

## TEACHING NPD AT DELFT UNIVERSITY OF TECHNOLOGY

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### Abstract

Since 1964 New Product Development (NPD) has been an official subject of teaching at the Delft University of Technology (DUT) in the Netherlands. This article will report on the development of this programme over the last forty years. It will reveal the problems we have encountered, the solutions which worked and which did not work and it will, hopefully, give others some insights into building successful NPD-curricula. Besides a historic overview we will describe the present program, compare it to other programs and go into details about two typical NPD-classes.

*Keywords: integrated product development, design education, curriculum*

### 1 Introduction

New product development (NPD) has been an activity for companies for more than hundred years, but is an object of official educational interest for a much smaller period. At the Delft University of Technology (DUT) exists the oldest school in the Netherlands in this field on university level. Designed in 1961, the first two students in 1964, accredited in 1969, this school, the School of Industrial Design Engineering (IDE), has now more than 1800 students, more than 2600 alumni, a staff of about 300 and a yearly budget of about 12 million Euro.

IDE teaches Integrated New Product Development in a five year programme, which leads to a Masters of Science degree in Industrial Design Engineering. The Schools' ideology is summarised in the slogan "Creating products for people".

Integrated New Product Development is a multi disciplinary approach, based on theories and experiences from four different domains. The first domain is that of industrial design. The second one is ergonomics (human factors). The third one is the domain of technology, especially engineering design, mass production, plastics engineering and electronics. The fourth domain is the field of management and marketing. Even the best and beautiful looking products which are easy to manufacture have to be marketed before they reach their clients, and every product is part of a larger system called the company. Therefore management and marketing sciences play an important role in NPD. To these four knowledge domains a fifth one is added: Product Design. This domain is seen as the core of the curriculum. It integrates the four other ones into concrete NPD-projects for students. Design studio work is the backbone of the NPD-curriculum in Delft. By learning how to design new products students have to apply the knowledge from the four "basic"- disciplines. Design Methodology is the central integrating theory.

In IDE's view a new product development professional is a generalist: somebody who knows about all aspects of new product development, but is not an expert in one of those aspects. A Delft Industrial Design Engineer is a specialist in combining all the competing and conflicting elements of NPD, and knows how to make compromises and knows where to invite and

include specialized knowledge from other disciplines. Their own specialization is Design Theory and –Methodology [1],[2],[3].

To teach the students this difficult art of synthesis, of making design compromises, of handling design conflicts and of making design decisions, all IDE-students have to participate in all product design exercises. All this design studio work is based on real products; in the first three years the context is based on artificial companies, but in the later years the projects are executed in cooperation with real companies.

The basic teaching philosophy is experiential learning: learning by doing. Right from their first week at IDE the students do not only have to design a real product, but also have to manufacture and test it. By using the product themselves and by reflecting on that the learning cycle is closed and the real learning experience should happen.

## 2 Historical overview

### 2.1 The "old" teaching programmes (1964 – 1998)

Looking back at the nearly forty years of existence of IDE four different teaching programmes can be distinguished. First there was the experimental period from 1964 until 1978. The school was small, there were few students and sometimes the teachers and students together designed the teaching-programme the night before the actual class.

None of the teachers had an official degree in NPD, academic traditions were non-existent, but all had experience in NPD in industry. There were three full time chairs: one in technology, one in industrial design and one in ergonomics and marketing. The present basic disciplines are already visible. The total staff was about 25 persons. The first student graduated in December 1971 and was immediately offered a job. He still works as an associate professor in Design Methodology at IDE (Norbert Roozenburg). In total some hundred students graduated in this period.

The second period is labeled as the balanced programme. It was a five year programme. The design exercises were "coloured" per year: basic design in the first year; form and styling in the second year; needs assessment, consumer research and information gathering and analysis were the colours of the third year. The fourth year was focused on the engineering and technological aspects of NPD. The final year was an integration year: all NPD-aspects had to be taken into account. The theoretical courses were scheduled in congruence to the design exercises. This programme lasted from 1979 until 1983. The staff grew to about 80. The number of graduates was about 400.

In the early eighties IDE was forced to change its programme from a five year programme to a four year programme. All universities in the Netherlands were forced to do so. For IDE the reduction was found in throwing out most of the optional courses, throwing away some of the social, economic and psychological courses, concentrating on the engineering and technology courses, reducing overlap between courses, reducing the number of hours spent on product design exercises, and even cutting back the duration for the master degree project from 12 months to 6 months. This was the third teaching programme. The staff grew to some 200 people. The first own graduates with industrial experience were hired. The number of full chairs grew to ten. Besides the original three chairs in Technology, Industrial Design and Ergonomics, new chairs were appointed in Product Reliability, Informational Ergonomics, Product Safety, Formtheory, Marketing, Consumer Research and Productpolicy and-Planning. Parttime chairs were established in Graphic Design, Design History, Mass Production and

Electronics. The number of graduates of the period 1983 - 1992 is about 1500. In 1984 the first graduate obtained his PhD.

## 2.2 Changing the curriculum (1993 - 2000).

At the end of the eighties the Dutch government introduced a special policy instrument to stimulate the quality of the university educational system: international peer reviews. In 1989 the teaching programme of IDE was evaluated. The results of this evaluation were positive, but, of course, some suggestions were made for improvement:

- the gap between research and teaching had to be bridged (for instance, IDE-students were hardly involved in research programmes and it was hard to persuade own graduates to start with the PhD programme);
- there should be more emphasis on the scientific fundamentals of the field; the committee was probably aiming at more engineering fundamentals, IDE interpreted this as more emphasis on the methodological foundation of NPD;
- although the generalist character of the Delft Design School was accepted, the evaluation committee suggested that the Dutch industry was in a need for more specialization;
- although the official programme was a four year programme in reality most students used more than six years to finish their Master's degree. The committee strongly recommended a more realistic programme which was “do-able” in four years.

IDE took this challenge and in 1990 they appointed a Project Manager for the design of this new fourth curriculum. The fights for the new programme started right away: most teachers wanted to change the program substantially, but, of course, all the changes had to be done by the other teachers.

The New Curriculum Project Manager started a number of small project teams in which related subjects and courses were discussed, evaluated, changed and re-designed. For the change of the design studio work, which is still the core of the curriculum, a special task group was installed. Because 90 % of all theoretical courses were changed, either in content, or in sequence or in duration, all product design exercises were affected by these changes. A completely new design studio programme had to be developed. After all the discussions the final programme has six new design exercises. Ranging from 200 hours in the first year (the year-totals are 1680 hours); 360 hours in the second year, 280 hours in the third year and 480 hours in the fourth year. The character of these design exercises was not changed, but in some exercises there is now more emphasis on specific design methods and techniques than in the past. Most of the original design studio work was individual, now some were planned to be group-exercises.

Two issues had to be cleared quite early: the kind of specialization and the educational system. After long discussions the School decided to offer a basic programme of three years and on top of that two specialization streams. One is labeled Product Development (PD), the other one Innovation Management (IM).

To give answer on the question how to involve more students in research, it was decided to give a compulsory introductory course in research methodology in the basic programme and to offer students in each of the two specialization streams the opportunity to specialise either in research or in the professional practice. The majority of the students is expected to put an emphasis on professional qualifications, not on researcher's qualifications. It was also expected that most of the students will choose for the Product Development stream and that only a third will be interested in the Innovation Management stream. And less than 10 % of all graduating students will be oriented towards doing research in NPD.

The other issue was the educational system. Traditionally the Delft University has a semester system: large numbers of courses are offered parallel during half a year, after which all courses are examined in one month time. This is not the best system if you look at student failure-rate (the drop out figure for all Dutch universities is about 40 %), at study duration time ( the median duration time for Delft students is 6.4 year) and the financial basis for the universities (partly output related budgets).

A completely different system is in operation at the Maastricht University, the so called Problem Oriented Educational System. Here problems are central, the students are working in groups and they have to find the relevant theories for a given problem. Here teachers are seen as learning facilitators in stead of the more traditional role as knowledge experts. The results in Maastricht are above average, especially in medicine: a low drop out rate, good scores in study duration and positive feedback from students.

The New Curriculum Project Manager tried to get IDE to accept the Maastricht model, but, partly out of fear for innovation, partly because several basic courses are delivered through other Delft Schools, this idea was cancelled. He developed a compromise: the block-system. In this block-system only two theoretical courses run parallel during five weeks, in week six the examinations are scheduled. Nearly half of the time of a block-period is scheduled for more practical courses like design studiodwork, handdrawing or computer labs. Ideally in the new curriculum the two parallel courses per block have strong interrelations and should have one joint examination.

A lucky incident occurred during the design of this new programme. On national political level a discussion was started about the quality of university studies. Especially the three Universities of Technology had troubles in getting their four years Master's degree accepted in Europe as Chartered Engineers. So they started a lobby to change their program from four years into the old five years. This lobby was successful, so all engineering teaching programmes were back at a five year M.Sc.-program.

Practically for the block-system chosen, this meant that in the new 5-year program there are six blocks of seven weeks. In week 1 the practical and design courses start and there is time for re-examinations. From week 2 - 6 the two theoretical courses are given. The practical courses stop in week 6. Week 7 is for individual preparation by the students and for examination. Most of the product design studiodwork is scheduled over more than one block. Including three weeks holiday during the year the total educational year last for 45 weeks. The start is in the first week of September and the end in early July. So the new curriculum is a program of five time 1680 hours, scheduled in 42 teaching week of 40 hours per year.

Another result of this five year program was that the basic program was scheduled in the first three years, and that the two specialization streams were scheduled in the last two years. Design exercise 6, scheduled in the fourth year, is designed in such a way, that students of both streams work together in teams. They have to perform different roles in the team, just as they have to do in real NPD-life. The Product Development students will concentrate on form, technology and ergonomics; the Innovation Management students will concentrate on project management, market analysis, competitors analysis, market-introduction and group dynamics. Both pay attention to product design. Together they perform as real fully equipped NPD-teams.

Since September 1993 this new programme is in action. The first graduated in 1999. Now more than 600 students have been graduated according to this programme.

## 2.3 The present curriculum

An overview of the total curriculum is shown in table 1-6. A study year at a Dutch university has 1680 hours, divided into 42 study points of 40 hours.

Table 1. 1st year

Course	Study point
Introduction	1
Industrial Design, including human factors, handdrawing etc	11
Engineering and Technology	17
Mathematics	4
Productdesign (design studio work)	6
Integrated NPD	3
<b>Total</b>	42

Table 2. 2nd year

Course	Study point
Industrial Design	8
Engineering and Technology	14
Mathematics	7
Productdesign (design studio work)	9
Environmental studies	2
Marketing	2
<b>Total</b>	42

Table 3. 3rd year

Course	Study point
Industrial Design	5
Engineering and Technology	17,5
Economics and Law + Management	6,5
Productdesign (design studio work)	6
Consumerbehaviour	3
Research	4
<b>Total</b>	42

Looking to the division of the pillars of the Delft NPD-programme, the basic disciplines, Industrial Design (including human factors), Engineering and Management & Marketing and the Product Design studio work over the curriculum, we see the following. In the basic first three years Industrial Design covers 19 %, 38 % is covered by Engineering, 12 % by Management & Marketing and 17 % by Product Design. The rest, 14 %, are subjects like mathematics and other engineering basics.

Table 5. 4rd & 5th year Innovation Management

Course	Study point
Design theory and methodology	2
Marketing	5
Consumerbehaviour	4
NPD-management	7
CPS	2
TQM	2
General and supportive courses	9
Electives	14
Productdesign	13
Graduationproject	26
<b>Total</b>	84

Table 6. 4rd & 5th year Product Development

Course	Study point
Design theory and methodology	2
Industrial design	11
Engineering and technology	11
General and supportive courses	7
Electives	14
Productdesign	13
Graduationproject	26
<b>Total</b>	<b>84</b>

If we look at the specialization streams than the Product Development stream adds to this basic programme 13 % Industrial Design, 13 % Engineering, 18 % Product Design and 8 % supportive courses. The electives count for 17 % and the graduation project for 31 %. No extra Management & Marketing subjects.

For the Innovation Management stream the numbers are Product Design 18 % (the same as the PD-stream), Management & Marketing 24 %, supportive courses 10 %. The electives and the graduation project are the same, respectively 17 and 31 %.

So NPD-professionals graduating from IDE have a profile as shown in table 7 (numbers are percentages).

Table 7. Graduation profiles

Disciplines	Specialisation	
	Product Development	Innovation Management
Industrial Design	16	12
Engineering	29	23
Management &	7	17
Marketing &	19	19
Electives &	19	19
supportives		
Product Design	17	17
Graduation project	12	12
	100 %	100 %

### 3 Comparing the Delft NPD-program to other programs.

In the summer of 2000 28 Delft IDE-students went for a studytrip to the US and Mexico. They visited companies and design firms and also had meetings with students and staff from other universities. In their final report [4] they compared three different foreign universities in the field of NPD with their own Delft situation.

In California they visited Stanford University in Palo Alto and Art Center College of Design in Pasadena. In Mexico they visited the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City.

The conclusions of the IDE-students from both studying the official curricula and interviewing staff and students at those three other programs is that the Delft IDE program and the Stanford Design Division program are the most comparable. Both are theory and science based and technology plays an important role. UNAM and Art Center share their emphasis on formgiving/styling and are more design practice oriented. Design projects are important for

all four programs, but gets less attention at Delft and Stanford compared to UNAM and Art Center. Although these differences exist the students judge them as minor.

But besides this more or less shared content the four programs do differ on other aspects, like the role of NPD-research, the way students are admitted to the program, the profiles of the students and the scale of the program.

Only in Delft research is an integrated aspect, both in the teaching itself as well as that most teachers are also active in doing research. Research published in international refereed academic journals and books are important elements in the career development of the Delft staff. The Stanford Design Division is a pure educational institute, so are Art Center and UNAM. At Stanford, Art Center and UNAM the admittance for students is limited. Not only in numbers but also based on quality. UNAM for instance allows only 60 students out of 400 applicants (which all first had to pass a year at the School of Architecture). Art Center has a strict acceptance policy. The Stanford Design Division ask not only a bachelors degree, but also some years of industrial experience. Stanford and Art Center are expensive studies; UNAM and Delft are relatively cheap. In Delft all students with the right secondary school diploma has, based on the law, to be accepted. There is no limit to the number of students and therefor the quality is quite diverse. The Delft IDE students are, compared to the other three, younger, less experienced and are motivated for different reasons. The largest differences between Delft and the others are the scale of the operations and the importance of NPD-research in the curriculum.

#### 4 Delft NPD-professionals in the field

Dutch universities do have a system to get detailed figures about the professional practice of their graduates (*WO Monitor*). The last figures are from 1999. 97% of the IDE graduates get a paid job within a couple of months after graduation (90% within 6 months). 6% of them start their own company, usually a design consultancy, right after graduation.

The top-three of industries for the IDE-graduates of 1999 are design consultancies (26%), consumer and professional products (25%) and ICT related industries (23%). 60 % work for multi-national corporations and 40% for SME's.

The top-five of jobs in 1999 is product/graphic/interaction designer (47.5%), ICT work (16%), innovation management (5%), NPD-project manager (5%) and academic researcher/teacher (5%).

Their starting salary is about 2000 Euro per month, which is a little bit lower than for other Dutch engineering graduates. From the interviews we learn that the IDE-graduates prefer interesting jobs with high professional freedom over highly paid jobs.

One detailed longitudinal study was executed about what happened to the IDE graduates over the past twenty five years [5]. This longitudinal study covers all the 1178 graduates from the beginning in 1971 until 1995. The research found out that in 1995 70% work in NPD, from which 45% in industry, 31% in design consultancy and 10% in higher education as academic researcher/teacher. It proved also that even before the School had decided to start the two specialisation streams 52% of our graduates work in product development and 18% in innovation management. These figures prove that the decision in 1990 to specialise was a right decision.

Of the graduates which work at design consultancies 50% of them started their own firm; the other half is employed by these entrepreneurs. All the major Dutch design consultancies are

founded and managed by IDE-graduates (i.e. TNO-Productontwikkeling, N|P|K, Well Design, Flex, Fabrique, Springtime, EJOK).

The kind of products the IDE-graduates design are consumer durables (43%), services (22%) and user interfaces (7%). Packaging design counts for 3%, fast moving consumer goods for 2%.

The consumer durables range from trains and cars to computers, mobile telephones, public sign posts and hospital beds. The majority works for companies in Holland, but a growing number is working abroad. There are IDE-graduates working at Audi (Germany), Pininfarina (Italy), Design Works (USA), Apple Computer (USA) and Microsoft (USA).

The wages they earn range from starting salaries at 2000 – 2500 Euro per month to top salaries at 6000 – 8500 Euro (graduates with more than 15 years of experience and working in the innovation management field). The topsalaries in the product development field are between 5000 and 6000 Euro.

Looking at the careerpaths of the graduates three typical paths and one atypical path are distinguished. The typical paths are:

- (1) graduates making career within the product development field,
- (2) graduates starting in product development and switching to other functions and
- (3) graduates making career in innovation consulting, universities etc.
- (4) The 4th path was so bumpy that all logic seems to have vanished.

Asked for the appreciation of IDE graduates for the Delft NPD curriculum shows that they are very content; the large majority (over 85%) would choose the same education! The most important knowledge domains for their work as NPD-professionals are engineering (28%), management & marketing (23%), industrial design (including human factors) (19%) and design methodology (12%). If we compare this with the content of the latest curriculum (engineering between 23 and 29%, management & marketing between 7 and 17%, industrial design between 12 and 16% and product design, including design methodology 17%) the results are not bad at all.

The educational programme for NPD is still popular amongst young students. In 2000 the total number of Delft students was reduced by 4% (mainly due to demographic reasons), but the number of IDE students rose 14%. The number of female students is with 40+ % the highest amongst studies of engineering and technology in the Netherlands. Due to this popularity both the University of Technology in Eindhoven and the University in Twente started their own NPD-programmes in 2001. The total number of new IDE students in the Netherlands grew to more than 400. Delft's market share dropped only slightly.

## 5 Two examples of specific NPD-courses

Although we could claim that our total programme is a special NPD-programme, some courses are more specific for NPD than others (for instance the course in Material Sciences is also used in the School for Mechanical Engineering and the School of Aeronautical Engineering).

### 5.1 Course on Integrated new product development

This specific example is the development of a first year course to give students an idea about the business context of NPD. This course is labeled Integrated New Product Development.

The learning objectives of this course are:



1. getting knowledge about industrial organizations and their environment;
2. getting knowledge about the organizational aspects of new product development;
3. getting knowledge about the terminology of integrated new product development;
4. getting knowledge about the managerial aspects of integrated new product development.
5. showing role models of NPD-professionals in the field.

The teaching staff started thinking about the course in the Summer of 1993. The first draft version of a future book was ready in December. The book went to the university printingshop in the end of April. The book has six chapters, all illustrated by case material. All case material was original and based on our own research. We have interviewed 8 graduated IDE-engineers about their practice and their latest products and services. The cases ranged from the new train for the Netherlands Railways (the first operational services were scheduled for November 1994), new plastic products for girls (introduced in the Fall of 1994), packaging designs for dairy products (introduced in Saudi Arabia in 1993) to a high tech communication kit used in hospitals (introduced on the market in September 1994). The commercial version of the book (*Integrale produktontwikkeling*) was introduced in February 1996. It was sold also outside the Delft student population. In April 2000 an extended version was introduced, with updates of the cases, adding four new cases and some refinement of the theoretical backgrounds. Both books are sold so well in the Netherlands that an English translation is scheduled for the fall 2003 [6].

It is a 120-hour course spread over a seven week period. During the weeks students work in small groups to do some exercises. Every two weeks an other exercise. We give immediate feed back on the results. Grading is based on a portfolio of the group excercises.

Every two weeks we have a guest lecture of a NPD-professional (usually one of the persons involved in the cases in the book).

## 5.2 Course on New Product Development Management

Three years ago we decided, due to complaints by students over the scattered program, to combine the teaching subjects Project management, Organisational Behaviour and Product Policy into one new course: NPD-Management.

NPD-Management is a 7-points course (=280 studyhours per students) in the fourth year. Because our students still lack much practical experience and because the theoretical knowledge on Project management is easily understood, but difficult to apply, we decided to work together with design consultancies as client organisations.

The students have to work in groups of 5 - 7. They have to formulate an advice for the co-operating design consultancy how this consultancy can improve its NPD-management. The course is offered in one block of seven weeks. The first three weeks was to get introduced to the theory, the next four weeks the students have to generate end formulate their advice and in week 7 they have to make a formal presentation to the client organisation. This presentation was the examination. A jury from the design consultancy was judging the presentations. Afterwards the teaching staff also looked at the theoretical basis of the advices for the final grading.

In the year 1999 this course was given for the first time. The client design consultancy was TNO Productontwikkeling, the largest one in the Netherlands with more than 100 professionals. Some 45 students attended this class. Both the students and the client loved the course. TNO rated the advices very high and some of them are now being implemented.

In the year 2000 we refined the course a little bit. The basic formula was the same. Now we cooperated with two design consultancies: N|P|K and Fabrique. Both founded by IDE graduates. N|P|K has about 50 employees, Fabrique about forty. Both are highly respected, and they consider each other not as competitors.

Besides two clients in stead of one the other changes had to do with the didactics. The students had to form their own teams (in 1999 the staff formed the teams), work as project teams themselves according to the theory offered (the students have to reflect on that), they have to make their internal tasks explicit (conform the underlying theory), make sure they are accountable for all the time they spent on the project and they were made more responsible for the learning themselves. They were stimulated to behave as their own teachers. The teaching staff was only active as a facilitating body. This self-learning proved to be a shock to the students, also being held accountable was not easy, but after some weeks they got into gears and the course really got going. The sharing of theory part is just finished before Christmas, the formulation of the advices will be done after their holidays. The presentations took place in the end of January 2001. Once again both the students and the clients were very positive. In 2002 and in 2003 this course was repeated more or less on the same way, with new clients (Maars, an building industry and Flex Development, another IDE-graduate founded design consultancy) and with the same good results.

## 6 The future

Although the Delft School of Industrial Design Engineering has forty years of experience with developing this NPD-curriculum it is not stopping this development. Because the NPD-practice is changing and the new students are changing we have to continue to develop the program. There will be never a final stage in curriculum development. As New Product Development in practice we have to be open to innovation and change. If we, as NPD-teachers do not have that right attitude for change what can we expect from our future NPD-professionals?

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