Work in Progress: A New Role for Math in Engineering Education

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Abstract - **The role of the industrial engineer is under dramatic change. Until some decade ago, the engineering education was mainly focusing on computations as a basis for the selection of system components or for determining dimensions of construction elements. Such calculations had to be repeated for every new system design, every new building, bridge, amplifier, engine, transmission, etc. Computations by means of pencil and paper, but with the slide rule replaced by hand calculators. At least in Sweden, we are still organizing math education and training in engineering programs that way. However, today such calculations are, outside the math departments, automated. Design rules and general models are built into the computerized design and modeling tools.**

Index Terms – Engineering education, industrial engineer, mathematics.

BACKGROUND

We have designed our engineering programs in a situation where students were competing to be accepted and where there was a shortage of engineers. The criteria for the program design were mainly aiming at optimizing the use of lecture halls, laboratory equipment and lecturer time. The conditions for the students´ learning were of secondary importance. We were not forced to take the student effort or the student situation in general into account when we designed the schedule.

The courses required in a program and the contents of these courses have changed gradually due to the development of technology, but normally with a rather narrow scope. New materials, new components, new tools and methods have been introduced, but in general, the foundations of engineering or specific engineering branches have not been questioned. It has been assumed that the way we have been doing things in the past is the best and the only way to do it.

In recent years, the interest for engineering education has dropped drastically in Sweden. A large number of the students graduated have experienced unemployment. Not only assembling and manufacturing plants have been moved to low-salary countries but so have also research and development units. There is a major crisis at the engineering institutes and engineering schools at the universities.

In this situation The Department of Science and Technology, Linköping University, initiated a project aiming at defining appropriate actions in this situation.

THE PROJECT

Our students are the best and the most important ambassadors for our university, for our department, and for our curricula. When a student returns home to family and friends after the first semester, it is most important how she/he describes the experience from the first courses.

The department defined the goal of the development project: *Make the changes needed in the contents and the organization of the courses, such that our students, after the first semester as well as later, communicate to their environment that they are highly satisfied with their education, that they have worked hard but learned a lot, enhanced their capabilities and enjoyed the time at our department.* Sometimes, when talking to people not yet involved in the project, we have had to add the information that *we shall not reduce the examination requirements*. For the kernel team it has all the time been quite clear that we are aiming at *a better understanding, a better knowledge, and a better capability in general*, than has been required until now. Initially, as the major content of the first semester is mathematics, we were thinking of changes in the way we teach the math courses. However, as we will present below, we have widened the scope, and may return to the role of math and the organization of math courses at later stages of the project.

As a first step in our analysis, we decided to describe the current situation. We inquired representatives for students, faculty and staff about their views. In short, most of them consider our courses, our teaching, and our organization in general, to be quite satisfactory. The causes of the problems were as a rule placed outside the department: *low quality of secondary school courses, inappropriate funding, etc*. Thus, the response did not directly give any advice what to change within our department.

In this situation, an external consultant was hired to help us to ask the questions we had avoided. He put our intention to the fact that only about 30-40% of the students passed in the examination during the first semester. Therefore, they had to use time later to repair their failures. The organization of later semesters had to be designed to allow for such repair activities. The general mental models were based on the fact that most students fail in their examinations, already during the first semester. So one question defined by the consultant was: *which internal actions would be needed to enable 90% of the students to pass in their examination during the first semester, assuming the same "quality" of students as now and*

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with at least the same examination requirements as we have today.

The immediate response to the 90% was rejection. As the idea was completely unrealistic, it was just a waste of time to consider it. However, we failed to reject the idea completely. It was there and it challenged our mental models. We had to take a couple of steps backwards and look at our education at a distance. We started to focus on the students´ learning situation. We looked at the schedule from the student's point of view and not from that of the lecturer or that of the planner of lecture hall usage. We discovered that, from the student's point of view, the week was completely filled by scattered course fragments, each with a particular content transferred to the student. There was very little time for reflection and integration of all the information fragments. Therefore, when we started to look at the schedule with our new eyes, we were able to rearrange the week completely. The schedule could be design to enable and support student learning rather than to hinder it. Moreover, we were able to achieve this with same or less teacher effort. The major change, and the significant one, will be on the use of the real bottleneck, the student time for reflection and assimilation of information. The fragmentation of the week for the student will be replaced by a "full day schedule". New stuff, new problems and new questions are introduced in the morning: The students will work with this material during the day, supported when needed by teachers at different levels and access to laboratories, and there will by summing up sessions at the end of the day.

The presentation in this paper so far has been on shift of focus from use of buildings and teacher time to student learning regardless of subject and course contents. The next step in the planning will consider the sequence of courses and their contents, and we are just now about to enter this step. The new structure of the schedule, with more time for reflection, will enable a better integration of different courses studied in parallel. The focus will be on the constructivist model of learning rather than on the information transfer metaphor. Therefore, we believe that the students will be better on defining questions and problems themselves, and then look for answers and solutions, than they are in the current system. This will release the current constraint on course sequence a little bit. It will no longer be necessary to lecture or "talk" everything first, before the need is there. It may even be an advantage, at least for some students, to understand and to think of the problems themselves, before we serve the methods, tools, solutions and answers.

All this will enable a new view of mathematics, physics, computer science, *etc*. in our programs. It may be possible to move parts of this from the first semesters to later on, when (and if) it will really be needed.

CONCLUSIONS

The new ideas on how to organize engineering education has been tested in a pilot project for a small group of third year student during an eight-week period. The students as well as the teachers are in general happy with the new structure, but it is still too early to draw any specific conclusion. The model will be used for all our new students now the fall 2006, and after that, we will know better what works and what does not. However, one conclusion is quite clear, if you do not set ambitious goals you will not reach them.

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