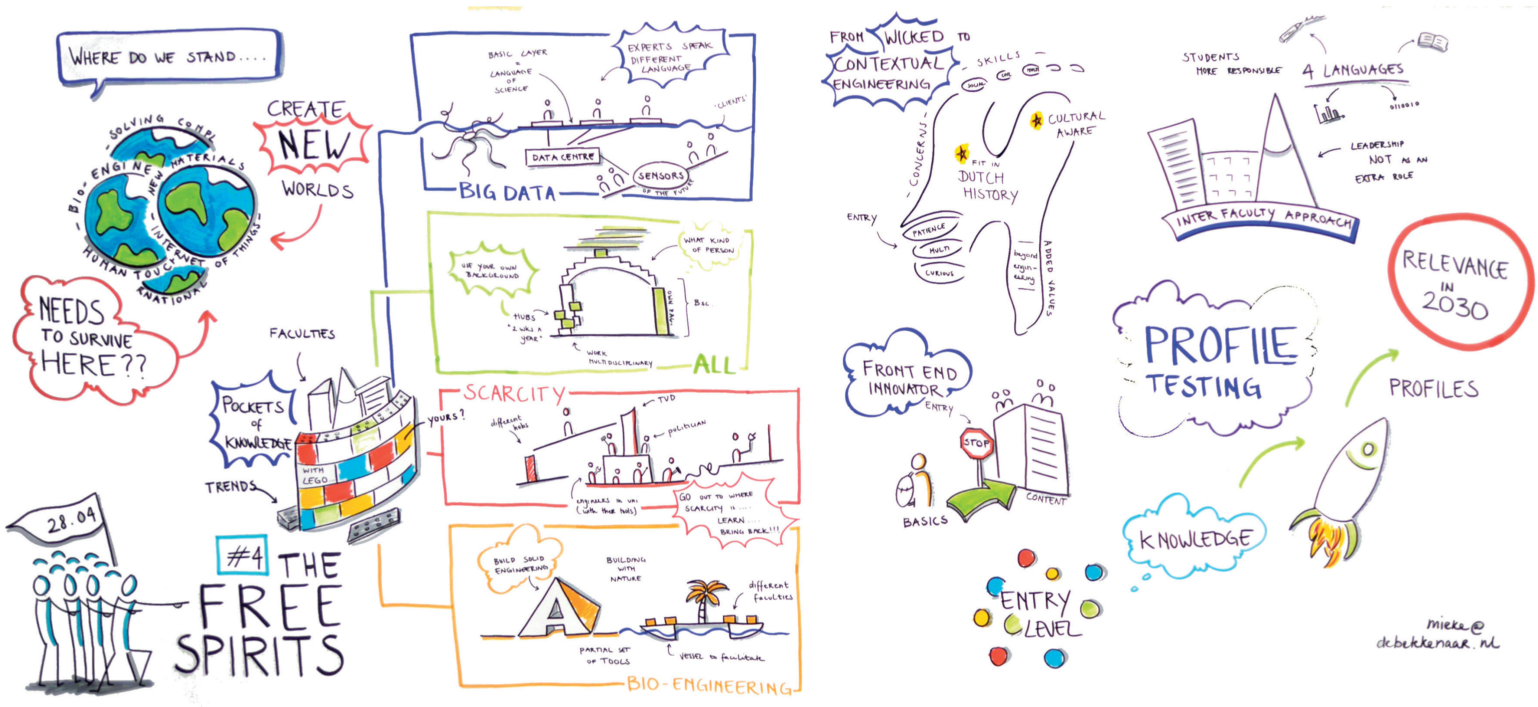


4TU. Centre for Engineering Education

Think Tank

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

WAGENINGEN UR For quality of life

4TU.

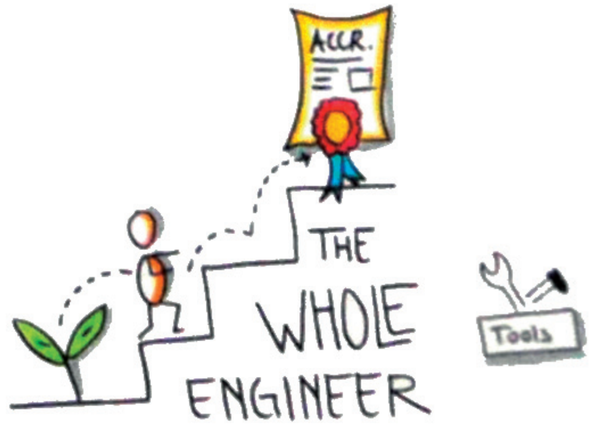
4TU. CENTRE FOR ENGINEERING EDUCATION

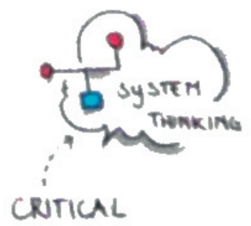
Our world has changed enormously within a very short period. In just twenty years, we have completely transformed the way we work, communicate and do business. Our societies and economies are shaped by digital information and technological innovation. Our globe is interconnected, and education and entertainment networks have empowered people across the planet.

These are trends that will only accelerate in the future, as the robotisation and development of cognitively intelligent computers will support and even succeed the human labour force. **Driverless cars, smart data, the Internet of Things - who knows what else awaits us in the coming decades?**

Yet we can be slow to respond to our fast-changing world. New technologies require new ways of working, which in turn require different skill sets and more appropriate training.

In the case of engineers, **we need to adapt - and we also need to help sub-sequent generations prepare for the exciting developments and unforeseeable events in the future.**





Core competencies

Working on solutions to many of our problems these days requires a multidisciplinary approach, integrating specialist knowledge of engineering, humanities and social sciences. So 21st century employers are looking for people with both in-depth knowledge and human-centred skills.

Engineering graduates therefore need to demonstrate qualities such as ambition, creativity, international orientation, organisational sensitivity and social intelligence; they should be skilled in the use of multi-purpose tools and methods as well as in mathematics, programming and visualisation; and they should also be imaginative, intuitive, agile and resilient.

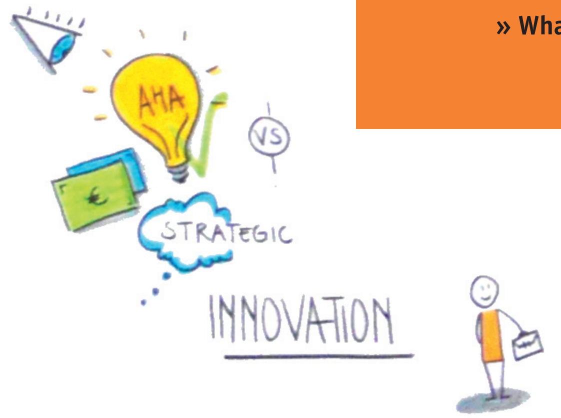
The question is: are our institutes of higher engineering education producing graduates with these sorts of skills and aptitudes?

Evolution of engineering education

"Today we attempt to educate 21st-century engineers with a 20th-century curriculum taught in 19th-century institutions." Grasso and Burkins (2010)

"The world of higher engineering education still stresses capabilities that are no longer critical in the new world and seems to ignore those that are gaining prominence." Kamp, A. (2014)

In institutes of higher learning across the world, change can be slow in coming. Yet in an increasingly global society full of complex and multi-layered issues, we should be reconsidering not only what and how we teach our future generations, but also why. In the case of engineering education, we need to ask the question: are our programmes good enough to absorb the expected changes in the world 10 to 15 years from now? Or should we now emphasise content mastery over content coverage?



Design Thinking

A 'Free Spirits Think Tank' was set up using 'Design Thinking', a method known to be effective in stimulating out-of-the-box ideas about news ways of working, the Think Tank:

- Explored current trends in engineering, science and society
- Established the most pressing needs within the engineering sector
- Developed ideas based on possible future worlds.

The results helped identify a number of important points:

» **Definition of a career route should start early in the higher education process, either at the point of admission or during the Bachelor's study programme.** This means that the educational institution should aim to identify motivated students who can excel in key scientific areas, are focused on personal development, can approach their subject matter from multiple perspectives, can cope with freedom of choice, are able to take the initiative and are self-regulatory in behaviour. Moreover they should have well-developed analytical and creative skills, and a talent for realising change.

» **Introduction of 'flexible learning paths'** - that is programme modules tailored to help students acquire the specific skills and specialist knowledge necessary to excel in their chosen prospective career direction.

» **Education based on real-life cases, projects and research** would give students a taste of collaboration, experimentation, failure and working with the outside world, and so introduce them to the key values of "passion, purpose and play". Working on projects at new TU Delft initiatives such as the Holland Particle Therapy Centre, the Smart Industry Digital Factory Composites Fieldlab, and the YES!Delft High-tech Incubator Centre would enable students to forge links with the professional market in the engineering market. It could also inspire and stimulate the next generation of visionaries.

» **Preparation for innovation would enhance the world-class reputation of TU Delft,** already strong in producing engineering graduates who can apply creative working solutions to society's problems. Increased contact and collaboration with external partners, including those outside the world of engineering, would help prepare students for future innovation, and also strengthen TU Delft's image as a more future-proof institution.

These new insights helped identify three new challenges. Namely:

» **How do you create an engineering education programme in which personal development plays an important role, yet is academic enough to satisfy the accreditation bodies awarding Master degrees?**

» **How do you create more tailored programmes that also form a coherent set of studies within the Master degree course?**

» **How do you create purposeful engineering profiles and programmes that will be useful to society in the future?**

Think Tank

In an attempt to explore how Master programmes in engineering might be adapted to meet 21st Century challenges, the 4TU.Centre of Engineering Education set up a **'Free Spirits Think Tank'** in response to a request of the TU Delft Directors of Education on **'What engineers in the future should learn and why they should learn it'**. This Think Tank comprised 14 members, including Full, Associate and Assistant Professors across eight different Faculties, Senior lecturers, Programme Directors, members of the Valorisation Centre and student bodies from every discipline at TU Delft.

The Think Tank's goal was to look ahead to the year 2030 and re-evaluate what engineering students should learn besides the core depth of specialist knowledge associated with TU Delft's graduates. Over the course of five dedicated workshops, the Think Tank considered the following key questions:

» **What sort of student should TU Delft be educating?**
» **What will be the major changes facing students in 2030?**
» **What 'added value' can TU Delft deliver in terms of educational content?**
» **What learning processes are needed to prepare the future engineer?**

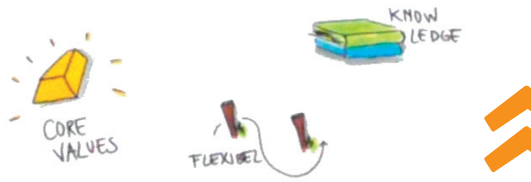
Possible future worlds

Nobody knows what's going to happen in the future but by looking at current trends, we can imagine a number of possible scenarios. If we then consider the sort of knowledge and skills needed to survive and thrive in those situations, we can also help prepare the future engineer to face the needs of each potential future.

So the next phase of the Think Tank's process was to look at current trends within society and engineering and then 'ideate' hypothetical worlds based on different combinations of these so-called 'megatrends'. Types of megatrend include Climate Change and Scarcity of Resources; Big Data-Smart Data, Robotisation and the Internet of Things; Bioengineering, Energy Transition and New Materials; and Urbanisation, Safety and Security and Globalisation.

Combining various extreme versions of these trends and then imagining the skills and knowledge an engineer would need in each of these worlds led the Think Tank to ask the following question: should we be training a number of different types or 'profiles' of engineer, whose knowledge would extend beyond engineering, science and design?

Putting all these thoughts together, the Think Tank came up with the following concepts to be considered when designing future engineering education programmes:



1. PROFILES

Specific engineering roles in particular contexts that may provide the opportunity for specialisation. The Think Tank further outlined four specific profiles:

THE SPECIALIST

Would be able to use specific scientific knowledge to improve and develop complex technological systems and at the same time, be able to work with non-specialists in order to integrate that knowledge into system and product development. Specialist training within a Faculty or Department would be complemented by multidisciplinary project work, which would broaden the specialist's more human-centred skill-set.

THE SYSTEM INTEGRATOR

Is system-oriented and has a helicopter view of technological fields but can look beyond technology to understand the importance of a broad range of issues from restricted budgets and regulatory frameworks to public safety impact and the ethical aspects of engineering. As with the Specialist, the System Integrator would be educated within the disciplinary department or Faculty, while developing interdisciplinary and interpersonal skills whilst working on multidisciplinary projects.

THE FRONT-END INNOVATOR

Is an entrepreneurial design engineer with a broad knowledge of both engineering and socio-economic factors. Able to work in small teams of Specialists, System Integrators, design engineers, business managers, customers and end-users, the Front-end Innovator has both a good understanding of the engineering context and an awareness of the user and client environment. The department or Faculty would provide the specialist engineering education, and the innovation-business components would be learnt whilst working on multi-disciplinary projects together with students from the humanities or social sciences sectors.

THE CONTEXTUAL ENGINEER

Would excel at understanding dynamic technological change within different socio-cultural contexts. Development teams within multinational companies make use of the diversity of cultures and socio-economic environments to benefit technological innovation, product design and engineering business. So the Contextual Engineer would need strong intercultural communication and collaboration skills, along with an open-minded approach to operating in differing cultural contexts. Technically adept, the Contextual Engineer understands constraints and consequences from the ethical, judicial, disciplinary and policy perspective.

2. HUBS

Interdisciplinary learning in engineering or research environments focusing on specific and authentic scenarios. A hub is a physical location on campus that is flexibly organised around a number of high-tech and innovative 'hot topics' such as driverless cars, energy transition, or advanced manufacturing. It is a flexible engineering research and learning space in which expertise from different disciplines (engineering but also social sciences and the humanities) come together with professionals from other areas (government institutes, industry, business).

3. COMMON ENGINEERING LANGUAGES

A set of universal professional skills in mathematics, design, engineering ethics, digital literacy and collaborative teamwork that enable engineers in all disciplines to be able to communicate both with each other and also with non-engineers. Ideally the Bachelor student would have mastered these basic skills at graduation so that engineers from all backgrounds would be able to understand each other and work together more effectively.

The future engineer

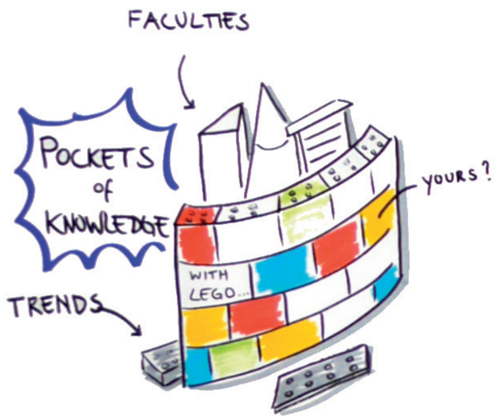
"Many of the societal and engineering challenges are so complex and multidimensional that they cannot be unlocked with the old-fashioned key of sciences and technology alone, but also need socio-economic capabilities....

Solving complex systems requires a solid foundation in mathematics and the natural sciences, and an understanding of human nature."

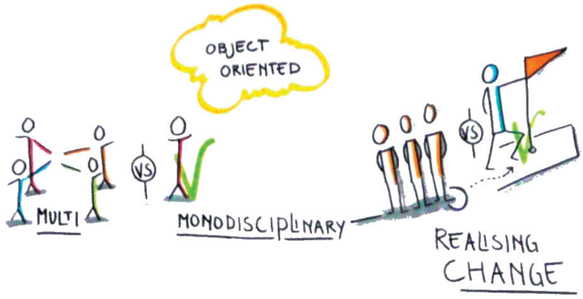
Kamp, A. (2014)

The 'Free Spirits' Think Tank expects that TU Delft's students will face many changes in 2030. During their education, they will be challenged to go out into the world and bring back real-life problems that need to be solved. The added value of research universities such as TU Delft remains the thorough foundation in engineering fundamentals but in order to face the future, mono-disciplinary projects on specialist subject matter should be complemented by flexible and diverse inter-disciplinary research and engineering projects, in collaboration with third parties from industry, R&D and other areas and sectors within society.

In today's world, it's no longer enough just to know stuff; we need to know how to use what we know appropriately and in which context. In the future 'that' knowledge will only become more important.



4TU. CENTRE FOR ENGINEERING EDUCATION



Think Tank participants

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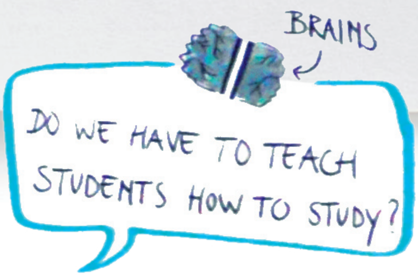

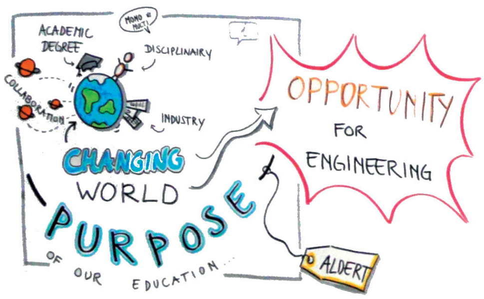

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