ESTONIAN TECHNICAL TEACHER EDUCATION IN THE PROCESS OF TRANSFORMATION

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Abstract

During the past 3 years curriculum development has been of essential importance in Estonian Centre for Engineering Pedagogy at Tallinn University of Technology. A three-staged methodology for curriculum design has been used. The proposed innovative methodology for the course design starts with decisions on overall goals, learning objectives and intended learning outcomes. The curriculum was designed according to the following model: Establish Qualification Profile, Establish Admission Quality, Define Course Content, Establish the Curriculum at Macro Level, Establish the Curriculum at Micro Level, Integrate the Curriculum within the University System. The new curriculum for technical teacher education on Master level was completed in 2006. Curriculum for technical teachers has been designed taking account of the most popular and perspective branches of industry in Estonia. Eight possible specializations have been proposed. As the required entrance qualification of the candidate is Master degree in engineering and professional experience for at least one year, it is assumed that the candidate has acquired knowledge in engineering speciality on high level. The curriculum is based on IGIP (International Society for Engineering Education) Recommendations for Studies in Engineering Pedagogy Science. The curriculum has been accepted and registered by Estonian Ministry of Education and Research. The curriculum is the only and the very first one in Estonia providing education in Engineering Pedagogy for technical teachers on Master level in the amount of 60 ECTS credits. The first students were admitted to the designed study programme in 2007.

Key words: *curriculum design, engineering pedagogy, technical teacher education.*

Introduction

Education is a dynamic phenomenon, recognising the changes in the environment and respond to growing demands and challenges. Engineering education is a large system and it is almost impossible to predict its behaviour over far too distant future since the system parameters show a high rate of change. Changes in society present challenges to education. In order to educate not reactors to changes but, first and foremost, directors and executors of changes, it is important to promote the development of corresponding attitudes and skills in the young. These skills and attitudes are developed with the support of school, the key person being a teacher. Without changing teacher education we cannot bring about changes in the overall educational system.

According to John Heywood (Heywood 2005) curriculum is a formal mechanism through which intended educational aims are achieved. Since educational aims are achieved through learning, the curriculum process is described by those factors that bring about learning. Thus, both learning and

instruction are central to the process of curriculum design.

For the purposes of the present study the following terminology proposed by UNESCO has been used (UNESCO 1973): *technical education* is designed to prepare technicians for industry, agriculture, commerce, medicine, etc., which is usually provided at the upper secondary or lower tertiary level. *Teacher education* or training is according to UNESCO terminology a programme of pedagogical studies, both – theoretical and practical – leading to qualified membership in the teaching profession. Teacher education may be given in conjunction with studies special subject area or may be the content of a professional programme taken separately. Teacher training for secondary and higher education takes place at the tertiary level. *Technical teacher* is a person teaching general and special technical theory in educational institutions on the upper secondary or post-secondary level the aim of which is to educate and train technicians. Usually the technical teacher is responsible for both classroom and laboratory work, but may also supervise practical workshop training to the extent required in order to integrate the theoretical and practical aspects of technical education. He may be assisted in laboratory work by appropriately qualified laboratory technicians.

All teachers in Estonia are trained on the level of higher education. General teachers are trained according to study based on integrated curricula of Bachelor's and Master's study (5 years, concurrent model), other teachers are trained according to the same model in three-year Bachelor's study, which is followed by two-year Master's study. It is also possible to take an one-year teacher education course in the amount of 60 ECTS (European Credit Transfer System) credits after completing Master studies in speciality.

Engineering education differs essentially from humanitarian education. Thus technical teacher education should differ from general teacher training. Technical teachers should pass preliminarily higher engineering education at least on Master level and obtain knowledge in a certain field of engineering. Successive teacher education courses for technical teachers should not exceed a year.

Length of the courses has been a key factor in the professional judgement of the standard of courses. In compliance with F. Hrdlička and J. Měřička (Hrdlička & Měřička 2006) one of the main problems of training teachers teaching technical subjects is the relation of technical education and educational studies. High technical competency is generally required which can be complemented by further educational studies. It is generally assumed that for teaching on secondary and post-secondary level more professional or specialised education and less educational training is required. This confirms a known general rule – the higher level of education, the lower pedagogical education of teachers is required.

Technical teacher education cannot be classified as within the traditional academic categories. It cannot be compared to Bachelor-, Master- or Doctoral level, as the aim of the education is not to obtain certain academic, theoretical level in pedagogy. Technical teachers must not only keep up with the new pedagogical demands but also with the new developments in the engineering speciality they teach; they are expected to be able to work with different target groups – young students and adult learners.

Pedagogical training is built on the teachers' professional specialty qualification and gives the necessary theoretical and practical pedagogical, didactical and psychological competencies. According to V. Manuilov, A. Melezinek and V. Prikhodko (Manuilov, Melezinek & Prikhodko 1998) teaching will never be completely formalised, in most cases knowledge and experience of technical teachers in the field of pedagogy cannot be presupposed. The future educator at a technical school must acquire these skills in addition.

Clear policy guidelines on the future provision of technical teacher education are needed in Estonia – wide variety of standards and curricula have been elaborated for teacher education, at the same time the understanding of a term "technical teacher education" is just very slightly developing in Estonia after the year 2000.

Technical teacher education was totally lacking in Estonia after World War II and started only in 2000 jointly between University of Tartu and Tallinn University of Technology. Today technical teachers in Estonia are educated at Tallinn University of Technology. The new curriculum on Master level has been designed and implemented in 2006.

Used Methodology

General trends in curriculum design have been used. Curriculum design and course development

have taken a new dimension today. Higher education has globalized, engineering education is no longer guided by national goals. Development of science and technology has advanced so much that no individual can learn everything (Melezinek, 1999). Students often go to other countries for higher education. The background knowledge and skills of students are often different. Communication skills, ICT skills and skills of learning are of essential importance today. Design and development of courses must consider all these problems.

Grayson (Grayson 1978) has pointed out that curricula may be organised in two levels. The first approach may be on a broad or macro level, in which decisions are made about the type of courses to be offered, the amount of time to be devoted to each, the way they will be arranged over the programme, etc. Second, the particular content elements and learning activities can be selected and organised to optimise the knowledge gained by the student. This latter approach usually deals with materials within and the relationship between courses and can be based on certain principles of teaching and learning and curriculum design. The two types of organisation may be compared to the adjustment made in tuning a mechanism: first gross adjustments are made, and then fine-tuning is carried out.

Grayson (Grayson 1977) presented a three-staged methodology for curriculum design. These proposed stages are:

1. *Problem Definition* – Identification of education-occupation linkages or needs which arise from three areas (establishing the goals and objectives or qualification profile in terms of desired knowledge, skills and attitudes) namely:
   - Society needs;
   - Professional needs;
   - Industrial needs.
2. *Structuring the Curriculum* – The objective of structuring is to achieve the qualification profile. Changes in ways of thinking, in fundamental habits, in skills, attitudes and interests, develop over time and require cumulative effect of many learning experiences. To produce the cumulative effect, educational experiences must be organised to reinforce each other. Curriculum development is conducted at two levels:
   - *Macro-level*, the end result of structuring is that the curriculum will be defined by syllabus, a timetable, an idea of teaching methods – lectures, seminars, laboratory work, independent individual work, etc to be used;
   - *Micro-level*, where the subject providers plan their activity.
3. *Implementation and Evaluation* – Implementation is the process of carrying out the designed curriculum into practice in the university and evaluating, modifying or improving as necessary. Evaluation is essentially the process of determining to what extent the educational goals and objectives are being met by the curriculum.

Grayson (Grayson 1977) also identifies the following five means for reinforcing the curriculum established at the macro-level:

1. Computers in instruction;
2. Laboratory work;
3. Individualised instruction;
4. Self-access media;
5. Project and research work.

According to John Heywood (Heywood 2005) there has been a marked reluctance to stick to the terminology related to the objectives. Today the term ‘outcome’ is preferred to ‘objective’ and some authors infer differences between objectives and outcomes that were not in the minds of those with whom the so-called ‘objectives movement’ is associated. Accordingly to Guenter Heitmann (Heitmann 2005) the paradigm shift to outcomes orientation and student learning have recently fostered the use

of systematic and comprehensive approaches. Pressures on programme providers and faculty have been world wide and caused by respective accreditation or external quality evaluation demands.

The proposed methodology for the course design started with decisions on overall goals, learning objectives and intended learning outcomes. The curriculum was designed according to the following model:

1. *Establish Qualification Profile* – expectations of employers, qualities (knowledge, skills and attitudes) the graduates should possess were considered and expressed as learning outcomes.
2. *Establish Admission Quality* – appropriate entry qualities were settled.
3. *Define Course Content* – the course content should develop communication skills, analytical capability, skills for project, research and laboratory work, the use of information technology and learning skills.
4. *Establish the Curriculum at Macro Level* – establish syllabus, teaching approaches like lectures, seminars, practical lessons, etc., and timetable.
5. *Establish the Curriculum at Micro Level* – establish module content, methods of assessments, etc.
6. *Integrate the Curriculum within the University System* – the university should have a course approval procedure and general awarding system for Master programmes.

The Curriculum design process is a complex activity: each stage involves an iterative procedure, the output of which is evaluated before being used as a part of the input to the next stage. Specific learning strategies will be required if the objectives are to be successfully obtained, and this requires an understanding of the complexity of learning. A multiple strategy approach to teaching, learning and assessment will be required.

According to Norbert Kraker (Kraker 2006) a successful curriculum meets the needs of the contemporary further education sector, while guaranteeing academic standards appropriate to the teaching profession. A curriculum of modern technical teacher education should make scientifically-founded and practice-oriented teacher training possible, so that teachers can expect to build a deeper understanding of the principles, problems and solutions associated with teaching students in technical institutions. Above mentioned principles served as a basis for the design of the curriculum.

Results of Curriculum Design

During the past 3 years curriculum development has been of essential importance in Estonian Centre for Engineering Pedagogy at Tallinn University of Technology. The new curriculum for studies in Engineering Pedagogy was completed in 2006. The curriculum has been accepted and registered by Estonian Ministry of Education and Research in 2006.

Engineering Pedagogy Studies in Estonia are provided only by Estonian Centre for Engineering Pedagogy at Tallinn University of Technology. The newly designed curriculum is the only and the very first one in Estonia providing education in Engineering Pedagogy for technical teachers on Master level in the amount of 60 ECTS credits. The curriculum is based on IGIP (International Society for Engineering Education) Recommendations for Studies in Engineering Pedagogy Science (IGIP 2005).

Students with Master degree in engineering speciality and professional experience for at least one year are admitted to the course from 2007. It is assumed that the candidate has acquired knowledge in engineering speciality on high level.

Curriculum for technical teachers has been prepared taking account of the most popular and perspective branches of industry in Estonia. Eight possible specializations have been proposed:

1. Civil Engineering;
2. Power Engineering;
3. Geological Technology;

4. Information and Communication Technology;
5. Chemical Engineering and Material Technology (including Wood Processing, Food Engineering, Textile and Garment Engineering);
6. Logistics;
7. Mechanical Engineering;
8. Technical Physics.

The interdisciplinary scope of the curriculum cannot be squeezed into one conventional university department. As there are 8 possible specialisations, corresponding engineering faculties of Tallinn University of Technology are all involved in the curriculum.

The first 20 students were admitted to the course in 2007. The study is state commissioned and free of charge for students. Henceforth every year 20 students will be admitted to the course.

Studies in Engineering Pedagogy have been planned and designed taking account of the main aspects of Klagenfurt School of Engineering Pedagogy (Austria). 23 professors of Tallinn University of Technology have passed the relevant international courses at Estonian Centre for Engineering Pedagogy and have been awarded the title of International Engineering Educator ING-PAED IGIP.

The structure of the curriculum is presented in Table 1. As it could be seen there are two main modules in the curriculum: Modules of Engineering Pedagogy, and Speciality Modules. Accordingly to Estonian legislation, the amount of Teacher Training Practice in the curriculum is 15 ECTS during which lessons should be given. The practice is built on the teachers' professional speciality qualification and gives the necessary theoretical and practical pedagogical, didactical and psychological competencies to enable the teacher to be able to work at school.

Table 1. Structure of the Curriculum.

Module	ECTS credits
MODULES OF ENGINEERING PEDAGOGY	
Engineering Pedagogy Core and Basic Modules	
Engineering Pedagogy in Theory and Practice	10
Laboratory Didactics	2
Engineering Pedagogy Theoretical Modules	
Psychological and Sociological Aspects	5
Ethical Aspects and Intercultural Competencies	2
Engineering Pedagogy Practical Modules	
Rhetoric and Communication	3
Understandable Text Creation, Scientific Writing	2
Working with Projects: Curricula	2
Media (Teaching Technology) and E-Learning	2
SPECIALITY MODULES	
Informatics	4
Product Development and Innovation	4
Standards, Qualification and Certification	2
Teacher Training Practice	15
Elective Credit Points	
Elective Engineering Speciality Subjects according to specialisation, including Didactics of Engineering Speciality Subject (1 ECTS)	7
Total	60

Education is completed by passing the final examination. During the examination the candidates must show that they have acquired the skills of an engineering pedagogue. The final examination consists of the presentation and discussion of the candidate's portfolio and an examination interview. The portfolio contains confirmations that the candidate has completed the studies in all the modules, the complete written planning and performance of a teaching session, including video recording, and a subsequent analysis as well as the problem solving of at least one didactic case study. Students who have fulfilled the curriculum and passed the final examination are awarded MA degree in education, and may continue their studies on doctoral level or enter labour market.

Norbert Kraker (Kraker 2005) has pointed out that the 'Circle of Engineering Pedagogy' is a quintet of five disciplines which help to develop teachers' competencies. The five components of the circle are applied sciences (mechanical engineering, electrical engineering, software engineering, etc), social sciences (pedagogical psychology, pedagogical sociology), subject-related didactics (didactics of teaching theoretical subjects, didactics of teaching in the laboratory, didactics of blended learning), supervised teaching practice (in the different learning environments) as well as additional courses (communication skills, a foreign language as a medium of instruction, administration, quality management, project work). Presented 'Circle of Engineering Pedagogy' has served as the basis of the proposed curriculum.

Based upon the principle of 'continuous improvement,' the curriculum should be revised (with changes in teaching materials and tools and re-examination of the strategies used) based upon the quality of the learning experiences as determined through assessment and evaluation. This constant adaptation will require flexibility on the part of both - the educators and the administration.

According to the legislation of Tallinn University of Technology, Estonian Centre for Engineering Pedagogy has the right to make necessary changes to the curriculum in order to improve and enhance the educational process.

Conclusions

Estonian Centre for Engineering Pedagogy at Tallinn University of Technology has been accredited by IGIP as Engineering Education Training Centre for International Engineering Educators in 2003 and reaccredited in 2008. The newly designed curriculum is the first one in Estonia that fulfils at same time the requirements of IGIP and the requirements of laws regulating teacher education in Estonia. Everyone passing the curriculum can apply for the title of International Engineering Educator ING-PAED IGIP.

There is a great deficiency of highly educated technical teachers in Estonia today – technical subjects have mostly been taught by vocational teachers without relevant required educational level in the field of engineering. Deficiency of technical teachers is amplified by the fact that their average age is high and 40% of them have already reached the retirement age. As the practice of Estonian Centre for Engineering Pedagogy shows there is a wide interest towards the new Master courses and interest will remain high as there are no other appropriate courses in Estonia today.

Today Estonia has reached the situation that possessing high technology there is deficiency of skilled and educated employees. Contradictions between the legislation regulating teacher education have given rise to brain drain of engineers from Estonian education system. Instead of higher pedagogical education, the primary qualification requirement for technical teachers should be higher engineering education in speciality after which the candidate has to pass teacher education courses, for it is in high priority for Estonia to bring technical teacher education to the international level. The decrees regulating Estonian teacher education should be amended, as technical teacher education needs modernization in order to meet the demands of labour market and industry.

Implementation of the designed curriculum verifies the beginning of the process of curricular development for technical teacher education progress in Estonia.

Possessing of relevant knowledge, creation of new knowledge and the capacity for its application have become the determinants of the strength of a nation. Consequently, technical education has come to the centre stage and is today the most important agent for change and development. Quality of technical education depends on the quality of teaching. The quality of teaching in turn

crucially depends on the quality of teachers. In order to improve the quality of technical education the foremost mission should be to improve the quality of technical teachers.

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