Faculty of Technology, Policy and Management

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Values in water

TU Delft

Inaugural address 16 november 2018

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Spoken in acceptance of the chair ‘Ethics of water engineering’
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by

Prof. dr. mr. ir. N. Doorn

Mijnheer de Rector Magnificus, leden van het College van Bestuur,
collega-hoogleraren en andere leden van de universitaire gemeenschap.
Zeer gewaardeerde toehoorders, dames en heren, Ladies and gentlemen,

"The storm surge barrier is closed. The Delta Works are complete. Zeeland is safe."

These were the words spoken by Queen Beatrix at the completion ceremony for the Eastern Scheldt Barrier (Oosterscheldekering) in 1986 (Figure 1). Even then, there was a realisation that the Delta Plan was not completely finished – plans were already being developed for the Maeslant Barrier (Maeslantkering) to seal off the Nieuwe Waterweg near Hook of Holland and so also protect the inhabitants of Zuid-Holland against flooding from the North Sea. But after that the Dutch sea defences really would be complete. At about the same time, floods in Bangladesh were regularly in the news: in 1988 three-quarters of the capital, Dhaka, and 60 per cent of the rest of country were inundated (Peters, 1997; see also Figure 2). It was against that background of major construction projects being completed at home, whilst abroad huge water-related challenges remained, that I decided to study Civil Engineering at Delft University of Technology.

Figure 1: Completion Eastern Scheldt Barrier (Credit: Rijkswaterstaat).

Feiten & Meningen

Dijken rampzalig voor Bangladesh

Bij de watersnoodramp die Zeeland in 1953 teisterde, verloren 1.835 mensen het leven. Hoge dijken en stormvloedkering (Deltawerken) maken het zo goed als onmogelijk dat een dergelijke ramp zich nogmaals voltrekt. In Bangladesh vonden in 1991 ongeveer 150.000 mensen de dood bij een door een cycloon veroorzaakte vloedgolf. Enkele jaren daarvoor maakten enorme overstromingen duizenden slachtoffers. Westerse donorlanden en VN-organisaties zien ook voor Bangladesh de oplossing in dijken en waterbeheersing. Zij lieten een plan maken dat in 1991 werd gepresenteerd als het *Flood Action Plan* (FAP). Tegenstander van het FAP — waaraan ook Nederland bijdraagt — vrezen echter veel grotere rampen als het water in Bangladesh wordt ingetoomd.

Nederlands project gaat hoe dan ook door

Honderden doden en enorme schade

Natuurramp treft weer Bangladesh

DHAKA (GPD) – Bangladesh is opnieuw door een ramp getroffen. Honderden mensen kwamen volgens de Bengalese autoriteiten gisteren om het leven tijdens een orkaan. „De ergste die Bangladesh ooit heeft meegemaakt", aldus de directeur Chowdhury van het Bengalese weerkundig instituut.

Windstoten met een snelheid van 170 km per uur trokken een spoor van vernieling in de zuidwestelijke kustgebieden en op de dichtbevolkte eilanden.

Duizenden mensen, die in de verafgelegen getroffen gebieden zijn gestrand, moeten worden geëvacueerd. Maar de overheid beschikt niet over de middelen voor een massale evacuatie, aldus het

waarschuwd via de radio, dieper het land in waren getrokken. Ook in de hoofdstad Dakha heeft de orkaan verwoestingen aangericht.

Twee maanden geleden kwam tweederde van het land onder water te staan door overstromingen, die werden bestempeld als de ergste sinds mensenheugenis. Duizenden mensen kwamen om het leven, terwijl miljoenen anderen dakloos werden. Een groot deel van de oogst en van de voorraden werden door het water vernietigd.

Na de overstromingen viel er over het land een periode van droogte, die een ernstig gebrek aan drinkwater veroorzaakte, vooral in de kustgebieden.

Ook de Oostindische deelstaat West-Bengalen werd getroffen. Er kwamen zeker 13 mensen om. Ettelijke duizenden runderen verdronken in 8 meter hoge vloedgolf die op de tropische storm volgde. Een groot aantal hutten en huizen werd vernield terwijl de oogst als verloren moet worden beschouwd.

Mensen in nood, Memisa, het Nederlandse Rode Kruis, Novib-/Gast aan tafel, Stichting Oecumenische Hulp, Terre des Hommes en Unicef hebben besloten gezamenlijk een actie te voeren voor hulp aan slachtoffers in Bangladesh. Daarvoor is het gironummer 800800 in Den Haag opengesteld.

BANGLADESH
GIRO 800800. DEN HAAG

Mensen in Nood, Memisa, Novib/Gast aan Tafel, Het Nederlandse Rode Kruis, Stichting Oecumenische Hulp, Terre des Hommes, UNICEF. Secretariaat: Hekelaan 6, Den Bosch

Figure 2: Newspaper articles from 1988 about Bangladesh floods.

At the start of my studies, I soon learned that flooding as a subject is not easy to delineate. For a year, some fellow students and I were allowed to sink our teeth into a major project. I opted to focus on Bangladesh, but where I had hoped to design an Eastern Scheldt-style barrier for the Brahmaputra I was told that we would be dealing primarily with an issue of distribution. Stopping commercial forestry activities upstream, I discovered, could be far more significant in preventing floods downstream than building a large, prestigious piece of infrastructure.

It was this revelation which first interested me in the interface between ethics and technology. In the next half hour, I shall introduce the plans I have formulated for my professorship. I start with the social context in which I am taking up my new appointment (Section 1), revealing in the process that many challenges in the world of water have an ethical component. I then link the remit of my chair and the type of problems upon which I intend to focus with a research agenda (Section 2), before describing the people with whom I collaborate in shaping that agenda (Section 3). Finally, I would like to share my reflections concerning education at the university and the faculty (Section 4).

1. Context

Since my student days in the 1990s, the context in which water professionals work has altered considerably – not least as a result of climate change. The Intergovernmental Panel for Climate Change (IPCC) published its first report in 1990. It still wrote in terms of "probable" and "possible", and even stated that it was unlikely that a strengthening of the greenhouse effect would be established indisputably on the basis of observations within the following ten years, or even further ahead (Houghton, Jenkins, & Ephraums, 1990: p. xxix).

We are now more than 25 years further on. Climate change has become one of the subjects no right-minded scientist or politician dares to question. The fifth IPCC report, published in 2014, states that "[It is] virtually certain that global mean sea level rise will continue for many centuries beyond 2100" (IPCC, 2014: p. 16). And it declares, with a "very high degree of confidence", that both ecological systems and people are very vulnerable to climate-related events such as heat waves, droughts and floods.

Not only is climate change causing considerable water-related problems, but it is now apparent that these affect some groups much more than others and that, as temperature rises continue, the differences are only going to be exacerbated (Field et al., 2014; pp. 61-62).

Also due to climate change, many of the water challenges we face today are far more complex than we have seen in the past. Where we used to say that problems associated with water were a question of either too much, too little or too dirty, we are now seeing more and more how all three aspects are intertwined and how solutions to them can conflict with each other. A good example of this is found in the most recent annual report from Rijkswaterstaat, the Dutch national public works agency, on the EU Water Framework Directive (RWS, 2017). The report warns that many measures designed to reduce the risk of flooding negatively impact water quality (Figure 3). This summer, the newspapers were also full of such concerns.

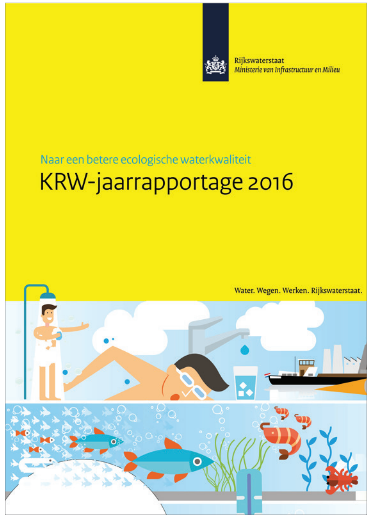

Figure 3: Annual report about Water Framework Directive 2016.

Another aspect of the context in which water issues play out is the changing relationship between government and citizens. In the Netherlands we are used to the government assuming a caring role when it comes to water policy. But that is going to change. Due in part to technological developments, people are now expected to be more and more self-reliant (cf. Bichard & Kazmierczak, 2012; Johnson & Priest, 2008; Nye, Tapsell, & Twigger-Ross, 2011). This raises a question, however: how far we can go down that particular road? For example, our constitution states that the government has a responsibility to provide a liveable environment. Where does that governmental responsibility end and personal responsibility begin? It is significant in this respect that the Organisation for Economic Co-operation and Development specifically mentions lack of 'water awareness' amongst the public as one of the biggest challenges for Dutch policy in this field (OECD, 2014).

These issues around water are not merely technological in nature, but also ethical. They are about the trade-off between different functions of water, about the division of responsibilities and about collective versus individual interests. I am proud that TU Delft recognises the urgency of these issues and has appointed me as Professor Ethics of Water Engineering, the first chair in the world devoted specifically to the ethical aspects of water management and technology.

2. Chair

My chair's remit brings together two facets of my academic background: water engineering as the domain on which I focus and ethics as the lens through which I study water-related issues.

2.1 Water engineering

What does that actually mean, *water engineering*? First, it is about systems. This means that we are not dealing simply with one isolated technical component, but with a system comprising various interacting components. Local interventions in the water system affect the rest of that system, or other systems: the energy system or the food system, for instance. Another complicating factor is that water systems often cross borders. Figure 4.a shows a photograph taken near Nijmegen in January 2018. The water level in the River Waal was exceptionally high at the time, 11.9 metres above the Amsterdam Ordnance Datum, due to heavy rainfall far further upstream, in Switzerland and Germany. The irony is that, as I was preparing this lecture, most rivers in the Netherlands were struggling with extremely low water levels. Figure 4.b is a photograph of the same location taken at the end of October 2018. The level of the river then was just 4.3 metres above the Amsterdam Ordnance Datum, almost 8 metres lower than in January.

a *b*

Figure 4: Water level in the River Waal near Nijmegen on 10 January 2018 (a) and on 28 October 2018 (b)

The second characteristic of water engineering is that its systems have both a material and a non-material side, making them what we call sociotechnical systems (De Bruijn & Herder, 2009). By that material side, we mean the physical objects involved. In the context of water, these physical are often most obvious. The Eastern Scheldt Barrier I mentioned earlier is unmistakably a physical object. When closed, it prevents water flowing into the estuary from the sea, and vice versa. However, water engineering also has a non-material side, a human side. This includes the institutions, and the people, who determine when the barrier has to be closed. Sometimes, human action is also required to implement this. To understand properly how the system works, it is important to look at both aspects (Kroes, Franssen, Van de Poel, & Ottens, 2006). For instance, people may act with particular intentions and these do not necessarily mirror the logic or rationality of the physical system. My colleagues in the Safety Science department, for example, conduct research into the cybersecurity of infrastructures and the question of how the software systems operating flood defences could be hacked (Chockalingam, Hadžiosmanović, Pieters, Teixeira, & van Gelder, 2017). This shows that the safety of a flood barrier is about more than just how robust its physical structure is.

To summarise, when we look at water we are dealing with systems with both a human and a material side and these systems often interact with other vital systems and in many cases cross geographical boundaries as well.

2.2 Ethical questions in water engineering

Now to the second part of my chair: the ethical issues involved in water engineering. For me, these have two clear components: a 'what', in the sense of what values are incorporated into the system, and a 'who', as in who should make choices in water policy and who is affected by them.

Value considerations in the water domain

First the 'what'. I mentioned earlier the example of the evaluation by Rijkswaterstaat of the Water Framework Directive and the concern that measures designed to tackle water quantity can sometimes have a detrimental effect upon its quality. If these two considerations clash, how do we decide which should take precedence? Needless to say, this question cannot be answered without looking in more detail at the role water plays in our society. In the terminology of of ecological economics, we are referring here to 'ecosystem services' (MEA, 2005). The idea behind this notion is that the water system offers different services or functions. Economists generally use the former term, 'services', whereas engineers prefer to say 'functions', but they actually mean more or less the same thing. For example, water can be drunk by humans or used as coolant in a factory (Gleick, 1994), an area of water can serve as urban cooling in situations of heat waves (Ghosh & Das, 2018), or water can even provide a non-material service as we see in certain religious rituals (Pradhan & Meinzen-Dick, 2010).

One common way to make a trade-off between conflicting services is to express everything in one outcome measure – this can be money, but does not have to

be – and then look for the highest value. In other words, seek to maximise the outcome. This raises a number of questions, however. First, can all services really be expressed in the same measure? From an ethical point of view, we can justifiably say that the values these services might represent – safety, health, ecology, the future availability of water sources – are incommensurable. That is, they cannot be expressed by the same standard of measurement (Chang, 1997).

A second question to arise when using a single unit in maximisation is whether this means we are overlooking important considerations in decision-making. Is it not much more important to maintain flexibility, or to prevent irreversible consequences such as the loss of unique ecosystems (Doorn, 2018)? In water policy especially, we sometimes already find ourselves forced to devise solutions along certain lines because in the past such factors as reversibility have not been factored in (Saeijs, Smits, Overmars, & Willems, 2004).

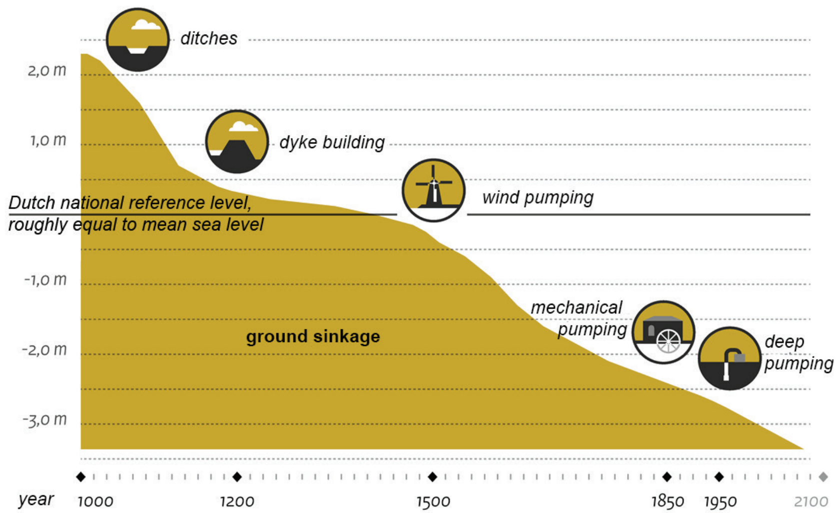

Figure 5: Ground sinkage through peat drainage (Source: Hollands Nooderkwartier/PBL 2016).

One well-known example of this is ground sinkage in the Dutch peatlands (Figure 5). Originally, we started draining these peatlands to make them suitable for agriculture. As a result, the soil began to settle and so had to be drained even more in order to further lower the groundwater level and keep the land manageable. The upshot of this is that we have ended up in a sort of drainage spiral, which is now too hard to break out of even though it degrades vegetation and local biodiversity (PBL, 2016).

We therefore need to look for other ways to deal with such value conflicts – approaches which do not require us to express everything by the same measure and into which we can also incorporate considerations in decision-making other than maximisation.

Thinking about conflicting values and means of finding a trade-off between them is one of the most important topics within the ethics of technology. I will discuss three – not mutually exclusive – approaches to dealing with value conflicts (Doorn, 2020), each with a basis in contemporary philosophy.

The first is to look for technical solutions designed explicitly to take different values into account. I realise that this may sound trivial, but in the past solutions were frequently designed solely with one primary function in mind – flood protection, for example. Often this was at the expense of the environment, with at most some effort to limit adverse ecological effects.

If we look at water-related problems from an ethical perspective, we can use value conflicts also as a reason to come up with better design solutions, in the sense that we look for a design which scores well on multiple functions or makes a positive contribution to multiple values. This can make value conflicts an incentive for innovation. This is also the idea behind projects undertaken in the context of the European *Responsible Research and Innovation* programme or the Dutch *Maatschappelijk Verantwoord Innoveren* programme (Van den Hoven, Doorn, Koops, Romijn, & Swierstra, 2014), programmes with an ethical basis, as well as technologically-based initiatives such as the Dutch programme *Building with Nature* (De Vriend, Van Koningsveld, & Aarninkhof, 2014).

An example of a Building with Nature project is the Sand Motor, an artificial sandbank constructed off the coast near Ter Heijde in the province of Zuid-Holland (Figure 6). Designed to make a positive contribution to coastal defence as well as to ecology, biodiversity and recreation, the Sand Motor has multifunctionality within the water system as the explicit basis of its design. I think it is wonderful that Delft engineers are playing a leading role in this approach. But even if you solve a value conflict primarily through technological innovation, this approach always requires normative choices: for example, deciding which values are important and when we can say that a technical design safeguards them in an effective way.

Figure 6: Sand motor (Credit: Rijkswaterstaat / Jurriaan Brobbel).

A second way of dealing with value conflicts touches on policy analysis. This approach focuses upon the question of how to structure a trade-off problem methodologically – for example, in the models which underlie policy. So, for instance, we can try to develop methods which, rather than seeking to maximise total outcome, instead offer the possibility to see how a design scores on individual criteria or components. In so doing, we can introduce thresholds for each of these separate parts or include reversibility as a precondition. One example of such a method is many-objective optimisation (Kasprzyk, Reed, & Hadka, 2016), which optimises various independent criteria. Using many objective optimisation allows us to include a much wider range of considerations, which may turn out better in the long term.

Finally, we can also look at value considerations in a more procedural way. How should the decision-making process be set up in order to arrive at a justified outcome (Doorn, 2016b)? As far as technical issues are concerned, including those involving water, these procedural aspects of decision making were rather neglected until quite recently (Pesch, Bombaerts, Huijts, Doorn, & Hunka, forthcoming). But interventions in the water system often have a major spatial impact and we almost always have to make a trade-off between collective and individual interests. It is therefore very important that this process be conducted with care. Again, values play a role here, such as transparency, impartiality and democracy. These must be properly safeguarded from a procedural point of view. The problems surrounding gas extraction in Groningen show what happens when this procedural aspect is ignored. Partly because of a lack of transparency in the decision-making process and alleged bias in the settlement of claims, a situation arose in which residents no longer had trust in the government (Mouter, De Geest, & Doorn, 2018).

To summarise, I have just described three approaches: multifunctionality in design, many-objective optimisation and greater attention to procedural aspects. In the end, each of these requires a combination of empirical and normative research. Normative research because the question of which values are important is ultimately about how we want to design our society (Adger et al., 2009). And whether we are looking at the values to be incorporated in the final design of the physical system or at decision-making, all the approaches discussed pose this normative question. Meanwhile, it takes empirical research to gain a better understanding both of the ethical implications of different design solutions and of how ethically relevant choices are continually made in the design process. If we talk about values in the water system purely in abstract terms, these aspects remain invisible (Doorn & Taebi, 2018).

Resilience

Now for the 'who', by which I mean 'who is affected' and 'who should and can act'. I want to use the concept of resilience to explain this 'who'.

In recent years, and certainly with regard to climate change, we have seen increasing calls for resilience. The national Delta Programme says it wants to ensure that our country has "the resilience to continue dealing with the increasing climate extremes" (Deltacommissaris, 2016: p. 9) while, in a design study for a 'climate-proof Netherlands', the Netherlands Environmental Assessment Agency (PBL) talks of resilience as the ideal way of "learning to deal better with uncertainties" (PBL, 2012: p. 9). In EU circles, too, resilience is put forward as the best way to implement climate adaptation.[1]

The term 'resilience' in this context is often linked to its ecological definition (cf. Folke, 2006; Adger, 2000); that is, the ability of an ecosystem to recover and adapt after a change. This is an emergent property, an ability derived from the composition of the system as a whole, with all its separate components (Walker et al., 2006). Because we are not talking here about a *targeted response* to an already *known* type of hazard, a resilient ecosystem is also very flexible. It is able to fend off various kinds of threat.

[1] For the EU Adaptation Strategy, see https://ec.europa.eu/clima/policies/adaptation/what_en#tab-0-1.

Certainly up until the 1960s, this notion of ecological resilience was diametrically opposed to engineers' prevailing train of thought (Holling, 1973). By the early years of this century, however, also engineers had developed a real enthusiasm for resilience (Doorn, Gardoni, & Murphy, forthcoming). Resilience had come to be seen as a promising alternative to traditional approaches in safety science, which often looked quite mechanistically at disasters and incidents. According to the critics, it was precisely this mechanistic approach which left systems only able to withstand one specific hazard (Hollnagel, 2014). With the introduction of a resilience-based approach to safety science, the emphasis has shifted to flexibility and learning ability, enabling systems to deal much better with unexpected threats.

So that it is what resilience means in ecology and safety science. But what about resilience in the context of water and climate? As already mentioned, in the face of water and climate risks, we often hear calls these days for greater resilience. Hence the notion of *climate-resilient cities* (Prasad et al., 2009), for example, or w*ater-resilient cities* (Herslund et al., 2017). Since resilience supposedly allows us to deal with unexpected events, it is understandable that it is mentioned frequently in this context. When we talk about water and climate risks, after all, in many cases we do not know their exact scale, where precisely they come from or in what combination. Climate change is making the weather more unpredictable, with more extreme events. To cite just one example, on 23 June 2016 a total of 45 mm of rain fell in the city of Delft (KNMI, 2018). That is the same amount as in the entire month of June the following year. In short, nowadays it is impossible to tell in advance whether a 'typical' June will leave us facing heavy rainfall or drought.

If we view resilience primarily as an ability to deal with uncertainties and unexpected shocks, then its pursuit in the context of water and climate sounds very plausible. But as I explained earlier, we are dealing here with socio-technical systems; that is, systems which include people. So what exactly does resilience mean for the people involved?

Analogous with its ecological definition, we can interpret resilience in these domains as an approach in which everyone plays their part, albeit in different ways, so that together we are able to deal with all the unexpected climate and water risks. But is everyone capable of doing this? If a resilient city involves individual citizens having to do more while the government withdraws, this could result in the emergence of undesirable inequalities.

a

b

Figure 7: Swimming pool (a) and Truus Mastpark (b) in Altrade neighbourhood of Nijmegen (Credit picture of swimming pool: Fred van der Burgt).

By way of illustration, I would like to tell you about the Truus Mastpark in the Altrade neighbourhood of Nijmegen. People familiar with Nijmegen will know that this is a neighbourhood with a relatively highly-qualified population. Figure 7.a shows the old situation, when there was a swimming pool on the site. After that was demolished, it was originally intended that the site would be built on. Thanks to an active community association, however, local residents managed to change the plot's designated use to one of 'green space'. So instead of being handed over to a property developer, it became a park (Figure 7.b). It helped that relevant planning and legal knowledge was available within the community, so that a well-documented appeal could be submitted at just the right time. The residents also knew their way around the municipal subsidy landscape. The resulting park certainly helps to make the neighbourhood more climate-proof, and it also fits in with a resilience-based approach: in times of heavy rain it acts as good buffer so that water is able to drain away properly, whilst during heat waves it has a cooling effect. All in all, it has made the area even more pleasant to live in than it already was, not only in terms of climate-proofing but by also providing an informal meeting place which often hosts cultural activities. In this case, then, we see that the social cohesion needed to develop the park in the first place has also been strengthened by it.

Looked at in this way, the park is a great success *in this neighbourhood.* While it is tempting to try to translate local success stories to other situations, especially when they involve idealistic concepts like autonomy and community initiative, it is also important to study the specific conditions which help determine their success in their particular circumstances. It is by no means self-evident that an initiative of the kind which resulted in Truus Mastpark would have taken off in the same way in another neighbourhood. If a local authority relies primarily upon the capabilities and organising abilities of residents on the ground to implement climate policy, then some districts may well come out of the process worse off than others. Before residents are given greater responsibility for their own neighbourhoods, it is therefore important to check that the conditions are right – and, if they are not, to create those conditions first.

In short, a resilience-based approach raises questions about who should act and who benefits (Meerow, Newell, & Stults, 2016), about who is given the responsibility or space needed to do so (Hegger, Mees, Driessen, & Runhaar, 2017) and about what those involved are actually capable of (Doorn, 2016a). If these 'who' questions are not properly considered, the approach can create undesirable inequalities and maintain or even strengthen existing vulnerabilities (Béné et al. 2017; Davoudi, 2012; Doorn, 2017).

3. Collaboration

So far, I have outlined a research agenda. Now I would like to mention the projects through which I am shaping this research agenda and with whom I am working on them. After all, as every researcher knows, plans are not created in vacuum and certainly never originate in the mind of one person.

In the *Values4Water* project,[2] we are looking for methods to ensure better public participation in decision-making around water projects. Specifically, we are focusing upon the role played in this by values – for example, ecology as a value in the problem of medicine residues in waste water (Pigmans, Doorn, Aldewereld, & Dignum, 2017).

In the *Frugal Innovations and Responsible Entrepreneurship* project,[3] we are examining how inclusive business models can ensure that people in arid countries are able to access clean drinking water (Howell, Van Beers, & Doorn, 2018).

In the *Crowd-Based Innovations* project,[4] we are investigating how social innovations in the water, energy and logistical sectors entail a transition of responsibilities and how this impacts key public values (Cuppen, Klievink, & Doorn, forthcoming; Slot, Cuppen, Doorn, Galeano Galvan, & Klievink, 2017).

[2] I am working with Klara Pigmans, Virginia Dignum and Huib Aldewereld on the Values4Water project.
[3] I am working with Rachel Howell, Cees van Beers, Peter Knorringa, Elsie Onsongo and Haye Hazenberg on the Frugal Innovations and Responsible Entrepreneurship project.
[4] I am working with Thijs Slot, Maria Galeano Galvan, Eefje Cuppen and Bram Klievink on the Crowd-Based Innovations project

In the *IN-WOP* project,[5] we are going to look at how we in the water sector can use many-objective optimisation to achieve better allocation of water in situations of scarcity.

In the E*UReCA* project,[6] we will be further developing our ideas in respect of resilience and climate adaptation.

Over the next few years, I will also be able undertaking a great deal of research into resilience under the umbrella of the *4TU.Centre for Resilience Engineering* and the De*SIRE* project.[7]

In addition, I am glad that I also have the opportunity to collaborate in projects not specifically focusing upon water. For instance, my participation in the *Smart Energy Systems* project[8] allows me to gain a better understanding of the institutional side of the energy sector (Milchram, Van der Kaa, Doorn, & Künneke, 2018; Milchram, Van der Kaa, Hillerbrand, Doorn, & Künneke, 2018).

The *BRIDE* project[9] offers me an excellent insight into the 'design' side of resilience.

Finally, together with Niek Mouter I am focusing upon the question of how we can give the public voice a bigger say in the consideration of different policy options in water management.

[5] I am working with Jan Kwakkel and others on the IN-WOP project.
[6] I am working with Udo Pesch, Samantha Copeland, José Carlos Cañizares Gaztelu and Lieke Brackel on the EUReCA project.
[7] I am working with Tina Comes and others on the DeSIRE project.
[8] I am working with Christine Milchram, Rolf Künneke, Geerten van de Kaa and Rafaela Hillerbrand on the Capturing the Societal Value of Smart Energy Systems project.
[9] I am working with Kars Alfrink, Gerd Kortuem, Michael Nagenborg and others on the BRIDE project.

4. Education

From a mention of Niek Mouter, it is but a small step to the educational side of my remit. After all, much of the research we do arises out of our joint supervision of students.

Until last year, I was heavily involved as a member of the Ethics and Philosophy of Technology section in the service teaching of students from other faculties, most notably on ethics but also with methodology courses. It is an explicit wish of the Executive Board that all students at TU Delft, undergraduate and postgraduate alike, include an ethics component in their programme of study. That is essential to their formation as a *T-shaped* engineer: sufficiently broad in their general academic education, but also a fully-fledged specialist in their own field. This was a point reiterated at the opening of the current academic year, an event themed around superheroes, when Vice-Rector Mudde reminded students that "we expect you to have three important qualifications". Ethical awareness is one of that trio of 'superpowers' (Figure 8).

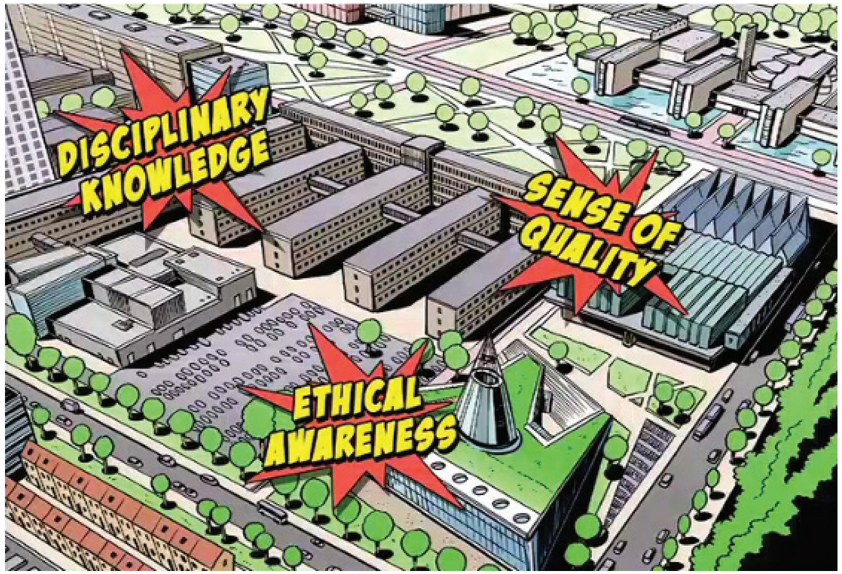

Figure 8: Presentation by professor Mudde during Opening Academic Year ceremony on 3 September 2018.

Currently, the breadth of the T-shaped profile sometimes has a magnetic effect. Why, people ask, should topics such as entrepreneurship or business administration not also be part of the curriculum for every engineer? In this respect, I think that we have to dare to make choices. After all, not every graduate launches a start-up or aspires to become a CEO. We need to be careful that broadening the profile does not come at the expense of its depth. And, in my view perhaps even more importantly, we have to ensure that students do not lose sight of the fact that the components making up the 'broad' part of the curriculum are still a core part of their programme of study.

This forces us to think about how to integrate such broadening into the curriculum, what content it should include and which courses we make mandatory for which students. Particularly in programmes with a strong monodisciplinary dimension, we may have to start thinking in terms of engineering profiles or roles: engineers with a research profile, with a design profile, with an entrepreneurial profile and so on. It would be great if we could tailor the courses to provide students with the necessary academic breadth to fit these profiles. To stay with the service teaching provided by my own section, we could, for example, introduce a course in Research Ethics for students with a research profile, while for the designer of the future there would be Design for Values, and for the aspiring entrepreneur Business Ethics. Choices require courage, but without them I am concerned that the courses adding breadth will lose their connection with the core of the programme.

Since I was made Director of Education in the Faculty of Technology, Policy and Management on 1 September this year, a lot of people have asked me about my personal vision on education. What I am going to do differently, what I want to improve. Gradually, I have noticed that I am having more and more difficulty with the question 'what should change?'. As Director of Education, I have now gained a far better insight into all those things which are going very well. I see committed students active in *Curius* or on one of the representative bodies, contributing actively to improving the quality of our teaching. I see an Education and Student Affairs Department which is keeping organisation of the educational process on the road under increasingly difficult circumstances. And I see programme directors making dedicated efforts to improve their curriculum. Sometimes, pursuing quality or excellence in education seems to be equated with emphasising what goes wrong: mistakes in the timetabling of rooms, students who register too late. Of course, such things do happen. But in my new role, what I see first and foremost is things going right. A lot of things. And I am not the only one: MIT recently named TU Delft as one of the institutions it wants to use as a benchmark (Graham, 2018).

I spoke earlier about resilience as a particular approach in safety science. One of the starting points of resilience engineering is that we should not so much

learn from mistakes as from things which go well, from successes (Doorn, 2019). By analogy, I would therefore like to see more of a resilience engineering mentality in our educational provision. Let us, too, try to learn from what is going well.

Learning from success stories does not mean resting on our laurels and becoming complacent. No, it means taking the trouble to drop in on lectures given by that member of staff whom students are so enthusiastic about and so trying find out the secret behind their success. It means coming to meetings at the *Teaching Lab* on topics like educational innovation. And it means really reflecting on why the chemistry with your students was so good at that one particular tutorial, and how you can repeat it at future sessions. As Director of Education, I hope to contribute towards an atmosphere in which we as lecturers want to – and dare to – learn from each other.

5. A word of thanks

I would like to conclude with a few words of thanks, even though it is impossible to name everyone to whom I owe my genuine gratitude.

In the first place, I would like to thank Theun Baller and Hans Wamelink for their trust in me. Theun was acting dean of our faculty when he initiated my appointment to this chair. Hans was dean when the process was completed a few months later. I must also thank the Executive Board for adding me to the Delft corps of professors and for my installation as an Antoni van Leeuwenhoek professor.

Within my own department, I would like to thank Ibo van de Poel and Sabine Roeser. I still remember coming to the two of you back in the spring of 2006 to enquire about possible PhD positions at the cutting edge of technology and philosophy. I could never have dreamt then that twelve-and-a-half years later I would have to come up with the words to thank you both in an inaugural lecture, never mind just how difficult it would be to do justice to everything you have done for me in the intervening years. You have supported me in my career in so many different ways; I can only hope that I will be able to do as much for others in the future.

Then there are my other colleagues, both within the section and in the rest of the faculty and the university, as well as those at the *4TU.Centre for Ethics and Technology*. I often say that it is easier to do stupid work with good colleagues than vice versa. I hope I have made it clear that my work is very enjoyable. And

I am enormously pleased that I do this enjoyable work with good and inspiring colleagues. Even though it is utterly impossible to mention everyone by name here, I have to give Nathalie van den Heuvel a personal mention. Thank you for all the support and backing you provide.

My address today is to accept not only the chair in the *Ethics of Water Engineering,* but also the teaching and research remit in *Humanism in Relation to Technology and Climate Change* from the Socrates Foundation. So my thanks also go to the Socrates Foundation. I look forward to a pleasant working relationship with the foundation, and in particular with the other Socrates professors.

Finally, my family. Dear Dad and Petra. I am always so happy and proud of what we have together. I just said how important it is to have good colleagues, but a great family is probably infinitely more important. Over the past year, I have realised just how important our relationship is, and people have probably heard me say, even more often than before, just how proud I am of you and of that relationship. And I include Mum in that!

Last of all, Mathilde. In the acknowledgements in my dissertation, I wrote that a thesis is probably the worst place to express what you mean to me. But now I think I was wrong. And I don't mean to say that an inaugural lecture is a slightly worse place, but more in the way philosophers can sometimes parry a question: the question of what makes a good place to express my gratitude to you is not the right question to be asking. On a day like today, it is just really fine to be able to end with a word of love. Thank you for what you mean to me.

I have spoken.

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