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### THE CHARACTERISTIC DILEMMAS OF ENGINEERING EDUCATION

#### INTRODUCTION

Recent development of engineering education has to fulfil many tasks given by the modern trends in the society development. Different studies define new goals of engineering education and the engineering schools have to face them. The dilemma of these studies developed in different countries is that they sometimes state requirements that are difficult to fulfil. It is to mention just an example of the ASEE report on goals of engineering education from the year 1968 [1] which recommended that during next decade basic engineering education in USA should be extended to include at least one year of graduate education leading to the master's degree. Another NAE study "Educating the Engineer 2020" [2] proposes that initial professional degree is to be the Master and not the Bachelor degree. This could have implications for the global student mobility and mutual recognition of qualification in context with the Bologna process in Europe. Comparison of these two reports shows one of the dilemmas in engineering education.

It follows from careful analysis of the higher engineering education that different approaches are used and some new ones are proposed. This paper will discuss several dilemmas to show the complexity of these aims.

#### DILEMMAS IN CURRICULUM DEVELOPMENT

Many studies and conference papers describe the growth of quantity, complexity and importance of new knowledge in technical sciences. For the engineering education only limited time is available. A solution of this dilemma is one of problems of curricula development. Extension of the length of studies is not useful solution because according some analysis the extent of engineering knowledge doubles every 10 to 15 years. Longer studies are also more expensive and postpone the exploitation of young engineers in practice.

Instead of longer studies it may be assumed narrower specialisations of studies enabling to include in specialised education only some parts of the growing extent

of scientific knowledge. But narrower specialisation has disadvantage for example in more difficult placement of narrow specialized graduates for permanently changing requirement of practice. Specialised knowledge becomes obsolete quickly and may form artificial obstacles between new branches of engineering. Also the argument for narrow specialization that school should educate specialists who are able to solve engineering problems just after the graduation is not correct, because the school cannot provide its graduates with all detailed knowledge needed for solution of actual technical tasks. Another disadvantage of a narrow specialization is also the fact that the technical problems of our time are difficult to solve on a narrow base. Team work of different specialists with broader overlapping knowledge is required to enable their creative cooperation. Nevertheless narrower specializations in engineering education are launched in coherence with the engineering knowledge development.

New knowledge should not be included in the contents of courses in form of unceasing supplying new engineering knowledge and/or isolated new facts in particular courses. Modernization of the contents should be understood in broader context. The solution of this problem should be sought in general principles and fundamental knowledge. It is possible to introduce quotation from the speech of Ch. Steinmetz, that time president of the American Society of Electrical Engineers, who already in the year 1902 said: "Quantity of material in education increases, so that it is not possible to reach full understanding at students. If it is removed a half or more from the total content of the electrical engineering studies and the rest is taught in such a way to be fully understood with special reference to general principles and methods, the graduate will be better and more successful in practical life".

Practical solution of this goal means transition from extensive to intensive concept of education, creation and application of unified, broad theoretical core of education. By introducing of general principles it is possible to omit more detailed facts from the contents of education. In concept of courses we should deliberate us from isolated facts and tyranny of details. In development of science and technical branches certain facts are in their turn absorbed by more general concepts and explanations, so that they need not to be explained. Quantity of facts in a given branch and/or courses changes in reverse proportion with its maturity. Making the contents of certain subject more concise is more difficult than simple crossing out some paragraphs or chapters. It requires deeper theoretical work-out, finding out more general fundamentals and unifying elements of the course. It requires also finding methods how to explain these more general principles in an understandable way and how to teach their active application. It is a demanding and creative educational and scientific work in individual courses requiring active access and work of teachers leading. Examples of such approach may be found in so-called core curricula at some engineering institutes of higher education.

Social sciences, ethics, psychology, economics, foreign languages etc. should be included in engineering education. The role of these subjects for forming the personality of engineers is obvious. They may assist engineers in solving economical, social and ecological problems in technical projects. Engineers must be aware of their social responsibility and they should take part in public activities. From these requirements another dilemma of curricula development follows. The question is whether to include general education in engineering education or not, which are the appropriate extent and proper methods. The methods of education should not be restricted to lectures and examinations only. Active participation, e.g. elaboration of essays, projects, individual students' presentation etc. should also take part in these courses. [3]

Further dilemma in curriculum development is the proportion of compulsory and elective courses. The electives should not be only some supplement to the compulsory study program. Under such circumstances the students seldom choose electives. Disadvantage of great number of electives is in greater demand on number of teachers, lecture-rooms, laboratories etc. Among advantages may be included competition of different courses and teachers. Unfortunately students sometimes do not always prefer better courses. They often search for courses that are easier to pass.

#### DILEMMAS IN METHODS OF ENGINEERING EDUCATION

Another dilemma can be found in seeking proper methods of engineering education that should not be restricted to lectures, exercises and examinations only. Methods of education must fulfil the requirement to prepare graduates of engineering schools in such way that they will possess for their future work competences for solving arising problems and to adopt in new situations. Students should not be concerned only with situations that their teachers know, but they should be prepared for the world substantially different sometimes unforeseeably different from that one in which they gain their knowledge. Institutes of higher education cannot be only institutes for transfer of facts and information. Such school is since the invention of letter-print only unnecessary luxury. It is necessary to pass from presentation facts to active teaching methods.

The goal of teaching is development of attributes and abilities of students in such a way they are able to analyze, critically evaluate and independently use knowledge with initiative, self-confidence and sound judgement for solving practical problems. It is to develop ability to work independently, in creative way and forming apparent own need of continuing education with the aim to keep up step with the development of science and engineering.

Independent work of student is not possible to limit only on creative thinking in lectures, seminars, laboratories etc. The most important part of the students' independent work is their own work mostly outside the school. Teachers of technical institutes of higher education agree that such independent work is

important. But different opinions exist on the motivation for such work and on the teachers' role in its control. This forms another dilemma in engineering education. Many teachers assume the student independent work is only an issue of initiative of students. They argue that students are to find relevant problems and methods of their solution. According to this opinion students are led to the independent work only by their own interests for the studied branch and their own responsibility to their studies and future profession. It is claimed, that independent work cannot be connected with any form of intervention from teachers, that any control of the student independent work means a introduction of secondary school methods to institutes of higher education, that it is keeping students on a spoon-feed.

Practice, research and experience of some foreign schools are in contradiction to these opinions. By management and control of the independent work of students it is on the contrary possible to gain their greater independence than by control of their reproductive abilities. It is therefore necessary to look for such contents and methods of education that are leading to more active work of students, that remove lecturing and testing of fait accompli leading only to ability for reproducing the presented matter. In so called "open book" examinations the facts cannot be examined but the ability of active application of such knowledge can be examined. Nevertheless the preparation of such examinations is more difficult for the teachers.

For development of the independent work of students exercises led in such a way that one student solves with help of the teacher a problem on the blackboard and the other students only rewrite the solution does not help much. Higher effect is gained when all students in the exercise hours solve the problems individually with possible individual help of the teacher or their peers. Although thus fewer problems are solved, also here holds that less is often more, when more intensive work of students is achieved.

Also in laboratories the students should not only observe experiments presented by the teacher or a more active student. The students should come to laboratories prepared for the experiments and they are to work individually or in very small group

All these consideration are based on the dilemma who is standing in the educational process on the first place - the student or the teacher. Against the concept of teacher oriented education stands the concept of student oriented education. One of problems is the fact, that student oriented education is more laborious for the teachers and requiring more abilities of the students.

It is to be found appropriate proportion of lectures to exercises. In some cases it is assumed to best proportion of lectures and exercises is 1:1. In other cases this proportion, e.g. in mathematics is 1:0, when active methods and students' self studies are exploited. We must keep in mind the obvious fact that curriculum and its structure is not prepared primary for teachers but for students. The dilemma of portion of the so called contact hours in engineering education should be

examined, because large number of lecture hours may lead to passive education and to development of reproductive abilities of students. The dilemma of shortening of contact hours at schools and extension of individual work of students solving problems, preparing project etc. should be assumed. Such approach is time consuming also for teachers that have to check and correct the students' individual work and therefore it is difficult to introduce it in the educational practice.

#### DILEMMAS IN APPLICATION OF TECHNICAL MEANS

Nowadays new technical means are introduced and used in engineering education. It should be recognised the aims of their application. The use of new media in engineering education has to help, support and fulfil its most important objectives. One of important area of their use is in lectures to make them more illustrative and better understandable. Does it mean that lectures are most important form of engineering education? According the previously introduced arguments the main purpose of them should not be only to introduce the knowledge, but to support the individual work of students. It should be also recognized that some technical means, as earlier overhead projectors, and now Power Point have also some disadvantages as quicker lecturing, more difficult making changes in ready made lectures and often less readable texts, figures and especially tables. The teacher should keep in mind, that technical means are not only to make them the lecturing easier, but that they are for making easier following and understanding the substance of the presented material.

#### CONSLUSIONS

The development of engineering sciences requires solution of the available time and the extent of the subject matter. Possibility of introducing narrower specializations is for its disadvantages limited. A way to solve this dilemma is an intensive concept of education, creation and application of broad theoretical core curricula. In methods of engineering education a way for intensification individual work of students should be sought. Such approach is appropriate for developing required competences of graduates. [4] New technical means should not be assumed as the main progress in education unless they are applied for fulfilling the main goals of education, i.e. the development of active work of students.

This article is extended and innovated version of original paper presented at the IGIP International Conference, 1–4 July 2007, Miskolc, Hungary. [5]

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#### **Abstract**

The paper deals with different approaches used in engineering education. It analyses concepts of engineering curricula, methods of education and technical means used. The main dilemma is represented by “teacher oriented” and “student oriented” concept of engineering education.