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Abstract: Mechatronics bringing together a number of technologies mechanical engineering, control engineering, electrical engineering, electronic engineering,computer technology. Mechatronics as an umbrella integrates areas of technology like measurement systems and sensors, actuation systems and drives, systems behavior, control, and microprocessor systems. Education in Mechatronics is highly interdisplinary. Graduates with a BSc or MSc degree in Mechatronics get usually higher or medium management positions in Industry requiring some knowledge in management. Therefore an education program "Mechatronics Management" was developed by an international consortium and implemented at UBT in Prishtina.

- 1. INTRODUCTION

In many engineering areas a lot of changes are taking place nowadays. The classical methods and working ways of mechanical engineering are changing rapidly. To be able to cope with the multiple futures' challenges, the traditional engineering working ways need to be replaced before entering the new technological area. This process is called mechatronics which is the technology that assemble together the traditional disciplines of mechanical engineering, electronics and data processing. Almost everyone is faced with this combination of mechanical engineering, electronic and electrical engineering in our daily life. We all know Discman or a Minidisk; they consist of both mechanical and electrical parts: a motor" mechanical" to turn the disc and a pickup that reads the music "electromechanical". Furthermore, the products are loaded with electronics, of which the most advanced components include microprocessors to reduce noise and adjust for movement.

Therefore 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.

2. MECHATRONICS & MECHATRONICS MANAGEMENT EDUCATION

Up to now, conventional engineering education throughout Europe, has been dominated by technical subjects, and had little to offer in terms of interdisciplinary academic training. Topics relating to economics, business management and jurisprudence have typically been addressed through short 'on-the-job' courses as part of ongoing professional development within the workplace, rather than as compulsory subjects within the context of third or fourth level engineering programmes. On the other hand, graduates from business schools, for example, have rarely had the chance to extend their knowledge in technical fields again developing these skills through ongoing (and typically short) professional development programmes organised through work or some professional body.

- 3. DEVELOPING A MECHATRONICS MANAGEMENT PROGRAMME

A number of well-educated economically-disadvantaged so-called "second" and "third" world societies have recognised the potential of developing a knowledge economy from a low level of development. It is readily apparent that similar opportunities exist for Kosovo, once socio-economic and political stability has been achieved (Ceccarelli et.al., 2006).

All this suggested the need for a new type of degree programme, requiring a non-traditional approach to curriculum development in engineering and advanced technology. This in turn implied the need for a new approach to the development of higher education inter-disciplinary programmes, especially in advanced engineering.

Therefore the main goals were:
- develop and widen their knowledge base in mechatronics engineering to Masters level standard,
- develop generic problem solving skills applicable to current, mainstream mechatronic engineering systems,
- achieve more in-depth expertise in selected areas of mechatronic engineering,
- engage in the planning, execution and written/oral presentation of an extended, industrially research orientated project.

- produce Master level engineering graduates who are able to participate effectively in a wide variety of industrial and/or research environments in the field of mechatronic engineering.

Typically, innovation in science, technology and engineering education has been somewhat constrained by well-established faculty structures present within European universities.

Usually pure Mechatronics programs are pieced together from a combination of lectures from existing engineering programs. Therefore, they address an incomplete mosaic of professional competences associated with mechatronics management. Based upon a well-defined educational competency framework directed at advanced technology curricula, the designers of this programme had the opportunity (and challenge) of designing an entire mechatronics degree program from the start in a green-fields site in an emerging economy. The program was particularly dedicated to realities of small and medium enterprises in small (developing) countries without ignoring the requirements of large engineering employers. The difficulties involved in balancing all these goals in a single objective, and creating a single coherent programme should not be underestimated. The main goal of this program was to educate engineering managers in the field of mechatronics with specific emphasis upon new companies so that the graduate is capable of starting-up, expanding and managing effectively a small or medium-sized company.

UBT thus represented a 'green-fields' site with a small but extremely motivated staff and student body. This in turn provided an ideal opportunity to design and deliver a truly interdisciplinary programme in "Mechatronics Management", a programme which was grounded in the reality of mechatronics in its industrial setting in a developing economy.

4. CURRICULUM DESIGN

Surprisingly, mechatronics has received comparatively little attention from engineering education researchers. For some years, and as illustrated for example in both Fischer (2004) and Devereux (2004), concerns have arisen about how to best prepare under-graduate engineers to work with advanced technologies in organisational contexts. Academicians and engineering managers have identified several key areas for engineering and technology educators to focus on.

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).

Devereux described the following key dimensions of educational competence for information technology and systems professionals:

1. Technical Competence: the individual has sufficient subject knowledge and can plan and organise so as to achieve maximum results
2. 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
3. Ethical Competence: The individual has moral standards which guide them in their decision making activities in the work environment
4. 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.
5. 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:

The main goal of the above design was to develop a curricula which would enable a mechatronics graduate to be conversant with business issues, and appreciate these in the context of the implementation of mechatronics technologies.
The MSc curriculum has the following structure:

Engineering Core
Decision Analysis
Advanced Technology
Research Methods
Math. Modeling for Mechatronics Management
Systems Engineering
End of Life Management

Management Core
Advanced Management Information Systems
Leadership and Organizational Culture
Advanced Operation and Project Management
Marketing Management
Major Mechatronics
Advanced Production Technologies & Robotics
Components of Mechatronic Systems
Design & Control of Mechatronic Systems
Micromechatronics
Ethics
Applied Mechatronics Project
Laboratory Project
Electives
Master Thesis

Furthermore, *ethics* was included as a mandatory subject for the curriculum (Stapleton and Hersh, 2004). Very few engineering and technology undergraduate programmes in the western hemisphere incorporate ethics as a major subject so that this is a relatively new approach.

As with numerous other programmes the issue of team working was primarily addressed through the delivery modes designed into the programme. The course was also preceded by courses in business communications in order to instil in students, at the earliest possible date, the importance of communication skills.

The final year project/thesis was designed to prove the candidates' ability to describe a special but usually very narrow field of interest with a deeper study. Through the integration of enterprise studies and related management knowledge in the program, it was envisaged that participating students would have the necessary skills and know-how to use the project as a basis for business start-ups. In this way the programme could directly support the economic growth aspirations of region.

Finally, it was 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.

Therefore a Mechatronics Laboratory was installed at UBT (Kopacek, 2006) and will be completed continously in order to develop some of the various competences and educational objectives indicated above.

5. SUMMARY

The proposed program provides broad-based Bachelor- and Master-level education in the basic principles of electrical, mechanical and computer engineering as well as business, information systems and human skills. It fills a major gap in current mechatronics programmes by focussing, in a balanced way, upon both technical and non-technical aspects of mechatronics management. In particular, the focus upon enterprise, systems engineering and mechatronics, as well as the provision of a broad foundation in science. It was envisaged that graduates would be sought after by a wide variety of prospective recruiters. Furthermore, graduates will have the necessary acumen to start-up their own companies which is a critical issue for the development of emerging economies.

It is clear that this program was one of the first trials worldwide to educate "Mechatronic Managers". The essential ingredients set out above are unique for the proposed program of study in a number of ways. Firstly, they are dedicated to the special interests of participants in their real-life work context. Secondly, the foundation program provides a wide range of key competencies from computing and engineering to soft skills and management in a single engineering degree.

There is an ever increasing demand for multi-disciplinary engineers for various positions covering many industries therefore graduates from this program are advantaged as they can work across different disciplines. Graduates can expect enhanced technological skills, which will improve their prospects in such roles as product manager, project leader, research engineer, systems engineer or product development engineer or any engineering role in automotive, rail, aerospace, process and biomedical and other industries. all of these jobs need MSc level mechatronic engineers to enable them to integrate products, processes and cultures...

Benefits for the graduates:

They are educated in technical fields (IT, ME, EE, Electronics,….) as well as in management (Acc., Fin., …….)

They can open an own company

They can work as a project manager or as a head of a department in a company (Medical, Agriculture,…)

They can work in a governement in a higher position.

They are educated on a international level.

This BSc programme started in the summer term 2010 and the MSc programme in Winter term 2011 at UBT in Prishtina.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Devereux, N. (2004). *Information Technology Professional Competence: An Empirical Study of Irish Higher Education,* M.Sc. Thesis, WIT, Ireland.

Fischer, G. (2004): *Industry and Participant Requirements for Engineering Management*. PhD Thesis; VUT, Vienna

Kopacek, P., M. Ceccarelli, E. Hajrizi and L. Stapleton (2006). Mechatronics education and International stability the development of university level education programmes in advanced engineering in Kosovo. In: *Proceedings of the Improving Stability in Developing Nations Through Automation ISA '06*, Elsevier IFAC publication, p. 1-8

Kopacek, P. (2006). A Mechatronics management laboratory. In: *Proceedings of the Improving Stability in Developing Nations Through Automation ISA '06*, Elsevier IFAC publication, p. 37-42

Stapleton, L. & Hersh, M. (2004). 'Technology Development and Ethical Decision Making: Identity Factors and Social Construction', *Proceedings of International Multitrack Conference of Advances in Control Systems*, Tech. Univ. of Vienna, Elsevier.