Innovative technological solutions designed by PDEng trainees

TU Delft Delft University of Technology

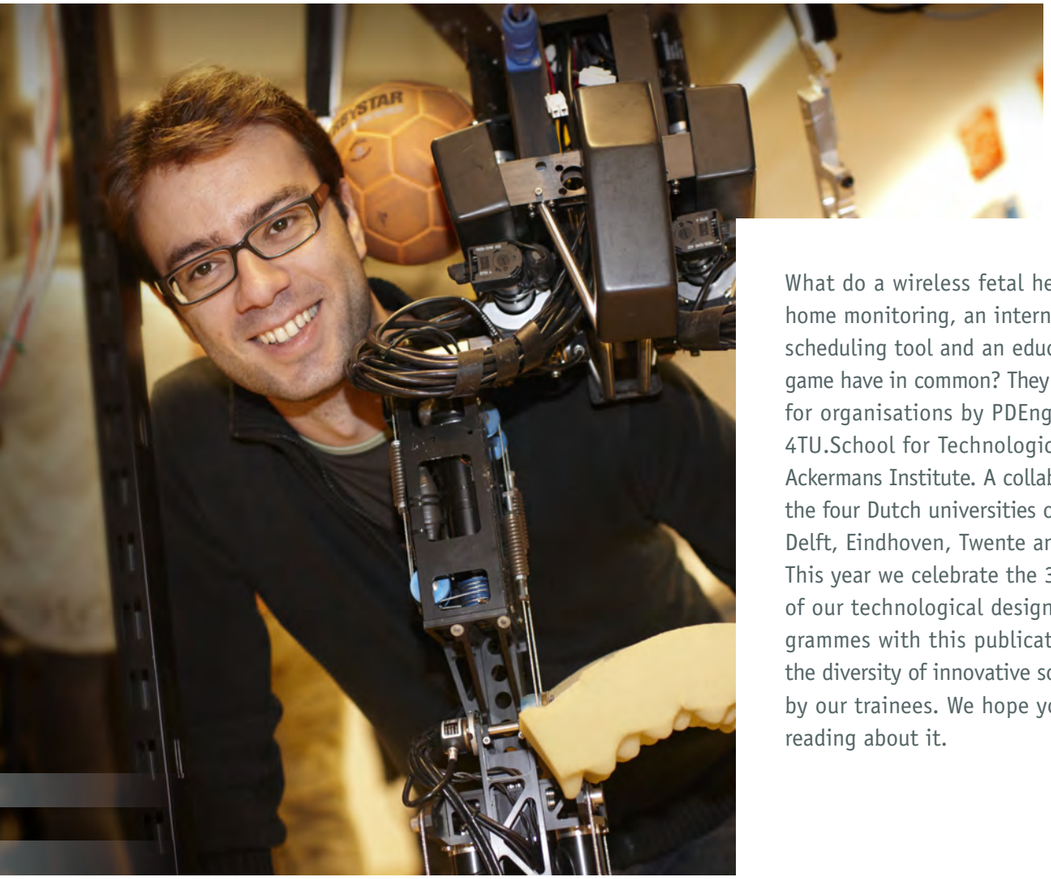
TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

WAGENINGEN UR For quality of life

A selection of projects

4TU. School for Technological Design STAN ACKERMANS INSTITUTE



What do a wireless fetal heart monitor for home monitoring, an international shipping scheduling tool and an educational diabetes game have in common? They were all designed for organisations by PDEng trainees of the 4TU.School for Technological Design, Stan Ackermans Institute. A collaboration between the four Dutch universities of technology, in Delft, Eindhoven, Twente and Wageningen. This year we celebrate the 30th anniversary of our technological designer (PDEng) programmes with this publication that shows the diversity of innovative solutions designed by our trainees. We hope you will enjoy reading about it.

Introduction

PDEng trainees are selected from highly qualified MSc graduates and are doing a full-time, two-year traineeship to become technological designers, ready to face the tough challenges in industry. After successfully completing the programme they will obtain the Professional Doctorate in Engineering (PDEng) degree, an academic degree on a similar level as the PhD.

Putting theory into practice

PDEng trainees spend one year following a curriculum, which involves courses, interactive workshops and group and practical assignments. They often work in close collaboration with industrial and healthcare partners, and carry out a one year in-company design assignment. University experts act as their supervisors, providing access to state-of-the-art technology, advising on the structure and execution of the project and watching over the project's goals. During the course of the design project, our trainees demonstrate their skills in turning their knowledge into innovative business solutions for the high-tech industry or healthcare sector.

More information

To demonstrate the value of the PDEng design projects, we've combined a selection of the latest design projects in this publication. For more information about our PDEng programmes, please visit www.4tu.nl/sai.

With best regards,

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Company: TNO Automotive
Project: Integrating new safety standards into an existing way of working
PDEng trainee: Arash Khabbaz Saberi

Automotive Systems Design

Safety and liability are very important in the automotive sector. Car manufacturers must follow strict ISO standards and be able to provide thorough documentation. This holds double for self-driving cars: they must adhere to the existing safety standards and a variety of new regulations. The extensive protocol for autonomous cars is set out in the new ISO26262 standard, which counts more than 450 pages and takes years to apply in detail.

TNO Automotive does rapid prototyping of subsystems for self-driving cars, such as a system that helps autonomous cars stay in their lane. To be able to continue to deliver their prototypes within a reasonable timeframe, TNO needed a streamlined approach that integrates ISO26262 in their current way of working.

For his PDEng research project, Arash Khabbaz Saberi developed the Functional Safety Methodology and an Architecture Framework for Functional Safety. He addressed product development, methodology, tools and system architecture. The project also included a case study to validate the applicability of the results.

Arash: *"When the project started, TNO Automotive had just started to look at ISO26262. Now, functional safety has become one of their six focus areas, in large part because of my work. That is very rewarding."*

Sven Jansen, TNO: *"We were specifically looking for a PDEng trainee to take this on because they tend to have excellent professional skills. Arash took on this assignment with a high level of ambition, using the skills and experience of the PDEng education effectively, with very promising results. Arash has both technical skills and soft skills and wrote an excellent, well-substantiated report. Now, TNO can adopt state-of-the-art methodologies in system engineering and design, and continue to play a role in automotive system architecture. We are very happy that he is willing to stay on as a PhD. We realized years ago that this designer's program is very special, so TNO takes on a few PDEng trainees every year. Investing in a PDEng trainee is investing in our knowledge, and in potential future colleagues."*

Company: DSM
Project: A model based monolith reactor design
PDEng trainee: Kalpana Samant

Bioprocess Engineering

With each additional year, we are adding one degree to our global temperature. To make a direct impact, we have to innovate, collaborate and implement new solutions. Carbon dioxide or CO_2 is one of the commonly known greenhouse gases whose percentage in the atmosphere is increasing every year. This project aims to use CO_2 -rich gaseous streams (syngas) that can be found in many industries to produce small molecules that can serve as building blocks for further chemical reactions. The existing commercial technologies are decades old and use high temperature and high pressure to convert the gaseous streams into the desired products, which is not very sustainable.

Innovation has come in the form of microbial conversion of syngas using mild reaction conditions. Commercializing this technology requires collaboration between microbiology and reaction engineering. This project aimed to build a mathematical model to provide easier insight into the optimal reaction design.

Kalpana: *"I made a mathematical model simulating a reactor. The model used microbial kinetics and mass and heat transfer models, and was combined with economic evaluations for an optimized process design. I also did a risk analysis of the project outcome was also done which clearly indicated the high price of the reactor and the high operating costs as crucial design decision points."*

This innovative project included a collaboration on many dimensions of reaction engineering, process design and technical and economic evaluation. The calculations for the optimum dimensions of the reactor, a reaction engineering question, were based on the optimum thickness of the microbial biofilm attaching the microbes to the reactor wall, which is a microbiology question. The project also looked at technical and financial considerations to fine-tune the design - a largescale monolith microbial biofilm reactor for gas fermentation.

The next step: verifying the results of the mathematical model and further developing the technology for commercial use, using CO_2 -rich streams to create the building blocks for further chemical reactions.

Company: BioSolar Cells
Project: Artificial leaf - producing hydrogen with sunlight
PDEng trainee: Mercedes Victoria Garcia

Chemical Product Design

Hydrogen, if produced from clean and abundant sources, has the potential to solve the concerns around security of energy supply, climate change and local air pollution. Photo-electrochemical (PEC) water splitting is a promising technology: using sunlight to split water to obtain hydrogen. This technology is also called artificial leaf, because it resembles the photosynthesis process. Although it is still under development, the technology has attained a sufficient level to justify starting to investigate its implementation on an industrial scale. This PDEng project for the BioSolar Cells consortium aimed to design a modular PEC water-splitting device that could be on the market by 2020.

Mercedes: *"We created and investigated various device alternatives using a step-wise design methodology. Each round, we evaluated the options according to previously established technical, economical, safety and sustainability criteria. We finally proposed a device consisting of a back-illuminated tandem photo-electrode with a metal counter electrode for further research and development. Designing a commercial-scale device also shed light on practical issues that need to be resolved before this technology can be marketable – we need to develop anion exchange membranes and protective layers to improve the stability of the semiconductor photo-electrodes."*

The economic feasibility of a hydrogen production plant using this device would have a potential cost below the target of 6 $/kg H_2. This device itself can be manufactured with commercially available components and manufacturing processes, at an estimated cost of ~70 $/m^2. A sustainability life cycle assessment (LCA) showed that the energy payback for this system would be shorter than 2 years. With these numbers, it can be concluded that the conceptual design could succeed in the market, providing a safe and environmentally friendly process for hydrogen production.

Company: Rijkswaterstaat
Project: Improving the use of systems engineering in integrated project management teams
PDEng trainee: Michiel Loonen

Civil Engineering

In 2007, systems engineering was introduced in the Dutch civil engineering sector. The introduction of systems engineering led to several positive changes, but its application in Rijkswaterstaat teams can still be improved. Rijkswaterstaat uses integrated project management (IPM) teams to carry out its public works and infrastructure projects. IPM teams consist of five roles related to project management, project control, contracting, stakeholder management and technical issues.
This project had the goal of improving the use of systems engineering in the IPM teams of Rijkswaterstaat. The project identified bottlenecks in the current practice and started developing interventions to improve the application of systems engineering.

Michiel: *"I collected expert ideas, best practices and current knowledge and used that to create the TeamToolbox, a coherent, simple and accessible product. For the TeamToolbox, I developed interventions to solve the bottlenecks the teams experienced around systems engineering. The interventions help teams apply systems engineering concepts better and collaborate better and more joyfully, which also improves the quality of their work. I designed the concept of the Toolbox and managed its further development with professional designers."*

As an outcome, the contracts and specifications for Rijkswaterstaat projects are now formulated better, leading to potential faster realization of public works and less chance on budget overruns. In addition, the people on the teams work with more joy because there are less struggles in working together as a team. Twenty-five Toolboxes were acquired and are currently used.

Cees Orij, Rijkswaterstaat: *"Thanks to Michiel's project, we have been able to measure the systems engineering maturity at Rijkswaterstaat. The interventions are one way we are going to apply that knowledge."*

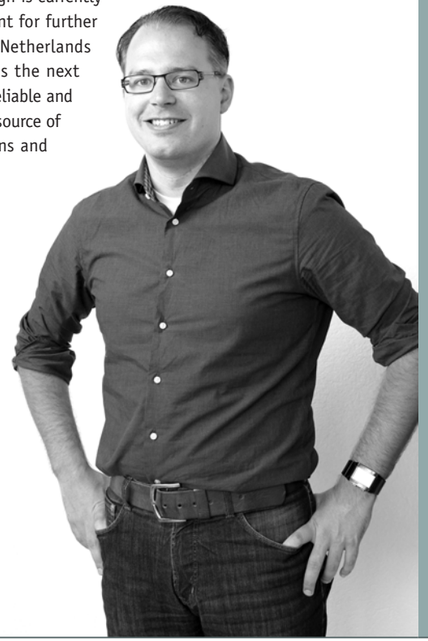
Institute: Antoni van Leeuwenhoek
Project: Building a translational date warehouse
PDEng trainee: Patrick Lubbers

Clinical informatics

The amount of medical information is growing – clinical diagnoses, images and treatment plans are increasingly stored digitally. Historically, this information is scattered over many clinical applications, which makes it difficult for clinicians, researchers and patients to see the complete picture of the patient. In this situation, medical researchers may miss crucial connections, and clinicians may not have the information they need to prescribe the best treatment plans.
The challenge was to create an organization-wide solution that integrates and standardizes information from multiple sources into a single system: the clinical data warehouse, a smart and complete data storage system that can handle the dynamic and semantic characteristics of clinical data. The warehouse is designed to provide clinicians with easy access to all relevant information and to support future developments in e.g. decision support systems. Of course, the data warehouse has a sophisticated access and governance system to meet increasingly stringent privacy regulations.

Patrick: *"It was essential to implement a robust metadata framework to provide the relevant context. For example, the mere fact of a 125 BPM heartrate is meaningless if you don't know if it was recorded when the person was sitting on a chair or had just run 5 km. I served as the lead IT and information architect for the project. The technology we used for the data warehouse doesn't overwrite data; instead it stores every change in the data's life cycle, which is great for researchers who want to review changes over time. In addition, we ensured that information can still be accessed even if the original clinical application is no longer available."*

The data warehouse design is currently being used as a blueprint for further implementation in the Netherlands Cancer Institute. This is the next step toward creating a reliable and legally compliant single source of information for clinicians and researchers.



Company: Philips Healthcare
Project: Improving the architecture and testability of the Philips MRI embedded software
PDEng trainee: Sean W. Wang

Design of Electrical Engineering Systems
Track Healthcare Systems Design

Large, complex medical devices such as Magnetic Resonance Imaging (MRI) scanners are costly, and hospitals and research institutes want to get the most out of their investment. Each new hardware launch offers great opportunities for ongoing software upgrades to explore its capabilities to the fullest. Conversely, software upgrades are a great way to extend a scanner's lifespan, so even older hardware can continue to benefit from performance increases and new clinical applications. To make it easier to develop and deliver these ongoing software updates, Philips recently defined a roadmap to improve the architecture of the embedded software on one of the three computers in an MRI scanner – the Data Acquisition System (DAS) that runs device control.
To contribute to this roadmap, Sean worked on a project to improve the architecture design and testability of the DAS Logging component, which sends logs from the DAS to the user interface for diagnostic and informational purposes. The project contributes to two aspects of the roadmap: the goal of releasing embedded software independently and the goal of fully automated testing. The DAS Logging component was modularized and redesigned, the new design was implemented on a real Philips MRI machine, and clinical application software was used for the functional integration tests. The experimental results were positive, showing that independent release and automated testing are very feasible goals. This way, embedded software has a better architectural design and is easier to test, maintain and deploy.

Sean: *"This new platform can reduce the amount of expensive testing which requires a physical MRI machine. The platform also helps Philips engineers to easily write, implement and execute test cases and collect test reports. Because the platform is generic, other embedded software engineers in Philips can also use it to improve the development efficiency of other embedded software on the DAS. I am proud that the automated testing platform will be deployed to the Philips MRI embedded software group."*

Company: Philips Lighting
Project: Mapping the interference of Wi-Fi signal on wireless lighting controls
PDEng trainee: Chara Papatsimpa

Design of Electrical Engineering Systems
Track ICT

Chara: *"It's really interesting to work on a challenge that you've experienced yourself. In my own house, I noticed that sometimes, I couldn't change the color of my Philips Hue lights while I was downloading large files over Wi-Fi. The Hue lights work with ZigBee, a wireless communication standard that uses the same 2.4 GHz frequency band as Wi-Fi. The design project that I did for Philips Lighting focused on the co-existence issues between ZigBee and Wi-Fi."*

Interference of Wi-Fi on ZigBee had been a matter of debate within Philips for a long time, and a theoretical model explaining the interference was already available. The project aimed to find ways to coordinate the two systems better. The goal was to develop a device to measure Wi-Fi and ZigBee traffic in an area, to check if the theoretical model was valid and, more practically, to check whether there was enough space in a certain radiofrequency environment for a ZigBee network.

The project allowed Chara to apply her broad theoretical background in mathematics and digital signal processing and increase her project management and risk analysis skills. Narrowing down the exact specifications of the research question required a lot of stakeholder management and collaboration.

Paul Linnartz, Philips Research: *"This project was perfect for a PDEng candidate. A master's degree student doesn't have the time and depth to develop a measuring device, and a PhD candidate tends to focus more on the theoretical. Chara tied the existing mathematical model to a practical device for measuring Wi-Fi and ZigBee traffic, thereby solving the essence of our problem. She did great work in translating an initially vague question into a concrete solution, which is of great value to a future employer. One thing Chara's device can't measure yet is encrypted messages. She is now staying on as PhD to measure the internal behavior of a radio network."*

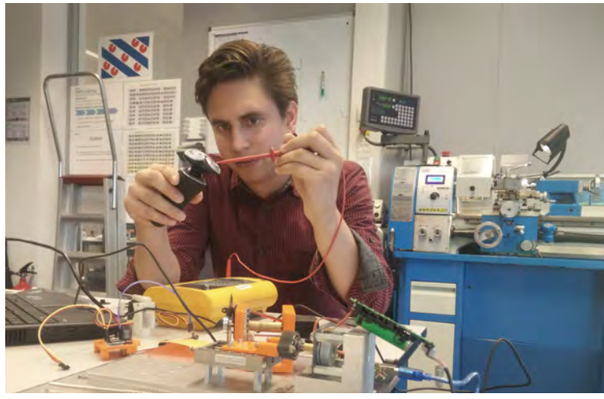
Company: Philips
Project: Improving the measurement system for contour-following mechanisms in shavers
PDEng trainee: Eelco Galestien

Design and Technology of Instrumentation

Electric shavers have contour-following mechanisms that allow the shaver to follow the curvatures of the face, enabling a close shave without irritation. To help product designers make better design choices, Philips started a project to create a new measurement system to objectively compare the performance of contour-following mechanisms.

Eelco: *"Contour following has many aspects, such as force, skin contact and handling. My first task was to distill the wide range of expert opinions and previous studies into a clear set of requirements for the measurement device. After I identified the main contributors to contour-following performance, I built a prototype using piezo-resistive load cells and skin impedance electrodes and verified its functionality. Perhaps the biggest challenge was measuring what the electric shaver was doing without influencing the user too much. Contour following is directly tied to the way the user handles the shaver and what he experiences during his shaving routine. You can imagine that asking someone to perform his normal shaving routine while carrying a heavy piece of equipment connected to hundreds of wires isn't going to work. Our measurement device had to resemble a normal shaver as closely as possible. In fact, we built it completely inside a production shaver body without sacrificing functionality."*

Wilko Westerhof, Philips: *"The system is still under development, and it is continuously being improved. We are adding even more sensors and improving the data analysis. With this data we can optimize our shaver design and provide a better shaving experience for our consumers. We are very happy with Eelco's work. He has the extraordinary ability to combine his electronic, mechanical and programming skills with the skill to get the essence from the assignment. What's more, he succeeded to consolidate his findings into a solution."*



Company: Cooll Sustainable Energy Solutions
Project: Designing an air-cooler for a gas-fired adsorption heat pump for residential use
PDEng student: Wietse Offringa

Energy and Process Technology

Efficient heating of homes can help drive down energy bills and reduce individual impact on the environment. In this context, a gas-fired adsorption heat pump is a promising technology, which can potentially have a significantly higher energy efficiency than the widely used condensing boiler, which is typical in the Netherlands. Cooll Sustainable Energy Solutions, a spin-off from the University of Twente, is cooperating with a number of experienced partners to develop a gas-fired adsorption heat pump for the use in existing homes and small offices. Since this type of adsorption heat pump can be driven by the same gas which is used in condensing boilers, it is ideal for a direct conversion.

The subject of the PDEng project was the design of an air-cooler that is the interface between the heat pump and the outside air heat source. The design had to include an efficient defrost cycle and an optimization for the space needed for the components, while keeping in mind performance sensitivities. In addition, for residential usage, noise and cost minimization were also of the essence.

Wietse: *"Heat pumps for commercial heating purposes often use a ground heat source, but that is only suitable for a limited number of existing buildings. Using an air heat source significantly increases the potential market share. The air-cooler is one of several key components in the gas-fired heat pump system, and its design was essential to be able to continue with future product development."*

Johannes Burger, founder and CEO of Cooll: *"Designing an air-cooler is a challenging task in a complex multidisciplinary subject. The PDEng project has made a considerable contribution to the air-cooler's design, but also to understanding the crucial aspects of the air-cooler."*

Company: SCS Multiport
Project: Sea shipping planning tool
PDEng trainee: Yun Fan

Industrial Engineering

Trade route optimization problems have fascinated mathematicians since the 1800s and are still relevant today. Finding the best shipping schedule for your cargo, ports and vessels can save money and improve delivery reliability. Transportation company SCS Multiport worked with PDEng trainee Yun Fan to develop a planning tool that supports short sea shipping on a triangle network with three ports, and includes shipping, loading and unloading in its scope.

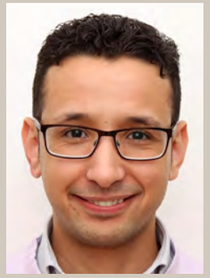
Yun: *"The original planning process was very dependent on a few people, who struggled to make cost-effective decisions in a complex and dynamic environment, including fluctuating demand and limited vessel capacity. I analyzed the current planning process at SCS Multiport, and designed the tool to reduce computation time and make it easier for the director and the planner to have insight into parameter changes. For instance, the influence of changing demand on the weekly profit. The tool can even be used by employees who don't have as much knowledge of ship planning. My simulation test results show improvements in reliability of port visit and cargo delivery."*

The planning tool works on three levels: yearly, every three months, and weekly. On a yearly basis, the tool takes the expected demand and calculates the optimal number of ships to deploy, their route and the long-term outsourcing volume. The tool also calculates ship utilization and maximizes the total weekly profit. Every three months, the tool takes different order scenarios and creates routes and schedules for them. By comparing the results, the planner can decide the preferred number of port visits and the corresponding port stay times. Finally, every week, the tool generates the weekly ship schedule and container assignment plan based on actual orders. This minimizes the total operation costs from quay to quay.

Currently, SCS Multiport is preparing to implement the planning tool. Since the tool is parameterized, it can easily be extended if SCS Multiport decides to service other ports in the North Sea area in the future.

Company: World Class Maintenance
Project: Developing a selection tool for condition monitoring technologies
PDEng student: AbderRahim Mouatamir

Maintenance



An ounce of preventive maintenance is worth a pound of repair. But there is a delicate balance: servicing a system too early is unnecessarily expensive and reduces operating efficiency, while servicing a system too late puts you at risk of breakdowns and expensive repairs. Ideally, maintenance scheduling should be done with a full understanding of the asset's actual state. This condition-based maintenance approach requires monitoring techniques, such as vibration analysis, temperature monitoring, radiographic testing or magnetic particle detection. These techniques are often expensive and not easy to set up.
The difficulty for companies is then to select the most suitable monitoring technologies. World Class Maintenance started this project with the aim to design a convenient selection method for companies to compare the available methodologies. Company case studies will be used to iteratively improve the preliminary design of the selection method.

AbderRahim: *"I brought all existing monitoring technologies together and consider their limitations - both technical, in terms of accuracy, the number of sensors required, and so on, and economical, in terms of their costs and benefits. The project deals with a wide range of disciplines, from physics to engineering to economics. All these aspects will be integrated in the selection method, so companies can base their decisions on all of them."*

The decision-support tool will help companies decide: whether condition-based maintenance is the best maintenance strategy for them, or whether preventive or corrective maintenance is more suitable; which monitoring technique and sensors are suitable for a given application; how to manage and process the raw data collected by the sensors; and whether switching to condition-based maintenance makes financial sense.

Companies of all types and sizes in the process industry have to deal with maintenance. Most of them still rely on a traditional way of scheduling. However, for companies that see the benefit of innovating their maintenance process and have the ambition to invest in condition monitoring, this decision support tool will soon be able to advise them on the best strategy.

Company: Ioniqa Technologies
Project: Designing a depolymerization reactor for Ioniqa's infinite PET recycling
PDEng trainee: Stefano Piccinelli

Process and Equipment Design

The PET polyester market is about 60 million tons per year and growing year on year, approx. 60% for textile, 30% for bottles and 10% for other applications. In 2014, around 60% of the PET bottles were recycled via mechanical recycling. Only 20% of that recycled plastic is used for new bottles; 80% of the PET is downgraded to either textile or other applications. Mechanical recycling degrades the PET polymer chain and cannot strip out the color, which makes it hard to guarantee the required performance for bottle grade. PET textiles are mostly too contaminated to recycle.

Plastic waste is one of the great pollution challenges affecting land and sea ecosystems. For instance, the Great Pacific Garbage Patch has an estimated polluted area two times the size of France. The other problem with plastic is that creating new plastics consumes oil, which is becoming increasingly scarce. A development in plastic recycling that could turn used PET plastic into high-quality new PET would be of tremendous value for our economy and the planet.

Ioniqa Technologies developed an innovative process to recycle any PET feedstock independently of the color or grade. Ioniqa's process depolymerizes even relatively low-grade feedstock down to colorless virgin PET monomer (BHET), which can be fed to any existing 'virgin' quality PET polymerization plants. With this process, PET plastic can become a truly circular economy.

Stefano: *"I designed a new version of the continuous-process depolymerization reactor, improving on the old design and testing the design options in a series of laboratory experiments and kinetic models. I also helped scale up of the process from laboratory scale (2 liter batches) to industrial scale (1000 liter batches), as a proof of concept for the investors. My design will be used in the scale-up to the pilot plant Ioniqa aims to build in 2017, which would process 10 kton per year. We also updated the entire process to include the new depolymerization section design and data from the 1000 liter scale-up test."*

Company: The Dow Chemical Company
Project: Developing enhanced tools for phase behavior prediction
PDEng trainee: Ana Fernandez Bernal

Process and Product Design

In plastics production, yield losses due to process fouling are sometimes unpredictable. In process steps where heat transfer control is essential, this fouling is often caused by undesired phase separation. For a plastics company like the Dow Chemical Company, the control of production is very important if they want to help meet the large polyethylene demand in the world – about 80 million ton annually.
The goal of the PDEng project was to develop a tool for the engineers at Dow's plastic plants to predict the right process conditions for operation. This way, they would be able to avoid lower-performance situations and the resulting production losses. Ana used computational fluid dynamics and advanced thermodynamic models for phase equilibria to calculate temperature profiles in the equipment. This knowledge was then captured in a new software tool that provided novel insights in how to define and to optimize the process window.

Ana: *"The special part in this project was that my work involved both design and optimization. The biggest challenge for me was to develop a tool capable of predicting the right settings in the production processes of a large number of plastics, each produced with different properties and characteristics for different markets. Phase separation prediction of a complex polymer mixture is crucial to improve the polyethylene process. Leveraging knowledge between different departments at Dow and the TU/e was key to accomplish all my design strategy goals.*
Ultimately, being able to generate results that are currently helping the engineers at Dow in their daily work was the most satisfying reward I had."

Jaap den Doelder, the Dow Chemical Company: *"Ana followed a very systematic approach and collaborated really well with her company supervisors, each mutually strengthening the other. It was also remarkable that Ana did not only do modeling but also performed some complex experiments to verify the modeling results. Such a combination of experimental work and high-level modeling within several disciplines is exceptional. Dow is now following up on this project and the methodology developed to extend our product portfolio."*

Company: Nemo Healthcare / Hospital: Máxima Medisch Centrum
Project: Wireless fetal heart monitor for home monitoring
PDEng trainee: Barbara Vermeulen

Qualified Medical Engineer

A cardiotocograph (CTG) device is used in hospitals to monitor fetal heart rate and uterine activity. CTGs are usually requested by the obstetrician or gynecologist in the last stages of pregnancy, to monitor fetal well-being or prodromal labor and contractions. Usually, pregnant women can get the CTG done in a quick hospital visit, but if it is necessary to do a CTG more than once per day, they are usually required to stay all day and perhaps even overnight. Even apart from the considerable expense, this situation is usually undesirable for the expectant mother and her family, especially if there are no further reasons to assume anything is wrong.

In this design project, a prototype was developed of a wireless communication system for home monitoring of the mother and fetus. With this system, a gynecologist can see from the hospital how the mother and unborn child are doing at home.

Barbara: *"This project built on an earlier innovation by Nemo Healthcare - the PUREtrace measurement device with Graphium electrode patches. Electrode patches are much more comfortable than the usual belly band method, and can be easily applied by a medical professional. The original PUREtrace system still needed to be connected to a CTG device, though. In this project, we designed a prototype wireless communication system. The electrode patch can be applied at home, and is connected to a box that receives and collects the measurement data. The data are sent to a server over the internet, and a web application allows the gynecologist to see in real time how mother and child are doing. This project was a proof of principle that brings home fetal monitoring one step closer."*

Company: University of Twente
Project: Advanced bicycle dynamics model to increase the safety of elderly cyclists
PDEng trainee: Hielke Kiewiet

Robotics

Electric bicycles are proving a big contribution to the mobility and social activity of elderly people. Even as their strength and health declines, elderly cyclists can use electric bikes to remain active and social. However, elderly people also tend to have reduced balance, vision and multitasking ability and are often keenly aware of their fragility. To prevent elderly cyclists from deciding they feel too insecure to cycle, project SOFIE aims to develop intelligent assistance devices for electric bicycles.

To test the design of the different assistance devices, it is important to be able to judge how effective they are. The first step, therefore, was to develop an advanced multi-body model of bicycle and rider dynamics to improve the understanding of bicycle and rider stability. The main focus of the design project for Hielke Kiewiet was the experimental setup designed to validate the model: a bicycle equipped with a wide range of sensors to monitor the dynamic behavior of the rider and bicycle and show how the rider balances the bicycle.

Hielke: *"We made a setup where the rear wheel of the instrumented bicycle rotated freely on a roller bench. The front wheel rotated on a treadmill, to preserve the tire-road contact. You can still steer to maintain balance. The roller bench was situated on a Stewart platform with six degrees of freedom, that could be controlled in each direction. We could apply disturbances to the bicycle, sometimes several at a time, collecting the reference data to validate the model in a safe laboratory environment in controlled circumstances. This paved the way to actually test the effect of products designed to enhance balance during cycling."*

Company: Heijmans and TU/e
Project: An integrated strategy for novel design approaches
PDEng trainee: Argyrios Papadopoulos

Smart Energy Buildings and Cities

The built environment is constantly in flux: novel building technologies are added to the mix, legislation changes, demands and financial circumstances change to reflect global developments. It is not easy to keep all these concepts in mind when rapidly developing design proposals, especially if the project in question has stringent energy demands.

The aim of this project was to develop a strategy for the integration, implementation, operation and maintenance of new technologies and practices in the design of the built environment. TU/e and building contractor Heijmans N.V. formed a team to link research and industry and to apply research outcomes to real-world development projects.

Argyrios: *"The main advantage of the strategy and tools we developed is the flexibility they provide for quickly developing informed early-stage design proposals without compromising on energy performance goals. This is important, since building designers and owners are increasingly looking for engineering consultants who can provide good early feedback on system options, sizing, energy use, and cost."*

The proposed design strategy allows for quick early-stage design optimization, reducing the time and resources required for the development of detailed designs. The strategy and tools were put to the test in the development of various Heijmans projects. For example, the design strategy was used to improve the design of the Heijmans ONE houses: beautifully designed prefabricated houses that can be deployed in derelict urban areas to create flourishing communities for young professionals whose income is too high to qualify for social housing but too low to afford private-sector housing. This is an excellent example of how this strategy can help the built environment respond to global changes.

Company: Kempenhaeghe
Project: Web-based visualization of guidelines and drug use in epilepsy
PDEng trainee: Trajche Masinov

Software Technology

Epilepsy is a chronic brain disease with unpredictable seizures. It is not curable, and the treatment is long and often difficult for the patient. That is why improving patient care is of great importance. Kempenhaeghe is a leading center of medical expertise in epilepsy, sleeping disorders and neurological learning disabilities. Their project aimed to design a solution that can provide healthcare professionals with the tools to improve epilepsy care.

Kempenhaeghe has almost a hundred years of experience. In that time, more than 30,000 patients have been treated for epilepsy. In the last 40 years, in parallel with the evolution of the computer, Kempenhaeghe has gathered a vast quantity of data about epilepsy treatment. The goal of this project was to integrate this historical information with the existing epilepsy guidelines and produce insights to guide caregivers in making better care decisions.

Trajche: *"Integrating 40 years of data can provide valuable insights, but these insights don't mean anything if they are not presented to the end users in a way they immediately understand. That's why data visualization was another goal of the project, as a way to convey information to end users. Our solution uses historical data to provide feedback and decision support to doctors, directly or indirectly improving epilepsy care. The tool is supported by visualizations that allow the user to interpret the data immediately and with ease."*

Prof. Johan Arends, Kempenhaeghe: *"Trajche applied very intelligent reasoning and a tactical attitude toward the health care professionals. He succeeded in his mission without overusing the language of an information expert. He showed the flexibility to adapt to the wishes of doctors, even if they weren't always logical. Thanks to him, we now have a very attractive prototype epilepsy program that allows us to give feedback to individual doctors, groups of doctors and other interested parties."*

Institutes: Máxima Medical Center and TU/e
Project: Diabetes and playful learning: an educational game for young seniors
PDEng trainee: Pieta van der Molen

User System Interaction

Education is of paramount importance for diabetics who want to manage their disease well. However, new diabetics often get overwhelmed and demotivated by the amount and complexity of the information. To help diabetics and medical professionals, the Máxima Medical Center and Eindhoven University of Technology worked together in the Eindhoven Diabetes Education Simulator (E-DES) project. The goal: to develop an educational diabetes game that helps diabetics understand and work with the factors that influence their blood glucose level.

The game is called SugarVita. It is based on a physiological model that can predict glucose and insulin levels of individual patients based on their medicine and food intake and their behavior. In the game, players are challenged to respond to events happening throughout the day. Each turn, players make practical decisions, such as what they're eating, drinking or snacking, and whether they're going to work, sleeping late or going to the gym. The winner is the person who manages to stay closest to their ideal glucose level and avoid the hospital. During the project, the game was researched, conceptualized, detailed and partly implemented. At the end of the project, a user-evaluated high-fidelity alpha version was completed.

Pieta: *"SugarVita is a digital multi-player board game that can be played on a tablet. We chose this format because it most appeals to our target audience, people in their fifties. They enjoy getting together and playing a game at the kitchen table much more than doing quizzes or videogames. It was very important for me to develop a game with a good user experience. I spent a lot of time talking to the users to understand their wishes and experiences, which led to many improvements in the design and functionality of the game. The goal is for new patients to learn ways to manage their disease while they're having fun."*

The Professional Doctorate in Engineering (PDEng) programmes in brief

Programme	Founded	Graduates 1988-2015	Location
Logistics Management Systems*	1988	342	TU/e
Information and Communication Technology (incl. Healthcare Systems Design) **	1988	237	TU/e
Process and Product Design	1989	386	TU/e
Mathematics for Industry***	1989	291	TU/e
Software Technology	1990	406	TU/e
Design and Technology of Instrumentation	1991	148	TU/e
Process and Equipment Design	1991	179	TUD
Bioprocess Engineering	1994	121	TUD
Architectural Design Management Systems***	1996	92	TU/e
User System Interaction	1998	288	TU/e
BioProduct Design ***	2008	34	TUD
Automotive Systems Design	2011	25	TU/e
Smart Energy Buildings & Cities	2011	18	TU/e
Energy & Process Technology	2011	3	UT
Robotics	2011	1	UT
Civil Engineering	2011	6	UT
Clinical Informatics	2012	32	TU/e
Chemical Product Design	2012	1	TUD
Healthcare Logistics	2014	-	UT
Maintenance	2014	-	UT
Qualified Medical Engineer	2014	5	TU/e

** Nowadays Industrial Engineering / ** Nowadays Design of Electrical Engineering Systems / *** These programmes are being built down. The current trainees will be supported during their finalisation of the programme in order to receive the PDEng degree.*

The 4TU.School for Technological Design, Stan Ackermans Institute offers two-year post-master technological designer programmes.

The institute is a joint initiative of the four universities of technology in the Netherlands: Delft University of Technology, Eindhoven University of Technology, University of Twente and Wageningen University.

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