ADAPTING ENGINEERING EDUCATION TO CHANGE how much, how fast, in what way?

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Delft University of Technology, The Netherlands
Agenda

1. VUCA World
2. Impact on Engineering profession
3. Millennial generation
4. Impact on engineering education
5. How to bring this in the classroom?
6. Engineering profiles
7. Heading for more DIY ethic in Master’s
Engineering education in 70’s
Today’s changing world

- Accelerating change
- Faster communication
- Hyperconnectedness
- Blurring boundaries
- Less hierarchy
- Infinite speed access to infinite data
- Emerging technologies (learning machines, Industry 4.0,...)
- Open-sourced networks
- Shorter innovation cycles
- Liberalisation and monetisation of education and research
- New business concepts (products become services)
Products become services

“Welcome to 2030. I own nothing, have no privacy, and life has never been better.”

- Ida Auken, Member of Parliament, Denmark

Source: Twitter World Economic Forum; Nov 2016
Megatrends in engineering and society

Solving complex problems

- Climate change
- Humanising technology
- Big data – Smart data
- New materials
- Scarcity of resources
- Urbanisation
- Robotics and automation
- Advanced manufacturing automation, distributed and additive manufacturing
- Circular economy
- Mobility
- The Internet of Things
- Design beyond nature genome engineering and synthetic biology
- Safety and (cyber)security
- Cloud computing
- Miniaturation
- Globalisation
- Mass personalisation
- Energy transition
Volatile
Uncertain
VUCA world
Complex
Ambigious
Big Data and Artificial Intelligence

Source: Futureoflife.org
Rational problem solving
Deep disciplinary knowledge
Analysis, optimisation
Understanding certainty
Developing order
Anticipation

ENTREPRENEURIAL BEHAVIOUR
= becoming entrepreneurial
≠ becoming an entrepreneur

EXPLOITATION
How and When mindset
“how we’ve always done”

EXPLORATION
What and Why mindset
“new ways of working”
Gaining prominence in engineering

- agility and resilience
- algorithmic thinking and programming
- business acumen
- creativity and innovation
- employability and lifelong learning
- engineering ethics
- entrepreneurial behaviour
- intercultural collaboration
- mobility
- multi- and interdisciplinary thinking
- systems and holistic thinking
“The 10 skills you need to thrive in the 4th Industrial Revolution”

<table>
<thead>
<tr>
<th>in 2020</th>
<th>in 2015</th>
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<tbody>
<tr>
<td>1. Complex Problem Solving</td>
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<tr>
<td>2. Critical Thinking</td>
<td>2. Coordinating with Others</td>
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<td>3. Creativity</td>
<td>3. People Management</td>
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<td>5. Coordinating with Others</td>
<td>5. Negotiation</td>
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<td>6. Emotional Intelligence</td>
<td>6. Quality Control</td>
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<td>7. Judgment and Decision Making</td>
<td>7. Service Orientation</td>
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Source: Future of Jobs Report, World Economic Forum
Millennials: a different breed
## Education in 21\textsuperscript{st} century

<table>
<thead>
<tr>
<th>Emphasis remaining on</th>
<th>Shifting to more</th>
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<tbody>
<tr>
<td>Monodisciplinary expert thinking</td>
<td>Multi- and interdisciplinary systems thinking</td>
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<tr>
<td>Reductionism</td>
<td>Integration</td>
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<tr>
<td>Analysis</td>
<td>Synthesis</td>
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<tr>
<td>Abstract learning</td>
<td>Experiential learning; common sense</td>
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<tr>
<td>Developing order</td>
<td>Correlating chaos and resilience</td>
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<tr>
<td>Techno-scientific base</td>
<td>Human factor and empathy; business acumen</td>
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<tr>
<td>Convergent thinking</td>
<td>Creativity</td>
</tr>
<tr>
<td>Understanding certainty</td>
<td>Handling ambiguity and failure</td>
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<tr>
<td>Rational problem solving</td>
<td>Complex problem solving</td>
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<tr>
<td>Independence</td>
<td>Collaboration</td>
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<tr>
<td>Rounded expert</td>
<td>Employability and lifelong learning</td>
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</table>
21st century curriculum

- Creativity and Collaborative Design Thinking
- Innovation and Entrepreneurial Behaviour
- Interdisciplinary Thinking
- Rigorous Engineering
Bringing the real world into the classroom

Increasing student engagement
Linking theory and practice
Labwork and makerspaces
Personal and career development
University-for-life

Tacit knowledge, common sense
Lifelong learning mind-set
Out-of-the-box thinking
Practice-based learning
Human interaction
Engineering ethics
Value creation
Role models

Connection industry - faculty
Continuous professional development
Understanding trends and needs
Work on real-world problems
Interdisciplinary projects
Engineering profiles
Sabbaticals

Adapted from Learning Factory
www.lf.psu.edu/
Mindmap Engineering Education

COMMUNITY
Sense of Belonging
- Practical solutions
- Common sense
- Tacit ingenuity
- Internship
- Adaptive capacity
- Career development
- Emotional intelligence
- Societal relevance
- Value creation
- Freedom & Autonomy
- Virtual labs
- Physical Labs
- Guest lecturers
- Cool technology
- World of work
- Mobilities
- Self-awareness
- Fast learning
- Ethical responsibility
- Digital literacy
- Complex Problem Solving
- Creativity
- Designing the right thing
- Idea generation
- Algorithmic thinking
- Logical analysis
- Rational Problem Solving
- Innovation
- Deep disciplinary knowledge
- Systems view
- Entrepreneurial thinking
- Logical analysis
- Global trends in engineering
- Failure as key for learning
- Communication & pitching
- Business acumen
- Customer thinking
- Convergent thinking
- Divergent thinking
- Makerspaces
- Rapid proto-typing
- Enterprise Systems Engineering
- Collaboration
- Interactive team-based learning
- Co-creation
- Human factors
- Common engineering themes
- Intercultural communication
- Influence
- International partnerships
- Study abroad
- Customised programmes
- Joint Summer Schools
- Collaborative MOOCs
- Multilingual & English proficiency
- Education and research
- Automation Security
- Big data
- Smart materials/structures
- Inter-disciplinary thinking
- Diversity in thought
- Convergent thinking
- Customer thinking
- Divergent thinking
- Makerspaces
- Rapid proto-typing
- Enterprise Systems Engineering
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- Inter-disciplinary thinking
Universities of connections
Sense of belonging: Labs and makerspaces
Think Tank Design Thinking

WHAT IS?  WHAT IF?  WHAT WOWS?  WHAT WORKS?

WHERE DO WE STAND?

RELEVANCE IN 2030

NEEDS TO SURVIVE HERE??

CREATE NEW WORLDS

SCARCITY

THE FREE SPIRITS

28.04

#4

BIO-ENGINEERING

PROFILE TESTING

ENTRY LEVEL

[Hand-drawn diagrams and text]
Think Tank tripartite concept that “wows”

I. Common engineering language across disciplines

II. Profiling on top of disciplinary specialisation

III. Hubs as pockets of knowledge for interdisciplinary learning
Idea number I

Common engineering languages

1. Mathematics
2. Digital intelligence (data analytics, algorithmic thinking)
3. Design skills
4. Academic communication
5. Engineering ethics
6. Collaborative interdisciplinary teamwork
Idea number II

Profiles, professional roles

Engineering roles in particular contexts that provide opportunity for specialisation

Specialist
Systems Integrator
Front-end Innovator
Contextual Engineer
Spectrum of profiles and professional roles

Current common situation at research-intensive universities
Profile: SPECIALIST

“How can I advance engineering knowledge and optimise technology for innovation and better performance by research?”

- Deep expert knowledge
- Understanding impact of their specialism on the interfacing levels
- Innovating at the fringes of their specialism
- Collaborating with other specialists or in multidisciplinary teams
- Respect for other disciplines; compromising
- Language gap with non-experts

required attributes

heuristic

“pain and frustrations”
“How can I integrate disciplinary knowledge and subsystem expertise for a complete solution?”

- Broad technical knowledge and business acumen
- Helicopter view; systems thinking
- Interdisciplinary teamwork (specialists, engineers, non-engineers)
- Human factor, agility and resilience

- Deeper specialisations = knowledge/design fragmentation = more integration time and cost for integration
- Lack of systems thinking of the specialist; making concessions
Profile: FRONT-END INNOVATOR

“How can I apply knowledge and use technology to develop out-of-the-box solutions that cross disciplinary boundaries and create value for society?”

- Broad knowledge in engineering and socio-economic factors
- Entrepreneurial attitude; value creation
- Interdisciplinary teams of specialists, engineers, stakeholders
- Good social and empathetic listening skills
- Intellectual property rights at higher TRL levels
- Fast decision making due to short innovation cycles
Profile: CONTEXTUAL ENGINEER

“How can I exploit diversity-in-thought in developing realistic and acceptable solutions that create value in different cultures and contexts?”

- Technically adept and understanding different realms
- Helicopter view, open mind
- Local and global thinking
- Good intercultural communication and collaboration skills
- Agility and perseverance
- Moral dilemmas when maneuvering between personal and local cultural habits, norms, ethics and regulations
Idea number III

**Hubs**

Interdisciplinary learning in an engineering or research environment that focuses on a specific pocket of knowledge

- Physical location on campus
- Flexibly organised around (families of) high-tech innovative “hot topics”
- Engineering and societal challenges
- Collaboration in interdisciplinary teams
- Jointly with industrial business partners, customers, government agencies
Heading for more DIY ethic in MSc

Discipline Engineering Sciences courses
40 EC

Professional Development
30 EC

Internship
20 EC

Thesis Research
30 EC

(all EC numbers indicative only)

CONTEXTUAL ENGINEER

Study Abroad
Systems Engineering
Project Management
Data Analysis
Certification & Safety Programming

Entrepreneurship
Personal leadership
Group dynamics
Strategic thinking
Intercultural communication
Academic communication
Business economics
Social sciences

Interdisciplinary Research
Collaborative research at a Research Institute, involving public and private sectoral organisations
Study engineering in 2030

- Fundamentals in math, science, engineering and technology
- Systems thinking
- Algorithmic thinking
- Knowledge sharing
- Lifelong learning
Available sources


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