The 2035 vision of the future of engineering

Society is complex and technology omnipresent, intertwined with our daily lives. The act of 'engineering,' or the 'clever act of making' as in its historical roots inginium en -neering, expands into several dimensions, and with this expansion, engineering in 2035 includes new activities and new meaning. For starters, the motivation to dive into the studies of engineering will become more diverse . Historically engineers are intrigued by technological objects and phenomena. Howerver in 2035, engineers will find more motivation and purpose in salient societal challenges. The way engineers work together, and the source of trust in collaboration is expanding from system-based trust and collaboration to include a more fluid type of trust invested in interpersonal networks. The temporal perspective of engineering stretches as the speed of development cycles are large, while at the same time long-term cycles are more pronounced.

This expansion of the meaning of engineering - literally in ***three dimensions*** *- reveals eight new meanings of engineering in the future; eight behaviours incorporating* ***"-neering"****, or the 'act of making' as seen in the word 'engineering'. Engineering education needs to be ready to cater to the expanded definition of engineering. We will need to acquire and convey new kinds of knowlegde, and we will need to reassess our relationship with the future engineering students. To emphasize this we introduce the word* ***'technee'*** *as a person of any age, beginner or longtime employee, and can alternately educate or be educated.*

Challenge
Interpersonal
Fast

1. origineering

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
Self-determination
Material gain
Individuality

Behaviour
Initiative and self-direction
Courage
Resilience
Business sense/economic realism
The ability to apply theory in practice

Challenge
System
Fast

2. swarmineering

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
Belongingness
Winning as a group
Resource provision

Behaviour
Being alert
Time/project management skills
Ability to prioritise
Shifting between a helicopter

Challenge
Interpersonal
Slow

3. engagineering

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
Equity
Public power
Positive self-evaluations

Behaviour
Fundraising and lobbying
Polling/sampling attitudes and opinions
Self-directivenes
Social media skills
Networking

Challenge
System
Slow

4. ingraineering

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
Management
Safety
Unity

Behaviour
Accountability
Contextual awareness
Institutional trust
Displaying tact and impartiality

Phenomenon
Interpersonal
Fast

5. tinkineering

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
Curiosity
Individuality
Excitement avoiding boredom

Behaviour
Trend awareness
Adaptability
Self-direction

Phenomenon
System
Fast

6. perfectioneering

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
Management
Mastery
Safety

Behaviour
Productivity
Critical thinking
Data modelling
Probability and statistics

Phenomenon
Interpersonal
Slow

7. imagineering

Fearless exploration of technological possibilities and dangers; Being at the forefront of technological evolution, on the one hand looking out for collisions and on the other 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
Intellectual creativity
Transcendence
Individuality

Behaviour
Cross cultural and social understanding,
Curiosity and imagination

Phenomenon
System
Slow

8. fundamentaneering

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
Understanding
Superiority
Curiosity

Behaviour
Patience
Effective listening
Structuring
Integrating
Reliability
Probing intelligence

The Personology Arena

We imagine an educational environment, a university of the future, where technees can play different engineering roles, and ultimately choose the most meaningful professional role: the role with which they best identify.

We call this environment the **'personology arena'** from 'personality' and 'technology' emphasising the fact that technees are encouraged to create a relationship between self-growth and societal purpose, ultimately giving them control over their own career path and ensuring social relevance.

The Technee has the possibility to develop on the 3 dimensions: Source of Engagement, Source of Collaboration, Pace of development. The 3-D framework was that it became relatively straightforward to envisage different engineering profiles based on every possible permutation of the two extremes of each Dimension (see figure below). For example, a Technee could be motivated by a societal **challenge**, work best by collaborating **interpersonally** and at a **slower** developmental tempo – and this would help define a specific engineering role optimising those specific strengths and preferences. Different combinations of each extreme in all three dimensions produced eight new engineering roles for the future.

Designing Engineering Education for the Future

Engineering education is entering a period of "*rapid and fundamental change*" and leading universities of technology may be quite different **within just five years** because "*the benchmark of what constitutes good practice is changing*" (MIT, 2018) At the same time, the industry is already questioning whether the latest generations of engineers have the right skill-sets to cope with the fast-paced global market place in our complex, ambiguous and uncertain future. New technology graduates have the deep, specialised engineering expertise but generally lack the 'real-life', socially relevant skills that are increasingly important to 'Industry 4.0'. Add to this an increased consciousness of urgent societal issues and of the ethical implications of rapidly evolving technology, and the question becomes: **how should we shape engineering education to meet the needs of this fast changing and unpredictable world?**

Call to Action

Currently TU Delft is developing a new Master programme which reflect the personology arena incorporating the three Dimensions: Source of Engagement with Technology, Source of Trust and Collaboration and Time-related Development Cycles and their knowledge foundation. Would you like to co-create this master programme or develop your own initiative based on the full concept please contact us and/or read the full technical report.

REFRAMING STUDIO 4TU. CENTRE FOR ENGINEERING EDUCATION TU Delft

Engineering Education Think Tank

In 2015, 4TU Centre Engineering Education, facilitated a " Think Tank' , that explored trends within engineering, science and society to try to find out what future engineers should be learning in order to be properly prepared for the labour market in 2030. The Think Tank highlighted the importance of encouraging personal development as part of an engineer's formal education. They defined new enineering roles and emphasised the imporotance that 'hubs' with differentiating learning paths should play in the future.

Crucially, it was envisioned that universities training students for these new roles would **extend students' knowledge beyond traditional engineering, science and design**. Since the publication of these ideas, the concept of new engineering roles has evolved and became a part of the TU Delft '*Vision on Education 2018-2024*'.

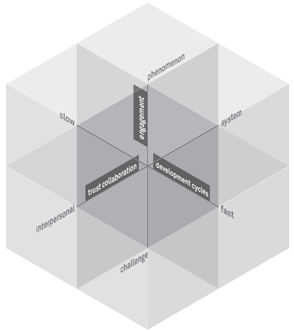
Since the Think Tank, research has focussed on critical follow-up questions such as; Are the new engineering roles complete or did we miss crucial aspects by starting our research from the perspectieve of education? What will our future society be like and what kind of engineering roles will be meaningful in it?

Reframing and Vision in Project Design

In order to understand what roles future engineers might play, it's essential to know more about what that future might look like; namely the context in which engineers would be playing those roles. To help us envisage this future, the TU Delft/4TU.CEE invited Reframing Studio to collaborate and use the 'Reframing' methodology also known as **ViP** or **Vision in Product Design (Hekkert & van Dijk)**. ViP works by gathering as much information as possible about a specific future, and then using that information to construct a 'Future Context.' Once that context is clear, ViP then "works backwards' to the present-day to help identify policies and programmes that would get us to that desired future. The main findings are presented in this document. Please contact 4TU CEE for the full

"When people talk about the future, they tend to pinpoint a few big trends and then try to relate those ideas to those trends in isolation. We don't want to do that; we want to try and understand the coherence between everything."

- Matthijs van Dijk, Reframing Studio, 2019



Changing the Education System

These new engineering roles, important for our society in 2035, have been defined by a number of characteristics and qualities that are not part of today's technology education. So engineering education needs to change. It has to become more diversified, integrating specialist engineering knowledge with humanities and social sciences. Training should be multidisciplinary and more flexible, allowing room for personal choice, better self-knowledge and self-development, a sense of purpose and increased opportunities for lifelong learning and retraining. **So how should technology universities begin integrate all these requirements into formal engineering education?**

Three Institutes reflecting New Dimensions to Engineering Education

To follow up on the concept of the three new Dimensions to engineering education three individual institutes are responsible for education in "dimensional" fields of knowledge.

The Engagement Institute - offering education relating to the dimension Source of Engagement with Technology leading to an enhanced ability to study phenomena in and across *different* disciplines and to building knowledge to address societal challenges. In order to explore personal sources of engagement with technology, societal challenges and technological phenomena would be studied in context. Each part of the dimension requires a different (development) space with built-in flexibility to respond to the various contexts of the challenges or phenomena being addressed. The guiding principle would be evaluative judgement and proofing of results according to academic standards, delivering responsible and relevant results for society.

The Decision-Making Institute - offering education relating to the dimension Source of Trust and Collaboration leading to an enhanced ability to work together in both small (entrepreneurial) teams and large, less personal systems. It would also foster the ability to apply ethics to the development of technologies within both personal relationships and larger systems. This dynamic set-up would allow the technee to try different ways of working, (interpersonal trust and collaboration) while promoting continuous (professional) development vs quick mastery of skills.

The Pace Institute - offering education relating to the dimension Time-related Development Cycles. Training here enhances the ability to respond to urgent dilemmas and create rapid results as well as the ability to continuously reframe - learn and develop an understanding of the world around us. *Technees*, staff and researchers) would be involved in both short time-cycles and long-term development of human and material resources, systems and products. Alongside product-development cycles, the Pace Institute would also address the often urgent developmental problems associated with human-related cycles.

Imagine Justin a Technee in 2035

Justin is a technee at the Engagement Institute. He's been obsessed by the recently discovered phenomenon of 'flash effects' in financial ecosystems. He collaborated with the Dutch National Bank for a short period where he worked on ways to increase the robustness of the European banking system using cryptographic hashes (Engagement with Technological 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 shared his experiences with other technees at the Engagement Institute and is now mobilising others to be alert and ready for action when the time comes (Engagement with the Societal Challenge).

The Personology Arena can be thought of as a **'shared space node'** where programmes are offered in multiple learning environments: within companies and in academic settings; online and offline; nationally and internationally. By offering students a curriculum in which they can play different engineering roles, they will ultimately be better able to choose the most meaningful professional role: the role with which they best identify. Through personalised learning paths, they will be able to combine self-growth with societal purpose, using or creating technology that is important to both them as a person and to the wider society.

The Personology Arena

a vision of Engineering Education in 2035

REFRAMING STUDIO 4TU. CENTRE FOR ENGINEERING EDUCATION TU Delft