RÅDET FÖR HÖGRE UTBILDNING
COUNCIL FOR THE RENEWAL OF HIGHER EDUCATION

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"Concurrent Education"
Interaction between parallel courses in higher technical education

(Interaction Between Parallel Courses in Engineering Education)

Abstract

The teaching at the institutes of technology in Sweden is traditionally performed in separate courses corresponding to different subject fields. These subject fields are commonly taught by different departments. We know from our own experience and from evaluations that many of the students feel a lack of coherence between the different courses. This is a serious problem, as integration of knowledge is one the most important requirements of a "good engineer."

Project concept

The objective of this project is to encourage and facilitate the integration of knowledge mainly by bringing the different courses "closer" to each other. We do this in four different aspects:

1 Contextual - Established boundaries of courses in Different subject fields are questioned. Are these boundaries adequate for the actual programme of study?
2 Conceptual - Connections between concepts and methods used in different courses should be clearly pointed out.
3 Timing - By elaborate planning the time between the study of courses in interdependent fields can be decreased. In this way, mathematicaltools, for example, may be used in applied courses very soon after the introduction in the courses in mathematics.
4 Applicability - Through project work the students are required to combine knowledge obtained in

parallel courses.

We denote this concept of interacting parallel courses "Concurrent Education" by analogy to terminology in computer science and in engineering.

Present status

During the school year 95/96, the concept of "Concurrent Education" has been applied to the two-year curriculum for electrical engineers at Lund Institute of Technology (LTH) in Malmö. New courses have been formed due to the contextual aspect, new multi-disciplinary project courses have been created due to the applicability aspect and the conceptual and timing aspects have been emphasised during the planning. To our knowledge, the project has been very appreciated among both students and teachers, however, the project is still in an evaluation phase. A report with documentation of the project will published in the spring 1997.

LUND UNIVERSITY
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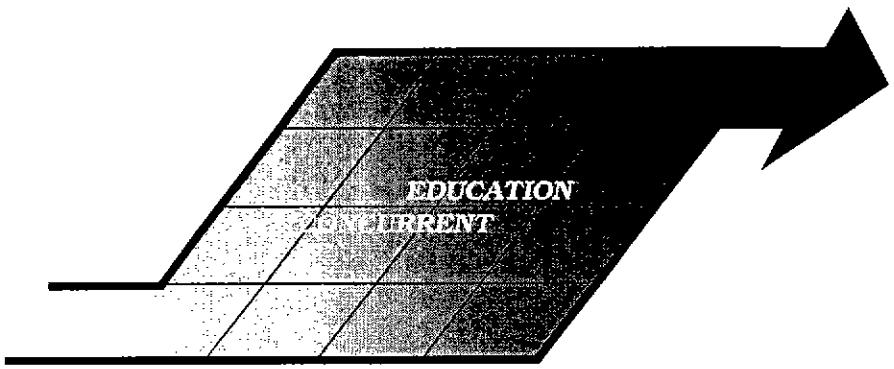
"Concurrent Education"

Interaction between parallel courses in higher technical education



Project report

December 97, November 2001
Tommy Andersson
project director

Abstract

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This approach has been much appreciated by both students and teachers.

Foreword

This report was mainly written in December 1997 and describes a project concerning the two-year academic programme for electrical engineers at Lund Institute of Technology (LTH) in Malmö, Sweden. The 1st of July 1998 students and personnel were transferred to the new Malmö University and a three-year academic programme for computer science and electrical engineers was started. The curriculum for this academic programme was developed 1997-1998 taking the described approach of "Concurrent Education" into account.

November 2001

Tommy Andersson

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Introduction

The teaching at the institutes of technology in Sweden is performed in separate courses corresponding to different subject fields. Different departments commonly teach these subject fields. Small or non-existent contact surfaces between the departments and often long intervals between basic courses and applied courses make many of the students feel a lack of coherence between the different courses. We know this from our own experience both as students and as teachers, but these points of view are also expressed in evaluations of the programme of studies at the institutes of technology, cf. Refs. [1] and [2]. This is a serious problem, as integration of knowledge is one the most important requirements of a "good engineer." Integration of acquired knowledge certainly has to be achieved by the student him- or herself, but the curriculum ought to be designed to facilitate such an integration. This is especially important for the shorter 2- and 3-year programmes of study, where the students in addition to having a shorter time to digest the material, are also expected to be "ready to function in the real world" more or less immediately after graduation.

This report describes an education project with the objective to create such a curriculum for the two-year academic programme for electrical engineers at Lund Institute of Technology (LTH) in Malmö, Sweden. To create a completely new curriculum is a very demanding task, our efforts were limited to changes of the existing curriculum. The planning and implementation were carried out mainly during the school years 1994/95 and 1995/96. The report focuses on the basic concept, the process of implementation and the evaluation of the project. The work has of course involved a large amount of subject and intersubject specific details. It is, however, not the objective of the report to describe this part of the work although examples will be mentioned and project descriptions, evaluation forms etc. are enclosed in the appendices.

Project concept

The idea of the project is to encourage and facilitate the integration of knowledge mainly by bringing the different courses "closer" to each other. This is done in four different aspects:

1. **Contextual** - Established boundaries of courses in different subject fields should be questioned. Are these boundaries adequate for the actual academic programme? Can present courses be combined or broken down into smaller units and joined in new combinations to achieve a higher level of coherence?

2. **Conceptual** - Connections between concepts and methods used in different courses should be clearly pointed out. In contrast, by tradition disparate terminology often hides such connections.

3. **Timing** - Traditionally, the students at the institutes of technology in Sweden study several different courses in parallel. This can be taken advantage of, by elaborate planning, to decrease the time between the study of courses in interdependent

fields. In this way, mathematical tools, for example, may be used in applied courses very soon after the introductory courses in mathematics.

4. **Applicability** - Through multidisciplinary project work the students are required to combine knowledge obtained in parallel courses.

We denote this concept of interacting parallel courses "Concurrent Education" by analogy to terminology in computer science and in engineering.

The concept is not restricted to teaching alone, but also includes examination. Research in pedagogy emphasises the importance of agreement between the type of examination and goal of the curriculum. If this is not the case, the examination turns out to be the true curriculum. Cf., e.g., Refs. [3] and [4]. In accordance with this different types of examinations can be used to ensure the necessary achievement of basic knowledge in the separate courses and to encourage the integration of knowledge.

Concerning the achievement of basic knowledge, we hold that conventional, written examinations of a problem solving nature are adequate. However, in line with the contextual aspect, the scope of such examinations should not be too limited.

The ability to integrate the knowledge acquired can be examined in similar ways, but with examination problems covering several subjects. Our intention is, however, to create "good engineers" who are able to use the acquired knowledge to solve real problems. Hence, it is natural that the examination problems have a character similar to those the future engineer will meet in working life. Our idea is, thus, that this examination will mainly be performed by supervised project work, where written and oral reports constitute the formal examination.

Project process

Project schedule

Planning and implementation of the concept of "Concurrent Education" has to some extent been an evolutionary process. It was actually started before the four aspects of the concept were explicitly formulated and the project group was formed. The main changes of the curriculum were made during the school years 1994/95 and 1995/96. Further minor changes have been made in 1996/97 and 1997/98.

Background - The teaching environment

The ability to perform a project of this kind is related to the organisation of the university or college in question. The organization of Lund Institute of Technology (which is a part of Lund university) is characterized by a function split into program committees and departments. Each academic programme is lead by a programme committee, which is responsible for the curriculum. The programme committee orders and purchases the separate courses from the departments, which have the executive function. The departments are normally subject orientated, hence the students studying at a certain programme are taught by teachers from several departments.

During recent years there has been one common programme committee for the two-year programmes of study in Malmö. The every day work, contacts with students and so on are handled by a director of study, one for each programme. This programme committee consists of representatives for the teachers, the students, the industry, the municipality and the master programmes. The directors of study are also members of the programme committee.

The organization in Malmö differs from the main structure in one way. One multidisciplinary department teaches the main part of the courses. Hence, in the same building, on the same floor, there are teachers in Mathematics, Computer Science, Control Theory, Mechanics, Electromagnetics etc. The directors of study are also teachers at the department. This means that the contacts between the teachers, representing different disciplines, and between the teachers and the directors of study work very well, the teachers meet every day during coffee breaks, at lunch, waiting for the copying machines and so on.

There are obvious pedagogical advantages in the organization in Malmö. The close contacts between teachers and disciplines encourage informal inspection and constructive criticism. It makes it easy for ideas to be hatched, to grow and to be implemented. Co-operation over the border of the disciplines can be established without bureaucratical problems. It is, e. g., easy to make arrangements for a teacher who wants to broaden his or her field to take part in the teaching of courses belonging to other disciplines. Actually, the idea and implementation of "Concurrent Education" is an outcome of this fruitful environment.

Participants in the project

When the project was started it relied on certain proposed changes of the existing curriculum. The participants in the project were chosen according to the designated areas. As the work went on there were minor changes in the "crew" due to new ideas and changing outer circumstances. The final list of participants:

Tommy Andersson	Ph.D., Senior Lecturer, Circuit Theory, Electromagnetic Theory (project director)
Håkan Asklund	M.S., Lecturer, Computer Science
Lars Björkman	Tech. Lic., Senior Lecturer, Signal Processing
Lars-Hugo Hemert	Tech. Lic., Senior Lecturer, Digital Circuits, Computer Technology (director of study)
Göran Johannesson	M.S., Lecturer, Control Theory
Lars Lithner	Ph.D., Senior Lecturer, Mathematics
Björn Nilsson	M.S., Lecturer, Analogue Electronic Circuits
Roland Thapper	M.S., Lecturer, Information Technology

Planning and implementation

As described above the programme committee is responsible for the curriculum for the academic programme. Major changes like new courses or substantial changes in the contents of courses have to be established by the programme committee. Minor changes like transposition of contents, new notations etc. can be introduced by the responsible teacher. Hence the project work had to be performed on two levels. This was facilitated

by the composition of the project group. The director of study and the responsible teachers were included in the group. It should, however, be pointed out that the project group did not have absolute power over the curriculum. The programme committee actually made some changes in the curriculum that was not supported by the project group.

First school year

Two new courses have been introduced in the first school year, Circuit and Measurements and Project Course 1. One course, Microcomputers and Interfacing was moved to the second school year.

The course Circuit and Measurements was developed in two steps. Due to changes in qualifications of new students, a new course in electrical circuit theory had to be introduced during the first school year 1994/95. At the institutes of technology in Sweden, electrical circuit theory is traditionally divided into two parts taught in two different courses often by two different departments and separated by quite a long time period. In line with the contextual and conceptual aspects described above, these two parts where joined in a new course at the master's programme at LTH in 1992-93. Personal experience from the developing and implementing of this course encouraged us to plan a corresponding course at the two-year programme. As such a course demands most of the tools acquired during the courses in mathematics, the idea of parallel, concurrent courses arose. We soon found that this was feasible with some modifications of the course in circuit theory and with just minor changes in the courses in mathematics. What is more, it was possible to make the circuit theory course interact in a similar way with courses in electrical measurements and analogue electronic circuits. This course, called Circuits and Circuit Theory, was introduced the school year 1994/95. In discussions with students we found that this course and the main part of the course in electrical measurements could be combined into one course. This would create a course with theoretical and laboratory parts integrated in a natural way. This new course was implemented 1995/96 and was called Circuit and Measurements. The examination consists of tests and reports accompanying the laborations and two conventional, written examinations of a problem solving nature. In line with the contextual aspect, the scope of these written examinations should not be too limited. An example of such a written examination is given in Appendix 1 (in Swedish). Note that knowledge of both circuit theory and of measurement technique are required to be combined in some of the problems.

Project Course 1 was introduced in the school year 1995/96. This course specially applies to the fourth aspect of "Concurrent Education," the aspect of applicability. The course runs the whole school year, but consists of several sequential tasks together forming a complete project. The tasks are of the type "real life problems," to train the students for their future career as engineers. The work is performed in groups of about 4 students and includes both theoretical and practical parts. Material covered in all the parallel courses are related to the project tasks, thus, encouraging and requiring the students to combine and integrate knowledge, but the timing versus the parallel courses is crucial. According to the contextual aspect a former separate course in information technology was integrated into the project course. Using computer tools, the students are taught how to find information,

how to write reports and how to make oral presentations. These skills are of course applied to the "real life problems" the students face in the project course. The intention is, to create "good engineers" who are able to use the acquired knowledge to solve real problems. Hence, it is natural that the examination problems have a character similar to those the future engineer will meet in working life. The examination of the project course is mainly performed by supervision of the project work and with the written and oral reports constituting the formal examination. A description of the project tasks is given in Appendix 2 (in Swedish).

The other courses in the first school year have been slightly modified to adapt to the new curriculum. Some changes in the sequence of the sections in mathematics have been made to achieve the timing with the course Circuit and Measurements. Computer lab exercises in Mathematics have been revised, extended and scheduled to support the new project course. A former project task in the course Digital Circuits and Design has been replaced by a new task in the project course. Lab exercises have been modified to support the project course. Connections between notions and methods used in the different courses have been discussed by the responsible teachers. Notions have been changed in some cases, in other cases the connections are pointed out and made clear in the teaching.

The complete schedule including links between courses for first school year of the academic programme 1995/96 is illustrated in Fig. 1.

Second school year

The curriculum for the second school year was completely altered 1995/96. This was made due to the changes in the first school year described above and due to a planned extension of the study programme with a supplementary year. Although the courses in the second year are not as interdependent as the first year courses are, the concept of "Concurrent Education" was considered when planning the new curriculum.

The curriculum for the second school year is centred on a project course, Project Course 2. Just as in the first school year the main purpose of the project course is to help the students to become "good engineers" who are able to use the acquired knowledge to solve real problems. Project Course 2 consists of two parts. Part 1 corresponds to 2 study credits while part 2 is larger and corresponds to 6 study credits.

Part 1 is planned similar to the project course in the first school year although just two parallel courses interact with the project course. Each project group, with 4 students, solves, produces documentation and reports a project task involving analogue signal processing and computer technology.

Part 2 mainly consists of one quite large project work. This work is performed by groups of 5 to 7 students. The students choose project task among a list of ideas and form project groups according to their choices. The list of ideas is made by teachers, students and industry. There are a great variety of project tasks, hence the students in this project can specialize in their own area of interest.

The schedule for the second school year 1995/96 and links between courses is given by Fig. 2. Besides the above mentioned links between the courses, Signal Processing and Microcomputers and Interfacing, and the first part of the project course there are, as can

be seen from the figure, several other links between courses. All courses interact more or less with part 2 of the project course. These interactions depend of course of the chosen project tasks, hence these links are not shown in the figure.

Third (supplementary) school year

In 1996/97 a supplementary school year was introduced at the academic programme for electrical engineers in Malmö. Although the supplementary year was not included in our project, the concept of "Concurrent Education" has to some extent been applied. Most of the courses in the supplementary year are independent of each other and do not interact, hence the timing aspect is of less importance. Contextual and conceptual aspects have been regarded in planning and implementation of the curriculum even if some difficulties have arisen, as some of the courses are not taught by our multidisciplinary department, but by departments in Lund. The applicability aspect is mainly related to the final thesis, which is normally performed in the industry.

Continuous evaluation, revision and evolution

The implementation of the concept of "Concurrent Education" is not a one-time job. The work has been characterized by continuous evaluation, revision and evolution and has to go on in this way. When changes are made in the schedule or in a course this may have to be followed by changes in other courses. Co-operation, co-ordination and evaluation are means to keep this process alive.

To ensure close co-operation between the teachers we decided at the start of the project that the teacher responsible for each course should also be engaged in at least one of the interacting courses. It has not been possible to achieve this completely due to practical problems. Still, we think this approach is very important.

Co-ordination is of course necessary. In our case we have found it to be natural that the teachers responsible for the project courses also are responsible for the co-ordination in each school year. The co-ordinator should have authority to get complete insight in every course in "his" school year, to make proposals for changes and to make evaluations, hence the co-ordinator should be appointed by the programme committee.

Continuous evaluation is of utmost importance to maintain and develop the concept of Concurrent Education. We have found informal discussions with students and evaluation meetings with student representatives very fruitful, but we also think that more formal written student polls should be performed to ensure quality and keep the programme committee informed.