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# Post-MSc technological design (PDEng) traineeships by Dutch universities of technology catalyse industrial innovation

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## ABSTRACT

The two-year post-MSc technological design traineeships organized by the Dutch Universities of Technology, and leading to the Professional Doctorate in Engineering (PDEng) degree, are still going strong after 28 years of existence. In 1986 the Dutch government and the Dutch industry - both aiming to increase the level of design competencies and personal and business skills of selected top-level MSc graduates in selected technical areas - jointly initiated these traineeships. The technical content of these traineeships, and the one-year design thesis projects from industry have been continuously adjusted to the industry's needs and the universities' research, design and education capabilities. Currently 20 PDEng programmes spread over many technical disciplines (automotive, (bio)chemical, food, energy, logistics, robotics, civil engineering industries) and where industry is actively pursuing innovation, are active. Six of these programmes were started in the last four years and cooperation with new industrial partners was initiated. The design theses (almost without exception executed under confidentiality agreement between the partners) lead to new innovation leads and trade secrets or patents. The vast majority of the PDEng graduates recruited from all over the globe, find employment at one of these innovative companies in the Netherlands, and populate the companies' technical career track for a very extended period of time.

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## PDENG TRAINEESHIPS: HISTORIC OVERVIEW AND INTRODUCTION

The three universities in The Netherlands – Delft University of Technology, Eindhoven University of Technology and University of Twente – offer two-year post-MSc technological design programmes (traineeships) to selected top-level MSc graduates recruited from all over the globe. The Dutch Government and the Dutch industries jointly initiated these traineeships in 1986, with the aim to train top talent in design competencies, in business and personal skills, to prepare them as key ‘knowledge workers’ who strongly contribute to the design of new products and processes, and consequently boost innovation. The PDEng traineeships are designed to train and educate top MSc graduates to become qualified excellent designers capable of designing ‘fit for purpose’ and ‘first of its kind’ products, processes and systems. The PDEng trainees are encouraged to actively look beyond the perimeters of their own disciplines and recognize the challenges and restrictions imposed by product chain management, time and money.

Over a period of nearly thirty years many of these programmes are still going strong - supported by long lasting and multinational industrial partners who actively and continuously pursuing (open) innovation and cooperation with the technical universities. Other programmes were terminated, and yet new ones matching with emerging innovation areas were started. This lifelike dynamics very closely follows industrial demand and opportunities for innovation, the demand for technical innovation talent and the universities’ research, design and education capabilities and strengths. Contribution from and participation by these stakeholders in innovation is a prerequisite for every successful PDEng programme. Regular contacts and active cooperation projects between the industrial partners, universities and PDEng trainees prove to be essential in this process.

In the late 1990’s the Dutch Universities started to internationalize their MSc curricula, and the PDEng (and PhD) recruitment followed suit. Currently over 90% of the PDEng trainees originate from outside the Netherlands, and both genders are equally represented. The PDEng traineeships have turned into truly global and gender-balanced doctoral training centres. This has increased the attractiveness of the traineeships for the industry, university and last but not least for the PDEng trainees themselves.

## POSITION AND CONTENTS OF PDENG TRAINEESHIPS OF THE DUTCH 3TU.SCHOOL FOR TECHNOLOGICAL DESIGN

The position of the PDEng programmes in the Dutch technical university education system is clearly shown in Figure 1. It builds on the first (BSc.) and second (MSc.) cycles of the Bologna agreement, and forms together with the research-oriented PhD track, the third tier of academic education.

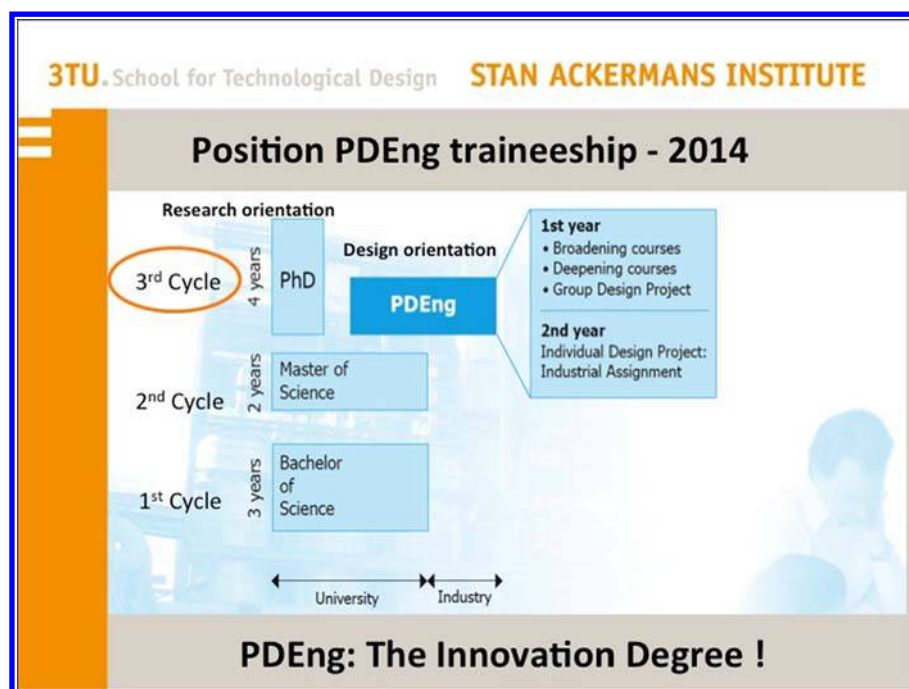


Figure 1. Position PDEng traineeship in the Dutch technical universities' education system.<sup>1,2</sup>

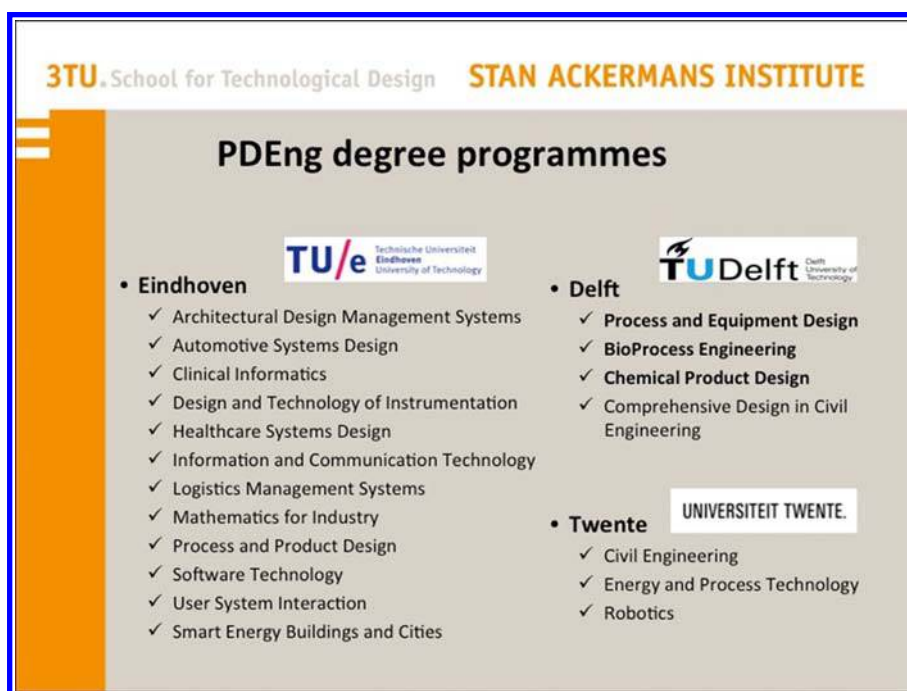
The design-oriented PDEng education reaches out into the industry domain, as after one year of competence building and knowledge acquisition, the full second year is spent on a individual design project initiated by and executed (mostly) at the industrial partner's site.

On successfully completing the PDEng programme, the graduates receive a certified diploma and are entitled to use the academic degree "Professional Doctorate in Engineering (PDEng)". All diplomas are registered in a central register kept by the Royal Dutch Society of Engineers (KIVI: "Koninklijk Instituut Van Ingenieurs").

Since 2006 the PDEng designer programmes have been coordinated under the flag of the 3TU.School for Technological Design – Stan Ackermans Institute (3TU.SAI), a cooperation between the three technical universities in the Netherlands (Delft, Eindhoven, Twente), and currently headed by director Prof. dr.ir. J. Fransoo – TU Eindhoven).

Nowadays between 200-250 trainees join – after a stringent recruitment and selection process - one of the 20 PDEng programmes in the various disciplines every year. They work as a salaried employee (PDEng trainee) for one of the three technical universities, on strengthening their skills through workshops and design cases, and on solving a real design case for (and at) an industrial partner during the full second year of their employment.

In Figure 2 the current PDEng programmes (traineeships) offered at the three technical universities in the Netherlands are listed. In this paragraph the general content of these programmes is discussed, whereas in the next paragraph as an example the contents of the TU Delft traineeships in the fields of (bio)chemical engineering will be discussed in more detail.



**Figure 2.** Overview of current post-MSc PDEng designer programmes (traineeships) at the three universities of technology in the Netherlands.

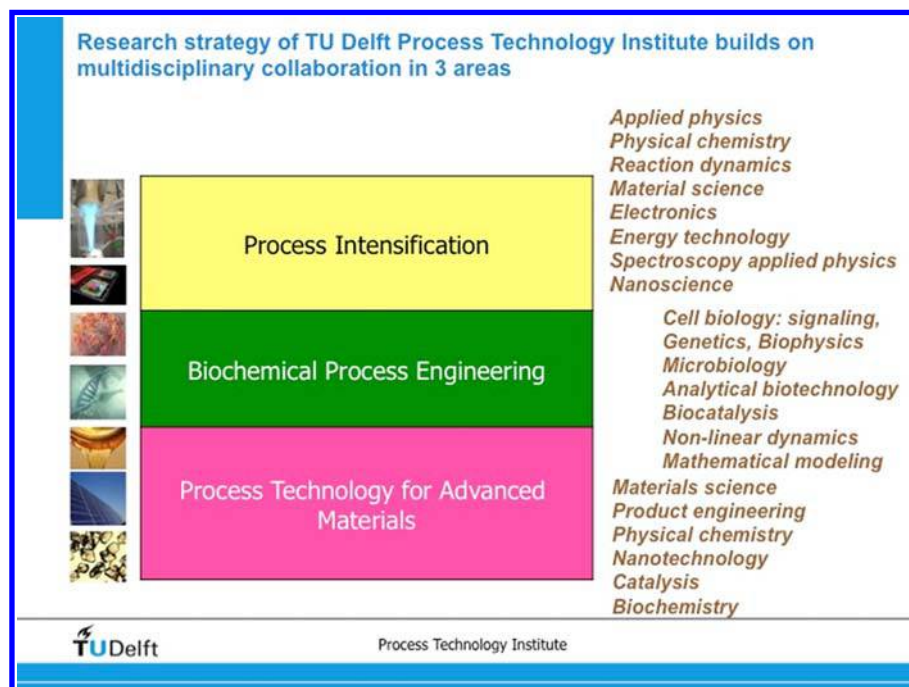
In key areas of Dutch industry like the energy, (bio)chemical engineering (incl. food, pharma) there are more than one programme. The different PDEng traineeship's signature is based on the university's research strengths and long-lasting partnerships with industrial partners, and will be illustrated more clearly in the next paragraph for the TU Delft and Delft Process Technology Institute case.

### **PDEng TRAINEESHIPS AT TU DELFT AND LINKED TO THE DELFT PROCESS TECHNOLOGY INSTITUTE (DPTI)**

At the Delft University of Technology three PDEng programmes are fully aligned with the research and education focus, strengths and industrial ties of the nineteen chairs in three TU Delft departments Biotechnology, Chemical Engineering and Process & Energy, clustered in the "TU Delft Process Technology Institute" (DPTI).<sup>3,4</sup> DPTI is currently headed by scientific director Prof. dr.ir. A.I. Stankiewicz

– TU Delft. The nineteen research groups have seen a strongly increased research, design and education cooperation and output, an increased international visibility, and worldwide recognition in recent years. In 2014 the TU Delft Chemical Engineering groups reached 8<sup>th</sup> rank in the world (3<sup>rd</sup> rank in Europe in the QS World University Ranking.<sup>5</sup>

The research, education and design is focused on three main areas: biochemical process engineering, process intensification and process technology for advanced materials as in shown in Figure 3.



**Figure 3.** Overview of the three key research areas of the TU Delft Process Technology Institute (DPTI). (source: A.I. Stankiewicz – TU Delft).

The DPTI offers industry and knowledge institutions a wide variety of partnership opportunities. It ranges from BSc. or MSc. internships to participation in large international consortia. The PDEng programmes thrive on the industry's interest in cooperating in providing, supporting (both in supervising the PDEng trainee, and in financial contribution) the one year individual design assignments as topic for the PDEng design thesis. Many of DPTI's multinational industrial partners in large multinational consortia also regularly provide design problems for the PDEng traineeships. Also small and medium enterprises and start-up companies are able to find their way via the TU Delft Valorisation Centre<sup>6</sup> to this cooperation with the PDEng traineeships. All industrial partners (small or big) not only benefit from a novel design solution for their design assignment (by the inputs of fresh minds, a sound design methodology, project management approach, and the latest academic research results), but also build and maintain a strong and lastig network with the university and with top level designer trainees who mostly start their industrial career in the Netherlands.

In order to prepare the PDEng trainee for the challenging one-year individual design project for an industrial partner, a technical training programme has been developed over the years to strengthen selected knowledge and competence areas. The structure of the programmes as described in<sup>7</sup> hasn't undergone major changes over the last decade. Strengthening the design methodology tools and fine-tuning and extending the advanced domain knowledge into the quickly developing research and education strengths are the major developments. Said knowledge and competencies are trained during the first year of the traineeship. The specific example listed below is taken from the PDEng traineeships in the (bio)chemical product & process engineering at TU Delft):<sup>3</sup>

- Personal skills (personal effectiveness, technical writing & editing, presentation skills)
- Business skills (project management, techno-economic evaluation)
- Advanced methods for product & process design (design methodology for sustainable product and process design),<sup>7</sup> computer tools)

- Advanced domain subjects (process intensification, catalysis & reactor engineering, nano-engineered materials & products) – linked to the research focal areas of the TU Delft Process Technology Institute and completed with a design assignment.
- A real design case from industry, executed as a Group Design Project for three full months, and intensively coached by industrial principals and TU Delft scientists and experienced design coaches.

The PDEng trainee's knowledge and competencies continue to be trained and coached during the full year Individual Design Project executed at the industrial partner.

### **3500 PDENG GRADUATES, €350MILLION LONG-TERM INVESTMENT IN INNOVATION**

On October 1<sup>st</sup> 2014 TU Eindhoven Rector Magnificus Prof.dr.ir. C.J. van Duijn awarded the 3500<sup>th</sup> PDEng (Professional Doctorate in Engineering) degree to the Chinese Ms Fangyi Shi MSc.PDEng from the PDEng programme Software Technology.<sup>8</sup> During this ceremony it was announced that the industrial partners and Dutch government have invested around €350million (\$440million) in the PDEng traineeships over a period of nearly thirty years.

It should be noted that over 80% of the 3500 PDEng graduates originate from countries outside the Netherlands, and that the female/male ratio has steadily increased to over 50%. More than 75% (and rising) of the PDEng graduates find technological challenging and permanent jobs in the Netherlands. From a recent alumni overview from the 23-year-old programme Process & Equipment Design (TU Delft), it was also evident that the large majority of these alumni progress their industrial careers in the technology or technology management career track. This is a very positive observation, as traditionally many (MSc) graduates from Dutch universities move into operation management, financial or general management roles rather soon in their careers, and stop contributing directly to technological innovations. As their business and financial counterparts don't make the reverse career switch, this loss of technical talent could easily become a threat. PDEng graduates seem to very naturally and effectively occupy and these positions, and keep pursuing a technical career track for a very significant part of their careers. Their technological design talent and ambitions leads and keeps them in this high-in-demand career track.

Training PDEng designers parallel to educating PhD researchers is an approach that has catalyzed and delivered many innovation benefits to the industries based in the Netherlands. With vast world-wide challenges ahead of us in the area's of energy, food, water, scarce resources and health, it is an example that could be adopted worldwide by more countries. The start-up and implementation of such PDEng programmes is not an easy task. To initiate these programmes it requires joint initiative and conversion on programme content, but also financial and intellectual property aspects between universities, companies and government. To sustain these programmes a continuous dialogue between these stakeholders is absolutely necessary. These are conditions that are not quickly and easily met. Dutch industry took the initiative in 1986 and universities and government converged quickly. Over twenty eight years these partners managed to keep aligned in the interest of the Dutch innovation agenda and of the many (inter)national technological design talents that found their career for life (and are living it).

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