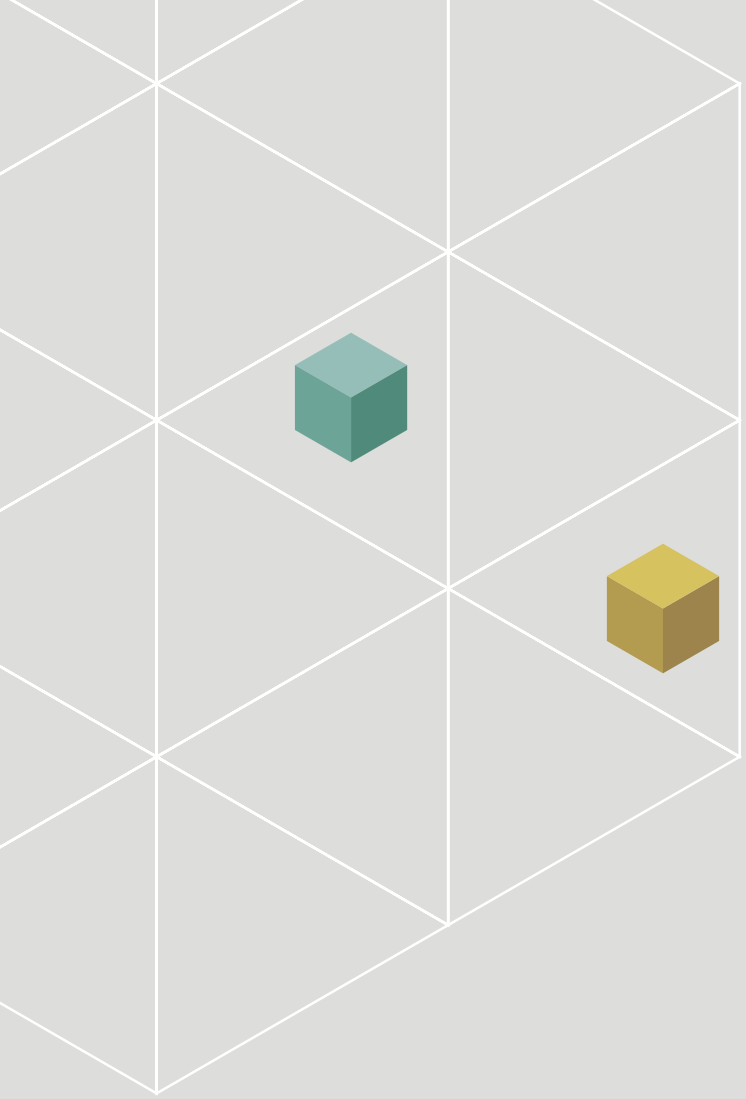

Engineer of the Future

envisioning higher engineering education in 2035

Renate Klaassen, Matthijs van Dijk, Roald Hoope and Aldert Kamp

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REFRAMING STUDIO

4TU. CENTRE FOR ENGINEERING EDUCATION

TU Delft

Colophon

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Authors
Renate Klaassen, Matthijs van Dijk, Roald Hoope and Aldert Kamp

Contributors
Daniëlle Ceulemans, Martin Jacobs and Maarten van der Sanden

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Autumn, 2019

In this report we have sketched the outlines of a 2035 future concept named the Personology Arena. We will now work on detailing it, on drawing up a long-term roadmap towards it, and on developing a new TU Delft Master programme as a first step. We warmly invite you to join us and become part of this project.

Contact
r.g.klaassen@tudelft.nl

Preface

The context in which engineers perform the act of engineering is changing in a rapid pace; information is increasingly accessibile, collaboration is ever more flexible and agile, the energy and mobility industry are experiencing ongoing transitions to name a few. Against this backdrop we are seeing an increased consciousness of societal issues and of the ethical implications of the engineer's actions. How do we prepare engineering education for this rapidly changing world?

In this report we will unfold our vision on the future of engineering education in 2035 and beyond. We will start with chapter 1 by introducing the innovation method we have used to make sense of this future context, and we will unfold the results in subsequent chapters according to the steps in this method. We have created an image of the future of engineering in the form of eleven driving forces, as described in chapter 2. We will show you how these driving forces relate to each other in chapter 3, and in this chapter we will present a framework revealing a variety of eight roles engineers have in this future context. In chapter 4 we will present the outlines of a future concept; a concept that enables these future behaviours and enables moving between them; a concept we have named the Personology Arena.

In the future concept, the Personology Arena, personal development and agency plays a fundamental role. We strongly believe that it is essential to enable future engineering 'technees'- so called to differentiate from the temporal and static associations that come with the denomination 'student' - to discover and familiarize themselves with the knowledge that underlies these future roles; to let them search out their own purpose and path and support them in making themselves useful to society in the future.

In chapter 5, we will describe the way forward; how we aim to continue this project in several directions, one of which is researching the possibilities of developing a new engineering master programme concept. We hope that you share our vision and will join us on this journey.

Aldert Kamp
Renate Klaassen
Matthijs van Dijk
Roald Hoope
Daniëlle Ceulemans
Martin Jacobs
Maarten van der Sanden

4TU.

4TU is an alliance between Delft University of Technology (TU Delft), Eindhoven University of Technology (TU/e), the University of Twente (UT) and Wageningen University & Research (WUR). Its main goals are to jointly innovate engineering education and share expertise on educational innovations.

4TU.CEE

4TU.CEE is the 4TU Centre for Engineering Education. The 4TU.CEE aims to gather, develop and implement up-to-date expertise in engineering education. (New) improvements in education are implemented and the effectiveness of these improvements is monitored and analysed. The expertise and experiences of all four partners is exchanged to benefit all partners.

free spirits
TU Delft/CEE Think Tank

The Free Spirits Think Tank was initiated by Aldert Kamp and Renate Klaassen at the TU Delft. It consists of academic staff from each faculty, students and members of the Valorisation Centre. The Think Tank started working in 2015 on outlining the future vision on engineering education in 2030. In 2018 this led to the involvement of Reframing Studio that was asked to join and elaborate on the results using their research approach.

REFRAMING STUDIO

Reframing Studio is a Dutch innovation consultancy best known for its innovative approach to (re)constructing the future and to anticipating societal transitions needed. Founding partner Matthijs van Dijk, who holds a Chair in Applied Design at Delft University of Technology developed the approach, known in Delft as the ViP method - vision in product-design - together with Paul Hekkert, who is full professor of Form Theory in Delft.

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Introduction

on reframing & the project

Reframing/ViP method

In the creative sector, design thinking is put forward as a promising strategy to transform businesses and realize (social) change. Design thinking refers to a set of typical designer skills as well as typical design tools and methods. One is Vision in Product design (ViP) method, which has been developed at the Delft University of Technology by Prof. Ir. Matthijs van Dijk together with Prof. dr. Paul Hekkert. Prof. Ir. Matthijs van Dijk is also a founding partner of Reframing Studio, an innovation consultancy with 25 years of experience in applying the ViP method - which they refer to as the Reframing process. The process is used to gain insights into future behaviour and to help organisations (commercial, public and non-governmental) to stay socially and/or economically relevant.

Human centered & context driven

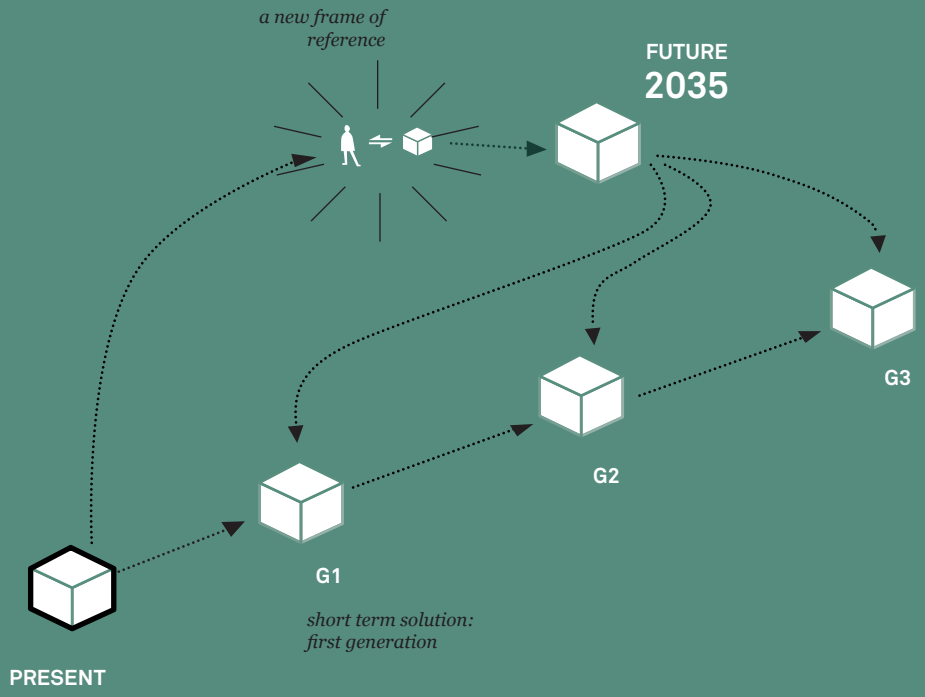
The premise underlying the method is that any design, whether it is a product, a service, or a complete system, is simply a means for people to relate to the world around them. Products and services enable people to experience things differently or to do things differently than they did before. A smartphone is meaningful because it allows people to stay in touch with their complete ICT needs remotely; a paperclip enables people to order and bundle documents with care. In other words, products and services only gain meaning according to the relations they make possible. However, to define what experiences and behaviours are meaningful to people, the future context first needs to be studied and mapped. Understanding the future is crucial since that is where the designed interventions will have to be meaningful.

Proactive & future-proof

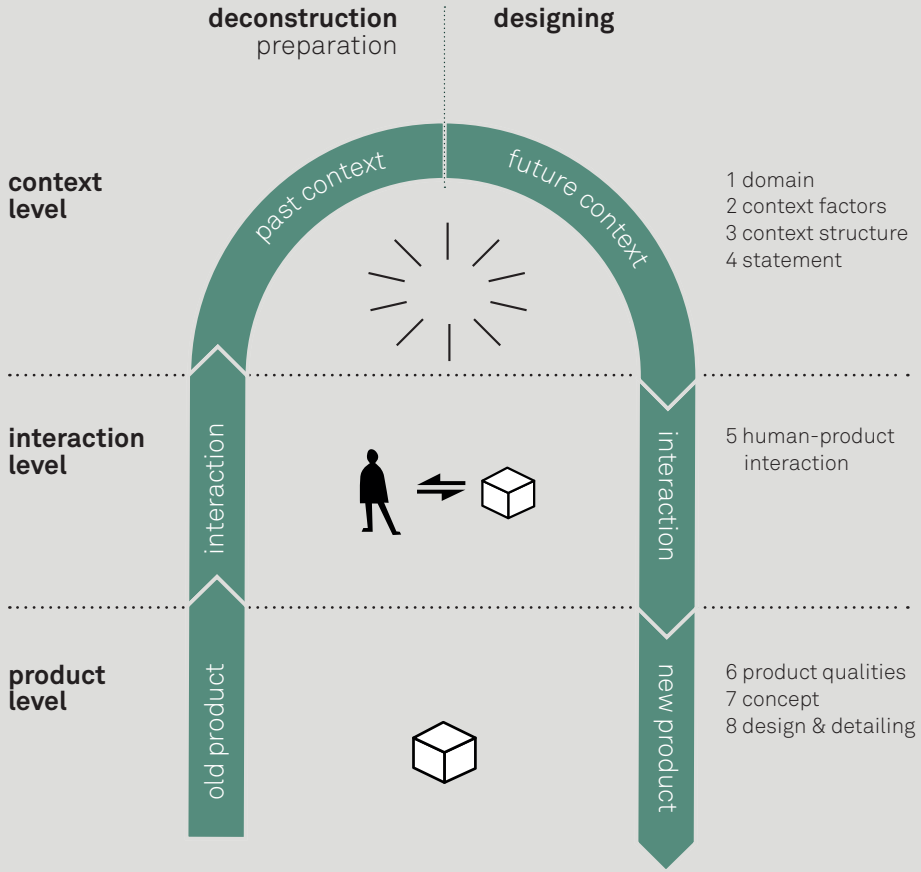
The development and implementation of a design, whether it is a product, a service, or a policy, takes time. What once appeared a brilliant idea may therefore be completely out-dated by the time it becomes reality. Our world is continuously changing. If we want our designs to have a reason to exist, we are forced to create an understanding of the design's future context first, to understand what issues will be at stake for the design by that time. This proactive attitude increases possibilities for innovation. It is quite common that innovation, or the urge to innovate, is a reaction to an undesirable or problematic situation. However, a 'problem frame' hardly ever provides the framework needed to design an innovative solution, and therefore easily leads only to incremental innovations. In fact, a reactive attitude implies controlling symptoms rather than understanding its cause. The reframing method helps organisations to reframe the situation to come up with genuinely new perspectives.

The reframing process goes through several phases and specific steps that provide a clear design trajectory for each project.

Future scope of reframing



Steps in reframing method



Project summary

The core of the project was divided into three phases 1) gathering context factors, 2) structuring the context and defining engineering roles and 3) concept design, in which qualitative specifications and ideas for the mid and long term future have been defined. Below each phase is explained in more detail.

Gathering context

Context factors were obtained in two ways. Ten interviews with influencers in the world of higher education, engineering and society have been held. Equally, several books have been read to explore these domains. These interviews and books resulted into a broad and well-balanced selection of context factors.

A matrix was developed to check the diversity of factors in fields and types (trends, developments, principles and states). Please refer to supplement B for more information on context factors. Over 200 factors were generated during these interviews. Secondly, the literature research added over 100 factors.

Structuring context and defining engineering roles

All factors are interrelated, making the context a complex web of interdependent factors. On the basis of 2 dedicated workshops with the design team, the collected factors, their importance, and their interrelations were clustered after which Reframing Studio turned them into a unified whole.

The emerging vision revealed 3 dimensions and 8 engineering roles that will drive engineers to engage with and contribute to society in 2035. These results were tested with stakeholders from the engineering field in a workshop during the Dutch Design Week 2017 and stakeholders within the institution in another 2 workshops. A total of 32 stakeholders were involved in 2017. And numerous others within and beyond TU Delft University contributed on an informal basis towards the results.

The participants discussed the newly revealed frame of reference in relation to (1) the relevance of the framework to their current job, (2) the ethical appropriateness to use this framework, (3) the strategic value of the framework for institutions and (4) the inspirational value of the framework to develop new educational systems. The framework was felt to be moderately to very relevant, of strategic value and of inspirational value. The ethical appropriateness proved to be more complex and should be addressed more thoroughly in the implementation phases of the design.

Concept design

The final concept design was realised in a small dedicated design team in which the qualitative specification through idea generation for the medium and long term future have been defined.

The way forward

The final results have been presented to the TU Delft Vice President for Education Rob Mudde. The framework has been positively received. The next step is to develop a master (pilot) to test the realisation of the concept. Alongside a team of researchers, a PhD and a think tank are exploring what it means to use the engineering roles in practice for:

a. the knowledge/skills of design and engineering processes
b. adaptive learning processes of engineering students
c. the structure of the educational organisation
d. accountability of education
e. the public-private collaborations

2

Future context

Ten driving forces
'engineer of the future' 2035

Introduction

In reframing the process of forecast development begins with mapping the future context. This is done by identifying and gathering *"building blocks"* which are referred to as "context factors". The process of collecting context factors, is discussed in more detail in the second part of this introduction.

A broad and balanced collection of context factors is not yet a forecast. The context factors must be clustered to serve a workable frame of reference for future actions. This clustering resulted in 10 driving forces that will be described in this chapter. The result of the clustering, in the form of a three dimensional framework, is presented in chapter 3. The framework reveals that engineers will interact with society in 8 different roles, revolving around 3 main dimensions. It describes a space within which the future engineers will engage and interact with society.

Finally chapter 4 will elaborate on what may be an appropriate response to the framework. The future concept is introduced: the Personology Arena.

Context factors

Context factors are observations, thoughts, theories, laws, considerations or scientific insights, related to a specific domain that will apply to Higher Engineering Education in the future (2035). In this case the domain of technology, education and society. They are value free descriptions of world phenomena as they appear. By first collecting these building bricks, you could say the conditions, a future world is conceived of, are explored.

These factors are distilled from interviews with key game changers in the field, literature research and reports that deal with the future of engineering education. All these different techniques lead to an understanding of which specific type of factors need to be taken into account. There are two time-dependent factors: the 'developments' (such as demographic changes over time) and 'trends' (behavioural change over time). And there are and two time-independent ones: the 'principles' (laws of nature, such as the theories on emotional response) and states (cultural phenomena that are not in principle stable, but stable within the scope we are doing research for).

Driving forces

The collection of context factors from interviews literature are not yet a forecast. With over 260 factors it is not possible to understand what the effect of each factor will be on the future society. All factors are interrelated, making the context a complex web of interdependent factors. The context must be structured to serve as a workable frame of reference for future actions.

The first step is to make clusters of factors based on common qualities. Factors are grouped in such a way that they are mutually exclusive i.e. no single cluster represents any other cluster ("no overlaps") and no factor is clustered twice. In a clustering workshop with education and engineering experts the context factors were clustered into ten clusters.
These clusters represent the major driving forces in the context. Each cluster will be discussed in detail on the following pages. These clusters in turn form a three dimensional framework, which reveal three dimenisons and eight new engineering roles of our future society; eight behaviours incorporating "-neering", or the 'act of making' as seen in the word 'engineering'. This framework will be discussed in chapter 3.

The number of clusters, dimensions or variables can never be predicted beforehand. The number of 10 clusters and eight types of behavior is coincidental. Therefore, the 10 clusters should not be confused with the eight emerging Engineering roles. The clusters, or driving forces, as we will call them are an intermediate step in the process (a means). The eight engineering roles can be seen as one of the main results of the reframing process (an end).

It is important to note that the 10 driving forces were not invented by Reframing. They are an outcome of the the interviews, literature research and cross checking. There is also no moral right or wrong in these driving forces. They can simply be seen as observations into the future without moral judgment. The driving forces have been brought to light and will influence the way in which the engineering roles will be shaped in future society. Awareness of these forces is of the utmost importance.

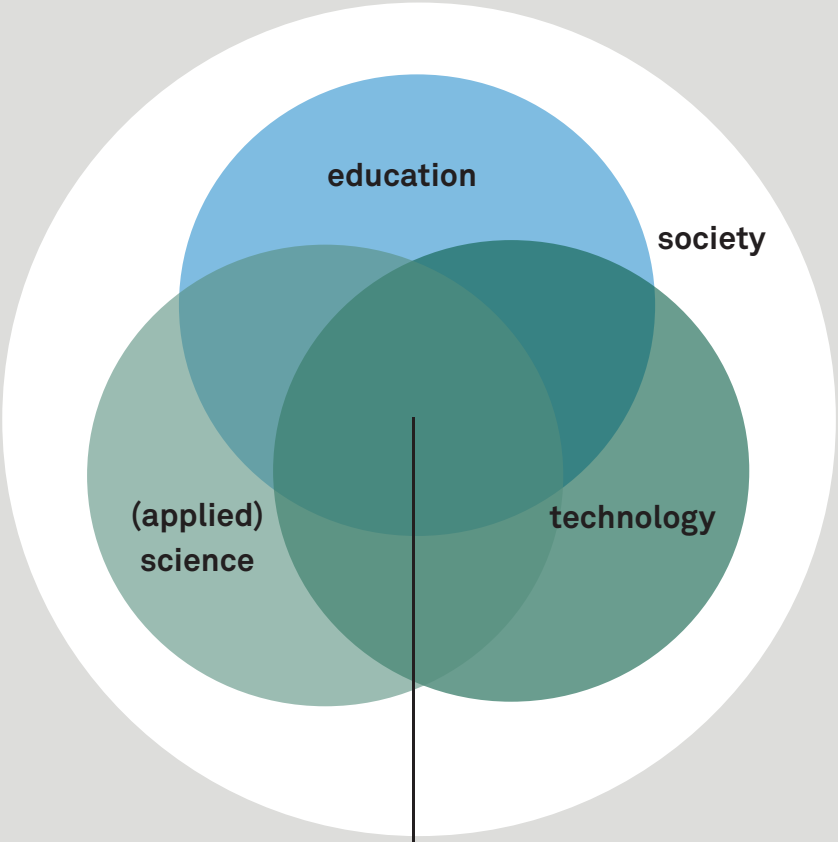
Technological science

The technological sciences have at least six defining characteristics that distinguish them from the other sciences. They have human-made rather than natural objects as their study objects, include the practice of engineering design, define their study objects in functional terms, evaluate these study objects with category-specified value statements, employ less far-reaching idealizations than the natural sciences, and do not need an exact mathematical solution when a sufficiently close approximation is available.

In combination, the six characteristics are sufficient to show that the technological sciences are neither branches nor applications of the natural sciences, but form a different group of sciences with specific characteristics of their own.

— Sven Ove Hansson in '*What is technological Science?*' Studies in History and Philosophy of Science Part A, Royal Institute of Technology Stockholm

Domain & scope



domain
engineer of the future
scope
2035

Ten driving forces

Engineer of the future 2035

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Underlying context factors

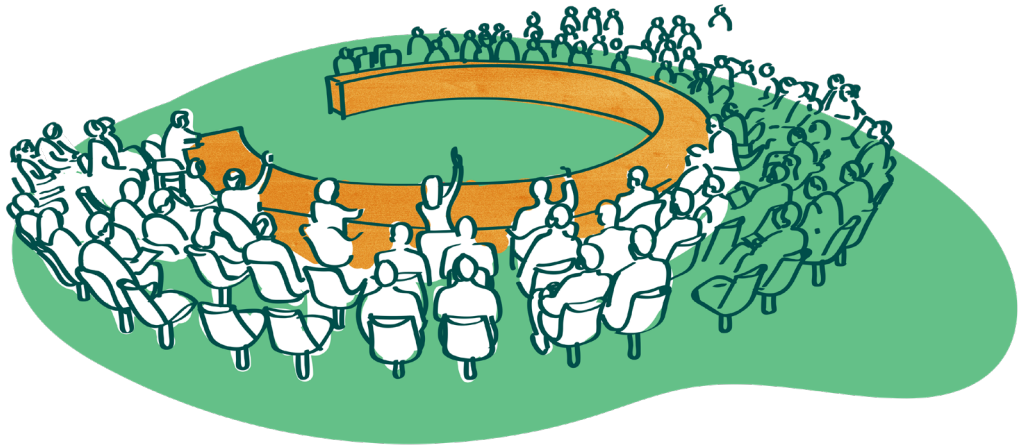
A shortlist of context factors is added to each description of the driving forces.
For a full list of context factors underlying each driving forces, refer to appendix B.

1 DRIVING FORCE

Engineers will increasingly find purpose in salient societal challenges

Like many engineers before him/her, **the future engineer is highly motivated to have a positive impact on the world.** Doing the right thing used to be relatively clear-cut in a technical sense. However, in 2035 most of the technology that surrounds us has however become so complex and socially intertwined, and so important for our functioning that it becomes 'too big to fail'. Changes increasingly create social dilemmas and potentially affect the lives of many. The enthusiasm, with which new technology was met in the initial decades of this century, makes place for cautiousness and deliberation. (signs on the wall: Uber and employment conditions/Airbnb and mass-tourism/prenatal health tests and genetic inequality).

"Do we want this?", "What do we want?" and "How do we want this?" are questions which society increasingly asks itself about technology. In 2035 science and engineering are largely societal matters, and the focus is steered by democratic models through political consensus and programs on a European level (signs on the wall: European Grand Challenges and Responsible Research and Innovation) and on a smaller scale through city governments (If Mayors Ruled the World, Benjamin Barber). The focus of engineering will broaden from topics like climate change, infrastructural security (water management, cyber security), resource efficiency and healthcare to also include urgent subjects like migration, financial systems, good governance and even language. Social urgency (topics that are, in the public opinion, considered urgent) will determine the scientific agenda. And engineers of the future will increasingly gravitate towards purposes we care for.



City council deliberating on social dilemma's involving technology

CLUSTERS

#121 The responsible engineer
Engineers are increasingly held responsible for their own creations. This responsibility is being abstracted, used to be very concrete (for example: safety) but is now more abstract (for example: sustainability or even the social effects of an invention). [state/ethical] - *(Ibo van der Poel)*

#246 The limitedness of ethics
As good as one's individual intentions can be, people will still make decisions that do harm or cause damage to others. As the saying goes "The road to hell is paved with good intentions". (Prisoners dilemma) [state/social] – *(Rathenau Institute)*

#14 The National Science Agenda
The social trend, under the high-educated, is to set (or have influence on) the scientific agenda (the National Science Agenda is first example globally). [trend/cultural] - *(Bert van der Zwaan)*

#104 Problem of many hands
The occurrence of the situation in which the collective can reasonably be held morally responsible for an outcome, while none of the individuals can be reasonably held responsible for that outcome. [principle/ethical] - *(Ibo van de Poel, Ethics, technology and engineering)*

#10 Science follows society
The nature of science is partly driven by social questions and funding. The last 30 years there was an excessive focus on life sciences (medicine) and technology. This focus will slowly shift towards governance, language, migration, social science and humanities. [state/cultural] - *(Bert van der Zwaan)*

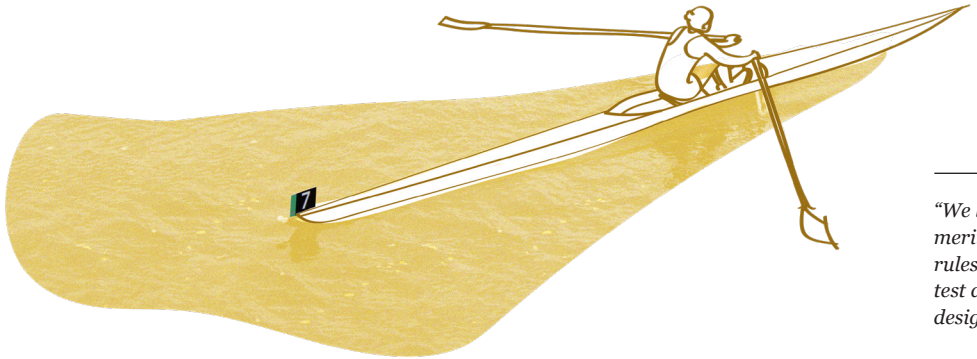
#148
The future society will face enormous challenges on many fronts . Such as growing world population (from six to more than nine billion in 2050), energy transition, infrastructure, mass migration, mobility, climate, healthcare for an aging population and safety (social-/cybersecurity). [development/cultural] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

2 DRIVING FORCE

Meritocratic engineering culture and education as ‘rite de passage’

Investing your time in becoming educated is smart and those who put in the most effort will be successful. The meriticratic belief that talent, capacity and abilities can be developed through hard work and intrinsic motivation is a persistent one.

There is no such thing as a free lunch, and there is no place for people who don’t put in the sweat and tears. If you want to participate in society you need to earn your place and perform a rite de passage of which a diploma is proof. As outdated as it may seem, companies will still look at formal qualifications and diplomas in 2035. And students still look to get them because they are a safe bet, open doors and are a symbol of status. And once in the door and comfortable in your new job, professionals are keen to protect the value of their own investment, selecting only those who have passed the rite the passage to join their ranks.
In order to appeal to this leading meritocratic way of thinking, a growing number of universities select students at the gate or install a numerus fixus. Furthermore, they offer exclusive forms of higher education like university colleges or special honours or excellence programs. Companies also create their own academic universities accessible to the best qualified students available as a pre entry to their workforce. Talent, hard work and money can get you in, and it is seen as an individual privilege. If you don’t get it, or don’t perform well, it is seen as your own fault. The group that is in charge is increasingly homogenous (filter bubble) and detached from society. This creates a form of super selection of talents. Of course the university needs to develop the relevant knowledge and skills of these students, but even in 2035 the symbolic value of getting an education must not be underestimated.



“We look to athletics to reinforce our faith in the meritocracy. Sports are controlled, with defined rules and obvious victors. We believe we can test athletes’natural ability in an environment designed to be fair”

— source: wired.co.uk

CLUSTERS

#42 Learn to participate in society
Meeting other people, diverse composite group of people and learning together are conditions to learn to participate in a diverse, rapid and ever changing society. [principle/sociological] - (SCP, De toekomst tegemoet)

#44 In search for excellence
More courses for excellent, ambitious students are offered (honors programs, research masters), the number of institutes that handle strict and selective admission increases, and institutions work on their own, distinctive profile. [development/educational] - (SCP, De toekomst tegemoet)

#46 Civil effect
Students want an official acknowledgement for the completion of an education/ a course or a class. Certificates, diploma’s and medals function both as acknowledgement and as ‘license to operate’ as soon as you start working. [state/cultural] - (SCP, Lex Herweijer)

#203 Credentialism University accreditation is exclusive, and alumni and academic professionals want to protect the value of their investments in this system. [state/political]

#264
Today, the silo effect seems to most managers a recipe for low productivity: employees tend to hoard vital information they think is to their personal advantage, and people in silo’s resist feedback from others. One remedy is to encourage teamwork, indeed impose it, but such enforced cooperation suffers from the solvent of short-term time. [state/cultural] - (Sennet, Together 2012)

#263
The engineering principle of minimal movement to get rid of friction and reduce resistance applies to the social behaviour of working together, only with minimal assertiveness does one open up to others in dialogic exchange. [principle/philosophical] - (Sennet, Together 2012)

3 DRIVING FORCE

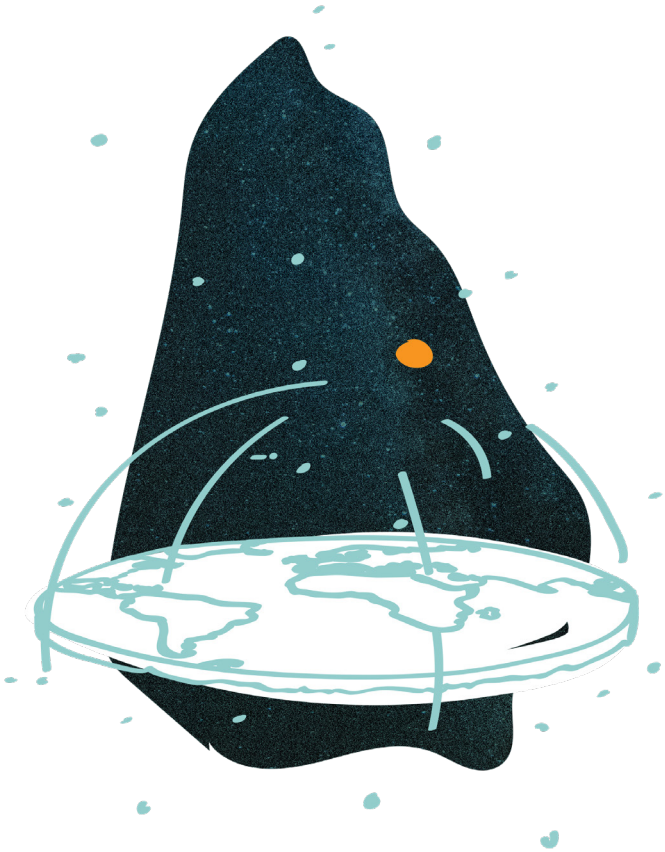
Science is no longer the only source of truth

Science, the shared body of research on which most of our society is based, is experienced by many as just another way of looking at the world. There are many more ways, and science is just one of them, next to religion, parapsychology, alternative medicine or simple traditional common sense to name a few.

This driving force describes the growing lack of shared meaning. The presence of a system of shared meaning has largely been taken for granted but as it turns out is missing; increasingly so.

Even within scientific research, different forms exist next to each other, like 'grey' research in between the black and white. Public scepticism and doubt of science will increase as people look towards other explanations and perspectives on life's questions.

To the engineer this seems irrational and the implications are difficult to comprehend. The future engineer looks at himself and sees failure to communicate, small mistakes, his/her inability to 'sell' the perfect solution in the cascade of information that is poured out over the public. And sometimes even engineers are convinced by non-scientific points of view, which, for example, can cause them to be a scientist and creationist at the same time. The "truth" is a very intimate and personal concept and therefore difficult to communicate about.



Despite scientific consensus that recommended vaccines are safe and effective, unsubstantiated scares regarding their safety are persistent. These are fueled by claims from the sources of religion, alternative medicine, anti-governmentalism, self-reliance amongst others.

CLUSTERS

#30
Knowledge will be omnipresent and fluid No longer in books and articles but available wherever you are at all time. Ranging from formalized knowledge with controlled quality to grey knowledge, of which the academic quality cannot be guaranteed.
development/cultural] - (Bert van der Zwaan)

#133
Increasing public scepticism about science There is an increasing public scepticism about scientific research, with huge effects in the behaviour of people. For example: climate-denial, fake news or the anti-vaccination trend.
development/cultural] - (Ibo van der Poel)

#154
The absence of a reflective system of shared meaning Philosophy as well as technology started out as the creation of a reflective system of shared meanings. Without such a system of shared meaning effective action is impossible. All effective technology is large-scale technology and supposes the problem of 'shared meaning' as solved. [state/sciencial] - (Trendsquestionaire TU Delft, Technology, Policy, Management)

#74
Scientists don't know how to communicate with the public Communicating in layman's language is a skill that tends to be under-rewarded in the current system. Being able to explain your work to a non-scientific audience is just as important as publishing in a peer-reviewed journal, but currently the incentive structure has no place for engaging the public. [state/sciential] – (The 7 biggest problems facing science, according to 270 scientists)

#134
emocratizing science As part of democratization, after doctors, mayors, notaries etc. The authority of scientists (and with that science) is decreasing. The public is not able to separate the scientist from the research; therefore, this degradation also has its effect on the role of science within society. [trend/cultural] - (Ibo van der Poel)

#268
In the future the world may no longer revolve around the belief of humans that everything is about humankind and humans as a source of all meaning an authority. Humanism as we know it today may no longer be relevant. [trend/philosophical] - (Yuval Noah Harari in 'Homo Deus')

4 DRIVING FORCE

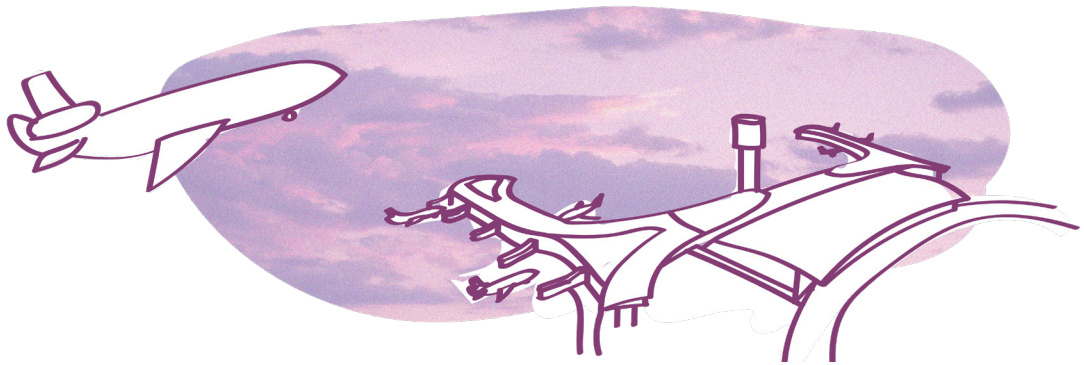
Engineering talent will hop to and from new urban hubs

University researchers and engineering students are increasingly mobile, and less dependent on place or university. In 2035 universities need to position themselves both physically and 'mentally' in relation to other technical universities,

This also applies to the workforce in general. This does not mean that future workers and students will move just anywhere. Talent tends to gravitate towards urban areas in Europe, which increasingly transcend national borders. These growing urban areas, or knowledge hubs, have strong ties to both the new region (a large (international) area that consists of a few universities) as well as the world. They are attractive places of residence because of their rich offering of people, culture and services and because they offer a high level of autonomy; job mobility is high even when settling in an area for longer periods of time.

Strong positioning is not only important to attract talent but also because the EU will play a significant role setting the research agenda. Bachelor students, mostly studying at local universities, stay in the local region after they graduate unless they find a motive/passion/interest they want to pursue further.

The flow of engineering talent will resemble the flow of football players from grassroots football to the professional league. Like a football club, a university create a strong position for itself within the educational ecosystem, forming ties with grassroots education as well as the best of the scientific elite.



CLUSTERS

#260 Perfection of the bachelor/master model
The meaning of the master and bachelor will change to closer resemble the American model. It will be more common to join the workforce with a broad bachelor. People who find their interest will do their masters, often moving to other parts of Europe to study. [development/educational] – *(Bas Haring)*

#140 Mobilizing talent
Moving jobs to where the talent is instead of recruiting talent for where the jobs are. Research is increasingly detached from production and for their R&D, enterprises search for excellence from around the world. Activities are broken down into smaller activities that are easier to share out to talents/qualified experts. [development/occupational] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#1 Urbanisation will lead to knowledge hubs
The continuing urbanisation will lead to mega-cities (talent and innovation pools of the future), in which the best universities and knowledge hubs will settle. This will lead to knowledge hubs in Asia, US and Europe. [development/geographical] - *(Bert van der Zwaan)*

#2 Regional knowledge-eco-systems
Regionalization within Europe will increase and regional knowledge-eco-systems (networks that consist of large number of institutes, universities, colleges, hospitals, companies, startups, ...) will become of big importance for the formation of knowledge and knowledge-transfer. [development/organisational] - *(Bert van der Zwaan)*

#7 War on talent
Attracting and keeping the right talent is a challenge for many companies. For every 13 jobs in the IT industry, only 1 Young Professional candidate is available. As soon as they found their talent, the next challenge is to keep them. Because only after 3 years the investment in a Young Professional will pay off. [trend/organisational] - *(Bert van der Zwaan)*

#12 High dynamics of science
The trend of interdisciplinarity within science results in new, high dynamics of science. Research groups can now interact easily, exchange knowledge and set up research or facilities together. [development/organizational] - *(Bert van der Zwaan)*

5 DRIVING FORCE

Meaning-making as the backbone for digital and analog growth

Meaning-making through storybuilding and reframing of the digital/analogue world will be the glue, the source of cohesion in this changing world as cooperation and social interaction remain the backbone of innovation and development.

The 4th industrial Revolution is a fact and a fusion of digitalisation (such as AI) and technology and biology are blurring the line between the digital and analog world. As the pace of this revolution is exponentially increasing so will the impact of digitisation take the analogue world forward in its wake. Into the democratisation of production processes at home, into technological innovation around the corner and into non-instutionalised dynamic knowledge networks established using open source information.

Physical proximity i.e. face-to-face meetings will be a fundamental aspect of social intercourse. Moving oneself physically will however be a deliberate choice and not self-evident. Hence, although there will be less face-to-face meetings, the impact of the meetings will grow.

As opposed to mimicking physical proximity in real life, digital tools will enable the workforce to manage their way independently in between real life meetings. The one-way, linear flows of communication will shift to continuous dialogue through multiple channels (narratives) with co-workers in different networks. The digital will also provide people with ways to test their skills in immersive virtual settings.

Cooperation and social interaction remain the backbone of innovation and development. Future tools will leverage the power of immersive virtual simulations and peer proximity. image: a team playing the game Keep talking and nobody explodes

CLUSTERS

#155 From teaching to coaching
More and more students gather the technical and scientific knowledge themselves. They do not need so much knowledge transfer, but coaching in making the right choices between alternative paths of scientific and technical inquiry. (this is not a return to the old-time idea of 'Bildung', the challenge is more to be able to move between different forms/values/modes of being.). [development/developmental] - *(Trendsquestionaire TU Delft, Technology, Policy, Management)*

#26 The value of social proximity in learning and research Physical proximity of co-researchers and – students are essential in a learning environment. In both the US and in Asia Universities have an active campus-life that influences the learning process and formation of students. [principle/sociological] - *(Bert van der Zwaan)*

#20 Peer teaching
In 2000 years the learning process is changed but, how we learn effective remained the same. Peer tutorial is the more effective then frontal learning. Knowledge transfer is best via peers. Students learn the most in fraternities, side-activities, practicum and the moments before and after a lecture. [principle/sociological] - *(Bert van der Zwaan)*

#37 Learning in tele-apprenticeships
Different students (from beginner to specialist) will be involved in a real-life case. Beginners will learn by observing, over time they will get the assignment to more actively contribute to the case. [development/technological] - *(SCP, De toekomst tegemoet)*

#41 Blended learning
ICT developments will make learning more flexible and independent from place and time. The line between institutional learning at school and learning outside the school will blur. We will increasingly learn in a landscape of diverse learning-environments in which formal and informal learning will overlap and overflow. [development/educational] - *(SCP, De toekomst tegemoet)*

6 DRIVING FORCE

Technology will smooth out people's fear of technological change

Yes jobs do disappear, but new jobs have always taken their place. People will still work a 40 hour workweek in 2036, doing things for the benefit of others. We will have the ability to simulate the behaviour of the highly complex systems we create. Technological change itself will increasingly be an unnoticeable part of our everyday of life.

Novel technologies make existing technologies and their business models irrelevant. History has repeated itself many times over the past centuries, and you would think people would get used to the cycle. But technology keeps on changing at a faster pace and since technologies are increasingly intertwined, the impact seems to be ever more far reaching.

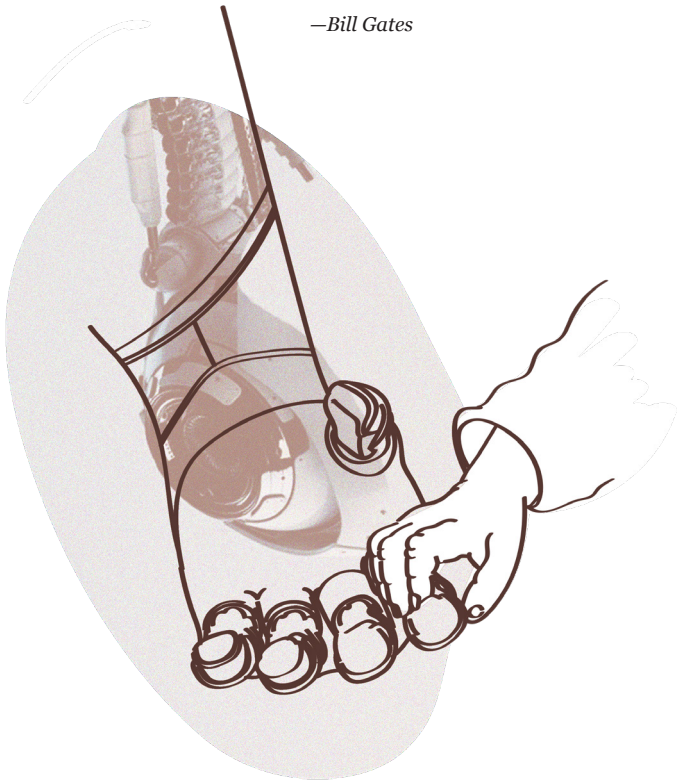
People's most feared disruption, which always looms at the horizon, is the fear of losing one's job. A new fear is that of powerful robots turning on humans. The fear of a robot dystopia is a fear of all times.

Looking back in 2036 we will see that in the past people were quite blunt when implementing technological innovations. We can test the impact changes will have on people and correct mistakes before they affect the lives of real people.

Part of the Artificial Intelligence breakthrough lies in the incredible avalanche of collected data about our world, which provides the schooling and reference that AIs need. AI society will be able to harness information in novel ways to produce useful insights or goods and services of significant value.

"Our biggest worry in the future is not an attack by rebellious robots, but a lack of purpose for humanity"

—Bill Gates



CLUSTERS

#267 Three rules on how we react to technologies
1) Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works, 2) Anything that's invented between when you're fifteen and thirty-five is new and exciting and revolutionary and you can probably get a career in it and 3) Anything invented after you're thirty-five is against the natural order of things. [state/cultural] – *(Douglas Adams, author of the Hitchhikers guide to the galaxy)*

#123 Insecure about the future
Partly because of technology the world is changing in a rapid speed. Simultaneously the opportunities that people get in life are also changing quickly (both positive and negative). Handling these dynamics and additional insecurity is a social challenge of this time and demands for resilience. Technology can function as a bridge but can also increase polarization. [state/psychological] - *(Ibo van der Poel)*

#49 Technology is intertwined with society
Technology is everywhere, without technology there is no society –as we know it. People are unaware of this fact and take the technology that surrounds them for granted. [state/cultural] - *(SCP, Lex Herweijer)*

#176 Precautionary principle
(the commonly used approach to new technologies) A technology must be shown to do no harm before it is embraced. It must be proven to be safe before it is disseminated. If it cannot be proven safe, it should be prohibited, curtailed, modified, junked, or ignored. (state/political) - *(Kevin Kelly)*

#138 Computational power is taking engineering away from the classical trial-and-error methodology
The rise of quantum computing and simulation may offer solutions to fundamental problems that are beyond the realm of the digital computers of today. The improvements in computational power is taking engineering away from the classical trial-and-error methodology. [development/technological] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

7 DRIVING FORCE

The future engineer is intrigued by ‘things’, and by the people in them

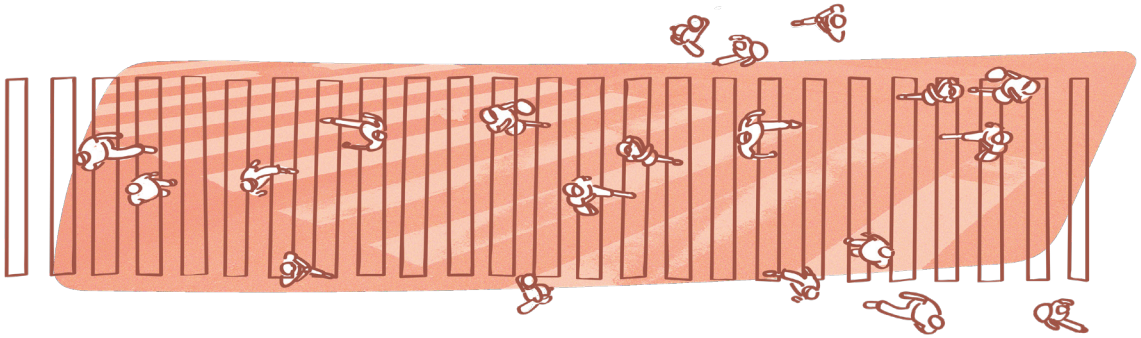
As the boundary between people and technology fades the relationship between technology and people increasingly intimate, and as people become integral part of ‘things’ (think smart cities, internet of things) the engineer in 2035 is increasingly intrigued by people. The ideal of the engineer of the future is an engineer that defies traditional disciplines and is partly beta, gamma and alfa scientist and can shift between statistical, social and technical thinking.

An ordinary person doesn’t even notice the complex systems mankind has created. If he would do so, he would barely comprehend them and usually do little more than complain at malfunctions. The engineer on the other hand sees the beauty in what others take for granted, and sees possibilities and make-ability. This counter-intuitive and conflicting approach is unique for the engineer, who feels knowledge is the unimaginable.

The future engineer is like a film-maker, creating possibilities where previously there were none. In reality future complex systems need the full spectrum from super-specialists to practical all-round engineers. But if not within one person, future teams will increasingly balance beta, gamma and alpha-thinking styles within a team. This shift will come naturally, as a social engineer will become a successful engineer and an example to others.

“Cities are technological artifacts, the largest technology we make.”

— Kevin Kelly in “What technology wants”



CLUSTERS

#119 Rise of the socio-technical engineer
Whereas the engineer used to have in depth knowledge about a very specific domain, engineers are now trained to have broader knowledge and a bigger skillset that go beyond engineering skills. Ethics and other social subjects become more and more important for the future engineer. Since technology is increasingly intertwined with society. [development/ethical] - *(Ibo van der Poel)*

#258 The engineer in essence loves things
The primary trait of engineers is that they are intrigued by things (artefacts). They find things fun and exciting they are very good at understanding things and dealing with things. Yes you can focus education on broadening knowledge on other subjects, on developing social skills or on understanding the role of technology in society. But when push comes to shove the engineers are more intrigued by things (and people interacting with things), than people (in solitude). [state/cultural] – *(Bas Haring)*

#243 Increasingly complex artefacts
People interact with increasingly complex artefacts, like cities (smart cities), financial markets and democracies. These are man-made technological phenomena that can be optimized from a technical point of view, and hence will increasingly become the subject of engineering. [development/technological] – *(Rathenau Institute)*

#55 Intimate technology revolution
Our relationship with technology is becoming increasingly intimate. This fusion between man and technology results in the fact that we become as transparent in the physical world as on the Internet. [development/technological] - *(Onderwijs de burger over de technologie die hem omringt, Rinie van Est)*

#240 Different styles of thinking
There are different styles of thinking, in broad term you could say there are three styles which are a reflection of the alpha, gamma and beta sciences; statistical thinking, social thinking and technical thinking. Most students only master one style and have difficulty with the other two, some master two styles and a select few master all three. [principle/psychological] – *(Rathenau Institute)*

8 DRIVING FORCE

People will have a life-long entrepreneurial mind-set

In 2035, life-long-learning is a mind-set, not an educational program. These future 'young' see work as a way to achieve autonomy, which goes beyond financial independence. They prefer to work on multiple projects at the same time instead of choosing one single vocation. Their creativity lies in their ability to reshuffle and rethink existing ideas, and in developing both the market and the idea in parallel. The currency they trade can be money but more often varies from time and skills to 'exposure' and data.

As small and large businesses are more exposed to intense competitive and operational disruptions they will increase their reaction speeds and focus more on short-term research and innovation that creates short-term value. It takes a certain mind-set to function in the 2035 economy. In order to thrive you need to be open to experimentation and rather just try something than overanalyse, you need to be able to get up quickly when you fail at something, become resilient, and you need to be able to mobilize people for your projects.

The rhythm of the future economy increasingly aligns with the rhythm of the adolescent brain; the young and the future economy are a perfect match. And so are the elderly as they are more mobile, fit, willing to travel and focused on self-actualization (the new third age).

CLUSTERS

#21 Formative years
Between the age of 4 and 22, people learn the most and are being formed. After these years, we learn incremental and little. [principle/psychological] - *(Bert van der Zwaan)*

#213 Easier than ever to start a business
Measured in the number of days taken to formally start a new business, there has been a dramatic decrease from 36 days on average for OECD countries in 2003, to 9 days on average in 2014. The growing emphasis and support for innovative startups as a means for nations to stay competitive and increase trade, has made it easier than ever to try starting a new business. [development/economical] – *(OECD Trends Shaping Education, 2016, p52)*

#22 The universal adolescent need
Adolescents show the need to form themselves, search for meaning, identity and autonomy. [principle/psychological] - *(Bert van der Zwaan)*

#93 The play deficit
Over the decades, there has been a continuous and ultimately dramatic decline in children's opportunities to play and explore in their own chosen ways. [trend/developmental] – *(Peter Gray)*

#95 Entrepreneurial projects
Larger organisations sponsor smaller entrepreneurial teams within their own walls to help generate new ideas and spur innovation. [state/economical]

#145 The high-speed of change and innovation implies short-term thinking
Business and organizations (now and tomorrow) are overexposed to intense competitive and operational disruptions, which requires greater resilience of both the enterprise and its employees. [principle/organizational] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#62 Most new ideas and new inventions are disjointed ideas merged
One *breakthrough* invention can lead to a further breakthrough invention, while retaining most of the virtues of the previous inventions. [principle/technological] - *(Kevin Kelly, What technology wants)*

9 DRIVING FORCE

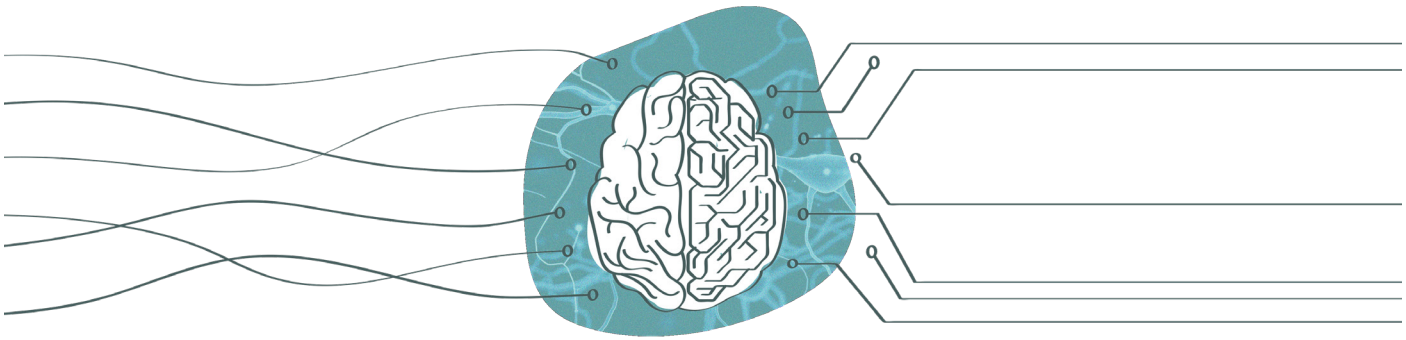
Collaboration will be more open, interdisciplinary and mediated by ‘black-box’ systems

Humans will place more trust in the ‘system’, which will be increasingly good at predicting and deciding, while the system becomes more of a black box.

Scientific research and engineering is increasingly shifting towards open innovation models, using open source, open data and open standards. This includes openness to existing scientific and engineering communities but also to the public, for example to aid in the collection of data. Science unites people in invisible colleges that are bound by their common interest to expand knowledge.

But scientific research requires a degree of trust among those participating that even as they compete, they will also cooperate by playing fair with their data. Machine intelligence and alternative forms of review will play an increasingly important role in quality control, as more people from outside the science community become involved in collection and analiysis of data, and as datasets become increasingly big and elaborate (like the Wiki-way of quality control and Facebook using updated machine learning to detect possible hoaxes).

This development is in line with the concept of Dataism as coined by Yuval Noah Harari in the book ‘Homo Deus’. In Dataism, humans and their feelings and decisions are no longer placed at the centre of the universe. Instead, the future is all about information flow. The human species can be seen as a single data processing system, and the people are the chips in this computer metaphor. In theory the system itself can know you better than you can know yourself, as it can with everyone. And ultimately people will rely on it more and more to make every decision, because it will do a better job.



CLUSTERS

#137 Rise of machine intelligence
Intelligent machines learn at an accelerating rate since they can incorporate the experience of any other machine of their kind through the cloud almost spontaneously. They are completing more and more non-routine cognitive tasks and develop broad abilities in domains that used to be exclusively human. [development/technological] - (*Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#84 Blurred boundaries
The boundaries between nations, disciplines and professions, academia and industry between applied science and engineering blur. We act increasingly in a network society, in which we are interconnected. [development/organizational] - *(Aldert Kamp, see source above)*

#27 Shared research and massification
The use of big-data, researching and editing enormous sets of data, will change the world of scientific research significantly. The size of data-sets offers an endless amount of possibilities for signal detection and reduction of background noise. But also the combination of data-sets from different disciplines offers endless possibilities. [devlopment/sciential] - *(Bert van der Zwaan)*

#15 Citizen science
The collection and analysis of data relating to the natural world by citizens, typically as part of a collaborative project with professional scientists, driven by a social conscience. The collaborating citizens are most often high-educated alumni of the University that promotes the research. [development/cultural] - *(Bert van der Zwaan)*

#143 Open-innovation models
Traditional innovation models (all disciplines in house) are shifting to more open-innovation models, which is particularly useful for lower levels of technology readiness. In open-innovation spaces, the resources are available for anyone with access to ‘the cloud’. The other participating parties are not necessarily rivals but may be an interesting resource instead. [trend/organizational] - *(Aldert Kamp, see source #137))*

#28 The Wiki-way of quality control As an alternative
to peer-reviews, researchers increasingly publish their concept-publications online to be screened and criticized by colleagues, inviting the scientific community to participate in quality control. [trend/sciential] - *(Bert van der Zwaan)*

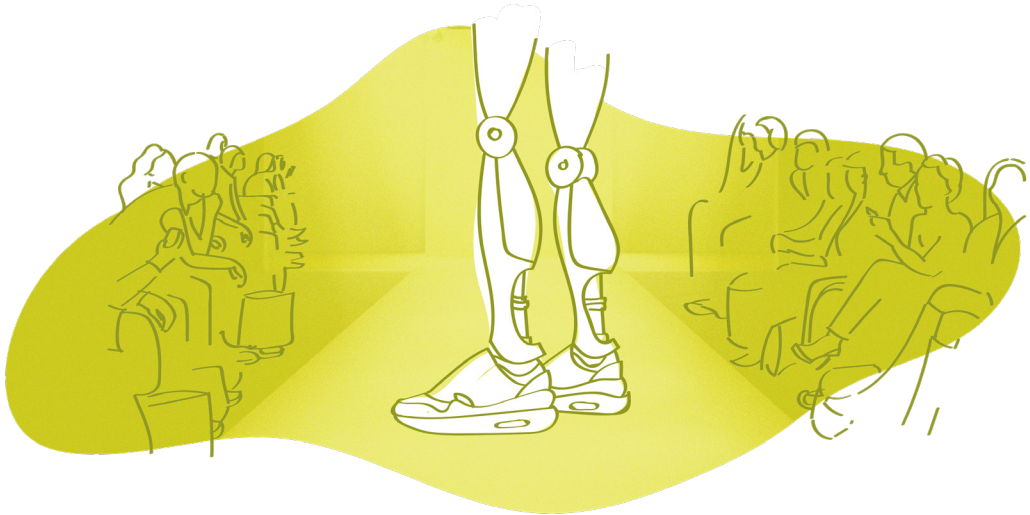
10 DRIVING FORCE

‘Learning’ will mean staying in tune with the next big things

In 2035 the profile of engineers will be much more diverse. Education for them will be a means to both show their identity as well as a way to apply themselves in areas where the next big things are happening.

Engineers will be people of all ages, from 18 - 80, people with or without work experience, people who may know more than their ‘teachers’ or people with an international/migrant background. These life-long-learning engineers connect to many communities of like-minded people based on taste, profession, religious beliefs cultural background or skills. And they all want to gain or sustain a unique competitive edge within these communities.

On-demand, trendsetting, tailored, fast moving: education in 2035 will metaphorically speaking move into the realm of fashion. One does not stay fashionable by listening to the advice of your parents, or choosing for the safe ratings of a renowned university. To be fashionable means taking a risk with new clothing items, putting together your own look and wearing it with conviction. The diverse population of students will be critical, demanding and picky looking for value for money and on the upside be sensitive to trends, daring and changeable. Like fashion, ‘Education’ will develop a symbiotic relationship with the ‘fashionistas’.



CLUSTERS

#38 Tailored learning
Learning can be more and more tailored to the student. By monitoring progress, but also by monitoring and analysing learning styles. Proactive interventions and quick feedback loops increase the motivation of students. [development/educational] - *(SCP, De toekomst tegemoet)*

#8 Demand driven University
Universities will shift from offer-driven towards demand-driven. A system in which they will receive money based on student satisfaction. The student will define their own curriculum. [development/educational] - *(Bert van der Zwaan)* (voorbeeld: Leidse Onderwijs Instelling)

#141 The horizontalisation of the socio-economic world
Consumers and end-users are given more power and demand personalized services that ‘feel’ local and one-off. These products compete on a local scale by customizing them locally. [trend/cultural] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#4 Universities are experiencing an unbundling revolution
No longer offering a curriculum of education, but offering knowledge in the form of independent chunks. These chunks will function as building blocks of a custom degree, certificate or diploma. [trend/educational] - *(Bert van der Zwaan)*

#9 The demanding, independent, critical student A trend in society showing that people become more demanding also has its effects on students. Because of digitization a student can be more demanding and picky. [trend/cultural] - *(Bert van der Zwaan)*

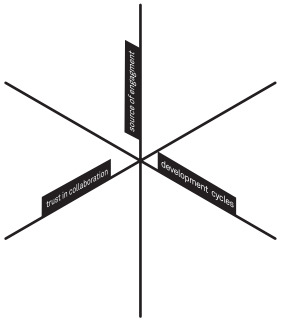
#265
Content of online materials will increasingly be provided by a few key players in the market (either universities or commercial parties), diversification and personal development of students will have to catered for in a different way, e.g. through on campus activities. [development/economical]

3

Future behaviour

Three dimensions that shape eight engineering roles.

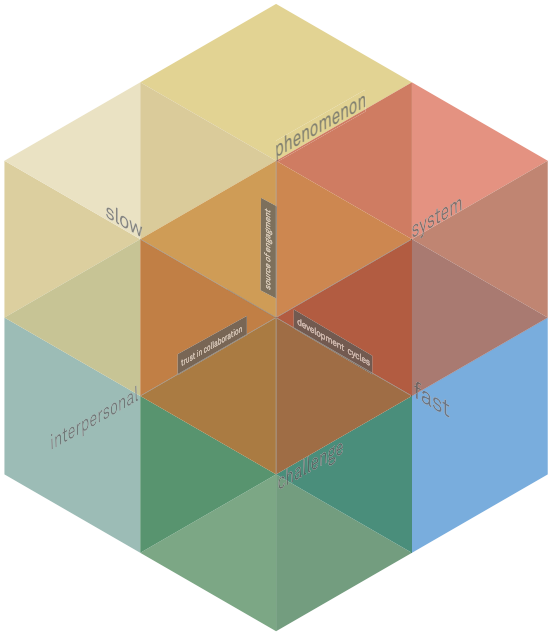
Framework



Three dimensions

1. Source of engagement
2. Trust in collaboration
3. Development cycles

p.32



Three dimensional space

Together these three dimensions, derived from the 10 driving forces, reveal eight engineering roles that may be embodied in future society and be offered in higher engineering education institutions.

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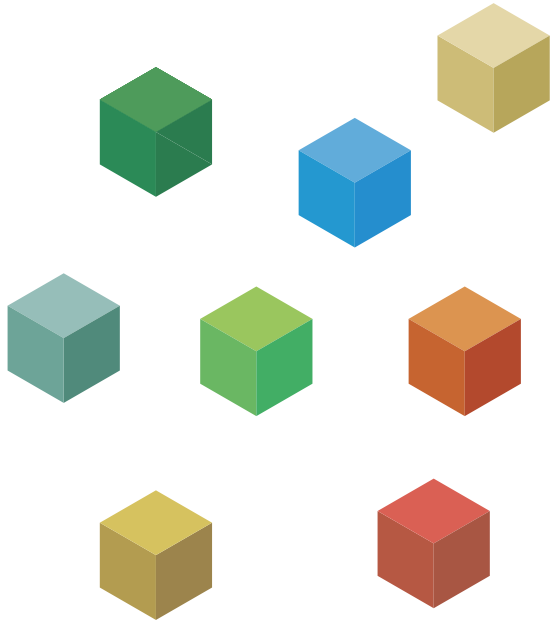


Eight engineering roles

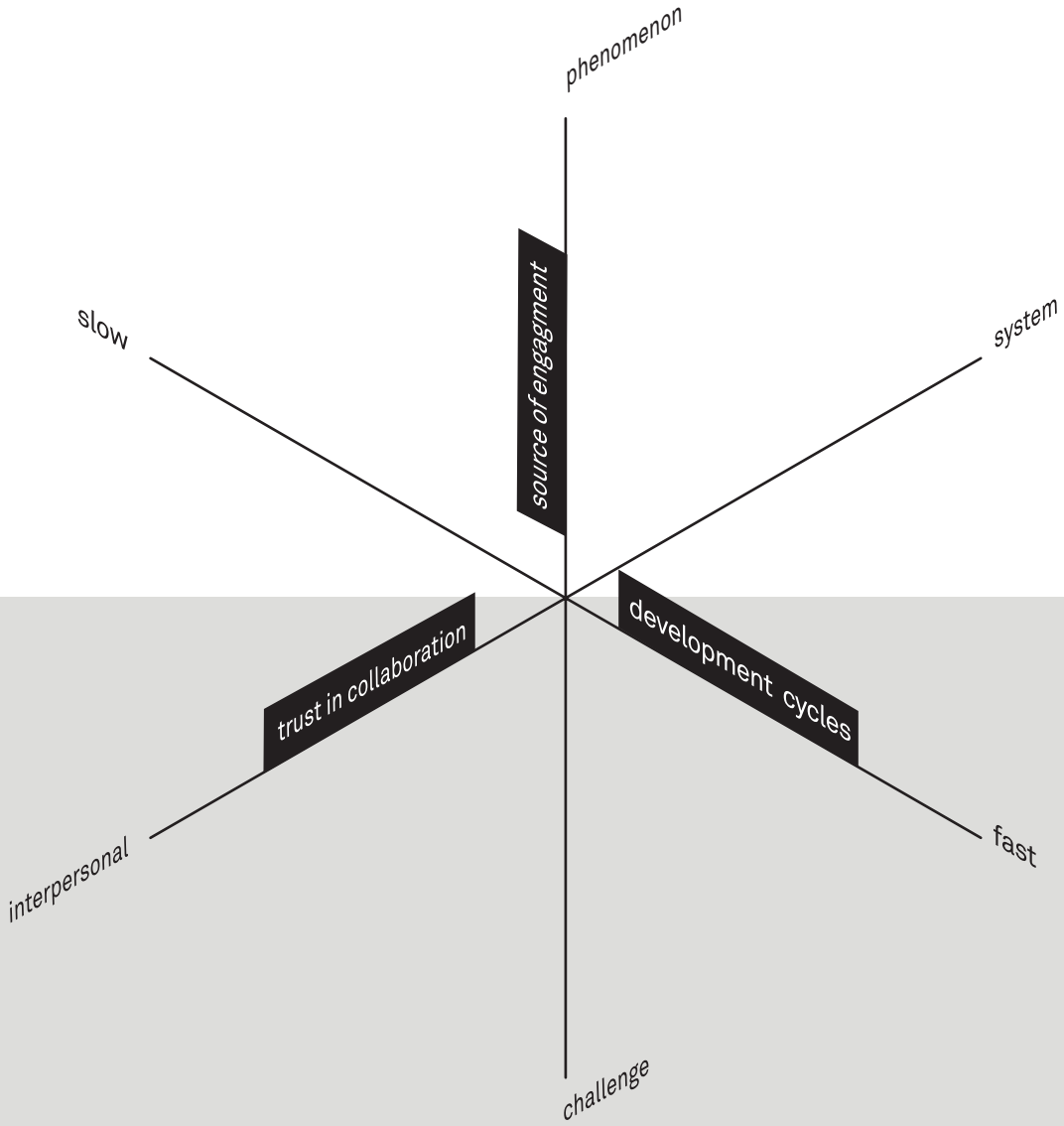
1. Origineering
2. Swarmineering
3. Engagineering
4. Ingraineering
5. Tinkeneering
6. Perfectioneering
7. Imagineering
8. Fundamentaneering

p.37

Three dimensions that shape the future diversity in engineering behaviour

The variety and complexity of the initial set of over 260 context factors has been reduced to 10 clusters of factors. These clusters became the driving forces, which were presented in the previous chapter. The final step in structuring the context is developing an understanding of what these drivers mean in relation to each other. The ten drivers must be turned into a unified whole, a complete and coherent picture of the context of higher Engineering Education in 2035.

Three dimensions have been identified from studying the relationships between the 10 drivers. The future of higher Engineering Education is steered by these three dimensions, each with their specific extremities:



The first dimension is about the **source of engagement** with technology, the intrinsic motivation underlying behaviour of people in engineering.

The second dimension is an economical dimension related to the **source of collaboration** and economic objective of behaviour.

The third is a time-related dimension, dealing with the **temporal connection to society** and the pace of (product/artefact) developments.

DIMENSION 1

Source of engagement

This dimension describes the origin of the engineers engagement; where does the 'drive to make' originate?

On the one hand technological artefacts are intriguing by their own right, especially as the artefacts we create are increasingly complex, cities and financial systems being amongst the largest. They provoke you to push yourself to comprehend them, and to improve and remake them. On the other hand the drive can originate in leveraging engineering to address the societal challenges of the future, like climate change, infrastructural security, migration or good governance.

Engagement of future engineers in the Quest for technological solutions are driven by societal challenges, like the grand engineering challenges or a deep desire to explore and contribute to the understanding of technological phenomena. Engineers will be faced with the fact that graduating as a "rite de passage" is opening doors to a future career and is necessary to grow. At the same time the results of scientific endeavours are no longer taken at face value and not necessarily accepted as a source for "the best" technological solution.

1 **Engineers will increasingly find purpose in salient societal challenges**

2 **Meritocratic engineering culture and education as 'rite de passage'**

The future engineer is intrigued by 'things', and by the people in them **7**

challenge — **source of engagement** — **phenomenon**

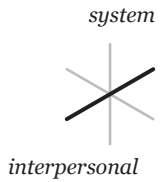
the origin of your involvement

Grand engineering challenge/societal challenge
Problem/opportunity oriented

An observable fact, occurrence, or circumstance object/system-focused

DIMENSION 2

Trust in collaboration



This dimension describes the basis for collaborating with others. As a result of specialisation and extreme subdivision of labour, engineering is in essence a collaborative feat. Future projects increasingly require multidisciplinary and open cooperation and two types of trust that serve as the lubricant for collaboration.

There is role-based trust where interaction is depersonalised; this is trust in the system enabling highly efficient collaboration. It is increasingly enabled by technology but also under pressure as people are increasingly falling back on heuristics and institutions are called into question. The other type of lubricating trust is interpersonal trust; a malleable type of trust based on intuitive judgment, proximity and personal contact. It is essential where systems have not been established yet; where games are being changed and opportunities attract entrepreneurial behaviour.

This dimension shows the interaction at an interpersonal level stimulating small disruptive innovations at a level where systems do not yet exist. Technological hubs like Silicon Valley or Singapore and other Asian hotspots are bringing together innovative kick-starter's and front runners in tech (Aalto University, 2017). To be on the edge of technological development the engineer needs to go where tech is big and happening and have trust in interpersonal relationships. On the other hand, we are all part or will become a part of the system through permanent dataflow. Institutes and multinationals will drive for more systemic change and engage different types of engineers to master, alter and steer the data flow systems. Although technological change is accelerating, it still needs a story. Meaning making as a part of trust and collaboration with the system or with individuals will still be at the centre stage for technological acceptance and in the domain of engineering education.

3 **Science is no longer the only source of truth**

4 **Engineering talent will hop to and from new urban hubs**

8 **People will have a life-long entrepreneurial mind-set**

5 **Meaning-making as the backbone for digital and analog growth**

Collaboration will be more open, interdisciplinary and mediated by 'black-box' systems **9**

interpersonal — **trust in collaboration** — **system**

the basis for collaborating with others

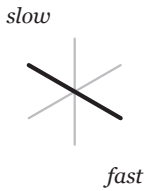
Interpersonal trust
No systems in place (front-running)
History of sustained personal contact
Slow to build

Hyper-specialization/extreme subdivision of labour
Geographic flexibility/mobility
Interdisciplinary collaboration
Synergy analog/digital

Trust in system that selects and trains
Role-based trust/merit based
Depersonalised interactions
Swiftly forwarded

DIMENSION 3

Development cycles



This dimension describes the tempo of development cycles that an engineer identifies with. It is about the tempo with which one prefers to move forward.

There are fast cycles; the cycles of fashion, the next big thing, being in the know, staying up-to-date and reacting quickly and swiftly to situations and opportunities. And there are the long cycles of technological developments; the inevitable but slow cycles of change. These are the cycles of governance, policy and legislation development, changes in cultural norms and values. Working in this 'medium' requires time, patience and endurance.

Development cycles are the last dimension driving the engineering and learning behaviour now and in the future. Development cycles are going faster all the time requiring swift entrepreneurial behaviour and forcing people to grasp every other opportunity. Moving on to the next big thing stimulates and pushes lifelong and very personalised learning for engineers in every walk of life. Contrary to the fast, we find slow development cycles. This process of long-term technological advances requires long and dedicated attention to development, implementation and systems adaptation. Governance, legal, policy issues and certainly cultural norms and values need to taken into account.

10 **'Learning' will mean staying in tune with the next big things**

Technology will smooth out people's fear of technological change **6**

fast — **cycles of development** — **slow**

the tempo with which you move forward

Timely
Fashionable
Perishable

timeless , steady, long-lasting

i.e. governance, policies, legislation, cultural norms and values

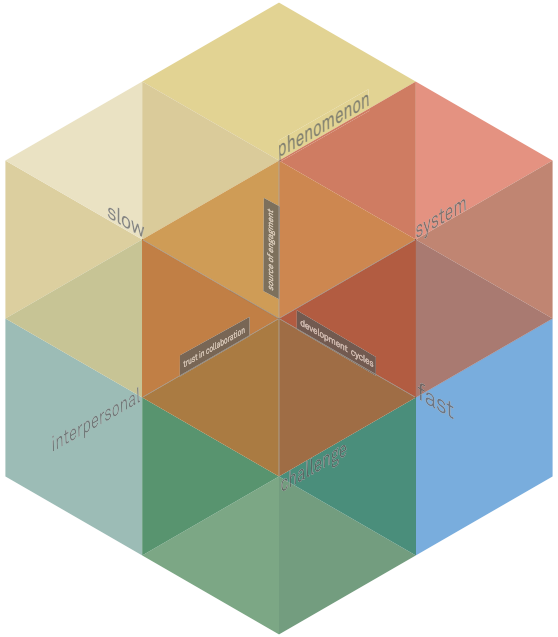
Three dimensions reveal eight engineering roles

Together these three dimensions, derived from the 10 driving forces, reveal eight Engineering Roles that may be embodied in future society and be offered in higher engineering Education Institutions.

It is easy to see how these 3 dimensions, each with 2 main values on the dimensions, create a 3 dimensional space in which different engineering-roles can be identified. Each being a composite of 3 aspects of the dimensions. E.g. phenomena, system, fast.

We have, on the one-hand, chosen to give new names to the possible new role an engineer can play in Dutch society of 2035. On the other hand we have given new names that refer to the 'act of making', thus still incorporate the word –'neering'.

The engineering roles are described as behaviour that may be displayed in future society. An example is given of a job profile, which might be associated with these roles and finally a skill set is defined which might be of importance when fulfilling this role.
These engineering roles are not to be used to pigeon hole any person into a particular role. Rather the three dimensional space is a space open for exploration of which the roles provide the outer bounds. The roles thus provides a typification of what we expect in a specific area of this 3 dimensional space. As such these engineering roles are used as a guidance through and making use of the dimensions by which the space is delinaeated.



The roles have been tested in 3 workshops with 32 stakeholder participants on their validity, appropriateness, strategic value and inspiration. Most stakeholders did recognise the roles as emerging from the current society and appropriate for higher Engineering Education in particular in Europe. Stakeholders considered them of strategic value for higher education institutions and experienced them as inspirational to think differently about the future of engineering.

Origineering

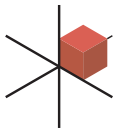
Swarmineering

Engagineering

Ingraineering

Tinkeneering

Perfectioneering



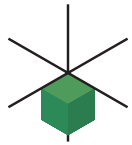
Imagineering

Fundamentaneering

1

Origineering

Like a serial entrepreneur



Challenge
Interpersonal
Fast

Creating value and impact on the short-term by seizing a societal opportunity to bring people together or work together. Capitalizing on fleeting opportunities to do 'good'. Optimistic, high-risk experimentation with familiar people. Initiating, making a return and moving on.

Concerns

1. Self-determination;
2. Material gain, gain resources and influence;
3. Individuality; feeling unique

Behaviour

- Initiative and self-direction
- Courage
- Resilience
- Business sense/economic realism
- The ability to apply theory in practice
- Market intelligence
- Ability to delegate

2

Swarmineering

Like a social crowdfunder

Challenge
System
Fast

Joining in and playing your small part in completing a 'project' or contributing to a cause. Mass participation with low-entry barrier. Constantly being alert to societal or civil challenges that you could contribute your time and skills to. Behaviour ranges from making use of participatory systems to making the system itself.

Concerns

1. Belongingness; building a sense of community;
2. Winning as a group; mastery;
3. Resource provision; giving support, assistance and validation

Behaviour

- Being alert
- Time/project management skills
- Ability to prioritise
- Shifting between a helicopter view and a deep dive

3

Engagineering

Like a lobbyist or human rights advocate

Challenge
Interpersonal
Slow

Advocating inspirational ways to tackle societal challenges using technology. Starting-off/participating in movements of change, be it cultural, legislative or governmental. Playing the system using historical, political and social insights; being aware of the impact on real people and acting in solidarity with them.

Concerns

1. Equity; promoting fairness or equality, avoiding unfair actions;
2. Public power; societal influence;
3. Positive self-evaluations; comparing favourably to others

Behaviour

- Fundraising and lobbying
- Polling/sampling attitudes and opinions
- Self-directiveness
- Social media skills
- Networking
- Public roles
- Politics
- Cross cultural and social understanding

4

Ingraineering

Like a United Nations Peacekeeper

Challenge
System
Slow

Working on challenges in a highly structured, formalised way, furthering society through a long-term dedicated effort. Being aware of your small essential contribution and of the workings of the system enabling you to contribute; Trusting the system and being an indelible part of it; Slowly preparing a system to embrace change from within.

Concerns

1. Management; maintaining order and organization;
2. Safety; avoiding harmful situations;
3. Unity; spiritual sense of connectedness

Behaviour

- Accountability
- Contextual awareness
- Institutional trust
- Displaying tact and impartiality
- Having high perseverance

5

Tinkineering

Like an amateur professional

Phenomenon
Interpersonal
Fast

Autonomous experimentation. Identifying with the 'state-of-the art' in several specific fields of interests and staying up-to-date through like-minded people with a similar strong interests. Finding ways to apply the latest insights/ discoveries/technologies in real-world settings and learning through prototyping. Leisurely; Start by playing around. Trial and error. Heuristics.

Concerns

1. Curiosity; satisfying one's curiosity; avoiding a sense of not knowing what's going on
2. Individuality; feeling unique
3. Excitement avoiding boredom

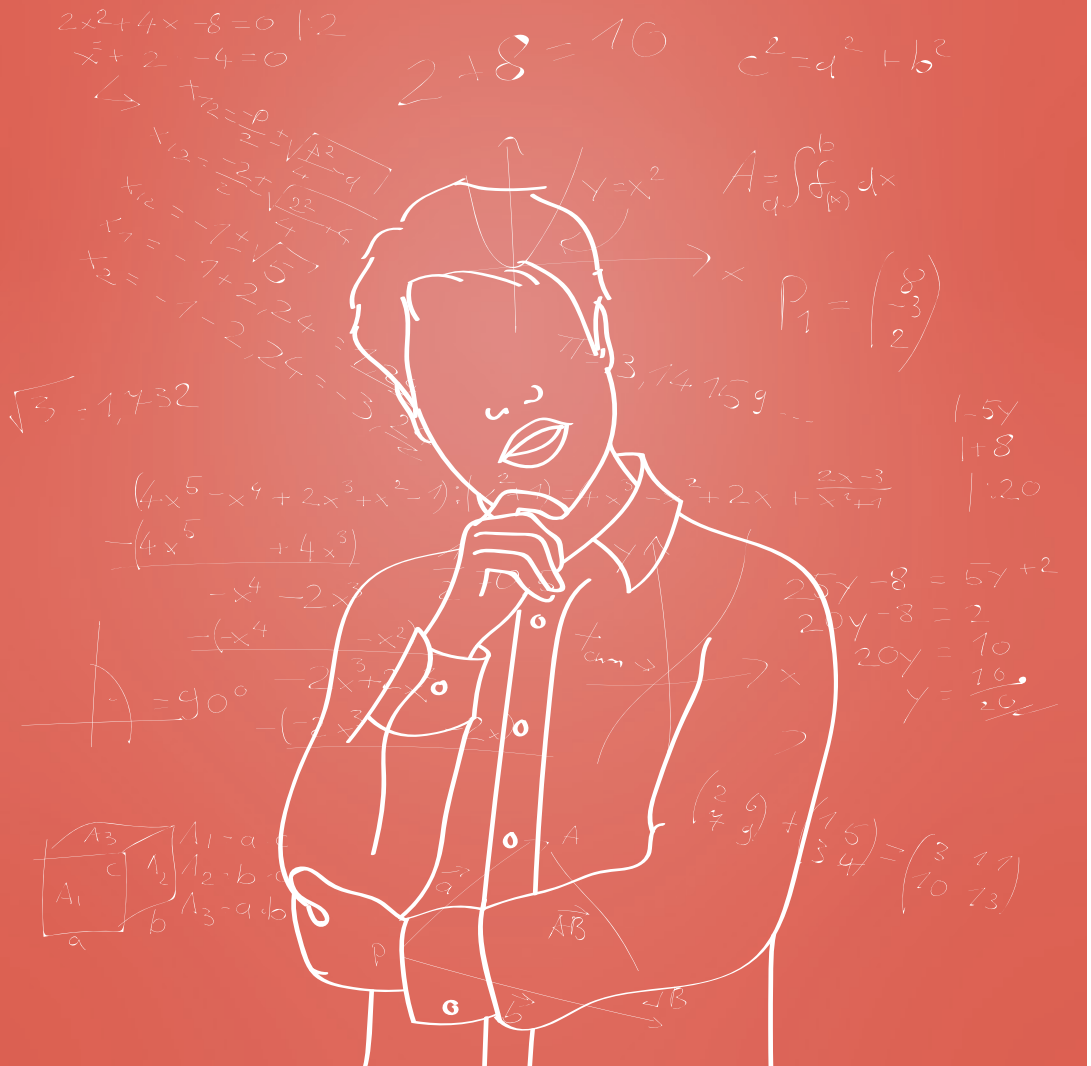
Behaviour

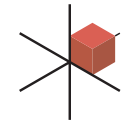
- Trend awareness
- Adaptability
- Self-direction
- Tech-savviness
- Practical ingenuity
- Prototyping

6

Perfectioneering

Like a quant





Phenomenon
System
Fast

Real-time iterative tweaking of products/practices/processes to work better or to better fit stakeholder demands. Gathering data, embracing what works and repeating. Incremental improvement (with potential large aggregated effect) and reinforcing current practices and standards. Responsive, alert and reactive.

Concerns

1. Management; maintaining order, organisation or productivity; avoiding inefficiency
2. Mastery; meeting a challenging standard of improvement
3. Safety; avoiding threatening circumstances

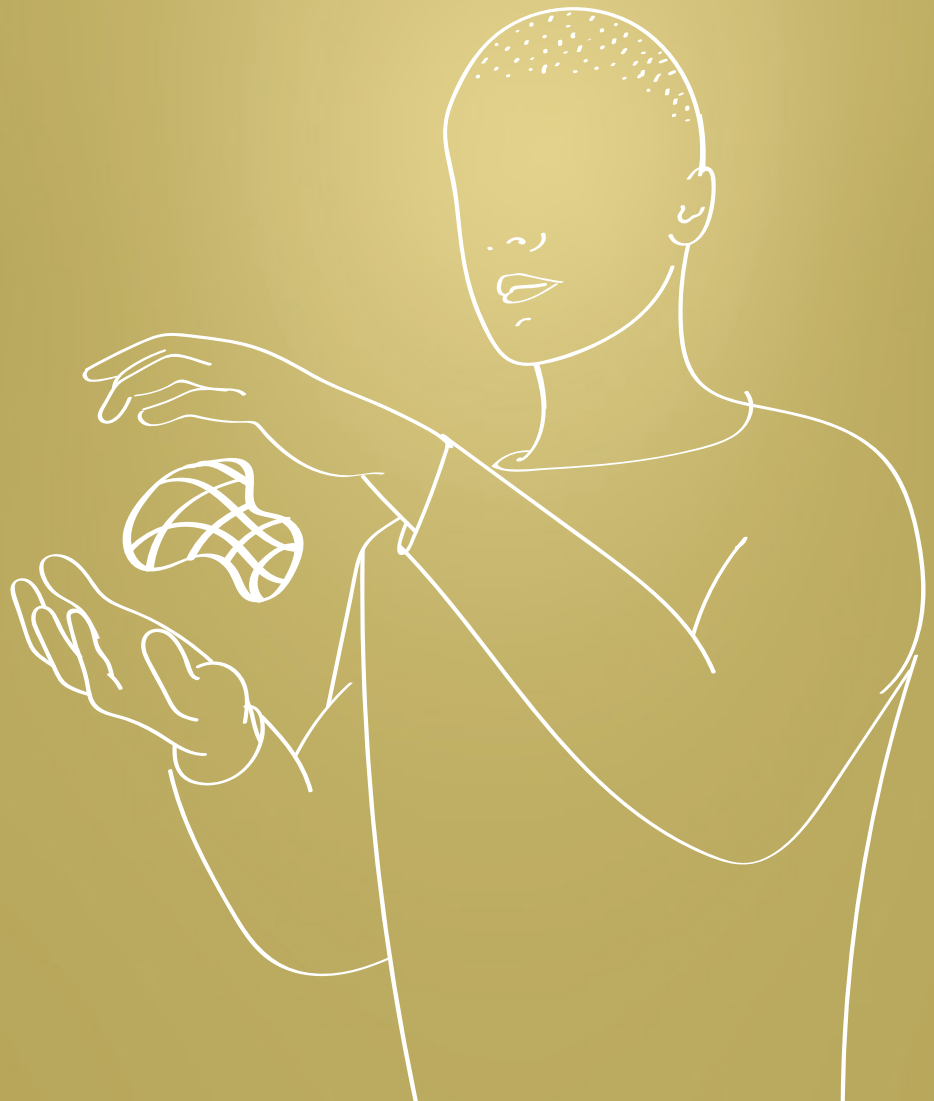
Behaviour

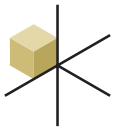
- Productivity
- Critical thinking
- Data modelling
- Probability and statistics

7

Imagineering

Like a sci-fi movie director





Phenomenon
Interpersonal
Slow

Fearless exploration of technological possibilities and dangers. Being at the forefront of technological evolution, on one hand looking out for collisions and on the hand inspiring stakeholders to reap more of the benefits of technology. Calling attention to structural or ethical dilemma's and starting discussions. Predicting and shaping the future of technology. Artistic freedom. Moonshots.

Concerns

1. Intellectual creativity; engaging in activities involving original thinking or novel or interesting ideas; avoiding mindless of familiar ways of thinking
2. Transcendence; avoiding feeling trapped within the boundaries of oridnary experience
3. Individuality; avoiding conformity with others

Behaviour

- Cross cultural and social understanding,
- Curiosity and imagination
- Working with ambiguity/uncertainty
- Ethical reasoning
- Self reflection

8

Fundamentaneering

Like a detective

Phenomenon
System
Slow

Immersion in a phenomenon with a deep sense of patience or disregard for direct rewards. Staying in contact with the tight-knit thought-leading community in the respective field. Slowly pushing the boundaries of what was thought to be possible through fundamental experimentation and knowledge building.

Concerns

1. understanding; gaining knowledge or making sense out of something
2. Superiority; comparing favourably to orthers
3. Curiosity; avoiding a sense of being uninformed

Behaviour

- Patience
- Effective listening
- Structuring
- Integrating
- Reliability
- Probing intelligence

Eight engineering roles

Origineering

Swarmineering

Engagineering

Ingraineering

Tinkeneering

Perfectioneering

Imagineering

Fundamentaneering

4

Future concept

From technology hub to personology arena

Introduction

Our conclusion is that these eight roles matter for society in 2035. How can future engineers give expression to a role, or a combination of roles that they can play in future society through the education they have followed? When we think of the ‘future university of technology’, what ’content’, what types of knowledge should the university take the responsibility to educate and do research on? What does this mean for the future meaning of the University of Technology itself?

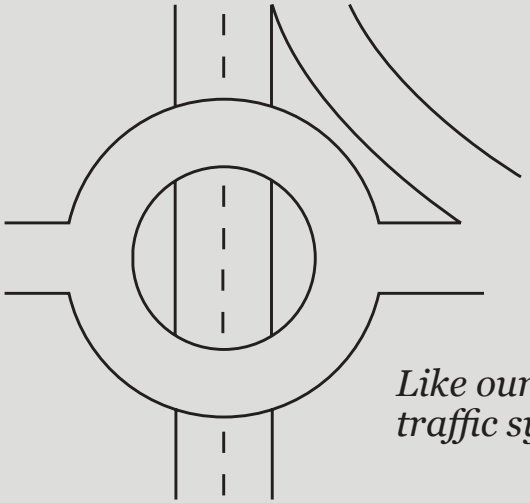
By offering students a curriculum through which they can play eight different engineering roles that are meaningful, eight different roles they can identify with, they are able to make their own choice for a specific role that connects self-growth to societal purpose. How to make technological output (artefacts, processes and knowledge) that is both relevant for yourself and for society.

Teaching the student how to create a relationship between ‘self-development’ and ‘purpose’ will give the student a sense of agency in constructing their own future, hence the name Personology Arena, a merge between ‘personality’ and ‘technology’. The goal underlying this new approach is that it will lead to a sustainable work-satisfaction for the future engineer on the one hand, and will lead to meaningful ‘outcomes’ for society on the other.

This new type of education is not only meaningful for students wanting to become a professional with a specific role in society, but also meaningful for professionals themselves, giving them the opportunity to rethink and re-design the place they already had achieved in society. Therefore we choose to change the name of student - as it is typically related to an 18 to 25 age group - , to technee. As these eight roles are applicable from 20 to 80 years old.

PRESENT

Technology Hub



Like our current traffic system

Efficiently transferring engineering knowledge

- Pipeline
- Student
- Study program
- One role
- Disciplines
- Learning knowledge

- Practice determined curriculum
- Learning from teachers
- Cognitive knowlegde
- Competition between universities
- Hub hopping

FUTURE

Personology arena

Like shared space in traffic

Steering self-development in technology

- Agency in self-development and roles
- Technee (both layman and professional)
- Life long learning
- Multiple roles
- Engagement with a theme (temporary discipline)

- Knowledge as a carrier for self-growth ‘Delft‘ as a supplier
- Societal-purpose determined self-exploration
- Discovery of kowledge
- Multiple types of knowledge
- Network of unique identities
- Arena harvesting

Technology Hub

efficiently transferring engineering knowledge

ensuring societal relevance

to give direction to the public debate about what is best for society

exclusivity entry-barrier

knowlegde as entry key to professional field

life-long learning is staying up to date in your field of knowledge

drivers license diploma

curated education program

external consciousness (regulation)

reducing uncertainty

reliance on authority of university

small number of engineering roles all are licensed road users

efficiency

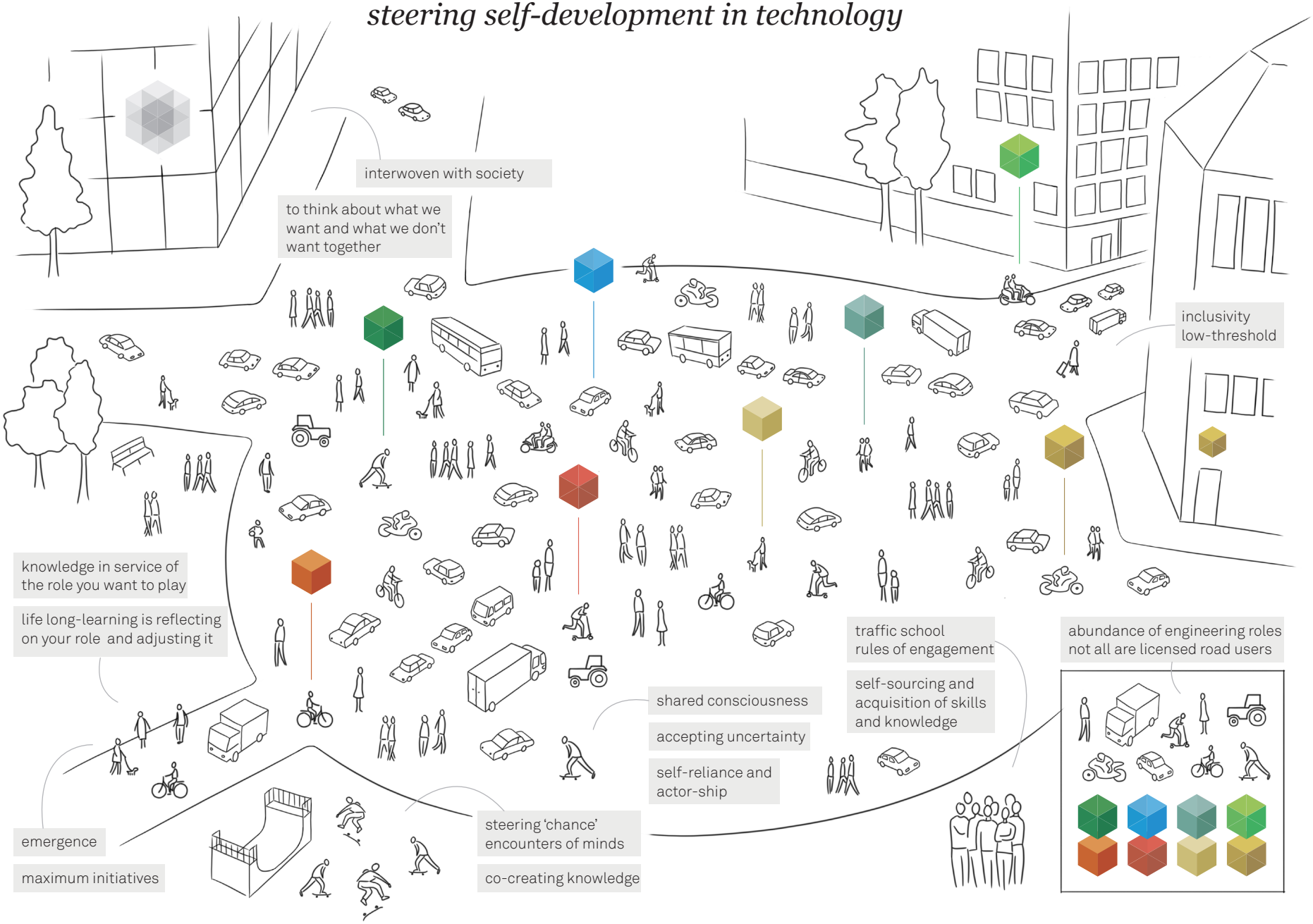
maximum speed

predictable paths of knowledge interaction

knowing-how

Personology arena

steering self-development in technology



Personology Arena

Pivotal in the Personology Arena is that the technee is educated (beyond cognitive knowledge) in relation to three independent knowledge fields that are instrumental to give expression to a possible role(s) the future engineer wants to identify with. These three knowledge fields relate to the three dimensions that determine the eight future roles engineers can have in the future:

- On 'themes' (scientific phenomena and societal challenges) that are the sources of engagement a future engineer can give expression to, and that can become temporary disciplines;
- On the act of decision making (in relation to how to work together in 'swift'-teams and the future 'ethics of science' as sources of collaboration);
- On the definition and development of appropriate processes and models within the time available (do we need a quick fix or should we dive deeply into the subject?).

To provoke exploration and discovery of your personal source of engagement with technology, the Personology Arena is set up as a science playground with shared (development spaces).

The Personology Arena is therefore, a place with three independent knowledge institutes taking the responsibility for these three different fields in education: The Engagement Institute, The Decision Making Institute and The Pace Institute. In relationship with each other, these institutes make the 'technee' aware and understand what possible role they themselves think is most relevant to fulfil in future society.

SOURCE OF ENGAGEMENT

The Engagement Institute

A networked way of learning

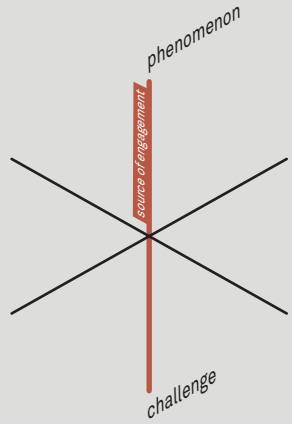
Learning Outcomes

- **The ability to study phenomena in and across different disciplines**
- **The ability to contribute to building knowledge to address societal challenges**

To provoke exploration and discovery of your personal sources of engagement with technology, the Arena is set up as a science playground with shared (development spaces) and comprise the following features. Challenges and Phenonoma are studied in context. Each part of the dimension requires a different (development) space with built in flexibility. To respond to the context of the challenges or phenomena addressed or to the conditions of entry into academia. The guiding principle is evaluative judgement and proofing of results according to academic standards of the studied phenomena or challenges, delivering responsible and relevant results for society.

Scenario

Justin is a technee at the Engagement Institute. He's been obsessed by the then just discovered phenomenon of 'flash effects' in financial ecosystems. He spent an interval collaborating with the Dutch National Bank where he worked on ways to increase the robustness of the European banking system using cryptographic hashes (engagement with the phenomenon). During his affiliation with the Engagement Institute he was made aware of the danger of predatory algorithms to society, and the vulnerability of our banking system. He started sharing his experiences with other technees at the Engagment Institute and he is also mobilising others to be alert and to be ready for action when they need to be (engagement with the societal challenge).



Above scenario illustrates the way a future technee is driven to acquire knowledge and grows his/her skills, and the role a knowledge institute plays.

TRUST IN COLLABORATION

The Decision–Making Institute

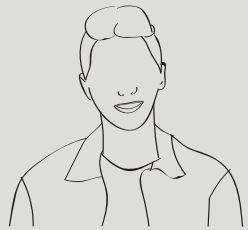
A dynamic system of relationships, supported by ethical values of Academia

Learning Outcome

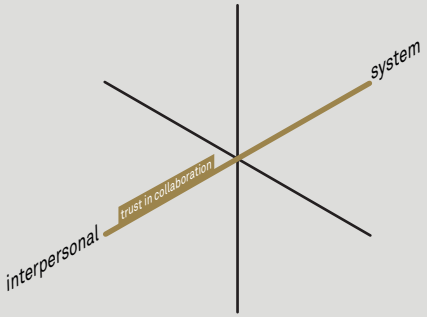
- **The ability to work together in small teams and or large systems**
- **The ability of working together across different collaborative formats in society (systems or based personal relations and trust**
- **The ability to apply ethics to the development of technology for society and use personal relationships or the system to apply these in a responsible, interactive way**

The dynamic system allows for experimenting on the basis of interpersonal trust and collaboration, yet equally contributes to the system in continuous flux building both personal engineering mastery as well as institutional top of the bill knowledge developments opportunities contributing to the societal and scientific system in the world. Continious p (professional) development vs quick mastery of skills on dimensions area's

Scenario



Simeon is a technee at the Decision Making Institute. He's spent an interval of a couple of months immersed at a global scientific research company. He worked with a tech team on a project commissioned by the United Nations to come up with ways to efficiently manage large flows of refugees across 'badlands'. They came up with a solution that sparked joy for the company's leadership team and that helped the company attract substantial European research funds (system based collaboration). He noticed that his work on the project changed the way he looked at refugees, and he found out that someone he knew was involved in housing refugees at a local level. He decided to join as a volunteer and discovered that he could play an important role attracting resources through the personal connections he made at the Decision Making Institute, and that the Institute could help him develop the interpersonal skills to leverage his connections.



Above scenario illustrates the way a future technee is driven to acquire knowledge and grows his/her skills, and the role a knowledge institute plays.

CYCLES OF DEVELOPMENT

The Pace Institute

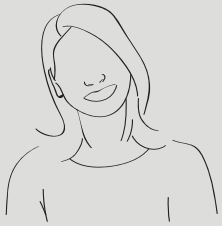
Developmental cycles of production in society

Learning Outcomes

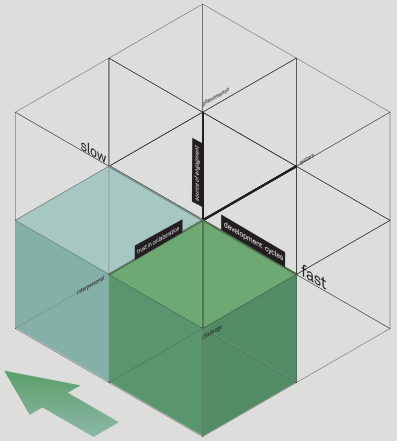
- **The ability to respond to urgent dilemma's and create rapid results**
- **The abilty to continuously reframe, learn and develop to make us understand 'the world' around us**

Learners (technees/staff/researchers etc) are involved in short time cycles and long term development of both human and material affordance, systems and products. Thus the Pace Institute is not merely addressing the cycles of the product development, but the cycle of acceleration of human evolution through knowledge building and (progress), contribution to developmental cycles of society with a sense of urgency.

Scenario



Cecil is a technee at the the Pace institute. She's spent a large part of her life starting-up social enterprises all over the world. She's become a master at solving technological scaling issues and dealing with all kinds of 'entrepreneurial growing pains'. The past couple of years Cecil has taken time to contemplate and look back on her career up until now. She feels that she could use her practical experience to make waves in politics and governance. These waves may be slower and smaller than she's used to but their effect more durable and longer lasting. At the Pace institute Cecile is making a career shift from origineering to enganeering. She is acquiring knowledge on network weaving, lobbying and political dynamics, and is being familiarised with the slower pace of this type of engineering role.



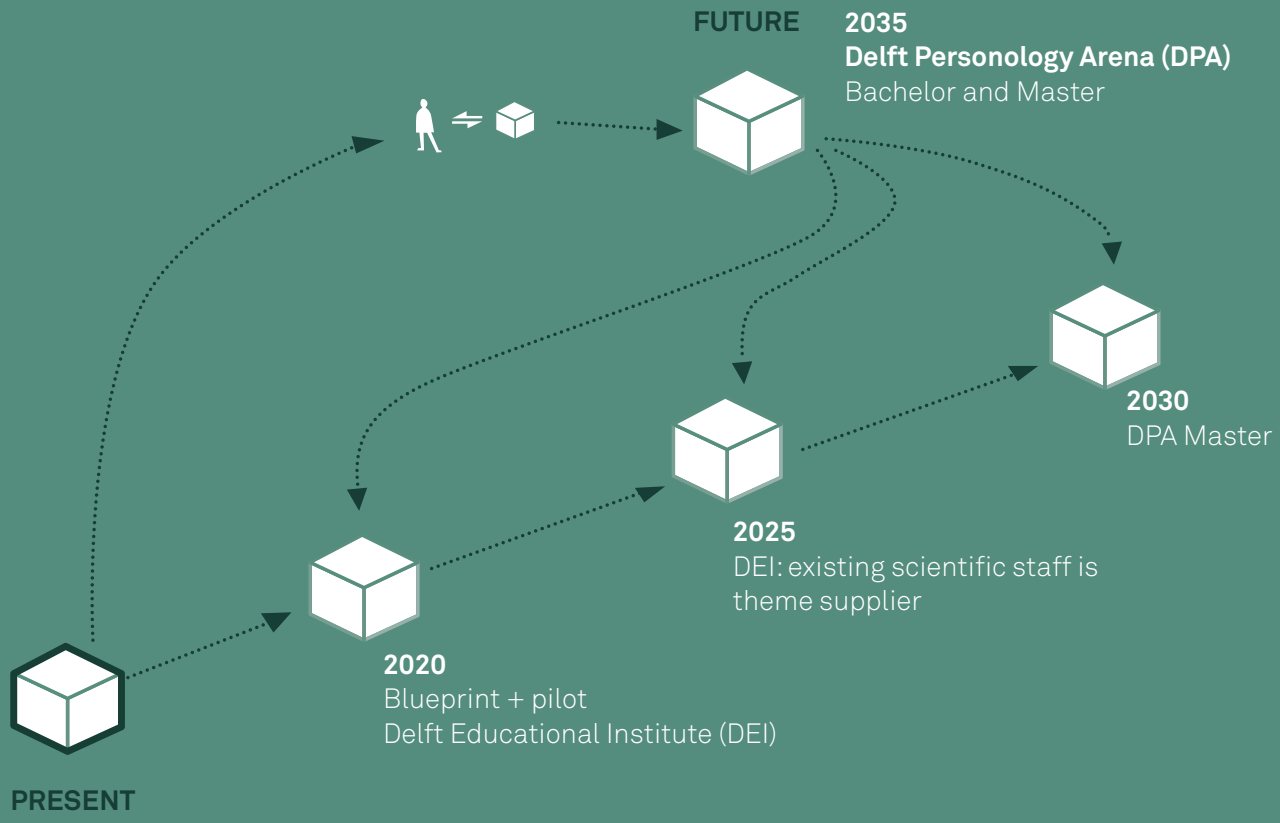
Above scenario illustrates the way a future technee is driven to acquire knowledge and grows his/her skills, and the role a knowledge institute plays.

5

Way forward

Next steps

HIGHOVER ROADMAP



Further development

We defined the Personology Arena as a place with three independent institutes taking the responsibility for three different fields in education. A concept for the future of 2035. Further development is necessary to translate this concept into a viable and realistic educational programme in the future.

A highover roadmap was created to give an indication of the steps necessary to develop the Personology Arena into a bachelor/master programme of education in 2035. The bachelor would focus on the exploration of 6 knowledge fields, related to 3 dimensions, i.e. 3 institutes, each responsible for 2 knowledge areas built around thematic content. Whereas the master programme would focus on the exploration of one or more of the eight possibles roles.

Desiging a new Master's programme

4TU has plans to design a new Master'a based on the concept of the Personology Arena. We are thrilled to take part in this process and put the underlying vision into practice. We will continue this project in a series of roughly three steps.

Step 1 - Elaboration of the concept
Before the actual design of the content of a new master programme it is vital to elaborate the concept further to make the Personology Arena 2035 proof. We will develop the following:

- An education model: diversity in forms of learning, stakeholder plan
- An organisation model: including a plan for public-private cooperation

Step 2 - Detailed roadmap
A roadmap will be made with further details, that will clarify all the steps to be taken towards 2035. We will focus on how to use existing infrastuctures and strategies. Therefore in this phase lobbying and giving presentations in the field will be one of the main activities.

Step 3 - Design of a new master
The design and research of all the necessary components for a new master programme will be realised in the upcoming years. The elements in step one will be further elaborated.

Step 4 - Prototyping
A pilot project will be started to test the new master programme on predetermined parameters like openness and inclusiveness.

Appendix

Appendix

We interviewed the following experts.

Barend van der Meulen - head of research at the Rathenau Institute and endowed professor Evidence for Science Policy at the CWTS

Patricia Faasse - researcher at the Rathenau Institute and co-writer (with van der Meulen) of “Future knowledge - 4 scenarios for the future of Dutch universities” and “Voor iedereen een universiteit”

Lex Herweijer -researcher at the Netherlands Institute for Social Research and contributor to the Social and Cultural Report 2016, specifically the chapter on Learning

Bas Haring - writer, professor “public understanding of science” at Leiden University, initiator of the Media Technology Master and “philosopher of the people”

Bert van der Zwaan - Rector magnificus and member of the CvB of Utrecht University and writer of the book “Haalt de Universiteit 2040?”

Ibo van de Poel - Antoni van Leeuwenhoek Professor ethics and technology and leader of the Ethics and Philosophy of Technology section

Rutger Botermans -professional engineer in the petrochemical industry and founder of training institute inIPED

Appendix

We gathered over 260 context factors.

1 DRIVING FORCE

Urgent societal challenges will steer the engineers agenda

#58 Our very own responsibility
Technology doesn't happen to us, we create it ourselves. It is an aspect of the human condition, for which we can take responsibility. [principle/cultural] - *(Peter-Paul Verbeek)*

#106 A growing sense of responsibility
Within the chemical industry there is a growing sense of responsibility. You can't create something without considering the decomposition of it. This is fed by the public, young engineers that enter the industry and from within the industry. [trend/ethical] - *(Rutger Botermans)*

#102 Active and passive responsibility
Active responsibility is responsibility before something has happened. It refers to a duty or task to care for certain state-of-affairs or persons. Passive responsibility is applicable after something (undesirable) has happened. [principle/ethical] - *(Ibo van de Poel, Ethics, technology and engineering)*

#121 The responsible engineer Engineers are increasingly held responsible for their own creations. This responsibility is being abstracted, used to be very concrete (for example: safety) but is now more abstract (for example: sustainability or even the social effects of an invention). [state/ethical] - *(Ibo van der Poel)*

#161 With growing technical possibilities come more human responsibilities
Only the availability of certain technologies (like available prenatal tests on the health of your future child) makes people more responsible and accountable. The dilemmas become more complex as well. [development/ethical] - *(Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)*

#163 Ethics help shaping the own subjectivity
Classic Greek ethics were about shaping the own subjectivity. This is not something that people do on their own, but in interaction with powers and forces from their environment. This makes ethics not a guard that protects people from technology, but a guide that actively contributes to the character of the mediation between mankind and technology. [principle/ethical] - *(Foucault; from: filosofie van mens en techniek, Prof.Dr.IR Peter-Paul Verbeek)*

#246 The limitedness of ethic
As good as one's individual intentions can be, people will still make decisions that do harm or cause damage to others. As the saying goes "The road to hell is paved with good intentions". (Prisoners dilemma) [state/social] – *(Rathenau Institute)*

#122 Justice is an overlooked value In engineering ethics, justice as a value, gets only little attention.
The development of technology can lead to inequality. How technology determines the distribution of welfare and for example the distribution of risks or opportunities and what the effects of this distribution are, is hardly a subject within engineering ethics. [state/ethical] - *(Ibo van der Poel)*

#14 The National Science Agenda
The social trend, under the high-educated, is to set (or have influence on) the scientific agenda (the National Science Agenda is first example globally). [trend/cultural] - *(Bert van der Zwaan)*

#120 Evolution of the social component of technology
Technical inventions and design increasingly contain social elements, they are no longer pure technology but intertwined with society. Therefore, designing for the social context of an invention is a crucial addition to the taskforce and an element of the development of new technologies. [development/technological] - *(Ibo van der Poel)*

#77 Technology will only lead to progress when it is accompanied by shared moral principles
New possibilities demand for ethical boundaries, social norms and even a new language (for example 'Facebook-friend') [principle/ethical] - *(Intieme technologie, Rathenau Instituut)*

#56 We lack the knowledge to join the discussion about intimate technology
While the intimate-technological revolution changes the world radically, politicians and citizens are hardly involved in the debate about it. This is partly due to lack of consciousness. [state/cultural] - *(Onderwijs de burger over de technologie die hem omringt, Rinie van Est)*
#104 Problem of many hands The occurrence of the situation in which the collective can reasonably be held morally responsible for an outcome, while none of the individuals can be reasonably held responsible for that outcome. [principle/ethical] - *(Ibo van de Poel, Ethics, technology and engineering)*

#159 Stretching the boundaries of mankind
Healing people does not only mean healing people from diseases, but also improving mankind. The newest technologies reshape to the image of the 'übermensch'. [development/ethical] - *(Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)*

#241 Attraction of contextual relevance
Students are attracted to new domains that relate to current and new contexts. Whenever universities develop new educational program to meet new contextual demands, like for example medical technology, forensic science or climate engineering, this draws new students. Often these new programs equally attract men and women. [principle/psychological] – *(Rathenau Institute)*

#188 If it can be done, it will be done It has been argued, and is believed by many today, that technological progress cannot be effectively controlled.
Human curiosity or ambition takes precedence over (often unclear) ethical concerns, and what is judged unethical and illegal in one country becomes a government sponsored project in another. The Manhattan Project is a famous example of the past, and the concerns about AI a more recent issue. [principle/ethical] – *(The Craftsman, R. Sennett, 2008, p2. Oppenheimers Choice, Mason, 2006)*

#103 Technological enthusiasm
Technological enthusiasm pertains to the ideal of wanting to develop new technological possibilities and take up technological challenges. This is an ideal that motivates many engineers. It is fitting that Samuel Florman refers to this as "the existential pleasures of engineering" (Florman, 1976). [principle/ethical] - *(Ibo van de Poel, Ethics, technology and engineering)*

#146 'Wow'-driven innovation
Entreprises choose diversity-in-thought as their strategy to innovation. The one that generates the most 'wows' wins the day. [development/organizational] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#107 No more pollution
The Dutch citizen does no longer want to be involved in polluting industry. Crowdsourcing platforms and petition-pages give citizens a way to very easily co-create and raise their voices. (voorbeeld: wijwillenhemweg.nl) [trend/cultural] - *(Rutger Botermans)*

#156 Circular design
In the near future, designers must not only be able to design well-functioning products, but should also include all processes involving distribution, maintenance, repair, 2nd use, reuse of parts and recycling of materials. [development/ecological] - *(Trendsquestionaire TU Delft, Industrial Design)*

#142 Increasing demand from governments and markets for sustainable products/processes
Innovations do not only depend on technical readiness levels, but also on technology acceptability levels, and enterprises have to be transparent at every step of the product's life cycle. [development/ecological] - *(Aldert Kamp, Engineering education in a rapidly changing world, 2016)*

#152 Increasing risk of water system failure All over the world the 'cost of (partial) failure' for water systems (drought, flooding, pollution) is rising rapidly. [development/geographical] - (Trendsquestionaire TU Delft, civil engineering)

#148 The future society will face enormous challenges on many fronts
Such as growing world population (from six to more than nine billion in 2050), energy transition, infrastructure, mass migration, mobility, climate, healthcare for an aging population and safety (social-/cybersecurity). [development/cultural] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#232 Contiuned growth in air transportation
Aviation will continue to grow by about 5% per year for the coming decades. As a consequence, aviation will double every 15 years. [trend/economical] – (Trend Report TU Delft Aerospace Engineering, p1)

#10 Science follows society
The nature of science is partly driven by social questions and funding. The last 30 years there was an excessive focus on life sciences (medicine) and technology. This focus will slowly shift towards governance, language, migration, social science and humanities. [state/cultural] - (Bert van der Zwaan)

#206 Cybersecurity
A new branch of national defence, and a new set of private and corporate security measures are made within the domain of cybersecurity. Not just against fraud, hacking or theft of identity or intellectual property, but agains psychological violence (bullying) on the personal level, and attacks on a company's reputation on the corporate level. On the national level, the focus is on understanding and managing new threats. [development/political] – (OECD Trends Shaping Education, 2016, p10)

2 DRIVING FORCE

Meritocratic engineering culture and education as 'rite de passage'

#42 Learn to participate in society
Meeting other people, diverse composite group of people and learning together are conditions to learn to participate in a diverse, rapid and ever changing society. [principle/sociological] - (SCP, De toekomst tegemoet)

#201 The real value of university education
Universities perform for students five different and quite distinct services: impartation of information, counseling, credentialing, coercion, and club membership. [state/cultural] – (The Dismantling of Higher Education, Wang, 1981)

#24 Upward mobility
Parents stimulate their children to obtain what they, themselves, didn't have. Mainly in rapidly growing economies (such as Asia) upward mobility is still possible whereas in the US and Europe this becomes hard and people will have to accept social descend. [development/cultural] - (Bert van der Zwaan)

#168 People will always organize themselves
Old types of organizations will be replaced by new ones. [principle/organizational] - (Sociaal en cultureel planbureau, De toekomst tegemoet, 2016)

#117 Comfortable culture
The comfortable culture in the big engineering corporates doesn't stimulate or motivate engineers to develop their skills and knowledge, to keep on learning. (Thereby: engineers aren't eager to learn from each other, since they are both 'specialists')
[state/developmental] - (Rutger Botermans)

#89 Curation within the walls of one single app
The old idea of a wide-open web – where hyperlinks from site to site created a non-hierarchical and decentralised network of information – has been largely supplanted by platforms designed to maximise your time within their walls, some of which (such as Instagram and Snapchat) do not allow outward links at all. The closed space of a chat app is an even more restrictive silo than the walled garden of Facebook or other social networks.
[state/technological] - (From the Guardian; How technology disrupted the truth, Katharine Viner)

#87 Extreme Filter Bubble
Algorithms such as the one that powers Facebooks news feed are designed to give us more of what they think we want. Filter bubble was introduced by Eli Pariser in 2011. He was talking about the personalised web, which means that we are less likely to be exposed to information that challenges us or broadens our worldview and less likely to encounter facts that disprove false information that others have shared. [state/ethical] – (From the Guardian; How technology disrupted the truth, Katharine Viner)

#205 Continuum and core values
As universities and the value of science itself is challenged, their core values and historical importance will be reaffirmed. [state/cultural]

#125 Discriminating in search for equality
The irrationality that capacities come from only hard work, instead of genes, luck, circumstances.
[state/cultural] - (Ibo van der Poel)

#124 Capacity over prosperity
Capacity, abilities and talent is increasingly more important than for example prosperity in the meritocracy of the western world. The abilities you have, determine

your opportunities and success. The one with less talent will be left behind (this group will grow towards the future). "If you perform well you deserve power and rewards. If you perform poorly, it is sadly, your own fault.". [state/cultural] - (Ibo van der Poel)

#44 In search for excellence
More courses for excellent, ambitious students are offered (honors programs, research masters), the number of institutes that handle strict and selective admission increases, and institutions work on their own, distinctive profile. [development/educational] - (SCP, De toekomst tegemoet)

#46 Civil effect Students want an official
acknowledgement for the completion of an education/ a course or a class. Certificates, diploma's and medals function both as acknowledgement and as 'license to operate' as soon as you start working. [state/cultural] - (SCP, Lex Herweijer)

#203 Credentialism
University accreditation is exclusive, and alumni and academic professionals want to protect the value of their investments in this system. [state/political]

#216 Women will be more disrupted than men
The participation of women in the workforce and percentage of women in managerial positions is increasing in The Netherlands, but they are so underrepresented in science, technology, and engineering that women will be more negatively affected by disruptive tech than men. [development/demographical] – ("OECD Trends Shaping Education, 2016, p50)

#214 The gap widens
GDP per capita has increased enormously in high and mid income countries over the last 40 years, but the so has the divide between rich and poor - both between nations and households. Those left behind constitute as much as 40% in many countries. [development/demographical] – (OECD Trends Shaping Education, 2016, p34; OECD (2015), In It Together: Why Less Inequality Benefits All, OECD Publishing, Paris)

#224 The tables have turned
Across the OECD, youth are now more likely than the elderly to be poor. At the same time, the average household debt has increased from 40% to 131% of the net disposable income. [development/economical] – (OECD Trends Shaping Education, 2016, p91)

#194 Persistent and growing social divisions People from disadvantaged socio-economic and migrant groups remain far less likely to enter and complete higher education, while academics and graduates are too often perceived as detached from the rest of society and the communities where they are located. [state/sociological] – (European Commission, "Renewed EU Agenda for higher education")

#17 The have and the not haves Until recently, we were in the exceptional situation that only a small (10%) part of the population was highly educated (the elite), which has now risen to 40% of the Dutch citizens. These 40% higher educated are no longer seen as the lucky few, which changes the social dynamics between the haves and the not-haves. [state/demographical] - (Bert van der Zwaan)

#264 Today, the silo effect seems to most managers a recipe for low productivity: employees tend to hoard vital information they think is to their personal advantage, and people in silo's resist feedback from others. One remedy is to encourage teamwork, indeed impose it, but such enforced cooperation suffers from the solvent of short-term time. [state/cultural] - (Sennet, Together 2012)

#263 The engineering principle of minimal movement to get rid of friction and reduce resistance applies to the social behaviour of working together, only with minimal assertiveness does one open up to others in dialogic exchange. [principle/philosophical] - (Sennet, Together 2012)

#252 Connectedness can hinder creativity
We live in a society where people are inclined to make connections, to share ideas and to co-create solutions. The downside is that we have less original thoughts; less sparkling ideas. It is hard to have these ideas when you're listening to others ("you need to be an island every once in a while"). [principle/psychological] – (Bas Haring)

#101 Resistance against technologies
The resistance against technologies is supported with two kinds of arguments. First, there is the fear that human freedom is threatened and that democracy is exchanged for technocracy, in which moral problems are solved by machines instead of people. Second, there is the charge of immorality. Actions that are not the product of our own free will but are induced by technology cannot be described as "moral." [principle/ethical] - (Ibo van de Poel, Ethics, technology and engineering)

#231 The way you organize determines the level on which you innovate
As technology and markets change, industrial-era departmentalization of businesses and academic institutions obstruct innovation and experimentation [principle/cultural]

#242 Proliferation of small colleges
Small scientific community with students whom they get to know well and whom can form from beginning to become well-behaved citizens. These colleges typically focus on small communities of full time students aged 18-25 who also live in campuses, and spend most of their time with each other (like solar challenge teams). [development/educational] – (Rathenau Institute)

3 DRIVING FORCE

Science is no longer the only source of truth

#251 Doubting science
People are more aware that you can find knowledge yourself, but typically they look for knowledge in a superficial way, and subsequently get ideas that are not true to reality. This in turn causes them to doubt science. [development/cultural] – (Bas Haring)

#105 Availability of information
Through the internet, a growing amount of people have access to an enormous amount of information. [development/cultural] - (Rutger Botermans)

#225 The pocket doctor
"The population is accessing the internet more and more across several types of devices. The majority of internet users also search for health information online. This is part of a general pattern of consumers becoming more informed in fields that were once exclusively the domain of experts. This also suggests that doctors and nurses will continue to be more likely to treat better informed patients who may challenge their suggestions or recommended course of action." [trend/cultural] – (OECD Trends Shaping Education, 2016, p101)

#134 Democratizing science
As part of democratization, after doctors, mayors, notaries etc. The authority of scientists (and with that science) is decreasing. The public is not able to separate the scientist from the research; therefore, this degradation also has its effect on the role of science within society. [trend/cultural] - (Ibo van der Poel)

#200 Reexamining the intersection between truth and meaning
The conflicts between the will of the people, as expressed in the elections of Donald Trump and the Brexit vote, and the opinions of established politicians and political scientists about "what is best for the people", has led to a profound reexamination of what is meaningful and of value for citizens. [trend/political] – (https://www.theguardian.com/science/blog/2016/sep/19/the-idea-post-truth-society-elitist-obnoxious)

#30 Knowledge will be omnipresent and fluid
No longer in books and articles but available wherever you are at all time. Ranging from formalized knowledge with controlled quality to grey knowledge, of which the academic quality cannot be guaranteed. [development/ cultural] - (Bert van der Zwaan)

#88 Facebook as a daily reference
Facebook has become the dominant way for people to find news on the internet. Social media hasn't just swallowed journalism, it has swallowed everything. It has swallowed political campaigns, banking systems, personal histories, the leisure industry, retail, even government and security. [state/cultural] - (Emily Bell, Facebook is eating the world)

#90 Validation by the click
Nowadays it's not important if a story's real. The only thing that really matters is whether people click on it. Facts, are over; they are a relic from the age of the printing press, when readers had no choice. If a person is not sharing a news story, it is, at its core, not news. [trend/ cultural] - (Neetzan Zimmerman, specialist in high-traffic viral stories)

#226 Fighting for attention
In general, having an online presence is increasingly seen as a necessity for individuals as well as companies. The trick, of course, is that with so much constant change, getting the attention and visibility you are looking for requires increasingly more effort. [trend/cultural] – (OECD Trends Shaping Education, 2016, p103, http://www.telegraph.co.uk/science/2016/03/12/humans-have-shorter-attention-span-than-goldfish-thanks-to-smart/)

#54 Attention competition
People experience an information overload, they are constantly confronted with information. When you have their attention your message needs to be short, clear and simple. [state/psychological] - (SCP, Lex Herweijer)

#86 Information cascade
People forward on what others think, even if the information is false, misleading or incomplete, because they think they have learned something valuable. This cycle repeats itself, and before you know it, the cascade has unstoppable momentum. You share a friend's post on Facebook, perhaps to show kinship or agreement or that you're "in the know", and thus you increase the visibility of their post to others. [trend/cultural] - (From the Guardian; How technology disrupted the truth, Katharine Viner)

#133 Increasing public scepticism about science
There is an increasing public scepticism about scientific research, with huge effects in the behaviour of people. For example: climate-denial, fake news or the anti-vaccination trend. [development/cultural] - (Ibo van der Poel)

#48 Authority of science is damaged
Authority of scientists is getting less self-evident. [state/cultural] - (SCP, Lex Herweijer)

#73 Toxic dynamic between journalists and scientists
Journalists and scientists enable each other in a way that massively inflates the certainty and generality of how scientific findings are communicated and the promises that are made to the public. When these findings prove to be less certain and the promises are not realized, this just further erodes the respect that scientists get and further fuels scientists desire for appreciation. [state/sciential] – (The 7 biggest problems facing science, according to 270 scientists)

#154 The absence of a reflective system of shared meaning
Philosophy as well as technology started out as the creation of a reflective system of shared meanings. Without such a system of shared meaning effective action is impossible. All effective technology is large-scale technology and supposes the problem of 'shared meaning' as solved. [state/sciencial] - (Trendsquestionaire TU Delft, Technology, Policy, Management)

#72 Science Hype
Science journalism is often full of exaggerated, conflicting, or outright misleading claims. Scientists themselves often oversell their work, even if it's preliminary, because funding is competitive and everyone wants to portray their work as big and important and game-changing. [state/sciential] – (The 7 biggest problems facing science, according to 270 scientists)

#85 Technology disrupted the truth In the digital age,
it is easier than ever to publish false information, which is quickly shared and taken to be true – as we often see in emergency situations, when news is breaking in real time. [state/cultural] - (From the Guardian; How technology disrupted the truth, Katharine Viner)

#250 What science is
Science is about asking a question, doing research and putting the answer you found to writing, usually in the form of a scientific article. [state/sciential] – (Bas Haring)

#237 Engineer-thinking
The idea that if you exchange arguments for long enough that you should be able to arrive at the best solutions. And that if you present your optimal solution in the right way that people will embrace it. [principle/psychological] – (Rathenau Institute)

#57 Emotions and technology don't match
Technology is 'hard', emotions are 'soft'. The idea that reason is superior to emotion is deeply rooted. [state/cultural] - (Addie Schulte, Bang voor robots? Gebruik die angst!)

#52 We only see a tip of the scientific iceberg
Society only sees little of what happens within the field of scientific research. Research is trial and error, all these iterations aren't reported to the public. [state/cultural] - (SCP, Lex Herweijer)

#118 Analytical champions, political losers
Engineers are analytical, problem solvers, system thinkers. They are often not good in presenting themselves, storytelling, they are often introvert and they mostly suck at political games or strategic power games. [state/cultural] - (Rutger Botermans)

#199 Mud Sticks "Several different "backfire effects"
have been observed when trying to debunk myths, arising from making myths more familiar, from providing too many arguments, or from providing evidence that threatens one's worldview."
[principle/sociological] – (https://www.skepticalscience.com/docs/Debunking_Handbook.pdf)

#268 In the future the world may no longer revolve around the belief of humans that everything is about humankind and humans as a source of all meaning an authority. Humanism as we know it today may no longer be relevant. [trend/philosophical] - (Yuval Noah Harari in 'Homo Deus')

#74 Scientists don't know how to communicate with the public
Communicating in layman's language is a skill that tends to be under-rewarded in the current system. Being able to explain your work to a non-scientific audience is just as important as publishing in a peer-reviewed journal, but currently the incentive structure has no place for engaging the public. [state/sciential] – (The 7 biggest problems facing science, according to 270 scientists)

4 DRIVING FORCE

Engineering talent will hop to and from new urban hubs

#234 Pressure on public knowledge institutions
As public research institutes (the TO2's) like ECN, NLR, DLO, and TNO become less visible, there is greater pressure on universities to take over their role. Although the relationship is partly symbiotic, historically there has always been tension between the institutes and technical universities; each claiming the other does things they can do better. [development/sciential] – (Rathenau Institute)

#235 Competition between cities
Urbanisation and the rise of cities causes competition between cities. Delft for example tries to position itself to Rotterdam and The Hague. This competition tends to be focused on relatively small geographical regions. [development/geographical] – (Rathenau Institute)

#245 Europeanization of knowledge and innovation
Technical universities increasingly need to position themselves in relation to other technical universities in Europe. Do you want to be a European university and compete there or focus more on regional training? Do you want to attract local business stakeholders or venture into the larger European space? [development/geographical] – (Rathenau Institute)

#12 High dynamics of science
The trend of interdisciplinarity within science results in new, high dynamics of science. Research groups can now interact easily, exchange knowledge and set up research or facilities together. [development/organizational] - (Bert van der Zwaan)

#259 Regional or international university profiles
There is room for only a handful of 'classical' renowned universities in Europe. Think of universities like Oxford, Cambridge, Bologna and Heidelberg. Most of the spots have been taken. And then there is room for universities with a specific profile like Wageningen (agricultural professionalization). Other universities will fulfil a more regional function. [development/geographical] – (Bas Haring)

#238 Bachelors are regional
In the bachelor, all universities in the Netherlands have a regional function. Most students come from the region, which have overlap on the edges. Fewer students from North-Holland and Amsterdam study engineering simply because it is not offered there. Regions often cross nation states. Maastricht for example receives a lot of German students. [state/geographical] – (Rathenau Institute)

#262 The market is currently the driving force behind change in Engineering education.
Governments start to realise the impact of technology on economic growth prospects and the capacity building position of technical Universities. It is a foundational choice to invest in engineering education. Students and staff will get a voice through voting with their feet. [state/economical]

#221 Brains over roads
Education plays a key role in creating urban innovation hubs: according to the OECD Regional Growth Model, the development of human capital is more important to an economy's long-term competiveness than its infrastructure. Policies that promote infrastructure will thus only be successful if human capital and innovation are also developed. [state/economical] – (OECD Trends Shaping Education, 2016, p69)

#83 Siloed engineering education
The discipline/department-based structure of many engineering schools and universities is constraining the innovation and excellence in engineering education. Multi-disciplinary learning and increased student choice will be constrained by the structural separations that often exist between and beyond engineering disciplines. [state/educational] - (Ruth Graham, The global state of the art in engineering education)

#6 Global job-market leads to global competition
Economical gravity shifts to Asia (foremost China) and thus the investment potential in the field of technology and life-sciences. This will increase the amount graduates in Asia, and threaten the competitive position West-European graduates. [development/occupational] - (Bert van der Zwaan)

#23 Universities depend on economic welfare
Throughout history universities have been in high degree dependent on economic welfare. An increasing economic welfare often results in a growing university. A decrease results in a shrinking higher education. [state/economical] - (Bert van der Zwaan)

#140 Mobilizing talent
Moving jobs to where the talent is instead of recruiting talent for where the jobs are. Research is increasingly detached from production and for their R&D, enterprises search for excellence from around the world. Activities are broken down into smaller activities that are easier to share out to talents/qualified experts. [development/occupational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#43 Brain circulation
Students are decreasingly locally bound. The amount of foreign students in the Netherlands increases. [development/demographical] - (SCP, De toekomst tegemoet)

#210 Multi-national enterprises give international opportunities
There is a continuing increase in the spread of multi-national enterprises , moving components of their value chain to the most competitive markets and recruiting talent globally. Mobilizing talent means moving jobs to where the talent is instead of recruiting talent for where the jobs are. [development/economical] – (OECD Trends Shaping Education, 2016, p29, 4TU Engineering Education in a Rapidly Changing World, p13)

#113 Patent-wars
The growing amount of "battles" between corporations or individuals to secure patents for litigation, whether offensively or defensively. There constant ongoing patent wars between the world›s largest technology and software corporations. [trend/legal] - (Rutger Botermans)

#1 Urbanisation will lead to knowledge hubs
The continuing urbanisation will lead to mega-cities (talent and innovation pools of the future), in which the best universities and knowledge hubs will settle. This will lead to knowledge hubs in Asia, US and Europe. [development/geographical] - (Bert van der Zwaan)

#219 Cities are growth centres
"The shift from rural to urban areas has been ongoing among OECD and BRIICS countries for over 50 years. Metropolitan areas produce a disproportionately high percentage of most countries' GDP growth, often centred on one big city for smaller countries, with The Netherlands as a clear exception with its multitude of strong urban areas." [development/economical] – (OECD Trends Shaping Education, 2016, p65)

#207 World metropolitan
Two cities on two different continents can have more in common than a city and its rural neighbour community. [principle/geographical] – (OECD Trends Shaping Education, 2016, p10)

#2 Regional knowledge-eco-systems
Regionalization within Europe will increase and regional knowledge-eco-systems (networks that consist of large number of institutes, universities, colleges, hospitals, companies, startups, ...) will become of big importance for the formation of knowledge and knowledge-transfer. [development/organisational] - (Bert van der Zwaan)

#45 Trans-national education
Institutes in different countries co-operate and offer a diverse education program, no longer bound to one location. [development/geographical] - (SCP, De toekomst tegemoet)

#209 Globalization creates diverse communities
Facilitated by fast changing technology and decreasing transport costs, individuals are moving more freely across countries and continents, bringing greater ethnic, linguistic and cultural diversity to OECD countries. Politically, this has been accompanied by the recognition that globalisation is here to stay, as evidenced in the growing numbers of countries that permit citizens to hold more than one nationality. [development/cultural] – (OECD Trends Shaping Education, 2016, p14)

#212 More emphasis on innovation as a competitive advantage
The number of patents filed within OECD member countries continues to grow, but Brazil, Russia, India and China are increasing their R&D efforts. Multi-national companies look to areas of high competence, and open research offices in knowledge hubs. [trend/political]

#7 War on talent
Attracting and keeping the right talent is a challenge for many companies. For every 13 jobs in the IT industry, only 1 Young Professional candidate is available. As soon as they found their talent, the next challenge is to keep them. Because only after 3 years the investment in a Young Professional will pay off. [trend/organisational] - (Bert van der Zwaan)

#144 The university's leading role as a producer of knowledge is under attack
Higher education is being liberalised, monetised and privatised by means of online courses and renowned professors. [development/educational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#260 Perfection of the bachelor/master model
The meaning of the master and bachelor will change to closer resemble the American model. It will be more common to join the workforce with a broad bachelor. People who find their interest will do their masters, often moving to other parts of Europe to study. [development/educational] – (Bas Haring)

5 DRIVING FORCE

Meaning-making as the back-bone for digital and analog growth

#239 Development of intellectual ability
The intellectual ability of a third year bachelor student is more developed than a first year student. For a first year student conceptual thinking is difficult and it is hard for them to pick up certain concepts, concepts that are addressed in the third year without problems. [principle/pscyhological] – (Rathenau Institute)

#182 Learning progress is not linear
In learning a craft, progress is not linear, depending among other things on level of concentration, mood, access to tutoring and tools. [principle/educational] – (The Craftsman, R. Sennett, 2008, p238)

#183 Small steps
If a problem is insurmountable, we break it down into smaller, manageable chunks. [principle/psychological] – (The Craftsman, R. Sennett, 2008, p222)

#187 10000 hours makes a master craftsman
Unless you make a choice, you will "age chaotically". Master musicians train from childhood, and "undefined" or "still searching" 40 year olds are looked upon as lazy. [principle/developmental] – (The Craftsman, R. Sennett, 2008, p20)

#20 Peer teaching
In 2000 years the learning process is changed but, how we learn effective remained the same. Peer tutorial is the more effective then frontal learning. Knowledge transfer is best via peers. Students learn the most in fraternities, side-activities, practicum and the moments before and after a lecture. [principle/sociological] - (Bert van der Zwaan)

#179 Show, don't tell
Language struggles with depicting physical action. In the workshop or laboratory, showing seems more effective than oral or written instructions [principle/ sociological] – *(The Craftsman, R. Sennett, 2008, p179)*

#39 Flipping the classroom
Student will be offered the class and instructions at their homes. At school, in a classroom and under the supervision of a teacher students will make their homework. This will redefine the role of the teacher and change didactics. [development/educational] - (SCP, De toekomst tegemoet)

#40 The new teacher
The role of the teacher will shift from expert or specialist (on a specific domain) towards designing the learning process and thereby guiding and supporting the student. Next to that the teacher will coach the student in his or her personal development. 'De docent wordt de makelaar in kennis' Lex Herweijer. [development/educational] - (SCP, De toekomst tegemoet)

#155 From teaching to coaching
More and more students gather the technical and scientific knowledge themselves. They do not need so much knowledge transfer, but coaching in making the right choices between alternative paths of scientific and technical inquiry. (this is not a return to the old-time idea of 'Bildung', the challenge is more to be able to move between different forms/values/modes of being.). [development/developmental] - (Trendsquestionaire TU Delft, Technology, Policy, Management)

#37 Learning in tele-apprenticeships
Different students (from beginner to specialist) will be involved in a real-life case. Beginners will learn by observing, over time they will get the assignment to more actively contribute to the case. [development/ technological] - (SCP, De toekomst tegemoet)

#36 Technology will bridge the gap between learning and doing
The gap between learning and doing, location of learning and the location of putting the gained knowledge into practice will be bridged by new technologies as augmented and virtual reality. [development/ technological] - (SCP, De toekomst tegemoet)

#261 Key skills in the near future for the engineering profession will be
Adaptability, system thinking, problem solving, sensitivity to societal problems/issues, the ability to take risk and a thorough understanding of the application of technology to real world problems, critical thinking and creativity. [development/economical]
#266 Online learning will only stay if institutions heavily invest in uncovering better ways of online learning through educational research and upgrade the level of content, beyond talking heads and old-style learning methods. [principle/educational]

#166 21th century skill: setting and guarding boundaries
The ability to set boundaries to yourself and your environment will become a necessity. 'On demand' and 'at a distance' will become more common. This flexibility can be a convenience as well as a burden. People will be 'forced' to deal with several things at the same time which makes them experience little autonomy and control. [development/psychological] - (Kossek et.al.; Peters en Wildenbeest, 2010; SER, 2016)

#26 The value of social proximity in learning and research
Physical proximity of co-researchers and –students are essential in a learning environment. In both the US and in Asia Universities have an active campus-life that influences the learning process and formation of students. [principle/sociological] - (Bert van der Zwaan)

#41 Blended learning
ICT developments will make learning more flexible and independent from place and time. The line between institutional learning at school and learning outside the school will blur. We will increasingly learn in a landscape of diverse learning-environments in which formal and informal learning will overlap and overflow. [development/educational] - (SCP, De toekomst tegemoet)

#178 Teaching requires the difficult act of regression
In music conservatories, for instance, the master often has trouble putting him- or herself back into the rude state of the pupil, unable to show the mistake, only the right way. [principle/educational] – (The Craftsman, R. Sennett, 2008, p186)

#186 Separating hand and head results in mental impairment
For instance - misuse of CAD programs diminishes the mental understanding in its' users compared to drawing and shaping by hand. [principle/psychological] – (The Craftsman, R. Sennett, 2008, p52, 81)

#223 Less homework, less stress
Between 2003 and 2012, 15 year old students in the majority of OECD countries decreased the time they reported spending doing homework, from almost six hours to almost five hours per week on average. Interestingly, results from PISA 2009 suggested that the achievement benefits from spending more than four hours a week on homework were negligible. [development/educational] – (OECD Trends Shaping Education, 2016, p89)

#233 Additive manufacturing
Reduces raw material usage, enables more customization, slower but different than series production, more crude but accessible material structures. [development/technological] – (Trend Report TU Delft Aerospace Engineering, p2)

#64 The power of language
Language accelerates learning and creation by permitting communication, coordination and, most importantly, autogeneration. [principle/cultural] - (Kevin Kelly, What technology wants)

6 DRIVING FORCE

Technology will smooth out people's fear of technological change

#127 Small inventions big effect
Relatively "small" inventions changed the way we live drastically. The invention of the toilet, sewerage, a cheaper way to make bread had a big influence on our prosperity. [principle/technological] - (Ibo van der Poel)

#60 The transforming nature of the Technium
New technologies constantly make it easier to invent better technologies. Whereas the power of our minds can be only slightly increased, the power of the technium can be increased indefinitely by reflecting its transforming nature upon itself. [principle/technological] - (Kevin Kelly, What technology wants)

#149 Technical revolution
We are on the brink of a period of irreversible change in technology. [development/technological] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)
#65 Moore's law Moore's law is the observation that the number of transistors in a dense integrated circuit doubles approximately every two years. [principle/ technological] - (Kevin Kelly, What technology wants)

#67 The path of technologies is inevitable
Throughout history inventions and discoveries have been made independently by more than one person. "Discoveries become virtually inevitable when prerequisite kinds of knowledge and tools accumulate." (sociologist: Robert Merton) [principle/technological] - (Kevin Kelly, What technology wants)

#126 Technology is the motor of change
The anxiety for technical innovation, is partly rooted in the simple fact history teaches us that big technological inventions can change a lot (everything) some will gain from new technologies and others will lose (as did happen before). [principle/technological] - (Ibo van der Poel)

#171 Coevolution
Every new development in the technium is contingent upon the historical antecedents of previous technologies. In biology, this effect is called: coevolution: the environment of one species is the ecosystem of all other species it interacts with. [principle/ technological] - (Kevin Kelly)

#79 NBIC-convergence
Four technological revolutions are pushing each other forward: nano-, bio-, information- and cognitive technology. [development/technological] - (Intieme technologie, Rathenau Instituut)

#256 The 40 hour workweek
The workweek will not become shorter, just like the travel time budget is pinned at one hour (global average time spent by a person for commuting each day) Through work, you can make claims on others. The distribution key remains the same. If you work 40 hours a week, you can make more claims, and people will always like to have more (from jeans to gardeners). [state/cultural] – (Bas Haring)

#255 Work is doing something for someone else
Work is ultimately lending your time for the benefit of another. Even when robots become abundantly present you will still be able to do something for the benefit of someone else. But we can't imagine today what kind of activities these are; what constitutes work in the future. We do know that of all the activities we consider to be work today, none would have been considered work 100 years ago. [state/philosophical] – (Bas Haring)

#253 The irrational fear of robots
The irrational fear that people have is that robots will take over their work; that they will have nothing to do and that life is a long holiday but without the money to celebrate it. Providing a basic income is a solution that caters to this fear. [state/cultural] – (Bas Haring)

#5 The polarization of the Job-Market
The middle segment of the job-market is decreasing (because of computerization and robotization), while the top segment is over-crowded. This will lead to a changing education-need. There is a growing gap between lousy jobs and lovely jobs. [development/occupational] - (Bert van der Zwaan)

#123 Insecure about the future
Partly because of technology the world is changing in a rapid speed. Simultaneously the opportunities that people get in life are also changing quickly (both positive and negative). Handling these dynamics and additional insecurity is a social challenge of this time and demands for resilience. Technology can function as a bridge but can also increase polarization. [state/psychological] - (Ibo van der Poel)

#169 The paradox of progress
While we become richer and smarter, the risk of redundancy grows. [development/psychological] - (Rutger Bregman, De race tegen de machine)

#59 great decoupling
Productivity is higher than ever, innovation has never gone so fast, yet the modal income declines and we have fewer jobs. [development/economical] - (Erik Brynjolfsson and Andrew McAfee)

#100 Technology shaping behaviour
Technologies do not only enable us to perform actions and have experiences that were scarcely possible before, but in doing so, they also help to shape how we act and experience things. Quite often, technologies mediate human actions and experiences without human beings having told them to do so. Some technologies, for instance, are used differently than their designers had envisaged. [principle/ethical] - (Peter-Paul Verbeek, Ethics, technology and engineering)

#176 Precautionary principle (the commonly used approach to new technologies)
A technology must be shown to do no harm before it is embraced. It must be proven to be safe before it is disseminated. If it cannot be proven safe, it should be prohibited, curtailed, modified, junked, or ignored. (state/political) - (Kevin Kelly)

#175 The predictivity of most new things is very low
At the introduction of phonographs, lasers, mobile phones and transistors the inventors could not predict what the invention will be used for. We make prediction more difficult because our immediate tendency is to imagine the new thing doing an old job better. (The first cars were called: "horseless carriages"). (principle/technological) - (Kevin Kelly)

#136 The implications of a new technology are often ambivalent
At its introduction, the implications of a new technology are often ambivalent. It is the way a technology is being introduced, used or the effect it has as soon as it is being used that will lead to either a negative or positive criticism. [principle/technological] - (Ibo van der Poel)
#173 Superiority of the man-made We give precedence to the made over the born. Even our cultural compliments for excellence have drifted to the mechanical: "smooth as glass", "bright and shiny" or "like clockwork". (state/technological) - (Kevin Kelly)

#185 We stand on the shoulders of machines
The machine has improved the quality of our lives, medicines, houses, food, communication - it is not just a problem, or a danger, or something to contend with, but also an enabler of our quality of life. This is also reflected in the "technosphere" - the total mass of technology we have put into the world to sustain us has been calculated to be around 100.000 as large as the total mass of humans it sustains. [principle/technological] – (The Craftsman, R. Sennett, 2008, p83)

#68 New tech is built upon old tech
To a degree that is invisible to us, new tech sits on a foundation of old tech. Despite the vital layer of electrons that constitutes our modern economy, a huge portion of what goes on each day is industrial. Cell phones, web pages, solar panels all rest upon heavy industry and industry rests upon agriculture. [principle/technological] - "Only when all required conditions generated by previous technologies are in place, the next technology can arise."

#172 Technology creates problems
Each new technology creates more problems than it solves. Most of the new problems in the world are problems created by new technology. (principle/technological) - (Kevin Kelly)

#174 Frankenstein syndrome
Once the machine is built, we discover that it has ideas of its own. (principle/technological) - (Kevin Kelly)

#138 Computational power is taking engineering away from the classical trial-and-error methodology
The rise of quantum computing and simulation may offer solutions to fundamental problems that are beyond the realm of the digital computers of today. The improvements in computational power is taking engineering away from the classical trial-and-error methodology. [development/technological] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#63 The evolution of the made
The difference between the evolution of the made and the evolution of the born is that species of technology, unlike species in biology, almost never go instinct. [principle/technological] - (Kevin Kelly, What technology wants)

#49 Technology is intertwined with society
Technology is everywhere, without technology there is no society –as we know it. People are unaware of this fact and take the technology that surrounds them for granted. [state/cultural] - (SCP, Lex Herweijer)

#99 Structure of amplification and reduction
When mediating our sensory relationship with reality, technologies transform what we perceive. This transformation of perception, always has a structure of amplification and reduction. The fact that mediating technologies amplify specific aspects of (the perception of) reality while reducing other aspects. [principle/technological] - (Ihde, 1991)

#51 People see technology as a threat
People often see technology as a threat. [principle/psychological] - (SCP, Lex Herweijer)

#177 Risk aversion
People will accept a thousand times as much risk for technologies or situations that are voluntary rather than mandatory. The acceptance of a technology's risk is proportional to its corresponding perceived benefits. More gain is worth more risk. [principle/psychological] - (Kevin Kelly)

#195 Agents of change
Engineering and innovation go hand in hand but the public is afraid of rapid change. When technological change happens faster than the investment cycle for a technology, major problems can happen. People will dig in their heels as a reaction to the newness of innovation. They will stick to old familiar processes, even when the new ones are faster, easier and more efficient. [principle/psychological] – (https://www.wired.com/insights/2014/11/solows-paradox/)

#162 Technology continuously contributes to the way we answer the question, and shape our perception, of 'a good life' (e.g. the car, birth control, the mobile phone, echoscopy) [principle/philosophical] (Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)

#98 Multistability
The phenomenon that a technology can have several "stabilities," depending on the way it is embedded in a use context. The telephone and the typewriter, for instance, were not developed as communication and writing technologies, but as equipment for the blind and the hard of hearing to help them hear and write. In their current use context they are interpreted quite differently. [principle/technological] - (Ihde, 1991)

#129 Factories on the horizon
The image of factories on the horizon is in Netherlands seen as visual pollution (horizon vervuiling), but in the east the very same image is seen as progression. The same counts for the noise of airplanes. [state/cultural] - (Ibo van der Poel)

#53 Success defined by the absence of failure
In the current education system, your route is defined by the subject(s) that you fail. At exams, your mistakes are measured and subtracted from your final mark. When you fail too many subjects you either need to change directions or try again. [principle/educational] - (SCP, Lex Herweijer)

#108 Naïve chemical consumers
In the eyes of the citizen the petro-chemical industry is bad for the environment. They all seem to agree upon that. But at the same time: they don't know that they surrounded themselves with products and materials that were produced in the very same industry. [state/ecological] - (Rutger Botermans)

#76 We surround ourselves with predictability
Over the past 25 years, there has been a proliferation of consumer products designed to meet our increasingly heterogeneous preferences, our desire for convenience, and our appetite for the latest technologies. An overlooked benefit that many of these products provide is that of predictability. Rather than using a map along with trial-and-error to find our next destination, we can now ask Siri to guide us seamlessly to that location. [trend/cultural] - (C.Page Moreau & Marit Gunderson, Downstream consequences of problem-solving mindsets)

#109 Hidden impact
People have a blind spot for the impact of: email, internet, phone-use, food-consumption, and many more every-day activities. [state/ecological] - (Rutger Botermans)
#66 Imagining Risk The acceptability of risk is directly influenced by how easy it is to imagine both the worst case and the best benefits, and those are determined by education, advertising, rumor and imagination. It is easy to think of potentially deadly worst-case scenarios involving a driverless car. [principle/psychological] - (Kevin Kelly)

#132 The anxiety for new technologies is of all times
People have been and always will be afraid for new technologies. Throughout history the arguments against technological innovation often contain the same elements (Frankenstein scenario): 1. Technology will lead to a radical change 2. Technology will be a force of its own 3. Technology will control society. [principle/psychological] - (Ibo van der Poel)

#267 Three rules on how we react to technologies
1) Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works, 2) Anything that's invented between when you're fifteen and thirty-five is new and exciting and revolutionary and you can probably get a career in it and 3) Anything invented after you're thirty-five is against the natural order of things. [state/cultural] – (Douglas Adams, author of the Hitchhikers guide to the galaxy)
#71 Citical mass Critical mass
; adoption or refusal of new technology is easier for a person in a group than for a person on his own volition. [principle/sociological] - (Kevin Kelly)

#32 Robot as a placeholder
Before we were using a dish washer we would call it a "robot". Robot became the name for everything that is tech, new, automated and not being used by the mainstream. [trend/technological] - (SCP, De toekomst tegemoet)

#268 The jobs of the future don't exist yet
Most of the jobs that exist in the future do not yet exist. By one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist. Ten years ago we never heard of app developers, Uber drivers, social media managers, cloud computing specialists or drone operators. [state/occupational]

7 DRIVING FORCE

The future engineer is intrigued by things, and by the people in them

#160 The fusion of human and technology
Todays technical possibilities fade the boundaries between humans and technology. In some cases, there is barely a distinction between what is human and what is technical. For example, in the case of a cochlear implant that is directly attached to the auditory nerve, hearing becomes a mutual activity of human and technology. [development/...] - (Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)

#55 Intimate technology revolution
Our relationship with technology is becoming increasingly intimate. This fusion between man and technology results in the fact that we become as transparent in the physical world as on the Internet. [development/technological] - (Onderwijs de burger over de technologie die hem omringt, Rinie van Est)

#78 Intimate technology
Technology increasingly exists in us (i.e. brain implants and artificial new heart valves), between us (i.e. social media) it thinks about us (smart camera's, intelligent medical equipment) and sometimes technology even behaves like us (chatbots and empathic robots). [development/technological] - (Intieme technologie, Rathenau Instituut)

#81 We've never been autonomous in relation to technology
We are not supreme over technology. We're mediated by technology. Our contacts are mediated by phones and computers, our opinions are mediated by newspapers, social media and television, our movement is mediated by cars, trains and airplanes. [principle/cultural] - (Peter-Paul Verbeek, 2009)

#228 The Bionic man
The biotech sector is booming, as evidenced by the rise in the numbers of patent applications, particularly in The Netherlands. One example of how biotechnology is becoming more integrated in our lives comes from genome sequencing, where prices have been dropping exponentially in the last decade. Brain-enhancing drugs are also expected to become a practical and political issue to deal with for educational institutions. [development/technological] – (OECD Trends Shaping Education, 2016, p108)

#128 Technology is invisible
Because we are so used to technology in our surroundings we are not aware of the fact that we are basically surrounded by it. The fact that we increasingly make use of wireless and even cloud based technology makes us even less aware of the technology that we use constantly and surrounds us. Factories will always be visible. [state/technological] - (Ibo van der Poel)

#80 The human border
The border between technology and humans fades and technology is less visual. This happens all without us taking an explicit position and attitude in this relationship. [trend/technological] – (Peter-Paul Verbeek, 2009)

#69 Dependence on technology
Once a technological innovation has been introduced, people usually become dependent on it. [state/technological] - (Kevin Kelly)

#157 People are throughout technological mediated creatures [state/cultural] - (Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)

#158 Technology is a human condition
Just as humans are not autonomous when it comes to language, oxygen or gravity, it is not autonomous from technology either. The human is a product of technology and technology is a product of humans. Neither of them are autonomous. [principle/cultural] - (Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)

#240 Different styles of thinking
There are different styles of thinking, in broad term you could say there are three styles which are a reflection of the alpha, gamma and beta sciences; statistical thinking, social thinking and technical thinking. Most students only master one style and have difficulty with the other two, some master two styles and a select few master all three. [principle/psychological] – (Rathenau Institute)

#119 Rise of the socio-technical engineer
Whereas the engineer used to have in depth knowledge about a very specific domain, engineers are now trained to have broader knowledge and a bigger skillset that go beyond engineering skills. Ethics and other social subjects become more and more important for the future engineer. Since technology is increasingly intertwined with society. [development/ethical] - (Ibo van der Poel)

#258 The engineer in essence loves things
The primary trait of engineers is that they are intrigued by things (artefacts). They find things fun and exciting they are very good at understanding things and dealing with things. Yes you can focus education on broadening knowledge on other subjects, on developing social skills or on understanding the role of technology in society. But when push comes to shove the engineers are more intrigued by things (and people interacting with things), than people (in solitude). [state/cultural] – (Bas Haring)

#243 Increasingly complex artefacts
People interact with increasingly complex artefacts, like cities (smart cities), financial markets and democracies. These are man-made technological phenomena that can be optimized from a technical point of view, and hence will increasingly become the subject of engineering. [development/technological] – (Rathenau Institute)

#257 You need other people to stay alive It is unthinkable that you can maintain any standard of living without at least a small involvement of other people. Each person is completely and utterly dependent on everyone else. That is actually the great efficiency of the society we live in (see wiki for division of labour, complex society, urbanisation and Milton Friedman's The Pencil video). [state/cultural] – (Bas Haring)

#112 Miniaturization
The trend to manufacture ever smaller mechanical, optical and electronic products and devices. Examples include miniaturization of mobile phones, computers and vehicle engine downsizing. [development/technological] - (Rutger Botermans)

#220 Smart Cities
The concept of Smart Cities has promised to help create more sustainable cities that support a better quality of life for their inhabitants. Through a large push for implementation of new technology in the development and operation of cities, the EU is investing in smart cities all over Europe. [trend/political]

#236 More applied research and lectorates
Colleges of higher education (hogescholen) are increasingly developing their own research profiles, expanding their practical research capacity especially in the technical domain. Higher education is becoming more knowledge intensive and the work field more dynamic; it is almost unthinkable not to conduct research. [development/sciential] – (Rathenau Institute)

#249 Fragmentation of science
Science is becoming more and more fragmentised. What you see is that graduate students often play a small part in a large project, and that these large projects are part of even larger projects. They lack overview and understanding of the larger question underlying a project. [development/sciential] – (Bas Haring)

#248 Practical versus scientific research
Formulated in an exaggerated way, universities typically either coach students to become future problem-solvers or coach them to become future Nobel prize winners; these are totally different goals. Both require different skills, different types of education and different expectation setting for students. [state/educational] – (Rathenau Institute)

#196 More high skilled jobs
Half of all job opportunities that will become available in the EU in the period up to 2025 - as a result of new job creation and to replace those leaving the labour market - will require high level qualifications (CEDEFOP in "Renewed EU Agenda for higher education". [development/occupational]

#50 Technological innovations are hard to understand
Most of the technological innovations are so complex people have a hard time to understand what it is about and what the consequences could be. [state/cultural] - (SCP, Lex Herweijer)

#130 Awe for technology
Layman have an awe for technology. It's something sophisticated they don't understand and could never comprehend. Made by smart people. [principle/cultural] - (Ibo van der Poel)

#82 The evolution of the engineer
The word engineering is derived from the Latin word ingenium, which means innate quality of mental power. Each type of new engineers emerged after yet another technological revolution. Together pushing the technology wave. [development/technological] - (Renate Klaassen, Engineers in the future)

#193 Engineers are seen as masters of technology and materials, not processes and people
This is strengthened by universities' focus on presenting the end product of any engineering enterprise - the bridge, airplane, medicine, it system etc. In reality, the success of any such enterprise depends on many other factors than technical excellence. [state/cultural]

#97 Revenge of the nerds
The nerd used to be a hopeless loser, but not anymore. The nerd is being revalued and is now considered crucial in solving the problems of the future. The new nerd is the most beloved, admired and valued type of human. The ability to focus on a subject for a longer period of time is today being valued more than before. [development/cultural] - (project Reframing Studio)

#197 Engineering is for the smart
The term Engineering is derived from the Latin ingenium, meaning "cleverness" and ingeniare, meaning "to contrive, devise". The public perception is that engineering education is difficult. This perception also shapes expectations of students. There must be some reward— in the future— for the sacrifice and hard work that is unique to engineering education. This reward is a high paying job and a comfortable lifestyle. [state/cultural]

#111 Super specialist practical engineer
As products become more and more complex, the different 'steps' (engineers) between a super specialist (back-and) and practical engineer (front-end) will grow. [development/technological] - (Rutger Botermans)

#70 Technology to manage technology
We increasingly rely on computerized means to manage the complexity of our built world. [development/technological] - (Kevin Kelly)

8 DRIVING FORCE

People will have a life-long entrepreneurial mind-set

#247 The formative years
The years from 4 -22 is the period in which an individual can experience great developmental change. In these years the individual is formed. After this learning phase people change in a more incremental way. The phase is extending as people get older and people enter the job-market at a later age. [state/developmental] – (Rathenau Institute)

#31 Life-long learning
Because of fast developments and an ever-fast-moving society, people will increasingly be concerned with aging or outdated knowledge and skills. This will result in a different distribution of learning throughout the course of life. Life-long formal and informal learning will become more important. Education level will have variable value over time. [development/educational] - (SCP, De toekomst tegemoet)

#217 Reskilling an ageing workforce through lifelong learning
The gap between retirement age and life exptectancy has increased, as has public spending on social expenses. The elderly will increasingly be seen as a resource, increasing the importance of lifelong learning and the empowerment to care for oneself. [trend/demographical] – (OECD Trends Shaping Education, 2016)

#147 Lifelong learning is produced in formats that assure diversity
To meet the needs of the technical, financial or governmental stakeholders and different cultures. [development/educational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#115 Problem-driven motivation to learn
Only a small percentage of engineers is looking for specialist knowledge or education during their careers. Very often the need for education is driven by a problem, incident or an employer. [trend/educational] - (Rutger Botermans)

#21 Formative years
Between the age of 4 and 22, people learn the most and are being formed. After these years, we learn incremental and little. [principle/psychological] - (Bert van der Zwaan)

#213 Easier than ever to start a business
Measured in the number of days taken to formally start a new business, there has been a dramatic decrease from 36 days on average for OECD countries in 2003, to 9 days on average in 2014. The growing emphasis and support for innovative startups as a means for nations to stay competitive and increase trade, has made it easier than ever to try starting a new business. [development/economical] – (OECD Trends Shaping Education, 2016, p52)

#22 The universal adolescent need
Adolescents show the need to form themselves, search for meaning, identity and autonomy. [principle/psychological] - (Bert van der Zwaan)

#62 Most new ideas and new inventions are disjointed ideas merged
One breakthrough invention can lead to a further breakthrough invention, while retaining most of the virtues of the previous inventions. [principle/technological] - (Kevin Kelly, What technology wants)

#167 Growing unpredictability of life
Work becomes more temporary, the durability of skills will decline. Because it is difficult to predict what the job market will look like in ten years, it is diicult to prepare yourself and your 'employability' for future jobs. [development/occupational] - (Sociaal en cultureel planbureau, De toekomst tegemoet, 2016)

#164 The durability of knowledge and skills decreases
Technical developments make the durability of knowledge and skills decline. It forces people who work, to learn longer and more often. [development/technological] - (Sociaal en cultureel planbureau, De toekomst tegemoet, 2016)

#116 Engineering needs context
Engineers can study between four walls but will learn in the field, mostly by mistakes (of themselves or others). [principle/educational] - (Rutger Botermans)

#33 Just in time learning
Because of the increasing need for adaptation to unknown changes, the ability to keep learning will become of more importance. Application-oriented, specialist and context-related knowledge (all aging at rapid speed) will be obtained according to the just in time principle. [development/educational] - (SCP, De toekomst tegemoet)

#91 The Creativity Crisis
Children have become less emotionally expressive, less energetic, less talkative and verbally expressive, less humorous, less imaginative, less unconventional, less lively and passionate, less perceptive, less apt to connect seemingly irrelevant things, less synthesising, and less likely to see things from a different angle. [trend/developmental] - (Kyung-Hee Kim, The Creativity Crisis, 2011)

#181 Play teaches us how to increase complexity
Playing is like creating your own game and testing what rules make it rewarding and interesting - thus also learning to prototype with increasing complexity. [principle/educational] – (The Craftsman, R. Sennett, 2008, 272)

#180 Flip the canvas
Shifting between domains of activity with a common reference point, liking turning your drawing upside down, stimulates fresh thinking about problems. [principle/psychological] – (The Craftsman, R. Sennett, 2008, 279)

#93 The play deficit
Over the decades, there has been a continuous and ultimately dramatic decline in children's opportunities to play and explore in their own chosen ways. [trend/developmental] – (Peter Gray)

#75 Playing with Lego can influence creativity negatively
Rather than challenging consumers to solve ill-defined problems, current toys often present them with well-defined problems along with the means to solve it. These types of toys have a negative influence on the problem-solving mind-sets of individuals, their creative performance as their choice to engage in creative tasks. [principle/educatonal] - (C.Page Moreau & Marit Gunderson, Downstream consequences of problem-solving mindsets)

#135 Utility science
The trend that (even in science) everything needs to be valorised and utilized. Especially within the Technical Universities there is this ideology that all research needs to be of purpose for the big tech firms. [trend/sciential] - (Ibo van der Poel)

#204 Instrumentalism takes a grip on research funding
There is an increased focus among EU research funds to produce valuable and implementable scientific results, requiring universities to apply for funding in cooperations with relevant organizations that can attest to the potential value. [development/sciential]

#184 You have to sell it to get it valued
Machine culture moved us from valuing hands-on-knowledge to valuing explicit knowledge. In teamwork, the solution that is easy to communicate and argue, may be selected in front of solutions that may be technically better. Thus, as someone skilled in making what is considered good craft, the good craftsman can be a poor salesman. [development/technological] – (The Craftsman, R. Sennett, 2008, p84, p117)

#95 Entrepreneurial projects
Larger organisations sponsor smaller entrepreneurial teams within their own walls to help generate new ideas and spur innovation. [state/economical]

#170 From technology to consumer driven
The blending of technical, economic and societal structures is leading to business and innovation approaches where technology-driven is replaced by more client- and consumer driven approaches. [development/economical] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#94 Alternative routes for funding or content
Angel investors, crowdfunding and crowdsourcing are increasingly used to obtain funds for services, innovative ideas or content by soliciting contributions from large groups of people, especially online communities. [state/economical]

#145 The high-speed of change and innovation implies short-term thinking
Business and organizations (now and tomorrow) are overexposed to intense competitive and operational disruptions, which requires greater resilience of both the enterprise and its employees. [principle/organizational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

9 DRIVING FORCE

Collaboration will be more open, interdisciplinary and mediated by 'black-box' systems

#137 Rise of machine intelligence
Intelligent machines learn at an accelerating rate since they can incorporate the experience of any other machine of their kind through the cloud almost spontaneously. They are completing more and more non-routine cognitive tasks and develop broad abilities in domains that used to be exclusively human. [development/technological] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#153 Growing big data possibilities
People and institutions produce enormous amounts of data; social-, medical-, customer-, scientific data, etc. Mankind can benefit from analyzing this data in new ways and with new technologies, which will also bring new challenges along. [development/technological] - (Trendsquestionaire TU Delft, civil engineering)

#161 With growing technical possibilities come more human responsibilities
Only the availability of certain technologies (like available prenatal tests on the health of your future child) makes people more responsible and accountable. The dilemmas become more complex as well. [development/ethical] - (Prof.Dr.IR Peter-Paul Verbeek, filosofie van mens en techniek)

#230 Open source, open data, open standards
If the owner of intellectual property wants to share, for example for the purpose of crowdsourcing imprevements or gaining publicity (and hence new business opportunities), new licensing models that are based on sharing and transparency have become standardized. [development/cultural]

#143 Open-innovation models
Traditional innovation models (all disciplines in house) are shifting to more open-innovation models, which is particularly useful for lower levels of technology readiness. In open-innovation spaces, the resources are available for anyone with access to 'the cloud'. The other participating parties are not necessarily rivals but may be an interesting resource instead. [trend/organizational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#13 Open science
The movement to make scientific research, data and dissemination accessible to all levels of an inquiring society, amateur or professional. Researchers and other academics worry less about publishing in the top-magazines and peer-reviews, open up towards the public (it is at least publicly funded), allow for feedback, criticism from the entire (scientific) community. An example: the shift from the white to the grey field: research produced by organizations outside the traditional academic publishing. [trend/sciential] - (Bert van der Zwaan)

#96 Open innovation
Traditional innovation models, with all of the relevant disciplines in house, are shifting to more open innovation models that make use of a supply chain for specific knowledge and prototyping. Technology-driven innovation is replaced by more client- and consumer- driven approaches. [development/organizational]

#131 Responsible upstream innovation
The demand for public engagement (involving the citizen at an early stage of technology development) in big innovation projects increases. [development/cultural] - (Ibo van der Poel)

#150 The maker movement
Technologies like 3D printing and CNC technologies will enable everybody to use those technologies in their daily life. This will change the position of the future consumer. [development/cultural] - (Trendsquestionaire TU Delft, architecture)

#16 Local science
Science is dependent of culture and location. African and Asian scientific agenda differ from the Western science agenda. [principle/cultural] - (Bert van der Zwaan)

#218 Participation and resourcing
Citizen involvement is an increasingly important element of governance on all levels. Social media and the

Internet help to spur citizen engagement by facilitating co-ordination and action within communities. New and innovative applications allow residents to report problems in their community and governments to respond quickly and efficiently to their concerns. [trend/political] – (OECD Trends Shaping Education, 2016, p66)

#254 People are inherently lazy
People are inherently lazy and like to outsource things. You will always have more readers than you will have writers. You will always have more consumers than people who like making things, than producers. [state/cultural] – (Bas Haring)

#15 Citizen science
The collection and analysis of data relating to the natural world by citizens, typically as part of a collaborative project with professional scientists, driven by a social conscience. The collaborating citizens are most often high-educated alumni of the University that promotes the research. [development/cultural] - (Bert van der Zwaan)

#28 The Wiki-way of quality control
As an alternative to peer-reviews, researchers increasingly publish their concept-publications online to be screened and criticized by colleagues, inviting the scientific community to participate in quality control. [trend/sciential] - (Bert van der Zwaan)

#151 Expertise shift
The world depends for more than 80% of its energy needs on fossil fuels. Slowly, alternative and renewable energy will have to take over. The demand for geophysicists and petro physicists shall reduce while knowledge on the exploitation of existing reservoirs will become more important. Work in multi-disciplinary teams will be a must because of the increasing complexity of the problems that shall be encountered in this domain. [development/developmental] - (Trendsquestionaire TU Delft, civil engineering)

#139 Open-collar workers bridge the gap between supply(designer/engineer) and demand (company)
Open-sourced networks have their own models, collect their own data and focus on specific aspects of a system. They deliver services in a decentralized pay-per-task structure. [development/organisational] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#189 We are moving from a split of social and natural sciences to a more holistic view of the world
Already advocated by great thinkers, it will happen due to the need to design products and services that present technology and society in meaningsful ways to people. [development/sociologial] – (Latour, 2000, When Things Strike Back)

#27 Shared research and massification
The use of big-data, researching and editing enormous sets of data, will change the world of scientific research significantly. The size of data-sets offers an endless amount of possibilities for signal detection and reduction of background noise. But also the combination of data-sets from different disciplines offers endless possibilities. [devlopment/sciential] - (Bert van der Zwaan)

#229 Business Intelligence
Both the promise of utilizing unstructured Big Data and the increased proliferation of structured Data Warehouses afford opportunities for the data-minded engineer. Investments in Data warehousing can help create more effective development, production/operation and maintenance for existing markets, while Big Data carries the promise of opening up entirely new opportunities. [development/economical] – (4TU Report, page 12, term definitions, insight by Truls from his work in the field of Business Intelligence)

#215 International scientifc collaboration increasing in the west
Researchers are increasingly working in collaboration with colleagues from other countries. As measured by the numbers of publications with international co-authors, almost all OECD countries increased their international scientific collaboration between 2003 and 2012. In the BRIICS countries, however, there has been a decrease. [trend/cultural] – (OECD Trends Shaping Education, 2016) #84 Blurred boundaries The boundaries between nations, disciplines and professions, academia and industry between applied science and engineering blur. We act increasingly in a network society, in which we are interconnected. [development/organizational] - (Aldert Kamp, Engineering education in a rapidly changing world)

#11 The power of convergence
s The collaboration among research groups but, more deeply, the integration of disciplinary approaches that were originally viewed as separate and distinct. This merging of technologies, processes and devices into a unified whole will create new pathways and opportunities for scientific and technological advancement. (Voorbeelden: scheikunde en taal, governance en klimaatwetenschappen, technische wetenschap en geschiedenis). [trend/organizational] (Bert van der Zwaan)

#19 Broadening the view
Niche Universities (i.e. Technical Universities, MBA, Medical Universities, Law Universities) are increasingly looking for interdisciplinary collaborations to add to their curriculum. For example the collaboration between Delft, Leiden, Rotterdam or the AMS Institute. [trend/organisational] - (Bert van der Zwaan)

#3 Digitization influences knowledge-supply
Digitization makes knowledge and the supply of knowledge independent of place, time and form. [development/technological] - (Bert van der Zwaan)

#267 Dataism is the new Religion
The commandments of Dataism are: 1) Maximise dataflow by connecting more and more media, and producing and consuming more and more information, 2) the missionary activity is to link everything to the system, including heretics who don't want to be plugged in. (Thing – refers also to the internet of things) and 3) freedom of information is the greatest good of all. [development/technological] - (Yuval Noah Harari in 'Homo Deus')

10 DRIVING FORCE

'Learning' will mean staying in tune with the next big things

#47 Asymmetrical pre-sorting
In the current education system, we pre-sort the kids in high school, by letting them choose an educational-profile. This is an asymmetrical system, people who chose the beta profile can still choose different kinds of higher education, people who chose the alpha profile have less freedom in choosing higher education. [state/educational] - (SCP, Lex Herweijer)

#38 Tailored learning
Learning can be more and more tailored to the student. By monitoring progress, but also by monitoring and analysing learning styles. Proactive interventions and quick feedback loops increase the motivation of students. [development/educational] - (SCP, De toekomst tegemoet)

#8 Demand driven University
Universities will shift from offer-driven towards demand-driven. A system in which they will receive money based on student satisfaction. The student will define their own curriculum. [development/educational] - (Bert van der Zwaan) (voorbeeld: Leidse Onderwijs Instelling)
#35 Free online courses The amount of MOOCS and other online courses and education will both in offer and usage increase the next years. [development/educational] - (SCP, De toekomst tegemoet)

#141 The horizontalisation of the socio-economic world
Consumers and end-users are given more power and demand personalized services that 'feel' local and one-off. These products compete on a local scale by customizing them locally. [trend/cultural] - (Aldert Kamp, Engineering education in a rapidly changing world, 2016)

#208 The student has become the master
Several technological developments have combined to create teaching situations where students know more than their teachers. The proliferation of advanced technology, for instance through free academic licenses, pirate copying or open source, has meant that interested students can pick up advanced tools like 3D Modelling and Rendering software. Additionally, these tools develop and go in and out of fashion with users in a pace that makes it to establish a stable curriculum and competency for an institution. [state/technological]

#202 Credentials on demand
More and more people will have qualifications from work experience, online training or un-accredited foreign institutions. The under-utilization of their resources is a large cost both an individual and a society level. [development/cultural] - (Foster, Lorne. 2006)

#4 Universities are experiencing an unbundling revolution
No longer offering a curriculum of education, but offering knowledge in the form of independent chunks. These chunks will function as building blocks of a custom

degree, certificate or diploma. [trend/educational] - (Bert van der Zwaan)

#9 The demanding, independent, critical studen
t A trend in society showing that people become more demanding also has its effects on students. Because of digitization a student can be more demanding and picky. [trend/cultural] - (Bert van der Zwaan)

#114 Opportunistic student
s Because of the huge offer of free education (most of it offered online) people aren't used to pay for a course/ class/ education-program. [trend/economical] - (Rutger Botermans)

#25 Education comes at a price
Because of the rising costs of higher education, the demand for part-time education and even single courses will increase. [development/educational] - (Bert van der Zwaan)

#265 Content of online materials will increasingly be provided by a few key players in the market (either universities or commercial parties), diversification and personal development of students will have to catered for in a different way, e.g. through on campus activities. [development/economical]

#244 Assessing quality of education
The education of part-time students and other types of education catered to life-long learning has largely been left to the commercial sector. Anyone can offer this type of education and the quality can be dubious. It can be hard to judge if you will get value for money. [state/ educational] – (Rathenau Institute)

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