. This requires economic restructuring to create sustainable growth as quickly as possible, and education in domains such as advanced engineering are key pillars in such a policy. Without educational development the underlying conditions for economic development are rarely met. Consequently the case study set out in this paper is of interest, both in and of itself as a exemplar of engineering education, well as of more general to TC 9-5 as a mechanism for creating (or at least contributing to) international stability. This case study demonstrates how new universities in less-stable regions can benefit from radical approaches to engineering education programme design. The paper present the case of the development of a BSc curriculum in Mechatronics Management for one of the new international universities in Kosovo. It clearly demonstrates how, through innovative pedagogical approaches plus international agency support (in this case through the EU FP 7 programme) that it is possible to develop higher-education programmes in advanced engineering, which have local economic context in an emerging economy. Mechatronics management is an entirely new field and since the programme was launched has attracted several cohorts of students in a region which has very low levels of economic activity. The authors show how it is possible to use theories of engineering and technology professional competence to develop a coherent programme which has the potential to deliver on aggressive economic and educational objectives.

TC9-5 is committed to addressing the problem of international stability and recognizes the important contribution of the IFAC community in this space. The related technical committee for Control Education which is also part of the CC 9 social effects group of technical committees within IFAC, is also deeply interested in innovations in the design and delivery of educational initiatives as set out here.

This paper contributes therefore directly to the aims of both technical committees. Its primary aim is to inspire other engineering consortia to “go and do likewise” by pushing the boundaries of control and automation engineering education
in order to address pressing problems of international development.
Graduates of mechatronics management are unique in the labour market. They have learned how to combine the intensive technical knowledge of mechanical engineering, electronics and IT with management insights and skills. They are a new breed of graduates with interdisciplinary approaches and expertise, holding a core set of well developed technical skills. As part of their BSc studies they learn about entrepreneurship and are inculcated with creative skills. They also take on major projects which have as outcomes concrete solutions to important mechatronics problems, worked out in practice in the mechatronics laboratory which is unique in the region. Consequently they are well positioned to start up their own companies and can also take up work as a project manager or as a head of a department in a company in fields where mechatronics solutions are, or will shortly be, part and parcel of the innovation stream needed to energise the regional economy, fields such as Medical, Agriculture, Transportation, Mining etc.

The case study project recognized that education in engineering and technology management generally and mechatronics management in particular, requires a departure from the “classical” higher education mentality. Key points are:

1. Incoming students must a good basic general education including science, mathematics, economics, foreign languages (especially English) and related domains. This is a real challenge in Kosovo where the secondary and primary education sectors require significant developmental effort and where education quality is patchy at best, when compared to more developed economies in the European Union to which the region is seeking to accede.

2. Curricula need to be more flexible than in classical engineering programs in terms of student centered learning and module provision

3. Instructors need to trained in and comfortable with delivery modes which go beyond didactic approaches. Problem centered learning (PBL) is particularly important for mechatronics and students must experience PBL-type learning both within the classroom and at module level (in modules such as “the final year project” . This in turn implies a radical shift in educational culture and mindsets of instructors and students alike must be challenged and a new culture of student-centred learning inculcated.

7. OUTLOOK

The outlook is excellent but not without challenges. Kosovo as a region benefits from starting almost from scratch. This means that the educational system, especially in new private universities like UBT, is open to radical new ideas and approaches. Thirteen years after the war and five years after unilaterally declaring independence the region remains economically very underdeveloped. Engineering education initiatives with the central goal of regional development are urgently needed. This study demonstrates the urgent need for IFAC educationalists to immediately engage with less-stable regions as a humanitarian and ethical imperative.

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