

# Combined Biomedical and Ecological engineering – Initial Experience from Realisation

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**Abstract** - Following the previous paper describing the basic properties of the experimental curriculum combining the biomedical and ecological engineering, the present contribution comments on the first experience with this type of study, both from the students' and teachers' views. It turns out that this branch of study becomes well accepted among students, although it is rather demanding. It may be attributed to the students' interest attracted by the unusual multidisciplinary combination of purely technological tuition with more human-sciences oriented view presented in the biomedical and ecological subjects.

**Index Terms** – Biomedical engineering, Environmental science, Ecology, Electrical engineering, Informatics.

taught by experts from outside of the technical university – was surprisingly positive. It will be shown in detail in the paper, how the students anonymously evaluated the individual lectures devoted to different aspects of ecology and environmentalism. Similarly (though less surprisingly) positive was also the reaction to the subject Ecological Engineering dealing with the technical aspects of ecology and with the technological concepts used in this area.

Presently, the diploma projects are worked on, which will be finalised soon. A survey of the projects, emphasizing those, which have to do with ecology, will be also given at the conference presentation.

## GENERAL CONCEPT OF THE STUDY

## INTRODUCTION

At the previous ICEE 2006 conference, a concept of biomedical engineering tuition combined with ecological aspects has been presented. Since then, the first group of students has passed their first MSc year of study and is presently enrolled in the second year, aiming at finalizing their study via diploma projects. It is therefore possible to summarize the experience with this first batch, both from the departmental, i.e. teacher's point of view and from the aspect of students, i.e. how the students evaluate the „unusual“ subjects and themes diverting substantially from what they were used to during the previous purely technological study. It seems that the possibility to study some ecologically oriented problems attracts relatively many students who – still thinking primarily technically – generally seem to gradually recognise the need of environmental care.

It can be primarily stated that the interest of students in this new curriculum exceeded substantially the expectations – the study branch Biomedical and Ecological Engineering turned out to be the second most desirable among the MSc specialisations at the Faculty of Electrical Engineering of Brno University of Technology. After some negotiations, the number of students of this specialisation in the first year stabilised near 40, a reasonable number for all kinds of the specialised tuition, including labs.

The reaction of students to the most „unusual“ subject – Introduction to Environmentalism, a rather natural- and social- science (thus non-technologically) oriented subject

About 5 years ago, a new reformed study scheme was started at Brno UT, effectively replacing the previous consistent 5-year curriculum by the two-stage study (BSc+MSc). In this frame, a new MSc two-year study branch has been established, encompassing not only biomedical technological concepts but also concepts used in ecological measurement and screening, including the interdisciplinary subjects from both non-technological areas, biomedicine and environmentalism.

The basic idea of the interdisciplinary tuition at the Brno UT was (for many years before starting the new curriculum, and still is, even in the changed environment) to produce high-quality master-degree electronic engineers with good theoretical background, while obtaining generic enough education enabling them to cope with the changing labour market. The interdisciplinary biomedical engineering education was formed, besides necessary theoretical background, by specialized subjects concerning the medical technical equipment and complemented by a system of biomedical courses, providing the ability to communicate well with the medical staff, as a kind of extra bonus to the technological qualification. The already well-established and consistent study system had to be reformed when the two-stage study system (BSc – MSc) was introduced based on the European concept of the sc. Bologna declaration. This has led to the new two-stage system, reflecting the needs of both the new regulations and the modern concepts of BME study.

In frame of it, we are able to accept relatively high numbers of students, who show a clear interest in the BME study, without exposing them to the danger of becoming unemployed when some of them do not find jobs in the medical, health-care or environmentalistic area. On the other hand, the necessary highly specialised skills particular to a concrete BME job (or also any other job in electronics) can be acquired more easily when the graduates have a good generic technical background than with a too specialised but not exactly matching knowledge; therefore the stress on the good generic background. What is now completely new in the present curriculum is the extension of the standard BME technology to the area of the instrumentation used in

ecology. This comes from two ideas: first, much of the instrumentation used for medical and ecological diagnostics are technically close to each other and therefore the principles can be taught in frame of the same subjects. Second, concerning the interdisciplinarity of BME, it is quite similar to that of environmental applications of technology, at least as far as the measurement area concerns: similarly as in BME, the ecological applications also require not only the good technical knowledge but also at least a basic knowledge of the non-technical environmentalistic concepts and terms. This is the reason for studying both biomedical and environmental concepts in parallel from both, the human science and the technological aspects.

TABLE I.  
STUDENTS' EVALUATION OF THE SUBJECT "INTRODUCTION TO ENVIRONMENTALISM"

Theme	Average evaluation by students	Evaluation by individual students																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Definition of environmentalistics and its basic concepts	1,06	1	2	2	1	1	1	0	1	1	1	1	1	1	2	1	0	2	0
Relations to nature, influence of mankind	2,83	2	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3
Demographic aspects, population development	1,67			2	2	2	1	2	2	2	2	1	1	2	2	2	1	1	
Estetic perception of nature and landscape	1,47	2	2	3	2	1	0	3		0	1	2	1	2	0	2	2	1	1
Relations between economy and ecological situation	1,47	1		2	1	3	2	1	1	1	2	2	1	2	1	1	2	2	0
Ethics, mind and emotions; why ethics should not be a science	2,17	2	2	1	3	2	2	3	0	2	2	2	3	2	3	3	2	2	3
Development policy and its social and environmental impact	1,67	1		1	2	2	1	2	1	1	2	2	1	3		3	1	2	
Philosofic concept of nature; role of culture in nature	0,59	2		1	0	1	1	1	0	0	0	1	0	0	0	0	0	2	1
Changes of climate; ways to climate protection	2,59	2	2	3	3	3	3	2	3	2	3	3	2	3	3	2	3		2

The subjects offered in the curriculum can be generally subdivided into two groups: primarily the technically oriented group providing both the generic technical knowledge from the area of electronics, measurement and applied informatics and also the specialised knowledge on biomedical and ecological instrumentation, e.g. imaging systems, diagnostic analytic equipment, therapeutic technology, etc. The technical subjects are generic enough to provide the qualification not only for just the medical or ecological applications but in the generic electronics field as well. Particularly, the specialised knowledge is acquired in frame of student projects.

The second - smaller - group of subjects is formed by the courses devoted to the interdisciplinary areas of both biomedical and environmental sciences. On one hand, there are subjects in this group presented by external medical and clinical experts, a biophysicist, and group of environmentalists; these courses aim at exposing the students to the particularities of technology application in a medical or environmental institution: the new non-technical knowledge, different language and terminology, and also the different ways of thinking that a cooperating technologist should become familiar with. On the other hand, there are specialised technically (or system-theory) based courses, devoted to basically the same problems but presented by technologists. The comparison of both approaches is a very important feature of our concept of teaching the BE engineering.

The details on the concept and relatively detailed content of this MSc curriculum were given in [1].

### CONCRETE EXPERIENCE WITH INCLUDING ECOLOGY

There were many doubts on if the students would be interested enough, and when so at the beginning, whether their interest would last longer. Now, after more than one year of running this study branch, it can be stated that the interest is rather high and steady, generally better than originally expected.

It can be perhaps best shown on the student evaluation of the most problematic course "Introduction to environmentalism", which brings the approaches and ideas totally different from what the students are used to after three or four years of technological study. The course is rather widely oriented towards human-science backgrounds, as it is needed when the environmentalistic concepts should be introduced. The content of the subject can be well seen from the names of chapters, to each of which usually one or two lectures are devoted (see Table I). On one hand, there are rather theoretical themes included, like Definition and basic concepts of environmentalism or Philosophic concepts of nature, on the other hand such "practically useful" themes like Relations between economy and ecological situation can

be found. In between, there are many concepts touching both the technological and human-science areas in a certain amount. The students responded to optional and anonymous questionnaires, with the evaluation in the range

- 3 . . . excellent, outstanding
- 2 . . . quality, good
- 1 . . . acceptable with reservations
- 0 . . . objectionable, uninteresting

As it can be seen, the "zero" marks are rather seldom and mostly appear at highly theoretical themes (thus very different from technological view). The best marks were given, as it could have been expected, to the themes concerning the technology in one or another way, or touching generic daily-life experience, particularly of young people (e.g. relations to nature, the climate change). More surprising is that the overall evaluation of the environmentalistic course is very good - between 2 and 3, and it particularly interesting that students who evaluated some lectures as 1 or even 0, give the total mark 2 or even 3. It indicates that the students accept this "strange" course as interesting and rewarding.

Besides this unusual course, the curriculum contains two specialised environmentalistic technological courses: Ecologic engineering (generic technological concepts for ecology, regulations and legislation) and Information systems in Ecology. Otherwise, the technology used in environmentalistic equipment, is treated in frame of the courses on measurement, diagnostic and laboratory technology. Even these courses are well attended and obviously attract the attention of students, as visible from the interest in student projects oriented towards ecology.

Presently, the first batch of students of the described study branch are finishing their MSc diploma projects, among them several from the environmentalistic area. Hopefully, even these projects, when defended, will show a comparable level of standard with that of the biomedical-engineering projects; this will be assessed later. So far, the attitude of this first batch of students may be rated as involved and motivated, thus justifying continuation of this unusual combination of fields.

### CONCLUSION

The combined biomedical and ecological engineering study, as described in [2] and [3] can be, based on the results of the first batch of students, considered a success. The students remained interested even in the relatively detached environmental concepts and particularly in related technical solutions. The so far existing results of the new batch of students of this branch starting in Autumn 2006, presently after the first semester of their BE engineering study, allows similar conclusions.

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