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PERSPECTIVES OF THE THIRD LEVEL EDUCATION IN MANUFACTURING ENGINEERING

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Abstract: *Rapid changes in the technical field takes place where success is determined less by traditional advantages – linked to technology or quality – than by the overall performance of the systems. Hence competence of different kind of technical management is needed, and the changes in the third level education in manufacturing engineering should be reflecting that demand. Education has a significant role to play in our present and future economic well being and it is necessary that educational establishments keep abreast of the fast changing technologies. In this paper the approach to develop the curriculum is introduced covering manufacturing strategy, industrial engineering and technology management. Curriculum is composed as modular one with high level of integration of the subjects. The knowledge supply scheme to support related activities is described as well. Activities described are partially supported by European Commission.*

1. INTRODUCTION

The industry has over the last decade undergone a significant change. It is no longer home-based; it operates in a global market. Digital business has become a strategy to survive. The extended enterprise is being implemented. Components and even products are made where conditions are most favourable. Non-core activities are out-sourced. These service companies then become part of the supply chain that also spans suppliers and distributors. They all comprise an integrated international co-operative network to provide manufactured goods and support services for a world market just in time, at low prices and with quality surpassing customers' expectations.

Mechanical engineers, industrial engineers and electrical, electronic and computer engineers provide the engineering competence in such companies. Frequently, these employees have the necessary technical knowledge about techniques and technologies for efficient working and co-operation in distributed production systems. Engineering courses for engineers and students are constantly extended by that knowledge and many books and articles have been written about these subjects (Hoheisel et al 2001).

This education does not completely reflect real needs of the industry that faces problems of integrative nature across the traditional disciplines, such as (Thoben&Schwesig 2002):

- Working globally in a multicultural environment
- Working in interdisciplinary, multi-skill teams
- Sharing of work tasks on a global and around the clock basis
- Working with digital tools for communication
- Working in an virtual environment

2. WHAT IS HAPPENING IN INDUSTRY

Opinions about the impact of the present and future developments in manufacturing technology diverge widely. In this regard, predicting the exact nature of future manufacturing strategies with any certainty is difficult. However, the future of manufacturing will most likely be a smaller workforce with a higher-order of multidisciplinary critical skills in management and labour process to respond radically to the opportunities and the constraints (Marinescu&Lavelle 1998). Competence in the optimal use of information and communication technologies supporting a global co-operation of enterprises will be the future key to industrial countries remaining competitive, in both the race for bringing new products to the market and sustaining a profitable presence in that market (Hirsch et al 1998). Fallow (1996) investigated the features that should be adopted in an engineering course at third level education to keep up with the rapid pace of the technological advancement and its integration into society. A frightening statistic is that 'in some fields', 20% of an engineer's knowledge becomes obsolete (Otala 1993) every year. It was reported that the globalisation of engineering education required further characteristics of the modern degree programme, particularly as the year-of-study abroad becomes an increasingly popular choice with students exchanging further a field and in greater numbers than ever before. This led to a suggestion that the basic engineering degree program should be extended to include: team skills, communication, international relations, marketing and economics. This program should include greater use of project-based, group 1earning, and the use of multimedia technology in the classroom.

Industry is facing with the fact that on the labour market there is not enough qualified labour force and that working has to be evaluated on the topic of skills' level. Hence, there is a clear need for a tool for active cooperation and coherence between enterprises (demand) and education providers (supply).

The likeliness of material supply chain and knowledge supply chain is accepted. As a result a knowledge supply chain is created. A knowledge supply chain is an integrated process that uses the core competencies of industry and academia to provide an enterprise with the information and wisdom it needs to run its business profitably, and to educate and train its workforce. A competitive enterprise will depend on continuous access and efficient distribution of knowledge. Its supply chain will include industrial, academic, and governmental knowledge-generation systems in addition to its own internal systems and processes (Jordan 2000)

With the objective to create the knowledge repository the project INNOMET was initiated.

The user interacts with the control module, the role of which is to work out the search strategy on the basis of initial data given by user, via user's interface.

The knowledge base connects in a certain field manufacturing enterprises, consultancy firms, educational organizations and universities to handle local resources for larger subcontract orders and production volumes. Such a network increases directly the competitiveness of enterprises located in periphery regions. In long-term, the system can also provide comparative know-how and practical examples how similar issues are dealt in different European countries.

The sectoral co-operation system and networking model helps to activate the labour market, transparency of labour force demand, lack of qualified labour force and links between all the different organisations of the sector locally and internationally. Pooling sector-wise information from different parties – companies, education institutions, students, and trainees is a very innovative approach. In implicit way, proposed system provides a set of tools: dynamic web-based sectoral job and trainee information (demand in private sector), dynamic profiling of sector companies for analyzing existing qualified labour force quantitative and qualitative level and human resource needs with current situation.

The integrated database system for educational and industrial needs in the sector includes also a database of existing educational opportunities – different levels of study programmes, and industrial needs for human resources based on the employee qualification standards.

It focuses on enhancement of the competence of students, employees and industry to act successfully on the European market in order to strengthen the competitiveness of the European industry, especially the manufacturing industry. This will bring together a critical mass of "customers of education" and "suppliers of education" for resolving above-mentioned shortcomings. Such a system increases directly competitiveness of the enterprises located in periphery regions. Elaborated model is usable with minor changes in any other industry field.

INNOMET database could also serve as a dynamic and constantly up-dated study on human resources in the sector if a relevant pool or so called critical mass of companies is included in the system. Companies will be motivated to renew information in certain periods, as INNOMET tool can be effectively used for companies' own human resources evaluation and development. The system can also be made use of in the development of trans-national skills' passports in Europe.

One of the effects of the system is that company can define the level and list of competences related to the job as well as has the exact overview about the competences of the employees. This output is for good use for the educational institutions as well for there strategic planning.

3. NEW CHALLENGE - COMPETENCY-BASED EDUCATION

As derived from afore said it's any more no way to teach in classical way – "pushed competency". It means to teach what we know.

Currently, in general, a typical undergraduate course in manufacturing engineering covers theoretical and practical use of CAE, CAM and CIM technologies. As a result of this study the students cover salient aspects to enable them to design cutting tools, gauges; jigs, fixtures and dies; to study production line layout, production forecasting, planning inventory control, and statistical quality control; to learn the methods of determining and distributing expenses and estimating material, labour and tool costs in manufacturing of the products; to make time studies of manufacturing operations; and to become familiar with hydraulics, pneumatics, automatic control, manufacturing processes and engineering material. The course includes basic engineering sciences (i.e. mathematics, physics, chemistry and mechanics) related to manufacturing engineering together with computer science. This approach can be adapted for Degree, Diploma and Certificate level.

Despite the widespread development of information technology nowadays, the delivery of the classes, in third level, in manufacturing engineering depends largely on the traditional class delivery.

The new approach should be on "pull bases". In (Shank, 2001) that approach is called as Competency-based Education (CBE). The level of competency is defined by industry and this merit is as basis for the programme composition. Actually undergraduate programmes supply graduates with the minimum knowledge needed for entering into industrial community. Due to the rapid development of technology the advanced educational needs in the third level education supporting life long learning philosophy should be available. The concept of competency based education is introduced in the figure 1.

In industry on the level of company the level of skills for the particular job will be evaluated as well as other supporting skills (personnel skills, team skills, optional engineering skills). The list of vacancies will be formed as well. Gathering this information in the information base (data and knowledge base) the proper starting situation for the pull basis education actions is created (INNOMET activities).

At the same time graduate programmes and those for the third level education should not be petrified. Hence the *Engineering Education Design Bus* should exist to enter the changes predicted by the industry and global technology development. For that activities the block of the *Modular Courses* exists, which is under the change on the time scale as well. The feedback from the industry and academic and research community giving the sign for changes are not shown in the figure 1. Significant role will play the *Decision Support System* incorporating the knowledge supply chain management, rules for the study course management and decision making environment. Not the minor role is playing the pedagogic approach, how and where the courses can be delivered.

As said that approach is defined by industry. If we can characterize and evaluate the processes in industry then we should be able to predict the outcome. We must be able to measure the outcomes – and to do so we must characterize the learning process. However, the problem in academia is a bit complex because we have such a variable as input stream of entering students. The level of skills of acting workforce is also quite different.

4. WAYS OF REALIZATION

To go in tact different activities are initiated. The graduate programmes are reformed taking into account the Bologna's declaration. The third level study courses and programmes are developed or are in the progress. To gain the best results the global cooperation in the field is initiated as well (look the description of the international programmes supporting the idea). Following the main concept using by the ongoing activities is described.

The new curriculum will be of modular with highly integrated structure, hence manufacturing strategy and technology management will be introduced as modules of specialization to the existing curriculum. Modular curriculum architecture and the use of curriculum platforms could follow the concept of reusability allowing development of customized curricula (principle of product family design). In such way the potential benefit will be gained from organized reuse of course material

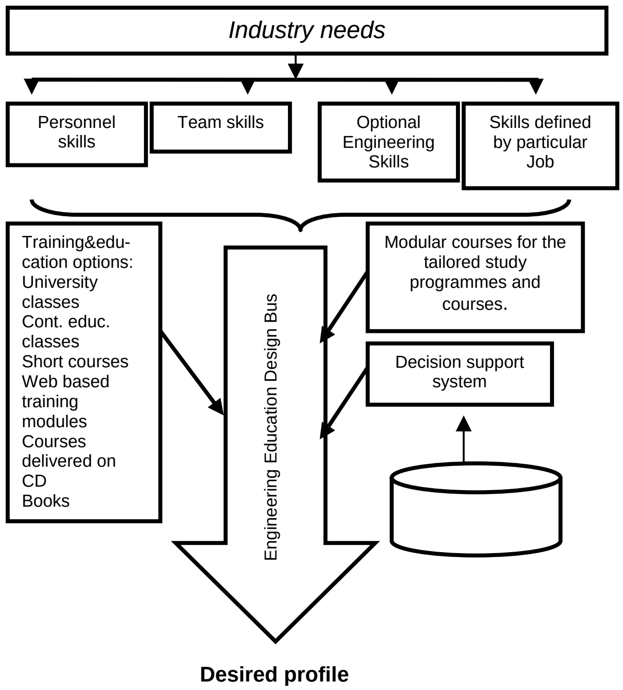

Figure 1. Competency based education concept

elements and course presentations. The gallery of pictures and bank of case studies will be of good support for such an approach as well. By designing the new curriculum the function of particular curriculum has to be stated. The related knowledge fields and content of the curriculum will be completed to support the stated function.

To gain the integrity of the content, to avoid overlapping and to spare resources all knowledge fields will critically analysed.

Objective is to use as much cross references between modules as possible. The existing programme will critically analysed as well in order to update latter with new information from the new modules.

Significant role in the new curriculum is using different pedagogic scenarios. As most applicants to this curriculum in Estonia are working, the e-learning approach is needed.

It is obvious, that to prepare e-courses in that of extent takes a lot of time and resources. Therefore different scenarios could be used depending on particular situation and supporting the development of new concept step by step.

5. INTERNATIONAL PROJECTS SUPPORTING THE REALIZATION OF THE NEW GRADUATE AND THIRD LEVEL STUDY ACTIVITIES

European projects with participating of the *Department of machinery of Tallinn University of Technology* targeted to increase the innovative competence in the fields of manufacturing strategy, technology management, rapid manufacturing and computer integrated manufacturing.

Global Education in Manufacturing (GEM-NAS) IST–2001-32059 (2002-2004)

Participants:

Norway (CO), Germany, Portugal, Ireland, Italy, Switzerland, USA, Japan, Australia, Korea, Bulgaria, Estonia, Hungary, Poland, Romania

Objectives of the project:

- Define and understand the needs of the manufacturing industry for training and education in manufacturing strategy on a global basis to comply with the concept of digital business and extended products.
- Develop detailed specifications for a manufacturing strategy curriculum focusing both manufacturing and business administration topics. This curriculum will provide a basis for a world standard. Selected modules will be tested in all IMS regions applying a modern IT-based delivery of training and education (web-based multimedia solutions). For further information visit www.sintef.no/gem/.

Integrated Knowledge-Based Inter-discipline Study Program on the Web Site (IKBISPWS), Leonardo, LT/02/B/F/PP, 2002-2004

Participants:

Lithuania (CO), Germany, Estonia, Finland, Poland, Sweden

Objectives

- a development of integrated knowledge-based inter-discipline study program, which could offer both for students in universities and colleges, and engineers in companies a new integrated approach to acquire the knowledge, which are at the boundary of neighbour domains. It means the knowledge that are at the boundary of mechanical engineering and computational sciences, etc., where the employees in companies are needed the newest information, data and methods.
- to facilitate for students and engineers from companies to learn above-mentioned material and to share it between partners.
- to create the integrated knowledge-based study program on Web site with appropriate study modules and teaching materials, which would help for mechanical engineering and computational sciences students and related engineers to acquire the knowledge that are on the boundary of neighbour above-mentioned knowledge fields.

Development of the real time system for adding innovation capacity of labour force and entrepreneurs of the metal engineering, machinery and apparatus sector (INNOMET) 2002-EE/02/B/F/PP-13500 (2002-2004)

Participants:

Estonia (CO), Germany, Finland, Hungary, Italy, Sweden

Objectives

The main goal of the project is to introduce a new tool to ensure qualified labour force for enterprises in the machinery, metal engineering and apparatus sector in terms of local and European needs

*Overall Strategy for Approach*For that purpose an integrated real time advisory system for educational and industrial needs in the sector - INNOMET system – will be built giving information about existing educational opportunities on the different levels of study programmes; industrial needs for human resources based on the employee qualification standards

Establishment of the Virtual Centre of Excellence for IST RTD in Estonia (eVikings II) IST-2001-37592 (2003-2005)

Participants:

Estonia (CO), Finland, Switzerland, Sweden, Finland

Project objectives:

- The aim of the project is to facilitate the development of Estonian ICT cluster in coherence with the vision of *Ambient Intelligence*, underpinning considerably international co-operation in everyday activities of the Estonian leading IST research and development labs and companies as a result. Virtual Centre of Excellence for IST related R&D work will be set up, which will primarily act as enabling competence building platform for establishing critical mass and performing top level integrated national and international research initiatives in the field of information society technologies
- enhancing the knowledge on e-learning and e-training education methodologies
- development of e-toolboxes for graduate and postgraduate as well as for the third level education in *Technology Management*

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