Requirements for Implementing the European Production Engineering Education

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Summary: Modern production engineers must be able to perform a wide variety of tasks with steadily increasing complexity. In this context, it is especially important to endow production engineers with cross-disciplinary knowledge since this is vital to changing technology and international competition. Production engineering (PE) curricula must therefore keep pace with changes demanded by future trends in advanced manufacturing. A homogenous production engineering curricula that specifies the most important topics in this field is a suitable platform to start from. The paper presents some results from the EPROME project being conducted by a number of European academic insitutions and industrial organizations for creating a framework for continuing education in production engineering. The aim of the paper is to anticipate the needs for education of European production engineers and to provide a unified curriculum for a common body of knowledge that meet these needs. The modular structure of the curricula creates a systematic framework that is able to respond faster to changes in the state of the art.

1. INTRODUCTION

Production engineering is a complex activity that transforms information into a product. The information includes design data, quantities required, and delivery dates. The transformation involves developing tools and processes, obtaining material, processing material, assembly, testing, and delivery. As a profession, production engineering is that specialty of engineering discipline able to understand, apply, and control engineering procedures in manufacturing processes. There is a minority today of engineers in general, and production engineers in particular, that can maintain their competence throughout their careers without additional education and training. The growing rate at which new technologies are being introduced into manufacturing requires a redirection of the focus for the education of production engineers. As regard the European manufacturing education, there is a great concern about the possibility to guarantee the reservoir of expertise in manufacturing and to meet the challenge imposed by global competition for the next decades. The manufacturing activity in Europe represents today approximately 22% of the EU GNP. It is estimated that in total 75% of the EU GDP and 70% of employment in Europe is related to manufacturing. This means that each job in manufacturing is linked to two jobs in manufacturing related services. European manufacturing has great potential as part of a sustainable EU economy, but its success will depend upon continuous innovation in products and processes [3]. European industry has created a large demand for production engineers competent in the new technologies. These new technologies cause a blurring of the boundaries between engineering disciplines.
making necessary a multidisciplinary approach to engineering education. European competitiveness will depend on increasing the productivity of manufacturing systems and the ability of production engineers to implement and operate advanced technologies, achieving product quality and lowering production costs. The major question that we seek an answer is: How can education contribute to the revitalization of European manufacturing industry? There is no doubt that considerable improvement is possible, in the short term, to make European companies in the long term competitive in most basic industries if technological and management resources are exploited and wisely orchestrated [4].

As manufacturing industry embraces and remolds innovative technologies and strategies aimed to increase its efficiency, the education system in production engineering must also keep pace with these changes in the way the new generation engineers will receive their education and training. The emergence and proliferation of the so-called 'knowledge-intensive industry' within the industrial sector demanded manufacturing employees to learn continuously and re-skill themselves. A knowledge-intensive organization is an organization where the majority of employees are highly educated and the production does not consist of goods and services but complex non-standardized problem-solving [1]. The rapid growth of industrial production that has occurred in recent years has been primarily concentrated in the knowledge-intensive branches of the economy.

This paper presents the main findings from the EPRODE educational project within the Leonardo da Vinci programme (please see http://epronode.iip.kth.se) that has been conducted by a number of academic institutions and industrial organizations from EUROPE. The aim of the project is to anticipate the needs for education of European production engineer of the future and to provide a framework for a common body of knowledge development that meet these needs. The focus is on continuing education programmes in production engineering and how to merge the efforts of industry, universities and professional organizations in a common articulated initiative to provide European nations with more cost-effective technical resources.

2. EDUCATION IN PRODUCTION ENGINEERING

The sophistication of the goods and services provided and required by manufacturing industry, demands that Europe raises its level of technological attainment and increase the ambient level of technical and managerial understanding throughout its manufacturing sector. This requires sophisticated knowledge and skills from the manufacturing employees [8].

Due to the variety of activities undertaken in manufacturing and the variety of products involved there is a significant ambiguity about the definition of production engineering (PE) discipline in terms of education and training, the skills and ideas associated as well as the attributes of a manufacturing engineer.

A production engineer requires qualifications for the application of principles, methods, and techniques appropriate to the field of manufacturing technology, combined with practical knowledge of the construction, application, properties, operation, and limitations of manufacturing systems, processes, structures, machinery, devices or material, and, as required, related manual crafts, instrumental, mathematical, or graphic skills [2]. One of the main themes in the discussion about manufacturing education curricula is the balance between the
engineering and non-engineering problems of manufacturing. There is a general agreement that a purely technical education is not enough for manufacturing engineers who have to direct much of the efforts to managerial problems in order to optimize the manufacturing systems.

Thus, the design of new understanding and of a new curriculum for manufacturing engineering education must be seen in the context of the engineering and managerial fields. The connections between industry and the university community must include both the engineering and non-engineering subjects, and these connections may play a role in which these two academic areas work together effectively to produce new systems understanding and methods for PE education [9].

The main goal with EPRODE is to establish a unitary, transparent European educational system in Production Engineering based on modular and flexible curricula. This will substantially ease mobility among European production engineers and will also be a basis for higher standards in many European companies, especially SME.

Today, the mobility among production engineers is very low, partly because the education and training level differs considerably among EU countries, being almost beyond comparison. The target for EPRODE is concentrated to the lower/middle education and training level within PE.

A European education for Production Engineers (PE) will ensure both quality and high standard of the education and training. The specific objectives for EPRODE are:

- Define and understand the needs and demands for education and training for manufacturing industry of the future.
- Develop and implement of a modular production engineering curriculum and education system for continuing education.

- To enhance the interaction among educators in PE from as many European countries as possible.
- Enhance the prestige of production engineering as a profession and as an intellectual challenge

EPRODE covers four related topics:

- Structuring the PE education system
- Industry-University cooperation in PE education
- Keeping updated in a PE career
- European and national priorities in PE education.

Production engineering education has the tendency to emphasize theory over practice. In addition, basic education has not always met the needs of industry, producing graduates with often inadequate skills. This has led to industries that are poor at turning innovation into successful products. This necessitates a change in priorities and closer ties between industry and educational institutions [5]. In the EPRODE context, continuing education programs will serve as a bridge between industry and academia. In the EPRODE concept the focus in production engineering education is not on basic engineering principles, but on the integration of these elements to develop the student ability to synthesize and to improve their critical thinking.

Although there is growing evidence that an increasing amount of engineering effort will move into service and consulting areas, for the foreseeable future many production engineers will continue to do work associated with the production of goods. Manufacturing in the modern sense cannot be performed without engineers, and production engineers will remain the major component for companies to achieve excellence in production of goods.
3. PE CURRICULUM

Production engineering is one of a number of interdisciplinary engineering specialties which are based upon both "classical" engineering disciplines such as mechanical and electrical engineering as well as topics in operations research, quality and management. While established engineering disciplines such as mechanical and electrical engineering are defined in terms of both educational degree and specific disciplines, production engineering is defined by function and has multidisciplinary dimension.

In essence, the function of a unitary PE curriculum can be summed up as a clear and concise statement of what matters in PE education. This translates the EPPODE educational mission into concrete terms for the matching between the curriculum content and the knowledge and skills which production engineers actually seem to need in their professional work in practice. This orientation function benefits students, while also will serve to improve the professional expertise of educators and the quality development at the institutional level.

The EPPODE curriculum focuses on modular programme of study, and outlines the intended knowledge, understanding, skills and attributes of a student completing that particular module. EPPODE curriculum consists of 12 modules, each of them rated at 15 ECTS (see Table 1). EPPODE modules contain courses that cover major areas in production engineering and management. The production engineering "core" modules provides a common language and fundamental base for all production engineers. Technological disciplines are designed to be unique and specialized. To date, EPPODE encompasses three specializations: Manufacturing, Forming and Joining. EPPODE programme specification gives details of teaching and assessments methods as well as forms a template for how to learn to teach in production engineering discipline.

### Table 1: EPPODE modules

<table>
<thead>
<tr>
<th>Module</th>
<th>ECTS</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>Materials Engineering</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Machining Technology</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>Integrated Product and Process Design</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>Quality Engineering</td>
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<tr>
<td>5</td>
<td>15</td>
<td>Information Technology</td>
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<tr>
<td>6</td>
<td>15</td>
<td>Manufacturing system</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>Forging Technology</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>Short Metal Forming</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>Joining Technology</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>Welding</td>
</tr>
<tr>
<td>11</td>
<td>15</td>
<td>Production Management</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>Mechanical &amp; Chemical</td>
</tr>
<tr>
<td>13</td>
<td>15</td>
<td>Manufacturing Technology</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>Forming Technology</td>
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<tr>
<td>15</td>
<td>15</td>
<td>Technology</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>Bulk Forming</td>
</tr>
</tbody>
</table>

EPPODE modular structure is based upon a unitary combination of theoretical or basic knowledge necessary to understand competence courses; practical activities perform in laboratory or industrial companies, language and culture courses to enlarge the European dimension. Typical courses in the production engineering program include topics in materials engineering, product and process design, production planning and control, discrete-event simulation and modelling, and quality control. These technical topics represent the core expertise of an engineer who is trained in modern manufacturing techniques.

Non-technical skills, such as technical writing and communications, will play an increasingly important role in engineering work. Emphasis has therefore been placed on the communication skills of reading, writing, listening, and speaking in both technical and non-technical courses. Professor Etter [7] emphasizes the need to introduce in engineering curricula courses in topics that develop an understanding of different cultures, political systems and the business environment. Parallel to curriculum development attention has been given to accommodating a consistent educational methodology reflected by the integration of...
traditional teaching, E-learning and team working for industrial projects.

The European dimension of a production engineering programme requires a certain degree of standardization. The degree of standardization of the EPRODE production engineering program will be reflected by curricula, educational material, resources, quality assurance system and the process for continual programme review. However, high flexibility is ensured to adapt to national industry's demands and to shape student identities in the light of structural features of different national industry's profiles.

4. IMPLEMENTATION MECHANISMS

Implementing EPRODE curriculum into European production engineering programmes requires the creation of a well functioning organization and efficient mechanisms. The organization main activities will be divided in Curriculum Development, Educational Methodology Evaluation and Quality Assurance, and Human Resource Development. Tools for linking production engineering education to the performance of engineers and for evaluating the impact of education and training programs on the competitiveness of the organizations has to be developed. Academic training and work experience are considered key elements in estimating an individual's ability to perform in the workplace. Two mechanisms to control that minimum standards of quality have been met in educational programs and personal experience are accreditation for the institution and certification/licensing for the individual. The accreditation implies both the accreditation of educational programmes and of institutions wishing to adhere to the European production engineering programme. The European dimension of the production engineering education programme implies a guarantee for a common level of knowledge and skills for the graduates but is not suffice by itself to assure a high quality level of the trainers. Methods of evaluating continuing education programs must be consistent and have to be designed to examine benefits that may result to the students and companies.

If European production engineering education is to achieve its own identity as a unique European discipline in the future, it must assume the responsibility for developing not only of a common body of knowledge but also of highly qualified faculties.

Therefore, an important feature of the European dimension of the programme is human potential development. The development is based upon the integration of international discipline-based groupings. Much could be achieved by these groups, especially in partnerships with staff and educational developers.

- Companies should set clear objectives for continuing education based on business plans.
- Professional societies and other influential groups should cooperate in programs designed to make corporate policymakers more aware of the value of continuing education to their companies.
- Industry and academia jointly should define their respective responsibilities in and support approved standards for continuing education [6].

Specific questions that will be addressed by EPRODE in the next period are concerning the quality assurance policies and practices, their efficiency and the priorities for improvement.

The primary purpose of European accreditation in PE is to ensure quality control and quality assurance, commonly
with reference to a certification system in the areas of education and training. The role of quality assurance and accreditation of European production engineering institutions is reflected in the continuous quality improvements. Translated into assessment programmes, EPRODE educational system is used for education monitoring and the evaluation of accredited institutions. These serve to ascertain and assess learning outcomes, and this feedback function contributes to the output-driven management of the PE education. Objectives, educational process, resources and quality assurance system must be periodically re-examined and renewed.

5. CONCLUSIONS

This paper underlines the importance of creating a unitary education programme for Production Engineers. This will substantially ease mobility among European production engineers and will also be a basis for higher standards in many European companies, especially SME.

The target for EPRODE will be concentrated to the lower/middle education and training level within PE. The EPRODE programme has analysed the differences between Production Engineering Educations within Europe and has developed a modular curriculum with a core part and three specializations. EPRODE programme also gives details of assessment methods.

REFERENCES


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