Importance of Laboratory Experience in General Subjects

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***Abstract* – Education efforts at specialized (profile) departments are often focused on students from the respective study branch, especially in Master stage, who are offered the full variety of support their department can provide, including laboratory equipment (also thanks to their advanced knowledge in the specific area). However, the structured study system has brought some lower-level courses for bachelor stage, which are of general nature and cannot go so deep – but it would not be wise to limit them only to theory and exclude all practical experience, so important for proper fixing of new knowledge. This paper uses an example of a newly introduced bachelor course (based on an older alternative, in which only theoretical seminars were included) to illustrate how laboratory education can be integrated into general subjects and what benefits this approach brings, especially when the area of modern communication technologies is concerned.**

Index Terms – Laboratory education, Hands-on experience, Electrical engineering.

INTRODUCTION

Traditionally, the Department of Telecommunication Engineering at the Czech Technical University in Prague, Faculty of Electrical Engineering, acted as a profiling department for the last two or three years of the engineering study. Students coming to its laboratories, even for the first time, were adequately equipped by all necessary experience for independent work, obtained from the courses of so-called common basis, which covered theoretical knowledge as well as practical skills; it was not necessary to explain the very basic principles of measurement techniques and demonstrate the work with common measuring devices. Those students were able to work quite independently and they understood what they were doing very well.

The same applied to the lectures. Students in the higher years, just before the beginning of work on their diploma theses, specialized in telecommunication engineering, which means they were familiar with all important concepts, with terminology, as well as with the state-of-the-art of the telecommunications technology. They intended to become engineers of telecommunications, to make their career in the telecommunication industry, and the appropriate technologies were the main area of their interest. The purpose of lecturing for these students was to go deeper below the surface and reveal the details hidden from the ordinary users, not only to lay the groundwork.

STRUCTURED STUDY SYSTEM

The reconstruction of the study system at our university towards so-called structured one introduced the bachelor and Master study plans. It brought more freedom to students who can not only decide about the desired level of their education, but also make their individual profiles composed "on-demand" from the subjects they can choose almost at will. [1]

The negative side effect of this approach is that, in the limit case, a student may become an engineer in a certain area without being actually touched by the specific subjects. But also, which is perhaps even worse from the teacher's point of view, students from different years may enter the same courses, especially those belonging to the "all-faculty" offer. Why is this so bad? Since many students in these cases lack the necessary prerequisites that should make them familiar with the "common knowledge" required for understanding of the special problems that are lectured in the higher-level subjects.

Although the system of prerequisites works well for the compulsory subjects, it cannot guard the multitude of freely selectable ones. Sometimes it even happens that some students who appear at the laboratory exercises do not have passed the basic tests from safety and health protection regulations, which is the necessary condition for admission to the laboratories, and before they obtain the certification, several weeks of the semester may be lost.

So, the major problem the teachers who have to prepare the "common" courses for students from virtually any study branch have to handle is, how their lectures and exercises should be designed in order to provide enough new information for most (average) students, keeping the level simple enough so that the matter is easy to understand even to the beginners in the area. There are numerous courses taken from the old engineering study system that have been re-designed for the new bachelor stage – they have to face the described problem. Let's illustrate the situation using the example of "Telecommunication Networks".

THE EXAMPLE: "TELECOMMUNICATION NETWORKS"

The original "Telecommunication Networks" [2] was a course intended for the penultimate or final year of Telecommunication Engineering students, with 4 hours of lectures and 1 seminar per week. Since its target group was formed by the future specialists in the respective area, it was focused on specific issues of networking from the

telecommunications' point of view, discussing quality and grade of service, network performance, reliability and serviceability, traffic load and dimensioning of networks, description and topologies of networks, etc. The seminars were specialized mostly on the dimensioning problems, giving examples of calculations for various system types and operating conditions.

Now, the new bachelor clone of the subject was reduced in extent to 2 hours of lectures and 1 exercise per week. We have to realize that the students registering for the course were not expected to have any previous experience with such sophisticated terms that are listed in the previous paragraph. Moreover, most of those students had other study plans than Electronics and Communication Technology, which is the closest to the original "Telecommunication Engineering. Totally different approach was needed to make the new course meaningful.

Firstly, it would not make sense to teach the bachelor students any high-level chapters from networking – the purpose of subjects at their stage is to provide common overview, not a specialized knowledge. Secondly, within the limited time it would not be possible to offer the same depth of the subject even to experienced students. We had to look for a composition that would be attractive, offering some real value, but not boring for novices because of too much complexity.

The solution was found in lectures providing the overview of all aspects related to telecommunication networks [3] – communication link and its components (including transmission paths), transmission of information and its protection, open systems interconnection (OSI RM), modulations, transmission and switching systems, traffic models, services and their classification, common types of networks (including telephone networks, data networks and intelligent networks), and also services and their quality – so that every student from any study branch can learn and understand the basic networking principles.

As for the exercises, the original proposal was to keep the form of seminars. But at this point we have encountered another serious problem, which might be described by the classical question: "Cui bono?" Of course it would be nice – at least from the scholarly point of view – if the students could get some calculation examples accompanying the lectured theory; but the question is, which examples should be chosen for the course with the nature of an overview. Wouldn't some real, hands-on experience be better?

Of course there are some pros and some cons. Obvious objection could be that the laboratory exercises, likewise the theoretical ones, cannot provide enough experiences in such limited time. Well, let's ask which experience is more durable: calculation of examples with copying of formulas from the blackboard, or personal contact with the described technology? Which is more attractive: paper, pen and figures, or real work with measurement apparatus providing immediate response to the given inputs? Since there is not much time for neither, we should decide for the approach that will fix the theoretical knowledge somewhat better, as we can rely on the specialized courses within the Master stage that will offer the necessary theoretical background to those who will really need it.

HANDS-ON EXPERIENCE

We decided to change the original plans and introduce some laboratory experiments that would accompany and illustrate the lectured topics. In winter semester of the last academic year, we applied something from the "school by game" principle and designed the following three laboratory exercises: black box analysis, analysis of a dialed number in telephone network, and analysis of cyclic redundancy codes (CRC) in a data stream. The tasks we quite simple, but still they helped the students understand the relevant principles much better than just talking about them. It could be concluded from the results of the final test that we were successful in this sense – only some 5 students from the total number exceeding 110 had problems with obtaining their credits.

The important thing is that thanks to the support provided by the Czech Universities Development Fund we will be able to purchase some more sophisticated equipment for the purposes of exercises in "Telecommunication Networks", which will be used from the beginning of the coming academic year. Specifically, the four new laboratory exercises will cover the following topics: modulation of analog signals, digitization of voice, signal transmission over optical fibers, and data transmission in host networks (including mobile ones). These exercises are in accord with the lectured topics and they touch important aspects of modern communication systems. Of course we plan to obtain some feedback from students at the end of the semester.

EVALUATION AND SUMMARY

This paper tries to explain the reasons for introduction of laboratory measurements in certain courses, which are not the "high-priority" ones, but should teach the students something about basic principles applying to a specific area of technology, in a way that does not go very deep, but still it helps to fix the important details in memory. The results of final tests performed at the end of the last semester have proven this approach as correct and applicable also to similar courses of general nature.

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REFERENCES

[1] Vodrážka, J., Hrad, J., Zeman, T., "Transformation Towards Structured Study with Respect to Needs of Industry", *14th EAEEIE International Conference on Innovations in Education for Electrical and Information Engineering*, Gdańsk: PTETiS, 2003, p. A52

[2] Popis předmětu 32TSI – Telekomunikační sítě (online, in Czech), http://www.fel.cvut.cz/education/bk/predmety/01/00/p10047.html

[3] Description of XE32TSI – Telecommunication Networks (online), http://www.fel.cvut.cz/education/bk/predmety/01/86/p18611.html