TU Delft

Highlights 2013

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TU Delft University of Technology

Content

Foreword

Dirk Jan van den Berg

'We are proud to be among the forerunners in the field of e-learning, a teaching method that we are in the process of expanding step by step'

I am very proud to present the TU Delft Highlights 2013. In 2014 our university, the oldest university of technology in the Netherlands, will be celebrating its 172nd birthday. It may be old in years, but it has always been very much up to date in terms of its activities. Security, for example, is very much a contemporary theme, as witnessed by its extensive coverage in the media. We are living in an increasingly complex society, where new technology and old values clash and where our welfare is causing greater problems than is poverty elsewhere. In a society of this kind, issues relating to security are becoming ever-more complex. The response to these issues calls for a multidisciplinary approach to research. You can read more about this in the interview with Pieter van Gelder, professor of Safety Science and the Foundation Day Lecturer on the occasion of our 172nd anniversary, when he spoke exclusively on the topic of security. Multidisciplinarity brings rewards in other respects, too, as it is on the cutting edges of different fields that outstanding new opportunities are to be found. This is the view of Mark van Loosdrecht, who as a professor of Environmental Biotechnology bridges boundaries effortlessly, whether between fields, between research and application, or between government, entrepreneur and research institute.

Cooperation, collaboration, in every possible form, is in our DNA. In our own organisation, we bring scientists and students from different disciplines together in our Delft Research Institutes Health, to focus on the societal themes of energy, health, the living environment, and infrastructure & mobility. To these have recently been added our TU Delft Institutes in the fields of climate, process technology, robotics, transport, and safety & security. These institutes also serve as a platform for interfaculty contacts, knowledge sharing, and cooperation. Looking beyond the campus, we are part of a cast-iron regional partnership with Leiden University and Erasmus University Rotterdam; meanwhile, we are engaged in collaborative ventures on the international stage too. New are the Joint Research Centres that we have opened in Brazil and China, an important step towards becoming a global university where science really does know no boundaries.

Education, after all, is our raison d'être, and it is pleasing to be able to welcome such consistently high student numbers. Indeed, so great is the influx of students that we have to pull out all the stops in order to be able to accommodate them all. This is an important sign that engineers are now highly sought after by the labour market even more than ever. It is still the case that the vast majority of our graduates find employment more or less immediately.

As high as the number of campus students may be, they form but a drop in the ocean compared to the numbers of people we reach through online education. This is an experiment that we believe in to the full. We are proud to be among the forerunners in the field of e-learning, a teaching method that we are in the process of expanding step by step. Our own students enjoy blended learning – a mix of face-to-face teaching and online learning. In order to make outstanding education more accessible, we recently launched online Master's courses. But our biggest success in 2013 was our Massive Online Open Courses on the renowned EdX platform: two courses on water purification and solar energy attracted 24,000 and 53,000 enrolments respectively. Free top-level education, accessible to all. Arno Smets, who developed and teaches the MOOC Solar Energy, describes it in greater detail.

Ultimately, what matters is that the results of our research and teaching work have an effect on society. An important way for this to be achieved is through entrepreneurship, something we actively encourage in our curriculum. We also assist young entrepreneurs through the YES!Delft enterprise centre. This inspiring breeding ground for high-tech start-ups is actually so successful that it is almost growing out of its premises. Inventor and entrepreneur Marcel gives you a look behind the scenes.

These and other inspiring accounts in the TU Delft Highlights 2013 offer you a glimpse of what is going on at our great university, and give me every confidence that 2014 will prove to be another year that is packed with highlights.

Drs. Dirk Jan van den Berg
President of the Executive Board
TU Delft

Pieter van Gelder

Prevention is better than repression

On 1 October 2013, Professor Pieter van Gelder was appointed as Professor of Safety Science at the Faculty of Technology, Policy and Management (TPM). Before that, since 1994, he was affiliated with the Faculty of Civil Engineering and Geosciences (CEG), where he conducted research on probabilistic methods in hydraulic engineering and construction. He would now like to apply that knowledge to other security domains.

On 10 January 2000, Pieter van Gelder was awarded the first TU Delft doctorate of the 21st century. "One of the propositions in my PhD dissertation was that I might not be able to defend it due to the millennium bug," explains Van Gelder. Fortunately it didn't come to that, and the irregular leap day 29 February 2000 did not cause any problems either. Van Gelder knows all about risk analysis, although in 2000 he was more concerned with the risks involved in hydraulic engineering than those in the digital domain. With a background in mathematics, he spent his first few years working for the Road and Hydraulic Engineering Division of Rijkswaterstaat. "After a while, I got rather tired of all the reading involved in such a civil service post," he admits. "I was constantly reading about what the Hydraulics Laboratory or Deltares had done, and then I had to provide feedback on it. I realised that it would be more fun to do research myself, instead of supervising and evaluating it." Van Gelder found a PhD position with Professor Vrijling, who was a Professor of Constructive Hydraulic Engineering at the time. The mathematical advisor from Rijkswaterstaat took some courses first. "While I was still working for Rijkswaterstaat, I attended a number of lectures on civil engineering, sitting among the first-year students. Over the years I began to feel like a civil engineer myself," says Van Gelder. His mathematical knowledge turned out to be extremely useful, as his PhD research was about probability models. "I studied the statistical models in order to assess the reliability of flood defences," he explains. "We want to quantify those risks. In other words, we want to determine the probability of an event and its consequences. For example, you can calculate the strength of a structure and the load on it. This tells you about the hazard zone, the overlap between extreme load and weak strength. But there are a number of uncertainties in the results of those calculations. How can you properly assess the parameters of those distributions?"

Dynamic model

Ultimately, such a model should lead to the design of the optimal flood defence. "We use optimisation techniques for that, because the optimal dike height not only depends on the consequences of a breach, but also on the investment costs in a higher dike. So we make a cost-benefit analysis," explains Van Gelder. You can also use models for the management and maintenance of dikes. "It's a dynamic model. We take matters such as rising sea levels and ageing into account. The dike subsides over time, in which case the model has to show that the safety is lower than the requirements and that measures need to be taken."

As a Professor of Safety Science, Van Gelder wants to apply his experience in hydraulic engineering to other domains. "The method used to quantify risks can also be applied to other sectors, such as transport, chemistry or occupational safety." However, this is not a simple process, as there is an important difference. "In hydraulic engineering we usually work with structures: bodies of soil, concrete walls, steel walls, etc. That makes calculations relatively straightforward. However, the other domains involve a human factor. Take

Lifelong Learning

Pieter van Gelder also teaches, not just regular students, but also professionals who already have a good bit of work experience. He does the latter as part of the Master's programme in Public Safety offered by Delft Top Tech, the TU Delft institute for post-initial education. "It usually attracts people who have already spent about five years in the workforce. They want to keep their knowledge up to date in the framework of lifelong learning. Delft Top Tech offers a huge range of study programmes. I helped set up the Public Safety programme and taught mathematical techniques. You're teaching people who provide their own interesting case studies and datasets from their work. Ordinary students often have very creative ideas. Students who take a very green approach to a problem, or students who approach it with a lot of experience. It's a lot of fun working with both," says Pieter van Gelder.

the transport domain for example: a driver can make a mistake and cause an accident, as can a pilot in a cockpit. High stress levels can lead to mistakes being made, as can a lack of colleagues who can correct those mistakes. All of these elements play a role," he explains. Apart from technical failures and human error there is a third factor we refer to as organisational failure. "The safety culture in organisations plays a major role in accidents," says van Gelder. The Faculty of TPM has developed a safety ladder for this, with different levels of safety culture; from the lowest level, which looks only at whether the rules are met, to the highest. "A company like Shell is really good at that and exudes safety, as it were." Is it actually possible to model at all when you're dealing with human factors? It certainly is according to Van Gelder. "You can work with Bayesian models, in which you can incorporate cause-and-effect relationships. You can combine technical failure and human error in these. You can update such a model repeatedly with observations from the field and you can feed it with recommendations from experts. This allows you to continually develop the model further and further so that you can make better predictions with it. There is still plenty of valuable research to be conducted on these Bayesian networks in the coming years", says Van Gelder.

Human aspect

The human aspect also plays a leading role in the distinction between safety and security. Because, although the Dutch word for both terms is 'veiligheid', security primarily refers to protection against the risks of malicious acts by humans. "For example, the probability of a terrorist attack is far more difficult to assess than the probability of a flood," says Van Gelder. "There are physical models we can use for a flood; we can look at what the outliers in nature are. But for a terrorist attack all we know is whether or not it has happened before in the past." This poses a challenge for the future, but not one that Van Gelder is afraid of. "If you want to weigh up risks, you have to quantify, no matter how difficult that may be." To do this Van Gelder wants to seek contact with authorities such as the Ministry of Security and Justice and the National Coordinator for Security and Counterterrorism (NCTV). He would also like to collaborate with other research disciplines. "Leiden University has a Chair of Terrorism and Counterterrorism and at Erasmus University Rotterdam there is a lot of expertise on the economic consequences of incidents. In Delft we can then calculate the technical measures you can take to reduce risks. The three of us could work together to make significant progress in this area."

Collaboration

Collaboration is high on Van Gelder's agenda anyway, starting with his "old home", the CEG faculty. "I still give lectures at CEG when there are interesting projects, and am happy to join in to carry the collaboration forward." Then there is the recently established TU Delft Institute for Safety

‘The probability of a terrorist attack is far more difficult to assess than the probability of a flood’

and Security. “It is an interfaculty institute, in which most of the faculties participate. We would really like to get them all on board. I see overlapping areas of interest with all of them.” The institute can also play an important role in the tendering for calls for the new European research programme Horizon 2020. “That is a huge pot of European funding, of which we hope to get a share,” says Van Gelder. “We are keeping a close eye on the developments and are actively seeking collaborative partners, so that we can submit successful proposals later on.”

Where do the results of all that research wind up? “The Ministry of Transport, Public Works and Water Management is one of the main users of the knowledge produced by the CEG’s Hydraulic Engineering research group,” says Van Gelder. “After all, it is responsible for protecting the Netherlands from flooding. Deltares is another important partner in the transfer of knowledge from research to application. We also collaborate a lot with offshore companies and dredgers, and with engineering firms that are commissioned by other organisations.” New models for other domains could also be useful for the government. “Security is funded mainly by tax revenues. The government should be able to use our models to set priorities regarding how they can allocate that tax money as efficiently as possible. There is a need for this both among government authorities and in the private sector. Big businesses are also tackling the issue of how they can further improve their security.”

Isn’t security the first area in which cutbacks are implemented? According to Van Gelder, that is disastrous short-term thinking. “In the long term, it is sensible to increase the security level as much as possible, in order to prevent disasters and tremendous damage. Preventative action is better than mitigation.” Does he agree, then, with Han Vrijling who, on his retirement as a professor, expressed his concerns that flood control was no longer being taken seriously? “Han Vrijling criticised the fact that attention is shifting from prevention to repression; in other words, to dealing with the consequences – handing out sandbags and survival gear, that type of thing. In his opinion, as long as there are still large sections of dike that are not up to standard, it is far better to spend that money on prevention. Whether I share that criticism? While prevention is very important, if things do go wrong we need to have thought about how we can normalise the situation as quickly as possible and how we can support people as well as possible to help them survive. So for that we also need to have models on the repression side,” says Van Gelder.

Plenty of work

Thus there is plenty of work to do for Van Gelder who, in his capacity as chair, will now also focus on subjects other than modelling risks. Other areas of research include regulations and standardisation regarding security and the inclusion of risks as a factor in the design process. Van Gelder also sees links with his previous position here. “Flood defence engineering of course involves design. How high does it need to be and which materials should be used? We use optimisation techniques for this, and standardisation also plays a role. What is a safe standard? Once every thousand or ten thousand years, or do we need even more stringent standards? All of these subjects have things in common with the world of hydraulic engineering. On the other hand, regulations to combat cybercrime are far more complex. Although copying the approach used in hydraulic engineering is a nice starting point, there are a lot of snags involved. That’s an interesting challenge for the next few decades,” Van Gelder philosophises. Fortunately, his range of interests has always been broad. “As a child I wanted to be a bank manager or a doctor. I liked counting money but I also enjoyed browsing in atlases or anatomy books.” He can indulge these interests to the full as a professor. “It’s a very broad field, and not just in terms of content. I also have to coach employees, conduct financial management, bring in projects and maintain my network.” That can be quite tiring, especially in combination with raising a one-and-a-half year old. “So yes, I am in a turbulent phase at the moment. But professors and academic staff are always busy anyway.”


MAPLE

Eline van der Kruk

‘I really go for it’

Eline van der Kruk studied for a Master’s degree in Biomechanical Engineering Design at the Faculty of Mechanical, Maritime and Materials Engineering (3mE). In 2013 she graduated with distinction in the Sports Engineering specialisation and became the Netherlands’ first sports engineer.

Eline van der Kruk had almost studied medicine instead. “I had high marks for maths and physics, so I already had a place. Then I went to an Open Day at Delft and realised that I was actually more interested in innovation and design,” Van der Kruk explains. At the last moment she switched to Industrial Design Engineering. It’s a loss for the world of medicine, but a gain for the world of design. Her idea for the “Tukkie” - a cushion with suction pads and a speaker that sticks to the window of a car - was awarded a 9 by TU Delft, but unfortunately failed to win the design challenge run by HEMA, a chain store in the Netherlands. Her final-year Bachelor’s project - innovative earplugs - earned her a UfD-Imtech Bachelor Grant 2012.

Despite the flying start, Industrial Design was not to be the final goal. “After a year I started to miss the technical side of things - IDE isn’t very technical. I took extra modules in mechanical engineering so that I could switch after my Bachelor’s degree.” That switch was to the Master’s degree programme in Biomechanical Engineering Design. The Sports Engineering specialisation was introduced a year later, and it all came together for Van der Kruk. “I was on a sports internship in Birmingham. I enjoyed it so much that I decided to switch. What I’m doing now combines technology, innovation, design and the human body. It has everything,” she says enthusiastically. And this has worked out well too - she graduated with distinction thanks to her graduation project on a dynamic model for skating motion.

Achievement

High marks and awards; if there’s one word that defines Van der Kruk’s burgeoning career, then it’s “achievement”. She wants to get the best out of everyone - including herself. “When I’m aiming for something, I really go for it.” That mindset will certainly be an asset in her work with top athletes. The period leading up to her graduation was a tense one, but luckily things soon became clear: she could continue her graduation research as a PhD student. “Half-way to graduation I found out that the project proposal had been approved.” In that project she is working on her three-dimensional skating model in collaboration with the KNSB (Dutch Speed Skating Federation), InnoSportlab and various metering companies. She also has a counterpart at the VU University Amsterdam. “The PhD student at the VU is working on the physiological side of the project – they’re strong in Human Movement Sciences there. We’re working on the technical and mechanical side. We’re translating people into systems, for example by envisaging the muscles as a spring-damper system.”

The aim of the project is to adapt Van der Kruk’s model so that it provides real-time feedback to skaters when they’re on the track. “We want to be able to give skaters direct feedback on how they’re performing, and tell them what they should be doing - perhaps with the help of smart glasses à la Google. Because when you’re bent forward over the ice, it’s not easy to see what your coach wants you to do.” But she’s not there yet. Van der Kruk explains: “First, we have to be able to make very precise measurements, but the instruments we need don’t really exist yet. I already looked into this for my graduation project.” The problem is that there isn’t yet suitable equipment for making three-dimensional measurements in an enclosed space, and there definitely isn’t a system that can cope with the high skating speeds involved. “At the moment we’re looking at iGPS, a system that uses infra-red signals. But it wasn’t designed for sport, so we’d have to adapt it. We’re planning to test part of the system on the track soon.”

Apart from the question of how to measure, the researchers still need to work out precisely what should be measured. The aim is to tell skaters what they need to do to improve their performance, but first we need to define the “optimum” performance. “We use our model to simulate skating motion, and we do all sorts of tests with that. What happens when the push-off is faster or slower, or if the skater pushes out less far? What precisely happens when ice friction is very high? Should you lengthen or shorten your strokes? We want

‘What I’m doing now combines technology, innovation, design and the human body. It has everything’

EchoStop

For her final-year Bachelor’s project, Eline van der Kruk designed earplugs to be worn at parties. “I’d just been wearing earplugs myself for a long time after a surfing accident that damaged my eardrums. I used to wear them when I went out, but the trouble is that your own voice sounds so loud. Research has confirmed that when people wear earplugs, many of them hear their own voice more loudly. It can sound as much as twelve times louder than normal. That’s why people don’t use them. I looked into whether that effect could be prevented with a filter. I found something that enables you to hear music and other people, but not that ‘underwater’ sound of your own voice. I’m thinking of setting up my own business to market the EchoStop earplugs. Hearing disorders in young people are an underestimated problem.”

to be able to determine that for each skater.” We’re already gaining many new insights, but there’s another step we need to make. “We can already determine how fast a skater would go in certain conditions, but actually we want to do the opposite. We want to be able to say: this is the speed he wants to achieve, and these are the parameters that are necessary. That’s the most difficult step, because it means we have to invert the model,” Van der Kruk explains.

The problem is that there are still too many potential parameters. “Which of them are the right ones? You can use them all, but which ones are important?”, wonders Van der Kruk. “Is the skater’s body mass important, or how much he steers back? We need to find the three or four parameters that make the difference.”

Obviously, we’re doing this in close consultation with people in the skating world. “Naturally, skaters and coaches also have ideas about the sort of feedback they’d like.” But it’s not that simple, in her opinion. “We shouldn’t start researching something that isn’t of interest to sportspeople. On the other hand, we shouldn’t simply measure something that they want to know about if it doesn’t add value to the model.” Interim results will play an important role in terms of keeping skaters and researchers motivated throughout the project. “We want to work towards ‘quick wins’, and not spend four years on research before we tell the world: here it is, we’ve done it.” An example of an interim product could be a buzzer that gives skaters feedback about the position of their back. “They’ll receive a signal telling them their back is too high. We’ll also be looking at how back position affects their course on the track. It might well be one of the parameters we’re looking for.”

Regulations

Would the regulations allow skaters to use a buzzer like this? “As long as the regulations don’t expressly forbid it, then it’s allowed,” explains Van der Kruk. “Take the women’s hockey team - they used earpieces for a year before these were forbidden. And even if it’s not allowed in competition, it can be used in training to teach skaters to skate as efficiently as possible.” And what about the skating suits we hear so much about? “We’re not studying those. If we know how they affect drag, for example, we can use that in the model, but it’s not something we’re focusing on. What we’re concentrating on is skating technique, namely how to improve it without adapting the materials in any way. There must still be something to be gained from that.” According to Van der Kruk, it’s high time attention was focused on skating motions themselves.

"We've been skating for centuries, but no-one really knows how the technique works. When you run, you push back, but when you skate you push to the side. Isn't that a bit odd?"

Prediction

TU Delft has all the resources in-house to unravel the mysteries of skating motions. In Van der Kruk's view, modelling is one of the university's strengths. "Earlier this year I went to a research meeting in Italy for all European study programmes in Sports Engineering. We spent a week researching skiing and snowboarding. I noticed that we're actually quite a way ahead of other universities. We do more than modelling - we also try to predict. That is our strong side. The VU does that too, but luckily we're collaborating with them on this project." Otherwise, we can only guess at what the competition's doing. "The problem with sport is that you can't just go ahead and publish everything," says Van der Kruk. "It's quite possible that we might discover something, but won't be able to publish anything about it until after the Olympic Games. And then we might discover that another country has done the same thing."

Not a clap skate but a measuring skate

The project includes the further development of a skate with a built-in meter for measuring forces during skating. The measuring skate, which was originally developed in Delft too, must be made into a wireless device. Eline van der Kruk wants to use it to further verify her model.
"Think of a rowing machine. You row a few strokes with at a certain force, and the machine tells you how many metres you've rowed. That's much more difficult with a skate," explains Van der Kruk. "We now have sensors fitted to both skates and to the upper body. They measure the distance from the skate to the upper body, and the height of the upper body. Using that information, we can calculate how fast a skater is moving on the ice."
The model should soon be able to predict how much force a skater needs to apply. Van der Kruk wants to verify the model by using the measuring skate to find out precisely how much force is applied to the skate. "Apart from that, skaters like to know how much force they can exert, so we can also use this to provide feedback."

Van der Kruk isn't thinking about what happens after the Olympic Games and her PhD award. "I only started a couple of weeks ago. I enjoy research now, and I'm also interested in education and how to improve it. Launching products on the market and setting up a profitable business also appeals to me. Not for the money, but for the challenge. Perhaps one day I'll be able to combine the two - research and business. For the time being, I'm where I want to be." That is why she is initially concentrating on research. "Very soon we'll be starting with measurements on the track. I already have an internship student and a final-year student." That's how fast things can move - even in the academic world.

Mark van Loosdrecht

Remarkable bacteria

Professor Mark van Loosdrecht is a professor of environmental biotechnology at the Faculty of Applied Sciences. He and his research group were there at the birth of two major new water purification technologies, Anammox and granular sludge technology. It was for this reason that Technology Foundation STW honoured him in October 2013 with the most important Dutch award for scientific and technical research, the Simon Stevin Meester prize.

The key to success, believes Mark van Loosdrecht, is to do what you like doing. "If you enjoy your work, it usually means you are also good at it." For him, that meant something to do with biology, he realised after finishing secondary school. "A pure biology programme did not appeal to me, as that was too fact-based. In Wageningen, I was able to do environmental hygiene, which included physics and chemistry as well as biology," he says. "That combination shows up in my Master's dissertation and in my PhD research. And in fact, that is still the area in which I work."

Van Loosdrecht gained his PhD in bacterial adhesion, the phenomenon where bacteria attach themselves to each other or as a layer of mucus - biofilms - to a surface. "I have always been interested in why a system functions and what its underlying mechanisms are." From his PhD and subsequent research into the morphogenesis of biofilms, it appeared that these mechanisms are primarily physical in nature rather than biological, as had long been thought. "Biologists assume a priori that the micro-organisms determine the structure. That is not the case; the role of the organisms is subordinate to the process conditions during the formation of biofilms." This is a crucial insight, as it is precisely the process conditions that can be controlled in industrial applications. According to Van Loosdrecht, the practical application of knowledge is inextricably linked to the work of engineers. "As an engineer, it is important that you solve problems, and that you actually help contribute towards change, and in my case that is in environmental biology. Most of what we do therefore has two components: one scientific, and one applied."

Granular sludge technology

The applied side is aimed at the purification of waste water, among other things. Purification plants often use micro-organisms, which digest the waste substances. Normally, these organisms clump together in flakes, which then slowly settle. One breakthrough achieved by Van Loosdrecht and his colleagues is that they let the bacteria grow into compact grains, which settle quickly. What actually determines whether it is flakes or grains that form? If we look at precipitation, then we see that it falls as grains or flakes as well – as hail or snow. The physical principles behind the formation of crystals are similar to what happens in the purification reactor. "If you understand the basic principles of crystallisation, you can apply them in order to control the processes in the reactor, so that you know if you are going to get flakes or grains. It is your design of the system that determines what happens."

Metabolic and growth processes also play a role. To get grains, you have to select micro-organisms that grow slowly. Under what process conditions can that be done? "You can first let the bacteria absorb food from the waste water and then stop the water flowing in. So first fatten them up by allowing them to absorb all the organic material, and then let them grow. Growth from reserves of fat is slower, as a result of which the bacteria will divide less quickly. This is how grains can be formed," explains van Loosdrecht.

This 'fattening and starving' process is part of the successful Nereda technology that is being applied in more and more purification plants in and outside the Netherlands. All the processes in the cycle of feeding with waste water, oxygenation and settling take place inside one reactor, whereas in the past several reactors and a settling tank were needed. That means that the process is less time-consuming and plants can be much more compact. It also saves energy, as no water flows have to be pumped around, from tank to tank.

Exchanging ideas

The formation of granular sludge

Publish or perish?

Mark van Loosdrecht has hundreds of scientific publications to his name, and as the editor-in-chief of the journal 'Water Research', he sees many more cross his desk. So how does he feel about the much-discussed urge to publish? "It is not too bad in the Netherlands. At Water Research, I notice that things are different in some countries, however. In China, for example, Master's students must have had something published internationally in order to be able to graduate." Personally, he has never perceived it as pressure. "You just have to enjoy your subject so much that you are simply happy to share it with others and therefore publish it. And if you keep breaking new ground, then you continue to publish, which also makes it easier to get funding. I think the urge to publish is caused in part by people who want to compare their achievements and indicators with each other." In that respect, Van Loosdrecht did not perform so well in the past. "If you do something new, such as with aerobic granular sludge, then there will only be three or four groups worldwide who are working on that subject, and you will not be cited very much. We were very lucky that a group in Singapore published on the adsorption of each individual element on aerobic granular sludge. The periodic table is rather large."

had been observed before in aerobic water purification plants, but it was not used for anything. "It occurred spontaneously, but nobody saw fit to ask any questions about it," says Van Loosdrecht. There was none of the curiosity that engineers need in their work, he believes. "Anyone who is interested in what they see happening should dig deeper. Nine times out of ten there will be a simple explanation, but on the tenth occasion - bingo! - and you find yourself discovering something new. As an engineer, you have to interpret your observations and convert them into knowledge." Interaction with other subject fields can be helpful here. "When, as a process technician, chemist, or biologist, you observe something new, you have to talk about it. The solution is often found at the interface of disciplines."

Moreover, the exchange of ideas with colleagues from other fields can lead to interesting new subjects. A few years ago, for example, the Geosciences department approached Van Loosdrecht with the idea for BioGrout, a method for strengthening sand by turning it into sandstone with the help of bacteria. "Usually, there is not much contact between civil engineers and microbiologists, but it can create some interesting leads. There are all kinds of possibilities offered by the process: you can build tunnels and retaining walls, or strengthen foundations." There is now an extensive BioGeoCivil research programme in place, which receives a grant from the STW Perspective programme.

Anammox

In the 1980s, Arnold Mulder of Gist-Brocades did contact TU Delft when he observed an unfamiliar process during the purification of industrial waste water. Together with Professor Gijs Kuenen, TU Delft scientists discovered at that time the remarkable anammox bacterium, which directly converts ammonium and nitrate into harmless nitrogen. The discovery opened the way to the anammox process, which is now applied in dozens of plants all over the world. That process has, in turn, led to compact granular sludge plants that consume less energy and raw materials and emit much less CO_2.

Nereda and anammox are now mature technologies, but they were preceded by years of intensive cooperation with water boards and the industry. In the case of Nereda it was mostly with DHV, and with anammox it was with the firm Paques B.V.

This certainly does not mean that the research is now over: there are still enough research questions on the subject of granular sludge. In the Nereda grains, for example, there are two highly promising biopolymers: alginates, and polyhydroxyalkanoates (PHAs). "Alginate is currently extracted from algae and harvested at sea, but there is just as much alginate in granular sludge as there is in algae, around 20%. We can harvest it, but we can also examine whether we could optimise the process and perhaps get that up to 40 to 50%. PHAs are actually a bioplastic. This shows how one subject leads you on to the next," explains Van Loosdrecht. "We are now looking not at how to get the bacteria to grow as slowly as possible, but at how we can get as many polymers in the cells as possible, so that we can use waste water for raw materials."

Production of raw materials

Van Loosdrecht is still working on making breakthroughs, now in the

‘As an engineer, you have to interpret your observations and convert them into knowledge’

field of extracting raw materials. This, too, includes new fundamental insights that lie at the basis of possible applications. “Until now, there was a different explanation for the role of storage polymers. It was thought that fat reserves were the result of limiting conditions, such as the availability of nutrients. However, it is actually an intrinsic mechanism for adapting to dynamic conditions, such as day and night rhythms and the effects of the tides. This means that bacteria do not have to grow as quickly as possible in order to win the competition in an ecosystem. They have developed all kinds of mechanisms for making the most of those variable conditions.” These are the mechanisms of which he wishes to gain a greater understanding, and which he wishes to apply. “We are now looking at whether we can make processes based around that kind of specialised bacteria. It concerns not just waste water, but also other waste flows. The quantities of organic material that are lost, in the cultivation of tomatoes, for example, are enormous. You can remove the fibres from the stems, but that still leaves a type of pea soup containing a complex mass of all kinds of organic compounds. We are looking for ways of making one or two usable compounds from that body of organic material that have multiple applications.” Alginates, for example, can serve as a raw material in the production of paper, textiles, foodstuffs, cosmetics, and medications.

Much is happening in this field as well. TU Delft recently concluded a so-called Green Deal with Attero, the Venlo city council, and bioplastics company Novamont, among others, for making biodegradable plastic bags from biodegradable waste that are actually used for collecting the biodegradable waste, thereby creating a closed loop. Part of that process involves another special bacterium discovered in Van Loosdrecht’s laboratory, the plasticicumulans, which has the unique ability to convert the fatty acids that are released during the fermentation of biodegradable waste into the bioplastic PHA. Another example is a new method for enabling algae to produce lipids in a highly efficient manner. This could represent a breakthrough for the large-scale production of dietary fats or biodiesel. “Anyone wishing to produce biodiesel usually looks for an organism that is well able to do so and applies it in axenic cultures. We take a slightly different approach. We do not simply conduct a search and then work in a sterile manner. We are investigating the role of lipids in microbial ecology and then set up an ecosystem in which the organism that makes more lipids than another is more successful. We call it ‘survival of the fattest’.” This ecology-based approach is, believes Van Loosdrecht, the reason that so many processes emerge from TU Delft. “The industrial microbiology sector works with known organisms and modifies them. But of all the microbial life on earth, the proportion with which we are familiar amounts to just a few per cent. We use the full 100%, and from that selection there is inevitably an organism that produces to an optimum level, and usually it was not previously known. Most researchers think at the metabolic and genome level. We look at the ecology, and that is unique.”

Trophy cabinet

The Simon Stevin Meester prize 2013 is by no means the first award that Mark van Loosdrecht has won. In 2012, he was awarded the prestigious Lee Kuan Yew Water Prize in Singapore, and in 2011 he became a Knight in the Order of the Netherlands Lion. In 2010, he received an honorary doctorate from the Swiss university of technology, ETH Zurich, and before that, in 2007, the Dow Energy Prize. These are just a few examples. Van Loosdrecht hastens to add that the honour is not just his, and neither are the prizes. “Fortunately, Nereda wins many prizes, so everyone at least has a turn.” Also of note is that this year the American Association of Environmental Engineering and Science Professors (AEESP) named Van Loosdrecht Distinguished Lecturer of the Year. “I will be visiting the twenty leading environmental study programmes to give lectures and to talk with the students and staff.”

Arno Smets

Free top-level education

Arno Smets is an associate professor in the department of Photovoltaic Materials and Devices (PVMD) of the Faculty of Electrical Engineering, Mathematics, and Computer Science (EEMCS). In 2013, he launched a Massive Open Online Course (MOOC) on solar energy on the prestigious EdX platform, on which more than 50,000 participants have enrolled. "When I was four, I wanted to be a postman. Now I actually deliver lectures to people in their homes", says Arno Smets.

Photovoltaic, what does that mean?

Photovoltaics (PV) is the technology where you convert sunlight into electricity using semi-conductor materials. PV is slowly becoming a mature technology, which is rapidly growing - at a rate of around 40% per year worldwide, no less. If we extrapolate the trend from the past five years, then solar energy will account for a substantial proportion of our energy production in 2020. That is a good thing, of course, but technical problems shift. You will have to deal with fluctuation problems, because you sometimes have a lot, and sometimes none at all. We therefore have to learn to be careful in how we buffer and store solar energy.

How could we do that?

At present, there are no effective ways of storing solar energy. Batteries, for example, are still fairly expensive, with limited energy density. We are better off looking for alternatives. You could convert solar energy directly into a solar fuel. It took nature millions of years to do so, via photosynthesis and the compression of bio waste; maybe we will soon be able to do this very quickly. Together with the Materials for Energy Conversion and Storage groep (MECS) and the Helmholtz-Zentrum Berlin (HZB), we have developed a concept where we combine a solar cell with a catalysis surface that also works on sunlight. We can use it to convert water into oxygen and hydrogen, thereby creating hydrogen gas as 'solar fuel'. That can then be stored, or you can convert it into a methane gas, absorbing CO_2 in the process as well. That is the idea, but it is still in its infancy. We have already achieved some good results in the laboratory. Using bismuth vanadate as a catalyst, together with a thin silicon solar cell, we have achieved a yield of around five per cent, the highest so far for a catalyst of this kind.

When will concepts of this type come onto the market?

There are all kinds of innovative concepts which probably will not get anywhere, even if they are improved on the short term. Ninety per cent of what is now on the market are the solar cells that everyone is familiar with, made with crystalline silicon wafers. That will remain the most usual type of technology for the next twenty years, as we are able to produce it inexpensively and the best yields are about twenty per cent at panel level, but it will depend on a learning curve lasting several decades. In addition, the panels are improving all the time: for example, many now have contacts on the front, but it is better if they are on the back so that they do not cast a shadow. We are also working on thin-film technologies, or solar cell foil, for which much less semi-conductor material is needed. The yield from thin silicon solar cells is now eleven per cent, which is not much less than that for the lower-priced normal panels.

You have also devised a lot of course material…

Yes, during the past two years, we have developed a special photovoltaics graduation profile for the Electrical Engineering and Sustainable Energy Technology Master's programmes. Students learn about everything from the various materials and technologies to the as yet unproven third-generation concepts. Our approach to the latter is very fundamental. We know what the limits are of the materials that we currently use, and we are looking for materials or structures that may possess characteristics that could enable them to function better. This is a challenge, because in practice there is no chance of that happening with 99 per cent of them. Students are very attracted to the subject of PV. We now have 25 graduates carrying out research from lab level to system level. That is like having a small army of people at your disposal, and their work often produces new research proposals.

‘If 3,000 people ultimately gain a certificate, then that represents sixty years’ work. It is fair to describe that as massive’

How did you end up at PVMD?

I studied applied physics in Eindhoven and gained my PhD in plasma physics. Plasma is ionised material – it consists of a gas in which some electrons pass through unimpeded. Fluorescent lamps contain plasma, for example. You can use plasma to deposit materials in very thin layers. In my research for my PhD, I applied this in order to deposit silicon layers, which you can use for solar cells. That is how I came into it. After gaining my PhD and doing a postdoc, I spent five years working in Japan at AIST in the Research Center for Photovoltaics. In 2010, I came to Delft to set up the PVMD department under the guidance of Professor Miro Zeman. The department has since grown considerably.

And all this can be learnt in eight weeks in the MOOC?

We deal with the same subjects as in the Master’s programme – basic principles, materials, technologies and systems, but I only give an introduction. You cannot really go in-depth, but it is still a tough course. It is based on my minor in Solar Cells, so it is at the level of a third-year Bachelor’s. We actually do more than in the minor: we also look at solar fuel and solar heating systems. Students who complete it have a good basis that enables them to understand PV and solar energy, and read up on the more detailed subjects in the literature.

It is a resounding success …

You could say that, yes. More than 53,000 people have enrolled for it. That includes people who want to watch the films out of interest, as well as students who take it very seriously and want to obtain their certificate. The dropout rate is high, but 45% of those who enrolled actually started the course, around 25,000 people. That does not seem many when compared to the total of 53,000, but in relation to the numbers of day students, it is a lot. Every year, around fifty TU Delft Bachelor’s students complete the subject. If three thousand people ultimately gain a certificate, then that represents sixty years’ work. It is fair to describe that as ‘massive’.

How do you construct a MOOC of this kind?

By investing a huge amount of time: I have been working on this day and night for the past four months. I first took a media training course, because you have to know how to be yourself when you are standing in front of a camera with 50,000 people watching you. I deliberately did not watch other MOOCs, because I believe I have to be myself. Later on, I will look to see how other people have done it. Our films are organised in short blocks, created in such a way that they could also be viewed as infotainment. We have some great animations as well, which explain things much more clearly than when I talk about them for an hour. We also spent a lot of time devising the exercises. You have to ensure that you appeal to different audiences, so that both the serious students and those viewing out of interest receive top-quality teaching. It is harder to generate enthusiasm among people online than those in a classroom, but then again, there is a forum where students can help each other.

What happens on the forum?

You might ask a question on a subject that has been covered, such as the future of solar energy. Thousands of people then have their say on the challenges for this technology of the future. And slowly, you see the main points starting to emerge.

It is a self-regulating discussion between all those participating. You only need to look at it. If a student is struggling to understand something, there will be ten others who can explain it. If someone gives an incorrect explanation, then he will be corrected. I also made a film about the history of

PV, but covering this in ten minutes hardly does the subject justice. So you ask the people what they themselves considered the most important developments, and what they would have liked to have seen in the film. You get so much input back, you could write a book on it. For example, someone sent me a copy of an article from 1916 that mentioned solar thermal plants. So the forum too is massive, it's impossible to read everything on there. In the first week we had 5,000 responses a day, as well as many messages of thanks and positive feedback.

Why is TU Delft taking part in this?

There are various reasons. It is good PR, of course. We can show that we provide top-level education and belong among those top universities on the EdX platform. With success, as many students agree TU Delft is a top university, after they have followed a MOOC.

The possibility of scouting also plays a role. We have five or six hundred participants who are right on schedule, and you can see that they are very good students. It may be that we can ask them to come and do a Bachelor's or Master's programme here. The academic world has become global and the competition for attracting the best talent is now very much on. Three-quarters of our students and PhD students come from abroad, and half will stay on to work here, because there is still a shortage of science students here. And of course it's a pedagogic experiment.

Please explain …

When you give a lesson, you have your suspicions about study behaviour, but you cannot be entirely sure. But now we can prove it by using the data from the larger group. We see how students learn: they are as efficient as possible. They work to deadlines and get down to work as a test approaches. Much more work goes into the assignments that count towards the certificate than into the interim and practice exercises, that kind of thing. We can use that next year when we organise the course again. For us, this first time was an experiment. How can we do it better? You notice, for example, that many people drop out after the first tasks. Maybe we can influence that, but maybe the dropout rate is a statistical fact of life. The work is not easy, though – they really do have to spend eight hours a week on it.

And what is it that motivates you?

For me personally, it is the idealistic character behind the course. I was fortunate enough to have had outstanding teachers and inspirational professors. There are many people in the world who are not as lucky, but who have the same or better or more talents than I do. As long as they have access to the internet, they can at least get a free taste of top-level education. Take for example students in some remote village somewhere, but with access to the internet. If I can inspire ten people in such circumstances to move forward... even if it is just one, then I regard that as a success in itself.

Sun-to-hydrogen conversion for CO_2 neutral fuels

Being able to store energy from renewable sources is a major step on the road to the sustainable provision of energy. A team of scientists from the faculties of Applied Sciences and EEMCS, including Arno Smets, recently submitted a proposal for further research into their concept for sun-to-hydrogen conversion. With their device – a solar cell combined with a photoanode – they hope to be able to achieve a yield of up to fifteen per cent. Their project is currently being funded by Shell, FOM (the Foundation for Fundamental Research on Matter), and the NOW (Netherlands Organisation for Scientific Research) as part of the Energy topsector 'CO_2 neutral fuels' programme.

Paulien Herder

700 energy scientists

Professor Paulien Herder is a professor of Engineering Systems Design in Energy & Industry at the Faculty of Technology, Policy and Management (TPM). In April 2013, she was appointed chairman of the Delft Energy Initiative (DEI), the platform for all energy-related research and education at TU Delft. And that is quite a large group, says Paulien Herder: "With over 700 energy scientists, we are a major player in the Netherlands".

How did you end up at Engineering Systems Design?

I wanted to study something technical and as far as I was concerned, in those days that was synonymous with studying in Delft. I did chemical engineering and found myself moving more and more towards systems. I gained my PhD on designing chemical factories, and gradually what I was doing was becoming more and more broad-based in terms of application possibilities. If you look at subjects like management and maintenance and the inclusion of the lifetime in the design of a factory, then it appears that that is also a factor in other sectors - on the railways, in road-building, the water industry, and telecoms. I do not pretend to know all about their infrastructures – for me the emphasis lies on the energy-related sector – but I am in a position to speak about methodology.

According to rector Karel Luyben you are uniquely placed to bring the technical and institutional aspects of the energy issue together …

That is something I very much enjoy, yes. Engineers mostly think in terms of quantitative models and focus on the physical design and the construction of systems. At TPM, in addition to technical scientists, we also have social scientists who know all about public administration and legislation, economists, and philosophers who concentrate on the societal and ethical aspects. These groups are increasingly conducting research on a joint basis. The way in which an engineer designs something has consequences for how it is managed from an administrative point of view and whether you can establish a market for it. And vice versa – you can see that the administrative framework affects what aspect of a system you can engineer. That interaction is very strong. Nowadays you cannot, for example develop a technical system independently and subsequently draw up legislation around it or develop a market for it.

Why is that no longer possible?

Before the energy market was deregulated, the production of electricity was mostly centrally regulated and depended on demand. But the generation of electricity is now in private hands while the infrastructure is still publicly owned. However, the process of generating solar and wind energy is variable, and cannot easily follow the demand for electricity. There is a partial technical solution to that, in the shape of smart meters that can steer the demand for electricity somewhat. Or you can improve the estimate of how much will be generated in the next few hours by combining data with an accurate local weather forecast. Storage within the energy network can also provide a buffer when generation and demand are out of sync.

At the same time, you have to think about a feed-in and feed-out pricing structure. The technical design influences how you can determine the price, on the basis of the data that the system can supply. You could say we are going to determine what the rate per hour will be, based on a chosen market model, but that also has to be supported technically by the underlying system. Conversely, a particular pricing structure will affect consumer behaviour and consequently demand on the system, as you can see with the current day and night rates.

How can your research help here?

We make models that give insight into the effects of policies. The government can incorporate all kinds of incentives in its policies for influencing consumer behaviour, for example. You can also encourage the energy companies in the form of grants to generate more solar energy, or to base themselves at a particular location. We model all these factors and show what the effects are and

whether the energy system is able to cope with them. Each of these factors affects the others, so these are complex systems and simulation models that we are talking about.

This also plays a major role in energy transition, as we ask ourselves what policies we are going to implement in order to make possible the transition to sustainable energy, without excluding anything or sending out the wrong messages. Here we also have to deal with unforeseen developments beyond our control, that nevertheless influence policy outcomes. An example is the shale gas revolution in the US. Because of the supply of shale gas there, coal in Europe is being sold at rock-bottom prices. This means that all coal-fired power stations are running at full steam. Because of all kinds of strange effects in that complicated world system, we now face extra CO_2 emissions.

That sounds rather complex…

Indeed. It is as if you are in the middle of a movement and that you hope to be able to at least have a little influence in steering it the right direction, that with your motives or technical knowledge you can move the right way. How, in the light of all these uncertainties and not knowing how exactly such a complex system reacts and works, can you nonetheless stimulate innovation and make policies? Our field is all about dealing with these uncertainties.

You have said in the past that the Netherlands is not known for its consistency with regard to its policies. That seems a tricky business …

That's right, it leads to tension in the market. If, for example, after two years you suddenly cut off a grant because there is no more money available, then that creates risks for companies that are too great to bear. Years ago, Germany committed itself to the establishment of a large-scale solar energy industry, including a long-term fixed feed-in tariff. You know then that you can invest and that it will be worthwhile. Things are moving in the right direction in the Netherlands now, with the Social and Economic Council of the Netherlands Energy Agreement on sustainable energy policies. Meanwhile, the innovation contracts in the Energy topsector mean that the relevant parties can invest in sustainable energy as well. That brings about stability for businesses and creates opportunities for applied research. There is also a lot happening in the way of market creation and pricing structures for the supply and transport of gas and electricity.

For example, who pays for laying the branch between the network and a farm that supplies biogas to the net? And how much and when should the farmer pay for distribution? And who decides whether he is allowed to supply gas when demand is low?

As the chairman of the DEI, you saw your first task to be that of ensuring that scientists and students just happen to meet each other more often …

The idea behind that is that different scientists often have more in common with each other than they initially realise. But you also notice that people do not always meet up by chance.

TU Delft is actively aiming for diversity, including gender diversity. Are you active in that area?

I am the ambassador of the TU Delft Technology Fellowship for outstanding female researchers. I also sometimes take part in DEWIS activities - DElft Women In Science. There have always been relatively a lot of women in the group that I am currently in charge of; it is about 50-50. If you look at the management teams and advisory bodies, then I can't help noticing that things are often different there. I do make the odd comment on that, from time to time, yes.

Looking at diversity beyond just the number of female scientists, then I think it is a good and nice thing that we have a lot of foreign PhD students. At the same time, we also try to retain a small Dutch contingent, because it is also good for the non-Dutch to be able to operate in a Dutch environment. In any case, cooperation is more effective in groups with a broad-based composition, and it is more enjoyable, too. Every year we organise a dinner in the group, when colleagues from one particular country do the cooking in their own style. We have already had Iranian and Indian dinners, for example. Or we all bring in a homemade dish, creating a lovely and colourful array of dishes. That social cohesion is very important to me to keep enjoying my work. That is also why I work at TU Delft, because it is simply a very social and friendly place.

‘We ask ourselves what policies we are going to implement in order to make possible the transition to sustainable energy’

Now and then you have to give a gentle nudge in that direction, to give them the opportunity to get together.

I was recently involved in a road infrastructure management and maintenance project. Road maintenance contracts often run from twenty to thirty years. During the tendering phase, Rijkswaterstaat has to describe what exactly is needed and to work out how to ensure that the contractors work quickly and inexpensively. The contractors for their part want to deploy their people as efficiently as possible, and earn something in the process. There is a game-like interaction here, and information technologists are good at game theory and develop algorithms for it. They helped us devise a ‘serious game’ in which Rijkswaterstaat and contractors can learn from each other, and explore the potential benefits of having several contractors working on a single road system gear their activities to one another.

That cooperation between member of the EEMCS and TPM Faculties is expanding all the time, now also in the area of smart grids. The same type of negotiation and harmonisation issues are a feature here, too. We have now developed this cooperation into the PowerWeb research programme, in which we combine our knowledge of public administration, economics, mathematics, algorithms, and mechanical and control engineering in order to research and shape the energy market of the future.

This all came about as a result of a chance meeting during a project on the margins of my field. It really inspired me. That type of cooperation, of course, is the very essence of the Delft Energy Initiative.

So this is now for students as well?

Yes, we recently had a meeting of all students with a TU Delft Excellence Scholarship. When you connect them with scientists you see them get really inspired. And it’s also great for the scientists to be linked up to an outstanding student. We now want to see whether the students can do their entire honours track in energy. We are currently developing a few interesting parcels of energy-related subjects. They will then be able to combine that with a research project with one of our scientists or with a project inside a company.

However, we already have a very active group of students in the Delft Energy Initiative - the Energy Club. They organise a whole range of activities: seminars, speed-dating with companies, study trips, and so on. It is partly thanks to them that the DEI is so dynamic.

What other plans do you have for the DEI?

I think we could certainly improve our visibility to the outside world. With more than 700 energy scientists, we have a large research volume, something that is not really evident in the public debate. The reputations of individual professors are of course the most important factor for visibility in the public debate. But if, as a professor, you are also able to say that your research is embedded in a group of 700 energy scientists, then surely that considerably enhances your standing? It would help raise our profile in the context of Horizon 2020, the new European funding programme for research. They simply shouldn’t be able to ignore us.

You are already wearing so many hats, do you still have time for teaching?

I really enjoy working with students, so I do give lectures where possible. Last quarter I taught a module in my old discipline. You suddenly find yourself dealing with chemical process design, reactors and distillation. I love being in the classroom, doing sums together, if you like. I get a huge amount of inspiration from the things that students ask me during lectures.

Otherwise, I am the thesis committee chairman for around thirty to forty students a year, which mostly involves a lot of reading, thinking, and talking. It is also great to see how students often make a giant transition from the start of the graduation process to the actual graduation moment itself. They start out as a student feeling their way and end up a fully fledged engineer. That is something I really relish.

Hans Hellendoorn and Hans Welleman

Keeping students on course

Professor Hans Hellendoorn is head of the Delft Center for Systems and Control (DCSC) and Director of Education at the Faculty of Mechanical, Maritime and Materials Engineering (3mE). *Ir.* Hans Welleman is a lecturer in Structural Mechanics and Director of Studies at the Faculty of Civil Engineering and Geosciences (CEG). Both faculties introduced a revised Bachelor's curriculum in 2013. Two education experts in conversation.

First, the introductions. Hans Hellendoorn's subject area is control engineering, more specifically systems with many regulators. "All manner of distribution networks - water, gas, electricity, containers - are becoming increasingly automated. The trick is to have all those systems working together in a hierarchy. I'll give you an example. The pressure in the gas network is slightly too high to ensure that everyone always has enough gas. But all the pipes leak slightly, so overall a huge amount of gas is lost. If we have more information about the users, provided by smart meters, we can reduce the pressure and limit the amount of gas lost," explains Hellendoorn. Having taught with pleasure for many years, he still supervises many final-year students. Recently, however, he has been mainly occupied with the Bachelor's review and lecturer quality.

Hans Welleman is not only Director of Studies, he has a full teaching schedule. Teaching is something he has done for many years with great passion. "I've been teaching structural mechanics since 2000. These are large modules, especially in the Bachelor's programme. I teach two courses with more than 400 students in Years 1 and 2, and another 180 in Year 3. You could call it 'mass teaching'," he says. If it is, it's successful mass teaching. "Over the years I've developed a well-oiled system for getting those large groups through the structural mechanics modules in a structured way." This is how the gentlemen know each other: Hellendoorn went to see his colleague in the run-up to the review to see what the success factors were in his large-scale teaching.

Priorities

Agreements with the Ministry of Education, Culture and Science about pass-rate percentages were the reason for the curriculum review, but was that the only reason? According to Hellendoorn, even before this, 3mE had been wanted to make changes. "For us, student motivation was the main consideration," says Hellendoorn. "We had a survey carried out, and the results showed that a first-year student has two priorities: going to live in rooms, with everything that involves: buying stuff, going through the housemate selection process. And meeting new people - at the sports society, the student society; in short: the social life that can take up so much time. Students view both these things as priorities. They think their studies are important, but don't make them a priority. In many cases, the first examination period was something of a cold shower." This is why many students fall behind in the first semester - in some cases they fall so far behind that they can never catch up. It was also the key to making changes. "That's when we said: we're going to make them see that their studies should have top priority too. We ask students to hand in homework assignments twice a week, and we give them interim tests. We give the 'cold shower' slightly earlier, so that they realise they have to pull their weight." And this works, to a certain extent. "They're still kids of eighteen who don't always like to toe the line; I've seen that at home too," grins Hellendoorn.

At CEG it was mainly a matter of the changing preconditions, according to Welleman. "Strictly speaking, if you look at the pass rates, we weren't doing too badly at all. But the old programme was no longer feasible due to the Bachelor-before-Master rule and the binding recommendation on continuation of studies," he explains. The changing intake also plays a role. "First-year students are all still really interested in technology, but they don't realise you need analytical and maths skills. Potentially, they have those skills and we can tap into them, but if you do that in a way that's too obvious, they leave," Welleman observes. "You have to entice them," agrees Hellendoorn.

‘Our students have to be able to tinker with things. Making things; that’s what makes them happy’

Happy

3mE has introduced a new programme that focuses strongly on the interests of students. “Research has shown that our students are true trial-and-error people. They like to learn by doing. They have to be able to tinker with things. Making things; that’s what makes them happy.” The new programme gives them every opportunity to do that. “In the past, our aim in the first year was to establish a solid theoretical foundation, but they had lost interest by the time we got to the practical side. Now we combine an essential maths and physics module with a related project. In strength theory, for example, they have to build a car that has very thin wheels but can still move. There’s still a lot of theory involved, but in this way they do something fun in every quarter.”

There is a similar development at CEG. “We want to preserve the things we’re strong in, such as scientific modelling and the technical side. At the same time, we want to link that to applications in a light-hearted way. We do this with ‘Bouwplaats’, a practical module with exercises, practicals and project assignments,” says Welleman. Both emphasise the importance of mathematics and physics. And things were quite tense for a while when there was talk that the separate maths module would be scrapped TU-wide. “The plan was to stop teaching maths as a separate subject and incorporate it in other courses. That might be possible for a faculty such as Industrial Design Engineering, but not for a construction-oriented faculty like ours,” says Hellendoorn. Welleman adds: “Then the whole analytical path in maths would become lost and no longer recognisable for students.”

Crème de la crème

In Welleman’s view, there are also improvements to be made with regard to the transition from pre-university education. “The teaching of maths at

Lecturer quality

High pass rates require high-quality teaching, and by dint of their standing, universities are obliged to provide teaching of the highest level. It has therefore been agreed that, in the coming years, everyone who teaches at TU Delft must obtain the University Teaching Qualification (UTQ), except those who are eligible for exemption. The Faculty of 3mE is already at an advanced stage in that process. And that is essential, thinks Hans Hellendoorn. “Anyone who wants to teach in secondary education has to follow teacher training, but at a university, lecturers are put in front of a class without training”. That is now a thing of the past. “All new lecturers work towards the UTQ. They learn all sorts of things that don’t come as a matter of course: the criteria for producing a good examination, how to interact with the class, dealing with other cultures. Lecturers are often very enthusiastic about what they’ve learned.”

Lecturers with more than five years’ experience don’t need to follow the whole UTQ programme, but are evaluated instead. “We’re looking for 360-degree information. What sort of books and lecture notes does the lecturer use, and what are the examinations like? What is the feedback from students and colleagues? After that, an education expert and a colleague teaching in the same field as the lecturer attend one of the lecturer’s teaching sessions. Then a discussion is held to determine what the lecturer needs to do to attain the UTQ level,” he says. This method was formulated by 3mE in cooperation with the Faculty of Architecture and the Built Environment. And it works. “Lecturers see it as an enrichment. They ask whether the education expert can come back to observe teaching in another subject, and some of them have signed up for the whole UTQ programme. The fact that people put their heart and soul into their teaching is sometimes overlooked, so it’s also a form of recognition.”

pre-university level is going in surprising directions. Vector analysis and linear algebra are no longer taught. Logic has been introduced, but at the cost of technical and analytical maths," he explains. The pace could also be increased, to avoid a culture shock when students start the subject at university. "What we teach here in seven weeks takes two years at pre-university level. On the other hand, the crème de la crème are still coming to us. If we're not able to train them, then we have a serious problem," he reasons. Hellendoorn agrees: "We really can't complain about students from pre-university education. They're certainly clever enough."

One of the principles of the new programmes is a different examination method. CEG is trying to avoid the well-known snowball effect. "In the past, all the examination stages were scheduled together, which made it difficult for students who needed to catch up, especially if they had fallen behind in more than one subject. Now we're trying to spread out the first examination opportunities, so that students can keep up sufficiently to earn at least 75% of their credits in the first year," explains Welleman. But that's not all. In Welleman's view, there needs to be a culture shift in the long term too. "Students should aim to pass their examinations first time, and resits should be for 'emergencies' only. They're not a right that entitles you to move your programme around."

The Faculty is already experimenting with the new approach. "Interim tests have been introduced in a number of subjects, with a single resit at the end of the period. I'm curious to see whether it works." 3mE also wants to work towards that in the long term, but has opted for an interim solution in the meantime. "We're now scheduling the resits in the middle of next semester so that they don't disrupt the normal examinations," says Hellendoorn.

The effects of the Bachelor's review are already evident. "We tried out the new measures last year and we're already seeing that new students are catching up with their seniors, who are starting to sense the importance of the exams. We're very busy with the second year, because they've really picked up the pace all of a sudden. A miraculous effect," says Welleman. Hellendoorn is seeing the same developments. "Entire bottlenecks are disappearing," he says. "It makes sense. It shows the changes are beginning to pay off."

Study success

Until recently, only one-quarter of students completed their three-year Bachelor's programme in four years; the rest took longer. The average time to graduation for Delft engineering students was no less than 7.2 years. These figures kept Delft at the bottom of the national league tables for many years. On the other hand, Delft graduates are much favoured by employers for their "nice to know" knowledge and practical experience - often gained through a range of extracurricular activities. The times are changing. "Society thinks five years should really be long enough to obtain a degree," stated Paul Rullmann, TU Delft Vice President for Education, in an interview in 2011. In 2012, higher-education institutions even entered into official performance agreements with the Ministry of Education, Culture and Science. TU Delft is aiming high: the percentage of Bachelor's students graduating within four years must increase from 27% to 55%. Not only to comply with the agreements, but also because higher pass rates benefit the university and its students too. 'Studyable' curricula should inspire students to study at a faster pace. TU Delft wants to achieve this through, for example, a modular structure with greater coherence within programmes, more frequent interim tests, and intelligent timetabling of examinations and resits. All these measures are geared to the methods of teaching and studying rather than to the content or quality of the degree programmes - because no-one wants to meddle with that.

Binding recommendation on the continuation of studies (BSA)
Students have to earn 75% of their credits in the first year. This requirement ensures that students who are not on a suitable degree programme don't discover this too late.

Daan Bruggink

‘Ecological building should also be attractive’

Architect Daan Bruggink graduated from the Faculty of Architecture in 2004. He is the founder and owner of ORGA architect, a firm specialising in bio-based building. The building world has honoured him with the Dutch Bouwprijs 2013, in the category ‘Talent with a Future’. TU Delft added to the compliment by naming him Alumnus of the Year 2013 because of his passion for sustainability and because he doubled his turnover for six years in succession, in spite of the economic crisis. “Our market is actually growing, and we are riding the wave”, says Daan Bruggink.

Eight years...

is how long I spent studying in Delft. I was interested in organic architecture even then, but the thinking in Delft was very matter-of-fact; one of my teachers thought that the Zwarte Madonna in The Hague was the most attractive building in the Netherlands. I did not find it easy being in that atmosphere; perhaps that is why it took me longer to complete my studies. I did a lot of work alongside my studies, at architectural agencies. Learning by doing is the fastest way to learn, after all. Nowadays, that is why you first have to spend two years gaining practical experience before you can call yourself an architect – that was not the case in those days. I think that is a step forward.

I once designed a ski slope...

in the form of a letter C. It ran like a kind of trunk through the dunes towards the beach. The advantage of the organic form was that you could snowboard on the inside of the C. It won the prize for the best project in my year. It was never actually built – it was a student project – but from a construction point of view, it was also too difficult. The sand from the dunes could have blown over it, but just as easily piled up three metres high, which would be too heavy.

My graduation project...

was a zoo for the Diemerpark in Amsterdam, part of which was the ‘Canopy’, a covered tropical rainforest. At 3.5 hectares, the project was far too big, so I was working on it for a long time. But it was great fun, and there was so much to think about. For example, how do you create the architectural illusion of the animals in the zoo wandering around freely? Then you use ‘go-away-green’, a green that makes the animal pens disappear into the background. Another factor is how visitors walk around a zoo of that kind? This latter aspect is still important in my work – the organic walking route through a building.

It was only towards the end...

of my time as a student that I really started to be interested in sustainable materials and what you could do with them. After graduating, I worked for the Vereniging Integrale Biologische Architectuur (‘Association of integrated biological architecture’) in Den Bosch. The network I built up at that time is still useful to me today. I learned all about materials, but sustainable buildings from that time could use a bit of punch, which is why I prefer to describe myself as ‘modernly ecological’ rather than sustainable. I want what I design to be architecture. It is very important for taking ecological building forward that we make attractive objects, although ‘attractive’ is a broad term.

Many people...

have misconceptions when it comes to ecology. The first house I designed as an architect was for a couple in Almere. They wanted a modern, no-nonsense home with a striking roof ridge that pointed up into the air. You do not actually need such an angled ridge, and certainly not on the northern side of the house, where there is no

sun. The dogmatic world of sustainable building would say in that case that it would be a waste of the material. I would say let us make it from material that can be regrown, in which case it would not make any difference. It is always a matter of trial and error. I want to build ecologically, but I also want to create beautiful architecture. Idealism is not enough; you have to remain practical. Sometimes something may be not quite as good, but still very beautiful. Which way do you go in that case? It just depends.

Nine people out of ten...

who describe themselves as sustainable are referring to energy. The emphasis on saving energy lasted for a long time in the Netherlands, which is logical – it is the easiest step to take, and easy money too. You can continue building in the same way, but then with some extra insulation and a few solar panels on your roof, and the government can easily stimulate it too. However, if you ask me, the shortage of raw materials is a much greater problem. Energy is a problem, but we already have the answer, in the form of renewable sources; it is simply a question of using them. That is now slowly changing. You notice that the environmental performance of building materials is also starting to count. Take wood fibre as an insulation material, for example: it is more expensive to buy than glass wool, but it is a more effective insulator. In addition, it is breathable and so can be used to regulate moisture.

Natural materials...

like wood and reed can be used as they are. You also need so-called technical materials, for below the ground for example, as wood and reed will decay there. Take polystyrene, which is oil-based, so therefore is of a long cyclical organic origin. Instead of that, you now have bio-based materials, such as biodegradable polystyrene.

There are many more interesting materials in the pipeline, such as Nova Lignum, which literally means 'new wood'. It is made from the stalks of aubergines that remain after the harvest. They can be hardened and turned into a ceramic material by pressurising them. You can also make it from other materials, such as tomatoes or grass from verges, as long as it does not compete with the production of food.

Not everything...

is as ecological as it seems. I was recently at a meeting about bamboo. That is a wonderful material, a grass that can grow ten metres a month. You can almost see it shooting out of the ground. Conversely, a wooden beam measuring ten metres long needs decades to grow. Pandas only eat the young shoots, so you would not be competing with them. It sounds tempting, but it has to come all the way from China. Then to use it you need glue, and what does the glue contain? So that is something I have no interest in, for the time being.

Individual customers...

deliberately choose us. They come especially for an ecological design. We have selection at the gate, so to speak. Not that we select are customers, but they come to us because this is how they want to build. And they never ask us for concrete or aluminium.

However, often the contractors were the problem. You may have spent months working with a client, and then a contractor submits a low bid in order to win your tender. Then the haggling started: no guarantee on bio-based materials, innovations being crossed out because of conservatism, etc. We also saw that the contractors were getting smaller and smaller, no longer were there forty people, only two or three people orchestrating freelancers. There came a point when we asked ourselves, why don't we get rid of that guy at the top? We need someone who coordinates it all himself and who can take on projects as the main contractor. That is why we set up ORGA bouw, a separate company that carries out our projects. Now we really can build ecologically, without everything falling by the wayside in the tendering process.

‘When the crisis began, everyone said we were doomed. However, the market for ecological building is actually growing’

That is not only more efficient, it also means fewer failure costs into the bargain.

The economic crisis is a blessing...

according to Jan Rotmans, professor of transitions and transition management. That is because people are now starting to think outside the box. When the crisis began, everyone said we were doomed. However, the market for ecological building is actually growing, and we are riding on the front edge of this wave because I started at an early stage. Many of our clients are private citizens who are concerned about the world. They have searched the internet to find out what is possible, and they know what they want – and they all have sustainability at the top of their list. After all, if you have the choice you would rather go for good, sustainable insulation than something less.

For existing buildings...

bio-based renovation is ideal. We are working on a project in an old farmhouse, which is made mostly of brick and wood. All you have to do is remove the bad materials that have been added in the last few decades, such as asbestos, glass wool and plastics, and replace them with ecological materials. You then have a very healthy building.

The Architecture and the Built Environment faculty building is another good example. The old building did have something about it, but for me it very much exuded the heavy architecture of Broek and Bakema. Now, going inside it makes you feel more cheerful. That has to do with the fact that they first had to use the building on a temporary basis. If it had all been conceived in advance, it would never have been as nice as it is. This way, it has grown organically, with input from students and employees. Old city centres grew in the same way, which is why everyone enjoys them so much. The outer districts that were all planned do not have that atmosphere.

The Bouwprijs...

was a real honour. The fact that the traditional building industry awarded such a prize for bio-based building is a sign that it is starting to catch on there as well. It is still a conservative world, though. There is just one architect, Thomas Rau, in the top of the sustainable top 100, and no property developers at all. At the same time, the bio-based economy is growing at an enormous rate in the Netherlands. And we are at the front of the wave, because of our excellent infrastructure, our large chemical industry, and a flourishing trade sector.

Why is the building sector lagging behind, in that case? Perhaps it is because building companies often fall back on their old networks. It is not really what their clients expect of them; they throw a dash of sustainability into the mix, but as soon as cost savings have to be made, it is all thrown overboard. Building ecologically in the way we do, is essential. Sustainability is an integral part of our projects, and without it, there will be no more projects.

The alumnus prize...

comes with a financial award for research. I have already thought of a purpose to which I can put it. We recently considered building a nature villa for Natuurmonumenten, in order to show how you can build in a way that helps promote nature. This led to all kinds of ideas, such as making sure that it is completely dark at night for the bats, and nest boxes for birds. Now I would like to build a nature villa like that in the Ardennes. It would be an entirely ecological home, completely off-the-grid, so there’s a lot to think about. We would fit a recycle shower that would reuse the water from the shower even while it was being used. We could also monitor the technical performance of the house. After all, it would not just be a calling card for ORGA, I would also like to derive knowledge from it that you could then use in cities. I would really like to involve students from TU Delft on this project, together with students from the Walloon provinces in Belgium.

In any case...

The prizes have helped us in many ways. My blogs and articles are read much more frequently now, which has led to new commissions. And I am getting lots of requests from TU Delft students for projects or interviews. I now spend about a third of my time giving presentations and lectures to the industry. That is fine, but there is a downside: I am an architect, and that aim of making the ultimate design is always being deferred, because I never get the chance to finish it. But whatever, I am still developing personally too.

Marcel Fleuren

‘I have always had the urge to invent things’

Ir. Marcel Fleuren graduated cum laude from the faculty of Industrial Design Engineering in 2011. His graduation project was the Exo-L, an external ankle band that is attached to the shoe in order to prevent the wearer from spraining their ankle. The Exo-L reached the finals of no less than six product competitions, ranging from the Philips Innovation Award to the National Sports Innovation Prize. Marcel Fleuren has just started his own firm at YES!Delft, the TU Delft business centre for high-tech start-ups.

The idea for the Exo-L was actually born of necessity: Marcel Fleuren used to sprain his ankle regularly. “It’s a very unpleasant injury. I often had to spend weeks with my leg up, and eventually I stopped playing football altogether,” says Fleuren. Existing braces and tape designed to prevent sprains hindered his ability to do sports properly, which is why he set about looking for alternatives. This was entirely in keeping with Fleuren’s nature: from a very young age, he saw himself as a bit of an inventor. “I have always had the urge to invent things. Wherever you go, you see things that could be done better – things that could be useful to people. And I always wrote them down.” It resulted in a book full of ideas, which is updated almost every day.

Patents

His urge to invent led him to a degree in Industrial Design Engineering at TU Delft, albeit via a rather circuitous route. “After completing my Bachelor’s degree, I worked for a year in South Africa, where I developed a sun boiler, which can now be found working on a large number of roofs. The original idea was to go travelling, but I wanted to combine that with gaining some work experience. It went so well, that I stayed in Pretoria for a year,” says Fleuren. After the first year of his Master’s degree programme, he spent six months working for Philips in Shanghai, where he developed a patented soy milk maker. Back in Delft, he added a mechanical wood saw machine to his patent portfolio.

The Exo-L came into being three years ago during his graduation project at Industrial Design Engineering. In partnership with Erasmus MC, Fleuren started to look for a means for supporting the ankle that did not hinder movement. “There are hundreds of products on the market, but they are medical splints rather than sports products. They have hard parts and ties that fix the position of your ankle.” Fleuren went back to basics and carried out extensive research into the anatomy of the foot. “In the dissecting room in Rotterdam, I analysed how exactly the tendons, muscles, and ligaments work.” It was here that he had the idea of making a kind of external ankle band – a form of biomimicry, or imitating nature, in other words. “The original name was Exo Ligament, external ankle band, but that was a bit of a mouthful.”

Made to measure

What makes the patented Exo-L so special? “The Exo-L moves with the body, but only up to a certain point. It only tightens up if the ankle is about to sprain. It protects you against the risks associated with moving, while still allowing you to do sports,” Fleuren explains. The Exo-L is also made to measure. “We visit all our customers personally. If someone is interested, we make sure that we call on them within a week in order to measure them up.” This is done with the help of a 3D scan and a 3D printer. “As a result, the external ankle band is a perfect fit and becomes an extension of the body, leading to far fewer pressure points and irritation than with normal braces. You attach the Exo-L on the outside of your shoe with a special attachment piece, which avoids friction inside the shoe,” says Fleuren. The Exo-L is now ready for the market.

A lot of work has so far gone into the product. Since graduating cum

laude, Fleuren has dedicated himself full-time to developing it. An application for a Valorisation Grant to Technology Foundation STW was honoured in 2011, with which he was assisted by his graduation supervisor. "Dr Johan Molenbroek was a great help. The Valorisation Grant enabled us to carry out research into how keen people were to have the product and how we could produce it commercially." In the last two years, the Exo-L has been further developed and tested extensively. Take the cord, for example, that connects the product to the shoe. "We looked at some 40 or 50 cords and tested them until the best remained. We tested how much strain they could take and the point at which they broke. We have countless folders full of research results. The Exo-L is a medical aid, so if you do not document everything neatly, you will run into problems if anything ever goes wrong," says Fleuren.

Potential

After three pilot runs with more and more participants, Fleuren was ready to start finding investors who are looking for businesses and products that have the potential to deliver returns in a few years' time." And the Exo-L certainly has potential, given that many people

‘I have discovered that how rewarding it is to come up with an idea that people actually start using’

have unstable ankles; in the Netherlands alone, there are around 750,000 ankle injuries a year.

Among customers, too, Fleuren has established a large number of contacts, such as the KNVB (Dutch football association). How did he get to them? “I just phoned them up,” says Fleuren matter-of-factly. “The KNVB would like to give it a chance and we are currently testing it on junior players. Most of the medical staff are very enthusiastic about the Exo-L. They see the similarity with the natural ankle ligaments and realise that it is better than everything that has been on the market for sixty years.”

This is a reference to the tapes and braces that many sportsmen and women currently have to make do with. “Braces are all the same,” believes Fleuren, “while taping irritates and sticks to the skin. It is also expensive, because you have to keep putting it on time after time.” According to Fleuren, many people are looking for a product that simply allows them to carry on playing sports, as indeed he used to be. “Footballers can only use tape, because they can’t put anything in their boots. Some people do not use anything at all, because they believe the available choices are worse than useless. For them, this is a real alternative”.

Name recognition

In order to reach all the people in this category, the next step is to generate greater name recognition. “We have to continue to develop our market and build up our relationships with the medical profession and athletes. Once one athlete has one, then his friends and colleagues will come along too, and the effect will then slowly spread. We want more and more people to know about us. That is why we are visiting a lot of trade fairs and holding question and answer sessions in sports medical centres and specialised shops,” says Fleuren. Potential customers there will get personal advice, as that is the trademark of Exo-L. “We do not want to supply an off-the-shelf product. People do not come in sizes S, M, or L.”

“We are easy to reach”, he continues. “Anyone who has had enough of braces and tapes and who wants to be able to practise sports unencumbered, can contact us. We will then make an appointment at a physiotherapist’s, at their home, or in a sports shop to make a scan.” After the scan, Exo-L will take the customer’s trainers in order to prepare them for use. “You only have to give up your trainers for a day,” explains Fleuren. “If you want to use the ankle band for more than one pair of trainers, or for a new pair, then we can alter them as well. We will give you a label to stick to the box and you can then send them. If you order your footwear directly from us, you shoes will be ready to be used with the Exo-L.” A lot of hard work has gone into arranging all the logistics for this part of the business. “Compared to mass-produced braces that are found on shop shelves, the Exo-L is more costly. But once we have explained what you get in return, then people agree it is actually very good value – and that it is a better solution to boot.”

Exo-L has the potential for great things, and Fleuren is already on the hunt for other parties to team up with. “We are currently prototyping ASICS shoes to integrate the shoe modification into their shoes, although that is still a few years down the road according to ASICS. We are not yet big enough to cope with several million shoes a year.”

The company is capable of coping with major growth in the next few years, however. “There is an excellent work space here at YES!Delft, where we are about to expand our assembly line. We could also outsource the work to a sheltered workshop.”

Motivation

What drives a young entrepreneur like Fleuren? “At the moment, it is developing our company that drives me more than anything else. It involves so much. I am still learning and it is something I want to be really good at. The dynamics of a business and forming a team really interest me. There are now five of us, and we are also taking on graduates and interns,” says Fleuren. He is aiming to make Exo-L the new standard for ankle protection all over the world. “We’re going to make a huge success of it, and then we’ll see what happens next. With my collection of patents, I always thought I would make a career as an inventor. But after two years as an entrepreneur, I have now discovered that it is much more rewarding to come up with an idea that people actually start using.”

Hayley Hung

‘Modelling human behaviour in a social context’

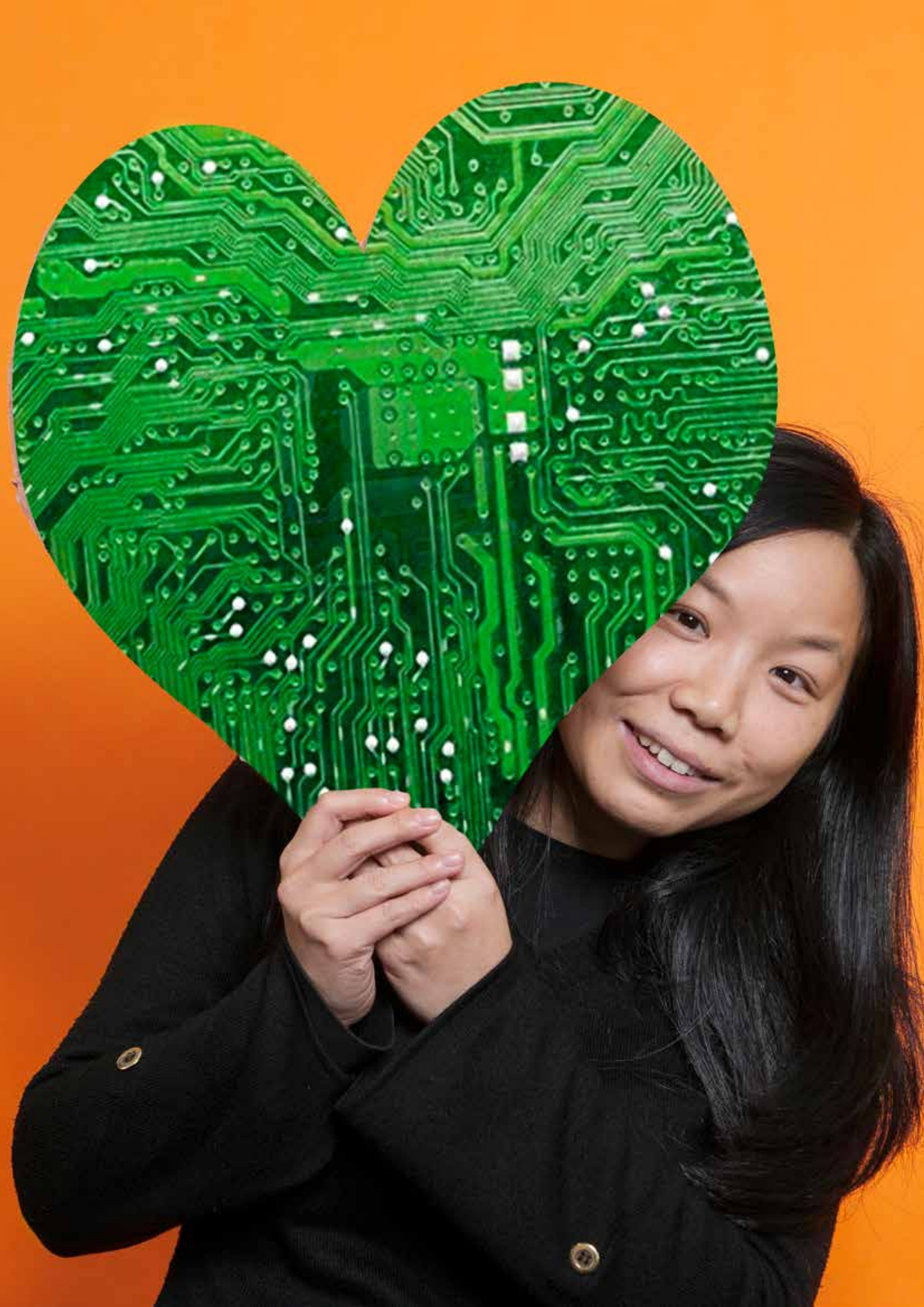
Dr. Hayley Hung focuses in her work on the question of how automated systems can be made aware of humans as social beings. In 2013 she was awarded a Delft Technology Fellowship to research this largely unexplored field of study. She is now an assistant professor at the Pattern Recognition & Bioinformatics Section at the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS).

Hayley Hung’s main research goal is to design automated systems that are perceptive to social phenomena. The idea is that machines that can interpret social behaviour will be better able to serve us. Perhaps that is best illustrated by an example. Hung is currently part of the Spencer project, a European research initiative aimed at developing a fully autonomous mobile robot for smart airport passenger flow management. Hung explains: “At airports there are a lot of stressed people. It is often said that people leave their brain behind when entering an airport. Yet, key objectives at an airport are to get people both to shop and not to miss their flight.” So how could a robot help out here? “For example, people have socially normative restrictions about jumping a queue, even if they are late checking in. However, if there was some authority that said it was all right for them to do so, they would”, says Hung. It is simply not possible to have enough staff on hand to deal with a sudden need for this type of service. Enter the passenger flow robot. “The robot can approach a group and tell them what to do. First though, it has to be able to detect what a group is, and then it has to identify the appropriate spokesperson within that group. You don’t want the robot to address the children, but even if the group consist only of adults, who is leading?” The main issue here is how to determine dominance within the group, and that is a subject Hung has researched before.

Smart meeting rooms

Working as a postdoc at the Idiap Research Institute in Lausanne, Hung was involved in a project that was looking at social phenomena, such as dominance, submission and social cohesion, during meetings. “The project was aimed at smart meeting rooms of the future. The idea was that all meetings would be recorded and people could then look back on them. The problem is: how are you going to search all that data?” To this end the system could look at the date or time of a meeting , but Hung found there are other, more meaningful ways of looking at human interaction. “We expected that people looking through the data would be more easily triggered by social phenomena. For example, it would be helpful if the system could look up a particular meeting where ‘X was very dominant’. But then what are the markers for dominance? How can the system recognize it?”

This is what first intrigued Hung. “Intuitively, we think of dominance as a very complex social phenomenon that cannot be identified by a single behaviour as such; there is a gap between the behaviours we observe and what we think is going on”, she explains. To solve this she looked at social psychology and in the literature she found inspiration to help her automate the process. For example, dominant people in a group tend to talk more, receive more attention from others when they do, and also listen less to others. “There wasn’t a direct line from what social psychology says to what machines understand, so the real question was how to make machines observe these things”. As this fascinated her, she set up her own project concerning the detection of deception during role-playing games. She discovered more ways in which you can extrapolate social phenomena from behaviour, such as analysing physical movement. “We performed a range of experiments and I realized there are many aspects of our behaviour – independently and in relation to other people – that



Delft Technology Fellowship

Hayley Hung is one of ten recipients of a Delft Technology Fellowship for top female scientists. Does she agree there is a need for more women in technology? "I think there is. In Delft I see more women in higher faculty positions in my discipline than in Amsterdam. That already provides an encouragement, in the sense that there are several female role models at TU Delft. Though generally speaking, I appreciate role models who have an open attitude, whether they are male or female. What is important to me is that I am able to do the things I want and that if I have a vision I get the support to carry it out. I really have that here and so far I have had a very positive experience. I also get the chance to establish my own research programme. The research I am interested in doing is not strongly tied to any traditional discipline. Existing positions tend not to cater for that, so this was just right for me".

we do not think about consciously, but that might be very measurable by machines".

Speed dates

Meanwhile, Hung's time in Lausanne was coming to an end and she decided to apply for a Marie Curie grant. "It's an intra-European fellowship that requires you to move from one country to another, but not to your home country. I wanted to come to the Netherlands for personal reasons, so I applied for and was awarded a fellowship to carry out research at the University of Amsterdam", says Hung. Her research interest had also moved, into the direction of social signal processing in crowds. "So far, I had been looking at controlled scenarios where the assumption was that there was always one group of people having a conversation together, but what happens if there are tens or hundreds of people in a coffee break and you don't know who is going to speak to whom? In Amsterdam I researched how you can automatically detect when people are talking together in social settings, and how you can analyse what is going on within those groups of people talking", explains Hung.

An interesting way in which she looked at this, was by analysing speed dates. "We measured the extent to which people were moving and used this to predict attraction to the other person", says Hung. "We found that a female moved more when she was attracted to a man. And when she moved more, the male was also more attracted to the female. I guess when you are on a speed date and you are attracted to someone, you become sort of larger than life". She also looked at related studies from social scientists that indicated similar behaviour. Next, she wanted to predict whether couples would exchange contact information, which proved to be more difficult.

"Typically, when women were attracted to a man, they might still not exchange contact information. Apparently, the way they think about the mating process is more complex. In contrast, men tended to exchange contact information whenever they were attracted". Hung points out that the difficulty with these kinds of studies is obtaining real data. In the speed dating experiment, only sixteen people participated, which is rather a small sample size. Hence she uses research

‘It is always a bit of a trade-off between what people are willing to share and being able to get the data that will enable us to answer our questions’

data from social psychology. “That gives us a larger pool of similar data to go on and thus backup what we observe. But our ultimate goal is to automate the process and show that it can be generalised to large groups of people”.

Unbiased

It raises a lot of questions Hung would like to expand upon. “Another study has found that if you are attracted to someone, you perceive their behaviour as flirting, even if it isn’t. So in this particular context it is probably useful if an unbiased measure can tell you whether this is true”. Of course, attraction doesn’t necessarily have to be of the romantic kind. Take a business setting, for example. “It would be interesting to see if you can predict whether people will actually have a very good working relationship, based on how they interact on their first meeting”. In fact, her work has an even more general scope, she stresses. “When people interact there can be a lot of emotion surrounding that interaction and it might be useful to have an automated means of measuring either the emotion or the behaviour to give an unbiased indication of how you are doing”.

Hung also would like to be able to observe communities as a whole, at conferences for example. She is now working with wearable sensors that detect the amount of acceleration in a person’s movement. “The way you move is closely related to the way you speak. And the way people speak in groups is very coordinated. With that knowledge I would like to predict what is happening in a crowded environment. In the future, we would like to be able to look at crowds of hundreds or thousands of people and detect who’s talking with whom. From that we’ll then be able to get information on the mood of an event. Do people mingle a lot, or stay with the same group, that kind of thing”. Could that have applications in the field of security, such as crowd control? “Possibly, but I shrink away from safety and security. It is difficult to measure real-life violent behaviour. They often use actors in projects to act that behaviour, but when you then try to develop models to automatically detect this, it is not clear what you are really detecting. When acting, we make assumptions about what the behaviour is. On the other hand, real behaviour has subtleties that you might take advantage of when automating the process”, comments Hung.

Acceleration sensors

Back to reality then, and Hung has already conducted an actual study involving these wearable acceleration sensors. “During my professor’s inaugural lecture in Amsterdam, we gave these sensors to seventeen professors and seventeen non-professor and tried to detect in which group they belonged”, explains Hung. The results were promising. “Their reactions during his speech was enough to separate the majority of these two groups, based on how they moved while they were seated”. Hung points out that these are still early results. “A lot more questions need to be answered. The question for me is now, given that you only have one acceleration sensor per person, how much information can you get? You may think that is not very much, but since motion is so closely related to speech, there may be a lot more we can extract than we think”. Using these sensors, which can be worn invisibly in a conference badge, has another advantage. “If you are not recording audio or video, people won’t feel uncomfortable about the way they behave. It is always a bit of a trade-off between what people are willing to share and being able to get the data that will enable us to answer our questions.” And Hung still has questions galore. “The social world is still relatively untapped in the way people interact and behave in face-to-face scenarios; this to me is really interesting and challenging.”

Nynke Tromp

‘Design can change society’

Dr Nynke Tromp is a researcher at the Faculty of Industrial Design Engineering at TU Delft and works as a social designer at Reframing Studio in Amsterdam. In 2013 she graduated with distinction in ‘Social Design’. Her research looks at how design can be used to deal with social problems.

The way in which something is designed influences our behaviour. If the stairs in a building are not clearly signposted, we take the lift. If a packet of savoury snacks isn’t re-sealable, we’re more likely to eat them all in one go. We take it for granted that our lives are influenced by marketing methods and subconscious influences. Nynke Tromp wants to turn this around. “It’s almost impossible to design a product that doesn’t have some form of impact. Why then don’t we use design to seduce people into displaying certain social behaviours?” In her view, the current approach puts the cart before the horse. “If you look around you, you’ll see, for example, an environment geared to efficiency and convenience. We hardly need to walk anywhere any more. And then campaigns are set up to tell people they need to do more exercise. That seems almost immoral.”

Tromp knows precisely what triggered her interest in social design. “I was following the Master’s degree programme in Design for Interaction, which focuses on how people can be influenced by design. For my graduation project I wanted to apply that knowledge to help solve problems in society. At the time Minister Verdonk was courting controversy with her approach to integration. I started to look into how designers can contribute to integration.” She thought up Cadeauslinger, a ‘gift chain’ scheme designed to encourage residents in a neighbourhood in The Hague to get to know each other by exchanging gifts. Professor Paul Hekkert subsequently offered her a PhD place, and a new field was born.

Worldwide phenomenon

But how new is Social Design actually? “When I graduated, in 2009, it was just at the time that you started to hear a lot about it. In traditional design, you know in advance what you’re going to design or which user problem you’re going to tackle. Dealing with a societal problem through design is a relatively new approach”, explains Tromp. Social Design has now evolved into a worldwide phenomenon including a wide range of different movements. “There are all sorts of initiatives. A good example is Katja Schuurman’s concept ‘Return to Sender’: making products with local resources and selling them elsewhere, but ploughing back the profit into the local economy”.

Tromp’s own interests focus on how products influence society without us being aware of it. “Think of television and the effect it has had on our view of the world and our family structures. These are the kinds of developments that are now being analysed by philosophers and sociologists. They are ‘zooming out’ further and further, and observing how society is changing. I’m turning that around. If you want to achieve something at societal level, how do you scale that back to the product level? I’m developing knowledge on that too. Making conscious use of the ‘side effects’ – I think I’m the only one involved in that”.

The concept of behaviour change through design has existed for some time. It’s known as “persuasive design”. Examples include the use of photos on cigarette packets to discourage smoking, and apps to help people stop smoking. But this isn’t quite what Tromp means. “These types of product are deliberately marketed as behaviour-changers. These have their value too, but designers of these products are sidestepping the ethical discussion”. In Tromp’s view, this is precisely where designers have a role to play. “If you can make it easier and more fun for people to do the right thing – to put it in rather banal terms – then it’s almost reprehensible not to do that. I want designers to adopt that ideological approach and be transparent about it. I want them to be able to argue

Available to download now: Temstem

Nynke Tromp works two days a week at Reframing Studio in Amsterdam. Her work there has involved designing products for municipal psychiatric care providers Parnassia to help people recover from a psychosis. One of those products is the Temstem app. Psychosis can sometimes involve the patient "hearing voices". This is due to the stimulation of the language-production area of the brain. Vibrations also occur in the vocal cords. The "voices" they hear are therefore voices they product themselves but attribute to others. Temstem activates the language-producing area in another way, namely through language games. The game then takes on the form of therapy designed to dispel the emotional response to hearing voices. This means people can continue to take part in social situations. After all, reaching for your smartphone has become very normal these days. The app, which can be downloaded from iStore, has been nominated for the Rotterdam Design Prize 2013.

why that's a good position to take." But doesn't this mean that designers will then be deciding what is good for society? Tromp expounds on this. 'We all know what sort of society we want to live in, and what's good for us in the long term. But that knowledge doesn't prompt us to alter our behaviour. Designers can make a unique contribution by designing from a social perspective".

Method

That's not as easy as it seems. Tromp has developed a design methodology for it. First of all, she deconstructs the social problem. "Take the problem of obesity. The standard approach would be to encourage people to eat less and do more exercise. But then you're jumping ahead to the solution without analysing the problem. You first need to understand why people eat too much, and which factors could persuade them not to do that", Tromp explains. Those could be any manner of things. As children we were taught to leave an empty plate, because throwing food away is a bad thing. And stress can lead to "comfort eating". According to Tromp, these are starting points that designers can work with. "You can think of ways for people who don't have a freezer to store leftovers, but you can also do something to change the way parents bring up their children. The 'place' towards which you direct the intervention doesn't need to be the behaviour itself. You can come up with calorie scales, but you first have to look at what's most effective. Not all behaviours are equally 'designable'".

It is also important to understand the user context. Every social problem conceals a conflict between an individual interest and a societal interest. "From the point of view of economics and health, we're aware as a society that we shouldn't become overweight, but as an individual I like chocolate and I want to treat myself", explains Tromp. She has identified three strategies for resolving that conflict. "You can solve it, for example, by designing something that can take place of chocolate as a treat. You can sidestep the conflict by associating the behaviour with another – positive – situation, for example making healthy eating part of fun time with the children. Or you can transform the conflict, for example by encouraging people to balance their diet on a week-to-week basis".

Police cars

Given the nature of her work, many of Tromp's research partners are social organisations such as public-sector bodies, political parties and charitable foundations. One of the topics Tromp has carried out research into is police vehicles. "It was mainly about developing a vision", she says. "Police vehicles are fitted out with more and more technology: automatic number-plate recognition, infra-red

‘Designers can make a unique contribution by designing from a social perspective’

cameras – you name it. Many aspects of police work can be done by expert systems, which means that police officers no longer need to head back to the station”. Meaning more officers on the beat – but how do we organise that? In this case too, Tromp looks at the interests of society rather than those of the individual. It’s not about which button to press for fast information but, for example, what the risks are if all these systems are instantly accessible. “The main pitfall would then be that police officers ‘hide’ behind the system. For example: ‘My system tells me you were driving too fast’. Police officers should always know why they are doing something. And the public have to be able to trust their expertise in order to feel safe”, says Tromp. Her suggestion is therefore to provide all possible information in emergencies only. During surveillance, they should be more involved in gathering their own information, and in doing that they will also get to know the area. Systems should serve first and foremost as learning systems, with officers being given access to other data systems as they build their knowledge. “If you’re a junior policeman who’s interested in fighting drug crime, then that’s what you specialise in. If all police officers are included in the database with their areas of expertise, they can share their knowledge with each other”. Although Tromp noticed that police officers have a certain predilection for gadgets, most of them agreed with her. “It’s good that technology makes all these things possible, but design it in such a way that the police officer remains the linchpin. That’s important for the public and, ultimately, police officers are also happier with that”.

Ivory trade

The IFAW (International Fund for Animal Welfare) is currently considering a funding application. The IFAW wants to reduce the trade in ivory but, due to the burgeoning middle class in China, the demand is only increasing. “Ivory is a status symbol in China”, says Tromp. “I want to apply the same approach in this case: resolve the conflict, sidestep it or transform it. What are the interests of the people who buy it, and can we address that need in another way? Can we change that behaviour through other priorities they have?

Or can we encourage them to consider our own concern – biodiversity – in their decisions to buy ivory? And which method for influencing their behaviour will be the most effective? Hopefully this will lead to tangible products.” Tromp doesn’t believe that public information campaigns are helpful. “By itself, awareness of the need for sustainability won’t lead to behavioural change in this case either. We all think it’s important, but that’s about as far as it goes. We need to provide the infrastructure that will support behaviour change”, says Tromp.

The time factor

What stops us from doing the right thing, even when we know better? According to Tromp, the time factor plays an important role. “If there’s uncertainty about the consequences of your behaviour in the long term, it doesn’t really motivate you to change. You don’t know for certain whether smoking will affect your health in the future, and if you light a cigarette now, you enjoy it. You need to weigh up the short-term gain from doing something now against a potential long-term gain from not doing it. Take another example: If we want improve the way in which people work together in the department, we organise an informal teambuilding day. The effect is immediate. But we could also change the walk route at work so that we pass each other’s desks more often and have more contact. In the long term you’ll notice that people tend to go and talk to each other more often. The effect is much more subtle, and therefore not always as popular, but it’s probably more long-lasting”. But perseverance is rewarded, with the help of products designed by Tromp or otherwise. “The things that make us happier as a society are often the things that make us happier in the long term as individuals.”

Edward Valstar

‘On my own I would achieve nothing’

Professor Edward Valstar carries out research into mechanical loosening of artificial hips and knees, his aim being to create prostheses that last a lifetime. In late 2012, he was appointed Antoni van Leeuwenhoek Professor in Delft. Originally a mechanical engineer, he divides his time between Leiden University Medical Center (LUMC) and TU Delft, where he works in the Biomechanics department. He also heads the Biomechanics and Imaging Group (BIG) in the Orthopaedics department of the LUMC.

Standing on the shoulders of giants. It is an oft-used metaphor to describe how scientific successes would not be possible without work previously carried out by other scientists. Edward Valstar, too, praises the contributions of his predecessors and colleagues towards his work, but in his case the shoulder has actually played a physical part in his career. His graduation project was on Frans van der Helm, Gijs Pronk, and Henk Stassen’s well-known muscle and skeletal model of the shoulder. For this, he worked on an x-ray/video project in Leiden. “I was carrying out tests with a few other students, when a Leiden professor of orthopaedics asked who would like to stay for three months in order to help develop software. The labour market for mechanical engineers was very bad in 1993, so I thought it would at least be a good chance to get some experience. That was twenty years ago.”

As the years passed, his interest moved from the shoulder to the hip and the knee, the places where artificial joints can be implanted. A significant development in those twenty years is that of Roentgen Stereophotogrammetric Analyse (RSA), a technique for showing in 3D to the last micrometre whether artificial joints are moving in relation to the bone. That is crucial because early migration of artificial joints is a clear sign of future failure. “Three-quarters of artificial joints that have to be replaced work themselves loose”, explains Valstar. Around ten per cent of hip implants fail within a year. That might not seem very many, but given that 2.5 million joint implants are made each year worldwide, the number of failures in absolute terms is very high. Moreover, the number of operations is expected to rise to around 7.5 million in the years to come, given that we are all living longer and getting heavier.

Quicksand

So there are many failures, and therefore a great deal of human misery as well, even though hip replacements are intended to eradicate pain. “Artificial joints are often implanted to improve the quality of people’s lives. The elderly experience a lot of pain; having an artificial joint often frees them from that pain and they can function better. It is one of the most successful forms of medical intervention”, says Valstar. The exception, of course, is with that ten per cent. “If the prosthesis starts to move, a layer of fibrous tissue is created, a kind of quicksand. This leads to problems and the thicker the layer becomes, the worse things get. At present, we can only resolve this by removing the artificial joint, so the best thing is to keep the first artificial joint in place for as long as possible.”

Some of that misery is caused by poor implants; Valstar believes this is the result of too little regulation of new products. “Getting implants onto the market is currently rather disorganised. The pharmaceutical industry, by contrast, is very heavily regulated. With artificial joints, there is sometimes some preclinical research, but not always. Once they have been introduced there is no consistent monitoring of what happens afterwards, which is why you sometimes get disasters on the market”. One such disaster was the

‘Let us make the procedures for new implants as strict as they are for new medications’

so-called resurfacing hip, a metal-on-metal prosthesis intended for young people. The best artificial hip joints actually consist of a metal head and a plastic socket. “Prostheses can also work themselves loose as a result of the wear and tear of the materials. The idea was that the metal-on-metal would lead to less wear and tear. However, although the metal ions that were released were less in terms of volume than in the case of other types of artificial joints, they did cause serious tissue destruction outside the bone. That was already known from earlier metal-on-metal prostheses, but we don’t learn from the past”, says Valstar.

The RSA technique can help prevent this. Valstar refers to the data from a 1998 study into artificial knee joints, in which three different ways of securing the prosthesis in the bone were examined. “You can attach a joint in different ways. If you use a kind of bone cement, then it is attached immediately. You can also make the surface a bit rough, so that the bone grows into it. Or you can cover the joint with a layer of material containing calcium in order to accelerate the growth process. We monitored three groups of ten patients for two years, after which it appeared that the cement and the material containing calcium worked fine, but that the joints with the rough surface were loose.”

Valstar therefore advocates a phased market introduction of new prostheses, first via preclinical research followed by RSA research, and then a larger-scale study involving more patients. “With RSA, we can see after two years, and using ten patients, whether a particular option is the right one or not.” In fact, he would prefer to tackle the issue completely differently. “We know exactly what the five best performing artificial joints are; if we keep them on the market and stop innovating, we’ll be fine. But I am a realist. This is a worldwide industry worth billions.” He would also like to see an international database for registering every implant. The benefit of this has already been proved, believes Valstar. “They have been registering implants in Sweden since 1978 and they now have the lowest failure rate in the world.”

ISO standard

Valstar and his colleagues at the LUMC recently took a step in the right direction. They launched the initiative for an ISO standard for RSA research, and after three years of meetings with colleagues from all over the world, the standard is now a reality. “In the future, we will be able to compare the results from RSA studies much more effectively.” That should form the basis for a database. Valstar is also hoping for European regulation. “Artificial hips have not been the only prostheses to give problems. Just think of the recent scandal with the PIP breast implants. Let us make the procedures for new implants as strict as they are for new medications.”

As a young mechanical engineer, Valstar never imagined his work would be so closely linked to money and regulations. But he had always been interested in medicine. “I was a bit of a wimp, though – I could not stand the sight of blood”, he admits. “Then I discovered that research was being carried out in Henk Stassen’s man-machine interaction group that was closely related to orthopaedics and rehabilitation medicine.” That interest has always helped him bridge the gap between technology and medicine. Doctors and engineers each have their own language, is a frequently-heard problem. What does that involve in practice? Valstar gives a few examples. “Two colleagues in Leiden recently had an appointment with an orthopaedist. They were a bit early, and they just caught sight of him walking away. This was because he was on duty and had been called to the operating theatre. When he returned three-quarters of an hour later, they had already left as they thought he was not interested. On the other hand, an orthopaedist may not understand that an engineer cannot develop a new instrument in three weeks, but that it has to be first worked on by a graduating student for a year, and perhaps by another student after that. If you can discuss that kind of thing together, you learn to understand each other better.”

That is necessary, because cooperation between different fields is becoming increasingly commonplace. Fortunately, this is becoming more and more evident in education as well. In 2004, the Biomedical Engineering Master’s programme was launched, a broad-based programme that combines medical knowledge with specialised technical knowledge. Valstar was the

coordinator of the programme during its first few years. "How often does it happen that a new Master's programme starts up that really interests you? Over the space of three years, I got to know very many of my colleagues in Delft, Leiden, and Rotterdam." That was also the time when the foundations were laid for what is now known as Medical Delta, the working partnership between TU Delft and the university hospitals in Leiden and Rotterdam. In September 2014, Medical Delta will be launching a new Bachelors' programme in Clinical Technology. Graduates will be qualified to perform a number of medical interventions and will be the link – which currently does not exist – between patients, doctors, and technology. "That way, you teach people to speak the various languages while they're still studying, something that took me many years."

Even though he feels at home among engineers and doctors, he would not like to give up either of his places of work. "The demand for technology must come from the clinics. In Leiden, I might end up doing things too superficially due to pressure of time, whereas here in Delft I am not in a position to think of what is needed, but the people here know much more about things like steerable instruments and software development. That is why I do not work in Delft only, or Leiden only". The demand for people like himself, who know both worlds, is growing. Valstar sees other developments on the labour market too. "I think it is slowly becoming clear that we really do have to do something, and that you cannot allow an economy to run by shifting shares around and letting things increase in value in a virtual world. Personally, I try to make a real contribution through good-quality research. I notice that more and more young people feel the need to do something similar".

The Anna Prijs

He has certainly made that real contribution. For his research into the mechanical loosening of artificial joints, he received the Anna Prijs in 2011. This prize is awarded every two years by the Netherlands Orthopaedic Research and Education Fund to honour outstanding orthopaedic research involving the musculoskeletal system. It is an important award, but not a lifetime achievement award, as far as Valstar is concerned. He still has plenty of ideas for the future. "Instead of replacing the entire prosthesis, we would prefer to remove that fibrous tissue, and we want to develop steerable instruments for doing that." At present, joints that have worked themselves loose can be refitted with the help of bone cement, an intervention that spares primarily older patients from undergoing a major operation.

Another idea is that of biological repair. "What if we find cells in that fibrous tissue around the artificial joint that we can stimulate to create bone again? What substances do we need to reactivate that process in the cells? They have a better idea of that in Leiden and Rotterdam then we do in Delft. On the other hand, we know more about biomaterials and coatings. It may be that we can incorporate biological factors that are released," suggests Valstar. "In projects of this kind, all our knowledge comes together. This is why mutual cooperation is so important." And credit where credit is due – the idea for fitting prostheses came from Professor Rob Nelissen of the LUMC. "We are like Siamese twins in research", emphasises Valstar - joined at the hip, you could say. "Too many researchers are working in terms of competition. If I was working on my own, without a team, I would achieve nothing".

Tim de Morée and Wouter Lion

'It's all about the team'

In August 2013, the DUT Racing Team won the unofficial world championship on the track at Hockenheim, with their electric race car, the DUT 13. In September, the DUT Racing Team broke the world acceleration record for electric cars, with a 0-100 km/h time of just 2.134 seconds. A week before, the Human Power Team cycled its way to a world record in Nevada, with a speed of 133.78 kilometres per hour on their high-tech recumbent bike. Two students from the faculty of Aerospace Engineering, Tim de Morée and Wouter Lion, were the team managers when the world records were broken. Both students are keen to emphasise that they are speaking on behalf of their teams, however.

Team effort is very important to both of you. What does a team like that look like?

Tim de Morée: The DUT Racing Team now consists of 86 people. Five chiefs head as many departments, each of which is responsible for a specific vehicle component: the powertrain, the electronics, the chassis, the vehicle dynamics and the aerodynamics. We also have a team manager, a financial manager, a chief engineer and an operational manager. So in total our management team consists of nine people.

That is a huge organisation, and only one of them gets to sit behind the wheel?

De Morée: No, we have six drivers, because each race includes several different components. You need to use your lightest drivers for the acceleration test. Then you have the skid pad – the figure eights – along with the autocross and the endurance test. Because Formula Student is a student competition, all of the drivers must be enrolled at TU Delft. They are also members of the team and work on the construction of the car. Although it's obviously an honour to be allowed to drive, we look for those who are best suited. We do this on the go-kart track, and the ones who perform the best there are chosen to compete in a DUT car test drive.

How does it work in the Human Power Team?

Wouter Lion: It's quite different for us. We build the bicycle here with a team of fifteen people: ten from TU Delft and five from the VU University in Amsterdam. The construction process is actually separate from the person driving the bicycle. The chance of us finding the ideal cyclist at the university is virtually zero. The previous world record holder was a former professional cyclist from Canada. But we also split these two parts deliberately. We are still checking the bicycle up until the last minute. During the race, the cyclist shouldn't have to worry about whether that one bolt might not stay in place. The cyclist should assume that everything is working, and be able to trust the bicycle completely.

You both depend heavily on sponsorship. How do you arrange that?

Lion: It makes a nice opening line when you can say to a potential sponsor, "We make a bike that can go 130 kph". We can also show that we've had considerable media exposure, and this increases the success rate. I was usually the one who contacted for example innovation managers by telephone. Then if we were invited for an interview, I would take our chief engineer along for the technical details. We're not talking about small change here, because we have to send 15 people to Nevada, plus the materials. We aimed to have the sponsorships arranged by February, so we could meet the larger expenses. Once that was done, I focused on PR, which in our case was mostly keeping our sponsors happy.

De Morée: All of the managers participate in sponsorship acquisition.

Introducing: Tim de Morée en Wouter Lion

Wouter Lion: I attended the information days at several universities, but when I saw all the high-tech facilities at the faculty of Aerospace Engineering, I was sold. I am currently working on my Master's degree, after spending a year with the Human Power Team. Originally, I was going to be helping to build the monococque – the shell. Then I discovered that I enjoyed sponsorship acquisition as well and the team felt that I had the proper negotiating skills. So I ended up doing that. Soon, I was doing most of the non-technical jobs and, later, I even became the team leader. Right now, I am still not sure what direction I want to take after I graduate. Perhaps an internship will help me along the way.

Tim de Morée: I've always wanted to do something engineering-related, and Aerospace Engineering is a fine application. I still need to complete one Bachelor's course, but after that, I might like to pursue a Master's degree in Automotive Technology at TU Eindhoven. Through DUT, I have come into contact with all the major automotive companies, and it's an industry that appeals to me. I started with DUT two years ago, as part of a minor. I designed the DUT 12 steering system. Last year, I organised a large number of events such as our roll-out, but I also kept up my studies as normal. Now, I am dedicating another year to DUT as the team manager. I'm doing this because we won the championship last year, even though all kinds of things went wrong. An urge to improve has convinced my teammates and myself to design, build and race the perfect car this year.

Three quarters of our budget consists of sponsorship for materials. The chiefs are best suited to do this, because they know exactly what they are talking about. For example, for the past two years, we've been able to borrow an optical sensor that is also used in Formula 1. It is an extremely expensive sensor, which can actually read the road and determine the speeds in all directions. We use four-wheel drive, which means we can't use the wheels as a reference. We also used it for the world record, because acceleration is also pretty tricky to measure.

How does a race like that work?

De Morée: We've already started with the preparations for next year's races. We ask quite a few questions of the organisation, because some of the things we do are right on the edge of what the rulebook permits. Participants are always required to submit a report about their car and, a month in advance, they must submit a video to show that the car is actually operational. The actual event at Hockenheim lasts a week. Teams have to present their business plans and account for their cost analyses and designs to a jury. There are also dynamic events, such as the skid test and the autocross. Each of these events is held on a different day. There are always around 50 people who come along, and races like Hockenheim also attract some former team members. We can use all the help we can get, for the technical work as well as support. In all, 140 teams and 4.000 students participate. At the end there is a huge Award Ceremony, and an even larger closing party.

Lion: We participated in the World Human Power Speed Challenge in Nevada. Setting a world record requires a road that is long enough: eight kilometres, plus two kilometres to brake and, preferably, this should be a straight stretch. The road at Battle Mountain is also at an elevation of 1.5 kilometres. It's an ideal place, because the air pressure is lower, but not so low that it affects the driver's oxygen supply. This road is blocked off once a year, especially for this event. Various categories of bicycles compete, but what we do is the most exciting one. Other universities participate as well, so you are around several other groups, and you can goad each other on a little bit. One strange aspect is that we put our bike and all of our tools into a container and ship it to the USA two weeks in advance. So during those weeks you can't work on it.

And you succeeded. How does that feel?

Lion: Strange. The time-registration takes place at eight kilometres, and the finisher determines what your speed was. Of course you look at your own meter, but you don't know whether that agrees with the official speed. We had already bought champagne, however. It was the last evening, and there was a dinner party. The results were to be announced then. We knew that we had to drive 83 miles, so when we heard '3', everybody went crazy. We stayed up the whole night, gave interviews and let off fireworks in the desert.

And the acceleration record?

De Morée: That was also a Guinness record. That requires measuring with

‘We’ve already started with the preparations for next year’s races’

several different measuring instruments, and there must be eyewitnesses. We drove it with the DUT 12, which we had optimised just for this purpose. It was a cold, wet day, and so we started by using a gas torch to dry the lane and warm up the tyres. We knew that we were going to break the record, because our cars can easily go from 0 to 100 kilometres in 2.5 seconds, and the world record was 2.68. We had trained Marly Kuipers to drive, because she was the lightest member of the team. It was a nice record to get. It was posted on technology websites all over the world; we received pingbacks from all the way to China. We even made the Discovery Channel in Canada.

Did the cycling record receive this much attention?

Lion: It was Sunday morning, so in many media we made the news on Monday. We had focused our press releases on the Netherlands, but we gradually became world news in the course of the week. We also received invitations from Dutch talk shows, but we stayed in the USA for another week. After that week the novelty factor had worn off a bit, but we did make it onto RTL Late Night, which was a great experience.

2013 was a record year. What can you do to follow that?

Lion: The problem is that, after a highlight, you tend to fade away again in the media. We want to keep our sponsors happy, and so we have set a second goal for this year. There is also a world time record in Germany, which takes place a few months before the sprinting records. We participated in this as well, but largely in order to test our bike and fine-tune everything. The trial is held on a nice long road on which you can drive quite fast. The team is making a concerted effort to win it this year, although I’m no longer involved.

De Morée: We want to keep what we’re going to do under wraps as much as possible, because we are going to be doing some unexpected things. ETH Zurich is our biggest competitor, and they have a much bigger budget. If we were to publish our choices now, I’m sure they would manage to find funding to do the same. Through the years, we have followed roughly the same line of development. We both now use four-wheel drive, assisted by wings to create downwards force in the curves. The general perception was that the major innovations are behind us. Now we think that we have hit on a new one, though. At any rate, we will certainly be continuing with the four-wheel drive. It allows you to recover much more energy when braking, and it provides much more power. We’ve developed our own control system that allows us to adapt the speed of each wheel individually at every turn. When it’s raining, we’re virtually unbeatable.

More on the teams:

dutracing.tudelft.nl
hptdelft.nl

DreamTeams

They’re called DreamTeams – the student teams from TU Delft that continually deliver outstanding performance. The Solarboat, the Wasub submarine, the Ecorunner, the Nuna solar car: all of these extraordinary projects have been designed for, and especially by, students, and TU Delft is happy to lend a helping hand. That is why the DreamTeams have access to their own D:Dream Hall on the campus. The D:Dream Hall is an enormous area with workshops, machinery and a proper kitchen for all-nighters. Being part of a DreamTeam takes time. Some students contribute their free time, while others put their studies on hold for a year. It is also possible to take a D:Dream minor – if you are accepted, that is, because these performance-oriented teams set the bar pretty high. TU Delft is very proud of its DreamTeams, because they achieve something that is even more important than racing victories and world records. In these teams, students learn the difference between theory, which can be pretty tough at times, and practice in all its obduracy. They offer a unique opportunity for emerging engineers to get their hands dirty.

Colophon

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