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DESIGN AND PRODUCT REALIZATION

- a student oriented course approach for high motivation and deep learning

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Abstract

Within the new program Design and Product Realization at KTH in Stockholm, a course block of 18 credits will be given to students in the second and third year. The new program is a measure to attract students and to better fulfill needs of employers. The new program has also been an opportunity to improve engineering education and to increase students learning. Two basic principles can be defined from the pedagogical efforts in the course block development: students should be the main actors in courses supported by teaching activities and assessment methods; and deep learning should be enhanced by strong relations between different subjects and problem based tasks. The course block encompasses the subjects industrial design, mechanical engineering, production, work procedures in product development, project planning, team work etc. These subjects should be trained in relation to each other, based on redesign of existing products as well as in project commissions including new product development.

Keywords: design and product realization, student orientation, deep learning,

1 BACKGROUND

This paper will present the development of a course block and the result up to now: structure and content, and objectives and activities in one of three courses. This is a course block within a new education program at the Royal Institute of Technology (KTH) in Stockholm, Sweden. The name of the program is Design and Product Realization and results in the first step in a Bachelor exam and in the next step in a Master of Science. This means that the education today contains 180 plus 90 ECTS credits. The first, approximately 100 students started in 2003.

The new program is a measure to attract students to the technical area and to better fulfill the needs of students' future employers. Besides increasing the attraction of technical educations by changing contents and creating new education profiles, large measures have been taken to change the pedagogy to improve the actual learning by students. In the course development several challenges have been expressed. These are in different ways related to the needs of the "education buyers", i.e. students and future employers:

- Industrial design, mechanical engineering and production will be handled together (students request educations were different subjects are logically related to each other/ product developing companies require a holistic view on these subjects).

- Theory will be learned alternately with practice (too many students finalize a master degree without really knowing how to apply theories in natural sciences which is unsatisfactory to both students/engineers and employers).
- Professional engineers will be able to collaborate within and between different disciplines. They will be autonomous in making work progress, and creative and inspiring in an environment where development work takes place (students request inspiring educations with good opportunities to self development/ product developing companies need engineers with a broad set of competencies beside deep technological knowledge and an ability to deepen their knowledge and find new ones).

The presentation of the course block is best facilitated by two approaches: firstly, the context of the block, i.e. how it is related to other courses in the program, secondly, the development process resulting in the actual curriculum. In between these presentations, the pedagogical outlook, an important base for the course block development will be brought forward. Finally the CDIO perspective utilized in the course block development will be briefly presented and some experiences of, and reflections on, course development will be given.

2 COURSE CONTEXT

Figure 1 describes the program structure for the first three years in the program. During the first year the students take *Perspectives on Design and Product Realization.* The purpose of this course is to introduce the areas Industrial design, Mechanical engineering, Production engineering and Work procedures in product development, train written and oral presentations, team work and to touch upon CAD, Matlab and designing products. Here, for the first time students meet sketching and modeling exercises used especially in industrial design. They also meet, and experience, the process of developing products.

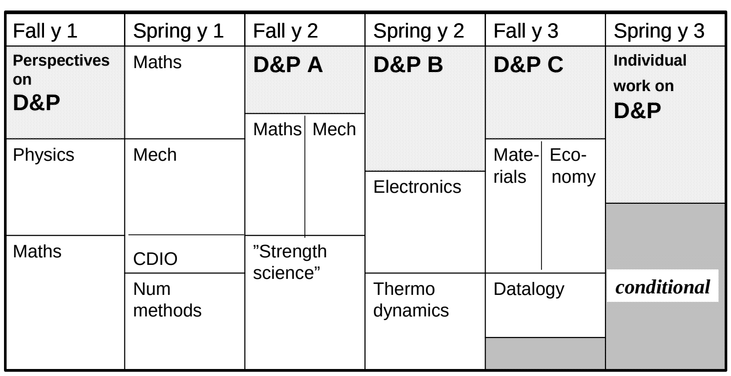

Figure 1, The Curriculum structure for the first three years in the program Design and Product Realization.

In the third year students will conduct individual work on Design and Product Realization which will encompass a thesis for the bachelor exam. To clarify the structure of the program, it is important to mention that the ambition of the faculty is that students should continue their education for a Master of Science at KTH or elsewhere. These first years will set a base for fulfilling the overarching goal of the program: *to be able to take an active part and/or lead the development and production of attractive products*. During the third year students will be able to choose a specialization that they will study year four and five.

In between the start-up and the individual work (thesis) the block of courses in Design and Product Realization, encompassing 18 credits takes place.

BASIC PEDAGOGICAL OUTLOOK

Two major learning principles have guided the course block development. These principles are not to be found in literature in the wording used here as the perception of different pedagogical theories has been formulated. Some of the written sources which have inspired and supported the curriculum development will be given.

The first principle concerns *student orientation*. Barr and Tagg [1] describe a shift in paradigms and say that a learning paradigm has replaced an instruction paradigm [in American higher education around 1995]. The different paradigms can be described by different factors, concerning learning theory, productivity and nature of roles. For example, the learning paradigm is described as knowledge existing in minds and being constructed and created compared to knowledge as chunks delivered by instructors, describing the instruction paradigm. In the learning paradigm teachers develop students' competencies and work in team with students. In the instruction paradigm teachers lecture and act independently of students. The different view of students respectively teachers can be related to Fox's theories of teaching [2]. According to the two *simple theories* Fox defines, transfer and shaping, teachers give knowledge to students (filling the commodity) and shape them into professionals. The *developed theories* Fox define, traveling and growing, say instead that teachers support students to gain knowledge and to learn and that students are explorers or "personality developers". What has been mainly picked up from these theories and sources in the course block development is that students should be learners and not be given knowledge and that they instead of the teachers should be the main actors. This means that a traditional structure of courses, i.e. the lecture-written exam structure must be abandoned. Still, lectures will be used during the courses, for orientation and inspiration.

The second principle guiding the course development concerns *the conflict between surface learning and deep learning*. This is strongly related to student activities and also to how students' learning is assessed. Surface learning is the result of a situation were students quickly get rid of the course and leave it behind and were the knowledge level that students reach is mainly linked to facts and presentations instead of understanding and application of knowledge. Deep learning is then the opposite. Deep learning benefit from a clear structure and context connections, and problem handling in order to give meaning to the contents taught and to ease understanding. A clear strategy in the course block development has been to enhance deep learning. As a consequence the relations between different areas will be highlighted at the expense of quantity of methods and technological principles. Biggs gives a number of factors encouraging deep learning [3].

The way students' learning is assessed is a key factor for both making students active and for encouraging deep learning. Assessment has many functions, according to Gibbs [4]. Distinguishing grades between students and assuring a certain quality is perhaps the most obvious and traditional function for assessment. However, equally important is the functions of capturing student time, generating the appropriate activities and providing feedback to students.

In the course block development a continuous assessment will take place, meaning that the examination of the course will be conducted divided after tasks and by submissions of task reports. As industrial design is one of the areas the courses encompass also sketches and models will be assessed. A continuous assessment is also believed to keep the student active during the whole time of the course instead of focusing a written exam in the end of the course.

Additional input to the development of courses has come from Grönlund (originally Bloom [5]) by the definition of a knowledge taxonomy. The taxonomy is describing a ladder of development: knowledge of facts – understanding – application – analysis – synthesis – valuation. The different steps are not to be seen as of different value, however, they say something about the ambition in a course and the expectations of the students. In the course block development it is and will further be used as a support of which level that is reached of the ladder in a specific course compared to the goal of the course and the program. Within the areas encompassed by the course block a development in knowledge should take place, meaning that knowledge of facts is not an ambition, but for many of the issues in the curriculum, application and valuation is.

DESIGN AND PRODUCT REALIZATION - A COURSE BLOCK

The course development could be compared to a product development commission: based in a need and in many ideas different concepts of the course structure were designed. By that time and actually from the beginning, a perception of the contents in the course block were formulated but not divided by course. This was followed by a selection process, mainly performed by an argument based on different teachers' experience, abilities today and in a discussion with the director of the program. As in product development the economical factors have played a determinative role in what is feasible. The concept selection was followed by a detailing of the structure into a schedule and description of themes, activities and assessment methods. As in the realization of many non-physical products the production of the product and the operation is simultaneous. This takes place for the first time in the fall of 2004.

Concept: the structure of the course block

The concept chosen representing the structure of the course block is illustrated in Figure 2. Each block represents one course, sized in relation to the number of credits: The first course encompasses four credits, the second eight credits and the third six credits, all lasting one term. Teaching and instructions should be strongly related to tasks and themes in order to activate students. The arrows in the figure illustrate the non-regular, need-based teacher interaction during the courses.

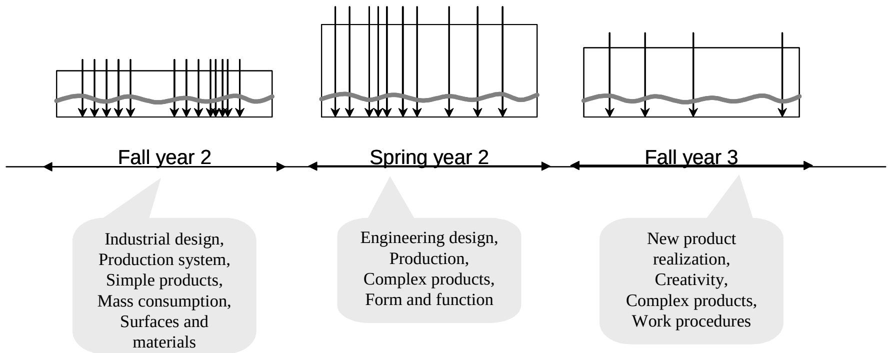

Figure 2, Each block represents a course in the course block, the arrows indicating teacher-student interaction and the grey line representing practical exercises. The callouts describe the different focuses of each course.

The third course differs from the two previous, as it is planned to be a project based course with only few instructions. Teaching will rather be supervision than instruction. Still, smaller projects will be conducted in all courses, in the sense of goal-oriented commissions with clear time limits. In the third course, projects will also include a larger element of team work, time planning and management of the product development procedure. The grey line illustrates the constant element of practical exercises, which as a governing idea will pervade the course block (and the program). This element includes to a large extent sketching and model building but also laboratory experiments related to engineering design and production.

The three courses will focus on different subjects, though there are several common elements and objectives in the courses. The callouts in the figure contain the focused subjects. Together they should build up a competence to develop and produce attractive products. The first course starts with industrial design of the product, i.e. as interpreted here, to give shape and surfaces to products and to prescribe product solutions. To be able to work with the products in practice, simple products will be chosen. As shape and surfaces are strongly connected to production of products, this subject is logically related to industrial design: Shape and surfaces determine how the product should be produced and/or production determines what shapes and surfaces that are possible to attain.

The second course adds the engineering design subject: the function of machine elements and design principles as well as selection of and giving dimensions to machine elements will be trained. Products that will be analyzed and redesigned will be more complex than those of the previous course. The subject production, related to the more complex products, will also be focused in this course. The same sequence as in the first course, namely production method, production planning and assembly system will be repeated.

In the third course new product development will be in greater focus than before. The process of conducting product development will be highlighted, and the course will in much be structured as a product development project in industry. Still, instructions in any subjects as industrial design, mechanical engineering and production could be needed related to the exact tasks in the course.

An important principle in the courses is that there will not be an exact quantity of any machine elements included in the course block. Rather than teaching a quantity of machine elements, the students should learn to understand the technical principles of a few and how to select and give dimensions to them. The ability to seek the facts of machine elements is more important than that of reeling off facts at a certain time. Consequently, the principle is taken in order to enhance deep learning. The same principle is directly comparable to production methods for which the sequence described above is central.

Details: objectives and contents of course A

For the first course in the block also some of the details of the course will be presented. As said before the focus in this course is on industrial design and production with an application on simple products. By simple products, products that include few components, few materials and few technical principles to solve a function are designated. The objectives of the course have been formulated in active verbs:

After completed course the student should be able to

- describe and motivate the shape and surface of a product, how it has been produced and which materials that have been used,
- suggest variants to existing product solutions,
- give shape and colors to simple products,
- select production method, joining method and surface treatment in a given situation,
- suggest production system for a simple product
- describe the spectrum of interested groups in design and product realization and motivate what makes a product attractive.

A basic structure of the weekly schedule has been decided for this course. To capture the students' working week this course is scheduled to Monday morning, Wednesday afternoon and Friday morning. On Monday morning a task is given that should be presented in the end of the week, alternatively the week after. In the middle of the week a workshop for the practical elements are held. The Friday activity holds presentation but is also important for making time for reflection. The subjects are arranged in themes, each theme including a task that will be assessed. Tasks will be performed individually and in smaller teams, i.e. a three person team. Sketches and models will be done individually and collected in a portfolio that will also be assessed. Each theme starts with a lecture, followed by an exercise. The task connected to each theme includes both theoretical and practical parts.

The themes in the course are:

Theme 1 The holistic perspective in design and product realization, the concept of function

Theme 2 Product users

Theme 3 Product usage
Theme 4 Form and structure variation
Theme 5 Production methods in Fictive Ltd
Theme 6 Product planning in Fictive Ltd
Theme 7 Assessment system in Fictive Ltd
Theme 8 Product presentations

In theme 1-4 different products will be analyzed and used in the tasks. These themes as well as theme 8 are taken during one week while theme 5-7 will be taken during two weeks, including one more exercise. In theme 5-7 the same product will serve as example and the themes are related to a fictive company case. Theme 5 is preceded by an “industrial witness” presenting a personal experience from mass production. During theme 5-7 two parallel processes will be followed by the students. The first one is related to the production subject and starts with a CAD drawing of an existing product ending in an assessment system for the product. In parallel, a design process will be followed. Here the product should be analyzed and given new shapes and surfaces according to defined needs for improvements. Thus, the processes are different parts of the design and product realization process, the first in retrospective and the second requiring newness.

In addition to the themes also CAD will be trained and laboratory experiment in production will be held. As engineering materials and the selection of materials is of crucial importance to Design and Product Realization, this subject will also be needed in the course block. In the first course the connection between industrial design and materials will be focused and trained in self studies. The book Materials and Design, by Mike Ashby and Kara Johnson, has been chosen and will be assessed in a written exam. The different tasks in the themes will include using the book and guidance for reading the book will be given off schedule. Other literature in the course will be customized for each theme including promemorias and articles.

THE CDIO PERSPECTIVE

Several of the challenges faced in the new education program and in the development of the course block are supported by the so called CDIO Syllabus. The CDIO Syllabus has worked as guidance in the course development, supported by that KTH is a member of the initiative. In short the syllabus stands for an initiative to develop engineering education to include more skills than theoretical technical subjects include, for instance problem solving, system thinking, individual and personal skills, professional skills, team work skills, communication skills etc. Besides, the CDIO Syllabus also drives that an engineering education should encompass all phases in engineering work: conceiving, designing, implementing and operating, i.e. the C-D-I-O [6]. The syllabus describes in detail all the skills that the members in the initiative have defined as important to train in an engineering education, which could work as a model to compare courses and program with. With a program perspective the required skills can be trained in different courses, meaning that in one course the training of a certain skill can be started, followed by further training in another course. Such skills identified for the Design and Product Realization course block is among others: team work, visualization, problem solving, product analysis, holistic perspective on design and product realization, environmental trade-offs.

ENDING REMARKS

In a concept development several concepts are developed and it could be interesting to say something about the concepts not chosen. Two quite natural course structures to consider in this area, design and product realization, is to organize each course as a project course or to strictly base them on problems without any scheduled teaching besides supervision. The decision not to chose project courses is based on a perception of a risk that students will develop differently, thereby not reaching a certain lower level of knowledge within the different subjects. Also the project organization can be a pedagogical activity that does not fit all students which is a stronger argument for alternating between different course structures. Not chosing a strictly problem based approach is in much based on too little experience among the teachers involved in course development. It seems to be too big a step to take given the limits in time and other recourses for course development.

In this course development some important success factors can be extracted. There has been a strong drive from the faculty to change the methods of teaching subjects and to enhance students learning, which has been important. Management commitment is an important feature in any change work. Though many different views on teaching have been represented in the course development team, a common ambition to do something new has been present. This has meant that a common goal has been clear to those involved, and different views and experiences have served as a base for evaluating ideas and suggestions. Also, extra financial resources have been allocated, and by the CDIO initiative teachers have had the opportunity to learn more themselves in workshops arranged by the Learning Lab at KTH.

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