

A COMPETENCY-DIRECTED CURRICULUM FOR INDUSTRIAL DESIGN ENGINEERING

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ABSTRACT

The Delft Faculty of Industrial Design Engineering developed a new bachelor curriculum which was introduced in September 2007. The school aimed for a radical revision of its bachelor curriculum in order to overcome some long-lasting weaknesses of former programs, in particular, the lack of utilization of engineering science and behavioral science in design projects. The new curriculum comprises of large thematic multi-disciplinary courses in which knowledge and skills are acquired in the context of realistic problems typical of the practice of product development.

Keywords: New curriculum, Industrial Design Engineering, design competencies, multidisciplinary courses

1 THE NEW CURRICULUM

1.1 The educational concept

A persistent problem of the Delft Industrial Design Engineering (IDE) program has been the gap between theory and practice. IDE students take courses in engineering sciences, human sciences, mathematics, statistics and the like; however in tackling practical design projects, they fail to apply this knowledge to the extent that their design would benefit. In our view this derives from the compartmentalized disciplinary structure of the former IDE curriculum. Like in most engineering curriculums, mechanics, mathematics, material science, as well as ergonomics and consumer behavior, etc., were taught in isolation and often with an emphasis on abstract theory without much reference to concrete practical problems. As a consequence many IDE students are not motivated to study these topics, and tend to postpone the courses concerned. Moreover, students who *have* passed these courses, are often unable to apply their new theoretical knowledge.

To address this problem in the new curriculum more attention will be paid to the development of the student's competencies. Knowledge, skills and attitudes will not be conveyed in mono-disciplinary courses in isolation from practice. Instead, the new curriculum shall comprise large thematic multi-disciplinary courses in which new knowledge and skills are acquired in the context of realistic problems typical of the practice of product development.

1.2 The new program

In the first two years two 7.5 ects courses per quarter have been scheduled (1 ects = 28 hrs). The courses cover much more ground than in the old curriculum, and consequently the number of courses is much smaller. Students will no longer need to divide attention among many different parallel courses. In the third year students follow a one-semester minor program of their own choice and two optional courses. A ten-

week bachelor-final project concludes the program.

Table 1 New bachelor curriculum of Faculty of Industrial Design Engineering of Delft University of Technology

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	PD1-Introduction IDE	Products in Action	PD2-Concept Design	Mech. Engineering Design
	People and Products	Design and Experience	Business, Culture and Technology	Research and Design
Year 2	Dynamic Systems	PD3-Fuzzy Front End	Interaction and Electronics	PD4 Embodiment and Detail Design
	Strategic Product Innovation	Industrial Manufacturing	Technical product Optimization	Modelling and Simulation
Year 3	Minor		Optional Course 1	Bachelor Final Project
			Optional Course 2	

1.3 The core: product development projects

Just as in the former curriculum a series of product development projects (the grey cells in table 1) forms the core of the new program [1]. In these projects integration of knowledge and skills is central. The complexity of successive projects increases from one project to the next, whereas the intensity of staff support decreases.

The very first course of the new curriculum is PD1 'Introduction IDE'. It is an introduction to the different aspects and activities of product development. We expect that this practical beginning will strengthen the student's motivation for more theoretical courses, as they will better understand the need and use of different kinds of knowledge and skill. The course PD2 'Concept Design' focuses on the phase of conceptual design, both from the point of view of use and technical functionality. In the course PD3 'Fuzzy Front End' students do not receive a design brief, but are challenged to generate a new business idea for a particular company. The students must demonstrate the feasibility and quality of their ideas by working them out into concept designs. The course PD4 'Embodiment and Detail Design' starts with conceptual design and runs into the phases of embodiment and detailed design. In this course students must completely work out their design concept and prove its viability by different forms of modelling and simulation [2]. The series of design projects is concluded by the bachelor-final project in which students must demonstrate their competence in product design.

1.4 Thematic courses

Thematic courses (see table 1) provide for the knowledge and skills to be integrated in the product development projects. Also the thematic courses are directed towards the development of the student's design competencies. This means that subject matter and study tasks and assignments are always presented in relation to realistic problems that product designers might encounter in practice. Contrary to the product development courses, which are project-based, the thematic courses make use of a spectrum of active educational forms and contrary to traditional ways of teaching, all thematic courses are

multidisciplinary. Next we shall give two examples of these courses, one in the domain of mechanical engineering design and another in the domain of business strategy.

2 TWO MULTI-DISCIPLINARY COURSES

2.1 Products in Action

A toddler leans on an open drawer. What weight of the child makes the chest of drawers tip over? A pedal bin is opened with foot pressure, what force is necessary? Design a garbage container that opens with exactly the same force.

These are typical questions asked in weekly assignments issued in the course “Products in Action” in which mathematics, basics of mechanics and engineering design are combined. After a human factors course and an introduction to the process of industrial design engineering in the first quarter, this course is the first in the new curriculum to educate students in the engineering knowledge and skills necessary in their professional career.

The course deals with very realistic design issues, putting emphasis on understanding the role of mathematical modeling used to calculate design parameters. Students are stimulated to actively explore the power of calculating and simulating before building physical models. They can do that because they are equipped with knowledge from lectures, skills from practicals and driven by a motivation from understanding learning goals by consciously building a portfolio. In our curriculum these same principles are the basis for all our technical courses [3],[4].

Each week a team of two works on one of these assignments. These are assessed and the team receives feedback a few days later. The problems they encounter, the mistakes they make direct them towards re-addressing theory, and in a following assignment students can show they are capable of handling the issues since there is substantial overlap in the aspects addressed in the assignments.

The course is a 10 week, 210 hours, product centered program of weekly assignments leading to a portfolio and an examination.

We integrated statics and mechanics of materials, mathematics and engineering design into weekly assignments in which students focus on one or two products.

With 400 students, we realized a course in which the students spent 2 hrs per week on math lectures, 3 hrs on statics, 2 hrs on engineering design and 1 hr developing measurement skills. They were expected to spend 8 hr on their weekly assignment and had 5 hrs left for self-study.

Translating real world situations into usable mathematical or theoretical representations, using robust simplification methods, recognizing the importance of contextual elements and developing skills in selecting relevant data from an abundance of information is what industrial design engineers need to be competent in. To educate our students in these competencies, we need to establish insight into how the different disciplines taught in the past relate to each other and to industrial engineering design practice. In separated disciplinary courses of the past, a typical exercise would be calculating forces and stresses in a fictitious structure, not recognizable as a realistic product, or solving a system of equations not related to any physical product situation.

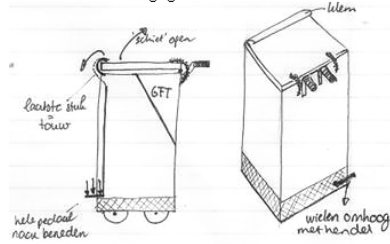
Depending on their individual assignments and interests, the relationship between the disciplines was encountered by many, but really mastered only by some, never discovered by still a few students. Only at a late stage of their education the discovery how these theoretical disciplines were helpful in product design was made.

Our goal was to integrate the disciplines in this course to give students the opportunity to discover this relationship in a very early stage of their curriculum.

Drie realistische combinaties (concepten):

1. a6+b1+c2+d2+e3+f4

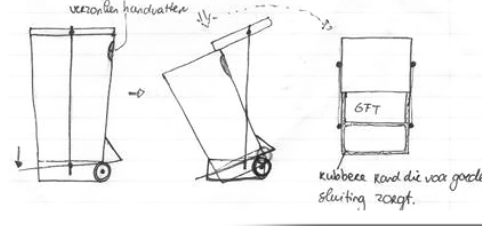
Schematisch weergegeven:



2. a1+b5+c1,5+d1+e4,5+f4

Schematisch weergegeven:

(a1 al enigszins aangepast)



3. a5+b4+c1+d1+e4+f1

Schematisch weergegeven:

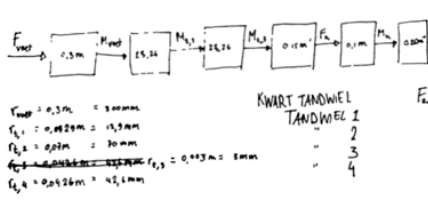
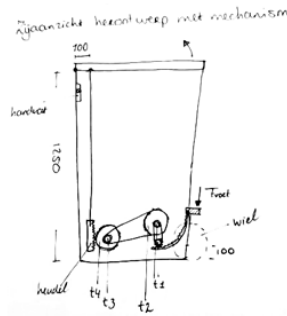
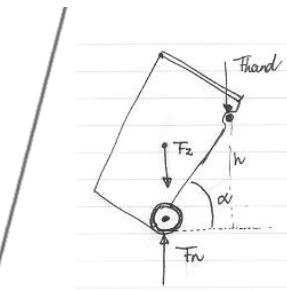
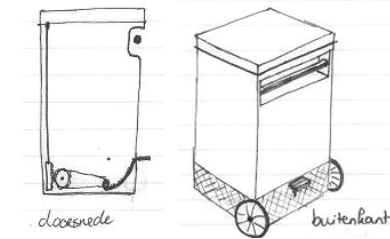


Figure 1 Redesign of a garbage container:

three concepts derived from a morphological chart, with engineering studies of the selected concept, No. 3. Top right: a free-body diagram to investigate user loads when moving the container. Bottom right: investigation of transmission ratios needed to lift the lid with a foot pedal, based on an introduction to block diagrams.

To help students realize the importance of the learning goals we set for them, we asked them to work on a portfolio, in which evidence is gathered of reaching those goals, together with their explanation of the importance of each learning goal for an industrial design engineer. We are in the process of investigating how this motivated the students to keep on actively participating in the course, and how this changed results in mastering theory and skills taught in our curriculum.

2.2 Strategic Product Innovation

The course 'Strategic Product Innovation' (SPI) is the first course in the 2nd year of the new curriculum. It is a thematic course with a business focus, which builds on the first year course 'Business, Culture and Technology' and finds its application in the design project PD3 'Fuzzy Front End'. The main issue of the course is how companies decide

which new products they want to introduce to the market taken into account all strategic considerations. Different tools and methods are provided that may help product developers to take their strategic product decisions.

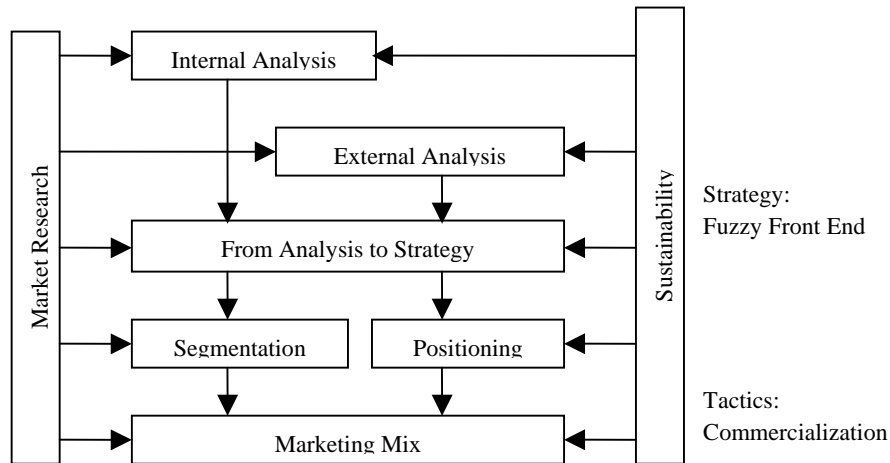


Figure 2 Global Structure of Strategic Product Innovation

The SPI course has a multidisciplinary character by mixing different aspects like marketing, sustainability, graphic design and design methodology with business aspects. To develop students' competencies on these aspects, the course consists of both lectures and assignments. The lectures and guest lectures are used to pass on the theory. Guest lecturers come from other departments inside the faculty as well as from outside. Practicing the theory is done in four assignments. These assignments follow the regular business model to come to new business ideas: (1) internal analysis, (2) external analysis and (3) strategy development. In the last (4) assignment, attention is paid to the introduction of the new product.

In all assignments, a deepening part is integrated in which specific product design aspects are addressed. In the 1st assignment, the internal analysis, attention is also paid to brand and design management. How are companies translating their vision into their product portfolio? In the 2nd assignment, the external analysis, students also have to describe how the companies are dealing with the issue of sustainability. What does sustainability mean for the company and how does the company deal with sustainability in new product development? In the 3rd assignment, the strategy development, students are confronted with the Vision in Product (ViP) design method [5],[6]. This is a specific method to come to new business ideas, developed within the faculty of IDE. To place ViP next to more commonly known methods like SWOT, students get insight in the value of different methods. In the last assignment, the Marketing Mix, students also must design an advertisement for the new product. Next to questions regarding the price and place where the new product will be sold, they have to decide how the new product will be communicated towards the consumers.

Having coaches for the assignments with different professional backgrounds reinforces the multidisciplinary character of the course. Students are therefore confronted with knowledge from different domains and have to integrate these into one advice towards the company.

To confront students with authentic problems, real companies are used as cases for the assignments. Information that is needed for the assignments is gathered from different kinds of public sources (Internet, yearly reports, but also looking around in stores, asking retailers and consumers). All assignments are based on one company for each student group to connect the assignments together. For example information gathered in the first two assignments is used in the 3rd assignment, where the students have to set up a strategy for the company. Also information of the analysis phase should be used in the last assignment, the introduction of the new product.

3 CONCLUSION

The new curriculum for IDE deviates strongly from the traditional discipline-based model of engineering design education. The program is build up from large thematic multi-disciplinary courses in which the ability to perform in an authentic product development context is central. We presented two examples of such courses. All three years of the curriculum have been introduced simultaneously in September 2007. The program has been received favourably by most of our students, but only the future will show whether it will fulfil its promise.

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