NINE COMPETENCIES, SIX UNITS: INDUSTRIAL DESIGN EDUCATION AT TU/e

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ABSTRACT
In September 2001 Eindhoven University of Technology (TU/e) started a five-year Industrial Design (ID) course with a focus on designing intelligent products, systems and services. Students learn to integrate various approaches in the design process such as human, socio-cultural and technological aspects. Generating innovative concepts and original ideas are emphasized in the course. Taking into account recent developments in both the professional and educational field the Department of ID has based the course on an educational model in which competency development and self-directed learning are pivotal. The metaphor used for this model is 'the student as a junior employee'. In the paper a comprehensive picture of the educational model is presented. In addition, first and second year projects are shown to illustrate how the focus of students' competency development shifts from awareness to depth and to identity building in the course of the Bachelor's.

Keywords: design education, competency development, project based learning

1 STRUCTURE

1.2 Introduction
Design education is very simple. Gather a bunch of students around a table and add a bunch of excellent teachers. This is the traditional "master-mate" model from the guilds. After a few years of practice the master has to make his 'masterpiece". Following this tradition, a design student's learning process is often structured by a set of courses on subjects that are relevant for the discipline. In our ID curriculum, however, there are no courses. Instead, students' learning activities focus on the development of nine critical ID engineering competencies (Table 1).
This implies that projects and assignments are not an end in themselves but a *means to generate learning processes*: they are a gate that opens up the knowledge, skills and attitudes students need in order to become a design engineer. The Department of ID is thus considered to be a company in learning processes, with 6 units as the company divisions: Communication, Entertainment, Health, Home, Mobility and Work. First-year students work in 5 units for 7 weeks each, second years in 3 units for 14 weeks each. In a typical week students devote 60% of their time to one unit-related project in teams of five and 40% of their time to several individual, unit-independent assignments.

Table 1. The 9 competencies

CORE COMPETENCIES
IDEAS + CONCEPTS: Develop visions and innovative concepts through creativity techniques, experimentation and the translation of research.
INTEGRATING TECHNOLOGY: Proceeding from a sound technological and scientific background, can select and integrate concepts and technologies from different fields during all phases of the design process, up to and including the realization of a prototype.
USER FOCUS AND PERSPECTIVE: Observe, analyse, empathize and interpret potential end user needs to create a successful product, system or service.
SOCIAL AND CULTURAL AWARENESS: Observe and analyse social behaviours and their cultural context in developing design applications for specific communities.
MARKET ORIENTATION: Construct a strategic viewpoint, which weighs the commercial opportunities of design concepts against existing and changing market sectors. This viewpoint enables a consumer orientated positioning of products and services.
VISUAL LANGUAGE: Observe, develop and express a visual language, which connects thought and form, in order to communicate specific properties of the design concept.
META-COMPETENCIES
MULTIDISCIPLINARY TEAMWORK: Is able to adjust his role in the dynamics of an international multidisciplinary team to the demands of the different phases of he design process.
DESIGN AND RESEARCH PROCESS: Masters the design process *and* the research process on an academic level and a pragmatic level and adjust this level to demands of the task that is to be fulfilled.
SELF DIRECTED AND CONTINUOUS LEARNING: Gives direction to his personal development by defining new learning goals, using a continuous process of self-reflection and through a curiosity for future developments in technology and society.

1.2 Projects and assignments

Projects are unit related. Each unit core team (see below) defines first and second year projects that fit the theme of the unit. These projects are open-ended: They describe a design problem, the relevant scientific and design fields and the deliverables, but not *the* solution. Students typically work in groups of five. This group is considered to be a ‘junior design bureau’. From day one, they work for a client from industry, fixing kick-off, interim and final presentation meetings. The client decides, on the basis of design proposals, which direction the project takes. For every project a number of experts from different fields, in and outside of the faculty, is identified. Every group has a project coach, a member of the unit core team. The project coach helps the students in the design process, criticizes their work, but again does not offer a solution.

All projects address several, but of course not all, competencies. In this way their emphasis shifts between the rather technological to the rather conceptual. They are all, however, about integration of human, socio-cultural and technological aspects: the key power of the designer. And they are aimed at a working prototype.

Assignments are unit independent and address typically one competency. Assignments are individual, last about 7 weeks and are organized for a group of 15 to 20 students. They consist for a large part of tasks the student has to perform individually, and not of a series of lectures. Assignments cover a wide range of subjects like drawing, materials, network architectures, circuits design, from and interaction, programming, social-cultural awareness. Students themselves choose the assignments they are doing, in function of their development over the years. The assignor evaluates their work in terms of objectives and deliverables met.

It is important that the research of the faculty reflects in the teaching. This is obvious for some highly specialized assignments. But it also goes for projects. Some are written from a design research perspective, and contain actual hypothesis testing. Some are about the design of a prototype, and the experimental testing of its feasibility. A few projects resulted in a conference paper [1, 2]. They are part of our academic outlet.

The industrial outlet isn’t forgotten either. A few projects are part of an actual industrial or construction project (see Operation Room Lighting below)

1.3 Units and Core unit teams

The six units are embodied in six halls where students do their projects and the core unit team has its base. A typical core unit team consists of designers (independent designers, Philips Design people, or teachers form the Design Academy Eindhoven), designers-researchers and researchers employed by the faculty. This interdisciplinary mix of the teams is one of our strengths. It guarantees the multidisciplinary and scientific design approach of the faculty. It is also a guarantee for the generation of learning processes, the gateway to the knowledge, skills and attitudes our students need in order to become a design engineer.

1.4 Evaluation

Students do not take exams, their work is not marked in the traditional way and they do not earn credits for every piece of work. Instead, students document their learning by building a digital learning portfolio. They write reflective narratives, the Portfolio Work Document (PWD), on their learning process and learning outcomes in terms of the competencies. They substantiate learning outcomes by including ‘evidence’ links such as interim and final products, and client and expert feedback on these products. The project coach evaluates these.

More importantly, though, students have to write a Self-Evaluation (SE). They have, for every project period, to evaluate their growth as a designer on the competencies they decided to concentrate on in the beginning of the period. To help them with this process they have an individual competency coach. This coach monitors the student’s growth as a designer by advising him on his choice of assignments, and even projects. Regularly this coach and the student have an in-depth talk about the difficulties and the challenges the student meets, and they make practical agreements on how the student should progress. After every period the coach reflects on the SE, per competency and overall. Again, in a personal conversation she explains this reflection. They then agree on which steps to take for the next period.

Twice a year a committee of staff members assesses the learning portfolios. The PWD's and CE's for that phase and the Assessment for the previous phase are reviewed, and an Assessment is made. The student receives one of the following marks:

- **R** renewal of contract. The student can engage in a new contract with a client (start a new phase/project)
- **Q** questionable. The student passes to the next phase but concrete demands are being made in terms of his competency development.
- **N** no renewal of contract. The result of the assessment is negative. If the student does not change drastically, we would prefer him to leave.

2 FIRST YEAR: SOLUNDA

Project Coach: Richard Appleby MDesRCA/Client: Ericsson

Within the design of communication products and services one of the key influences is time. So this project illustrates how a design task can help develop students design competencies. In order to give students some starting points to their research background information is provided to stimulate their design interest.

The concept of time has evolved over several thousand years. It is how we represent sequence of events happening relative to each other. Our perceptions of time have changed the way we plan our working day and leisure activities. Another influential factor is how the speed of travel has diffused our cultural boundaries across the world allowing us to be in many different places within the same year, month, and even the same day. Nighttime shopping, round the clock services to supply anything to anywhere make traditional time-keeping redundant. Or does it? What about our physiological make up, our empathy with our environment? How does the time factor change the way we interact and communicate? Time is how we represent the essential 'flow' of these events and happenings in our day-to-day existence and experience. Time is a quantitive dimension and is traditionally measured and demonstrated by a sequence of events. Such as a volume of water (as in water clocks), sand (as in an hour glass), or a shadow moving over a dial (as in a sundial). The first mechanical clocks were devised in monasteries where the monks had to get up in the middle of the night to pray, when a sundial is useless.Huygens invented the escapement, combining it with Galileo's pendulum, to make the first reliable mechanical clocks. Harrisson perfected the mechanical clock to such a high degree that it could be used to measure the degree of latitude on a ship.

So this project is about the consequence of time as an emotive influence for design, exploring different ways to represent this concept. Some clues are then suggested how students might start to think about this phenomenon:

1. Bird songs help people estimate what time of day it is because they have heard them sing before at that same time previously.
2. Looking at the sunlight is an emotional or experiential reference, the heat on your face, the bright sunlight or cloud effect, the inclination of the sun, these are all intuitive seasonal references.
3. The technical precision to be "on time for a meeting"

4. How do we represent instictive time (the body clock) and "objective" time.
5. How do we show time relative to places (the changing time zones)

The project team agree a *research and design process*, with activities that target the project objectives and deliverables. They also realise that these planned design activities will help them experience and develop their industrial design competencies. Following initial research about the time context, this team progressed their *ideas and concepts* development through brainstorming techniques to stimulate creative ideas, followed by scenario building. This is where they use photography, sketching, and explore different materials, to help map these ideas into categories. Looking at contrasts of day and night, work and play, cultural extremes, they can start to understand how their ideas might match or be interesting in different situations. Using simple mapping techniques they can introduce parameters that help ‘position’ their creative ideas in context. Once more information is built concerning the user type then these ideas can be developed into potential concepts. The team eventually chose specific scenarios of:

1. *Emo Light* - domestic living environment and how light changed your emotions
2. *Grass Hopper* – which looked at how natural plants change with sunlight
3. *Tree time* – how wood show the passing of time through its annular rings
4. *Life time Object* – how personal objects increase their value with stored memories over time.

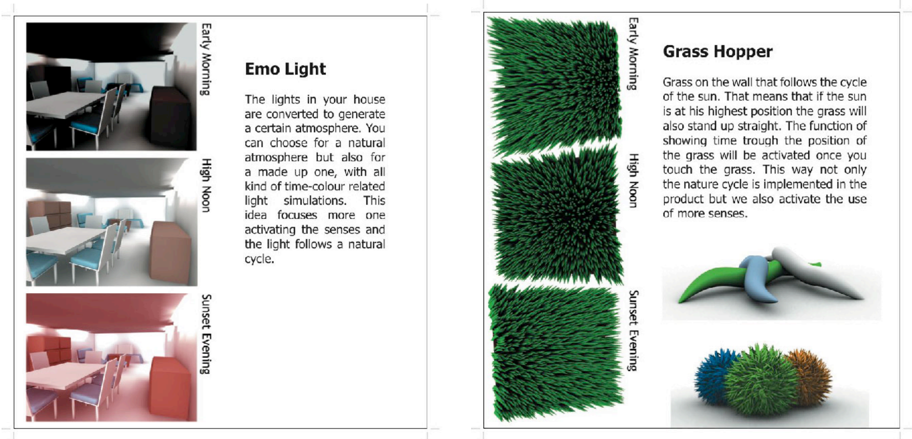

Figure 1. Contexts that illustrate the passing of time

At the same time the project team would research, interview and build a profile of different user types. In most cases the students choose respondents who are close to them – friends, family, these are easy subjects to document and represent. They analyse all the differences in the *socio-cultural* behaviour and lifestyles of the interviewed users, noting how their activities are influenced by the concept of time. They can then start to establish *user focus and interaction* for their ideas – shaping conceptual experiences and objects that might be useful and interesting to these chosen user categories – In this instance, the characters were called *Marco* and *Richard* where the student team build imaginary ‘User Types’ around these characters. Expressing this time flow with a moving structure had some meaning, enabling the changes with light sensors. By *integrating technology* from intelligent computer sciences, sensor and communications applications, the prototypes could be quickly assembled and tested.

Figure 2. Simulated 'intelligent grass' which can be programmed to simulate this environmental effect within any context.

They simultaneously demonstrated the 'flow and light effect' in physical devices and virtual animations.

Figure 3. Here we can see the model showing the sensitivity of natural objects have with light, to communicate the passing of time

With some development the *visual language* becomes more sophisticated and the intelligent metaphor is complete. They have created a new product to represent time. Business models are constructed to include possible materials and processes for commercial application and *market orientation*. Throughout the exercise different experts are available to consult where more specialised knowledge is needed from other technology domains, this is part of the *multidisciplinary teaming* process giving students a 'fast track' to get the right answers. Finally they reflect on the project and the knowledge and experience gained. Through the *self-directed and continuous learning* process, they document ways to improve their competencies with the next challenge.

3 SECOND YEAR: SEMOTION + OPERATION ROOM LIGHTING

3.1 SEMotion

Project coach: Dr. Tom Djajadiningrat MDesRCA/Client: Philips Design, Steven Kyffin MDesRCA

SeMotion is an exploration into the semantics of motion in new object typologies. While semantics often are about expression of static form, in our focus on intelligent products *interaction and movement* are important as well. We want to design products that *act* in an appropriate way to their context. In this 14 weeks project, the students developed products on the basis of selected emotions. While analyzing the concepts & expression of emotions, they trained themselves in microprocessors and servomotors. With cardboard they made *4d sketches*, enabling them to quickly build physical, dynamic expressions of emotions. Through an ongoing evaluation of these 'sketches', they developed the elements of *languages of movement*. After an exploration of formgiving, they integrated ''everything'" into interactive objects. Five of them are realized and used in a user experiment. Results show that people can indeed recognize the motions expressed by the behaving objects.

3.2 Operation Room Lighting

Project coach: dr. K. Overbeeke/client: Catherina Hospital, dr. Jakimovicz

Operation room lighting is a more *practical* project. The faculty offers a mix of more conceptual and more applied projects. The Catherina Hospital in Eindhoven is currently building new operation rooms. Last year a project group has made a thorough analysis of the lighting problems in the operation room.

Figure 4. The scale model

They also developed the integrated concept of *zones of lighting and visual information displays* that has been approved by the client. This second project is about the implementation of this concept in an actual operation room. The students now built a physical 1:5 scale model of the interior (including the lighting of course) to show positions of the lighting and product components. They also made an interface to control the lighting and interaction displays for different operation procedures and stages. And they made a walkthrough virtual model, to try out different lighting conditions.

4 CONCLUDING REMARKS

It goes without saying that for staff members this model, where they hold diverse positions like competency coach, project coach, assignor etc., differs dramatically from traditional teaching. Experience teaches us though that this system has major advantages for student and staff:

- The traditional distance between teacher-student diminishes, and not only in the spatial sense where 100 students are listening to a lecturer in a lecture hall. This results in the students becoming more demanding of their teachers. Personal contact enhances the motivation for both teachers and students.
- The personal conversations as a competency coach results in a thorough knowledge about the student's development as a designer.
- The fact that real clients are involved in every project enhances the motivation of the students. They know that they have to present their work to an outsider that might become their employer.

It goes without saying that this new approach to teaching design is not heaven on earth. Questions have been asked about the quality, in terms of breadth and depth, of the knowledge and skills acquired by the students. Especially people form a traditional science background, quite rightly so, wonder if a systematic approach to, e.g., mathematics wouldn't yield deeper insight. On the other hand, traditional designers insist on a systematic course on the basics of form. The faculty is continuously updating the content of the assignments to mend possible lacks.

The faculty is neither the first nor the only one to implement this model of teaching. It is, however the first design faculty to do so. And for good reasons we believe. Design in itself is an activity, and cannot be taught without practice. So why not make practice the core of our teaching.

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