4TU. CENTRE FOR ENGINEERING EDUCATION

ADAPTING ENGINEERING EDUCATION TO CHANGE

how much, how fast, in what way?

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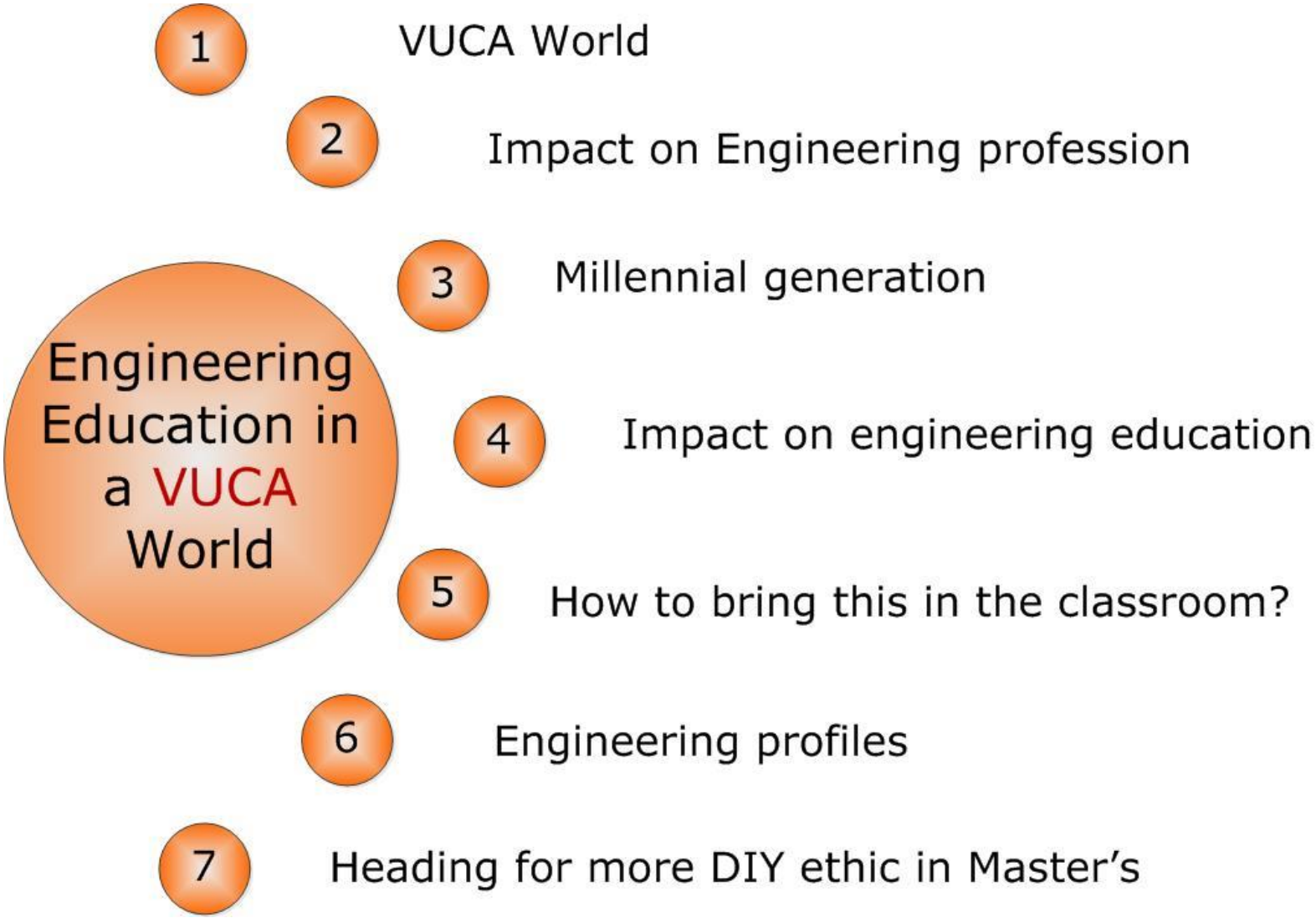
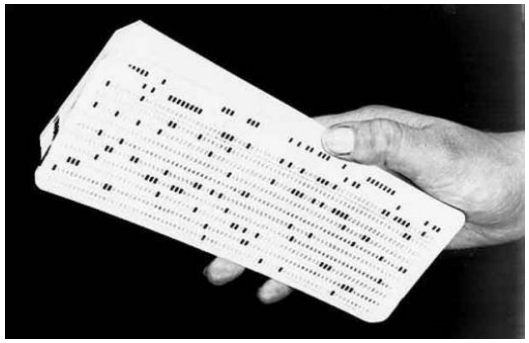
UNIVERSITY OF TWENTE.

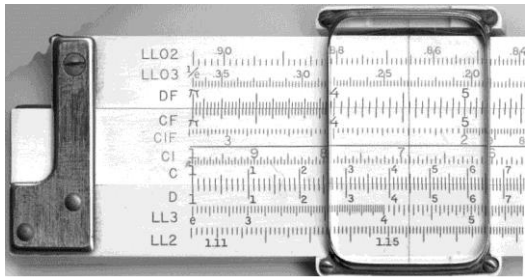
WAGENINGEN UR For quality of life

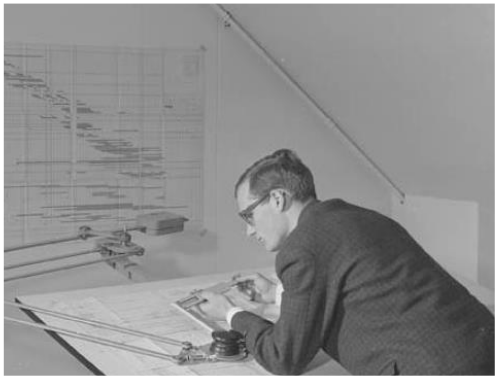
Agenda


Engineering Education in a VUCA World
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

Source: Twitter World Economic Forum; Nov 2016

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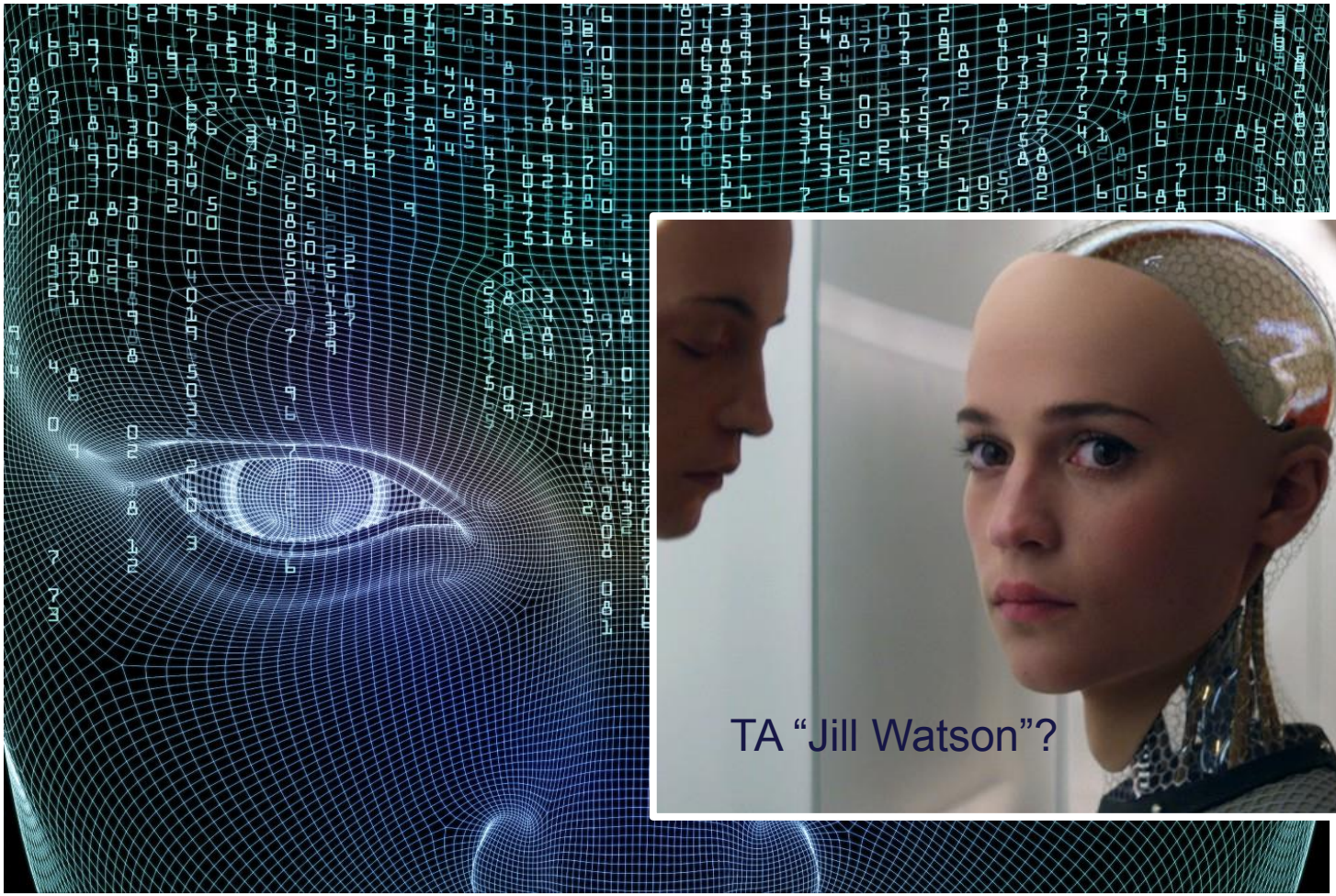
Megatrends in engineering and society

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	Miniaturisation
	Globalisation	Mass personalisation	Energy transition

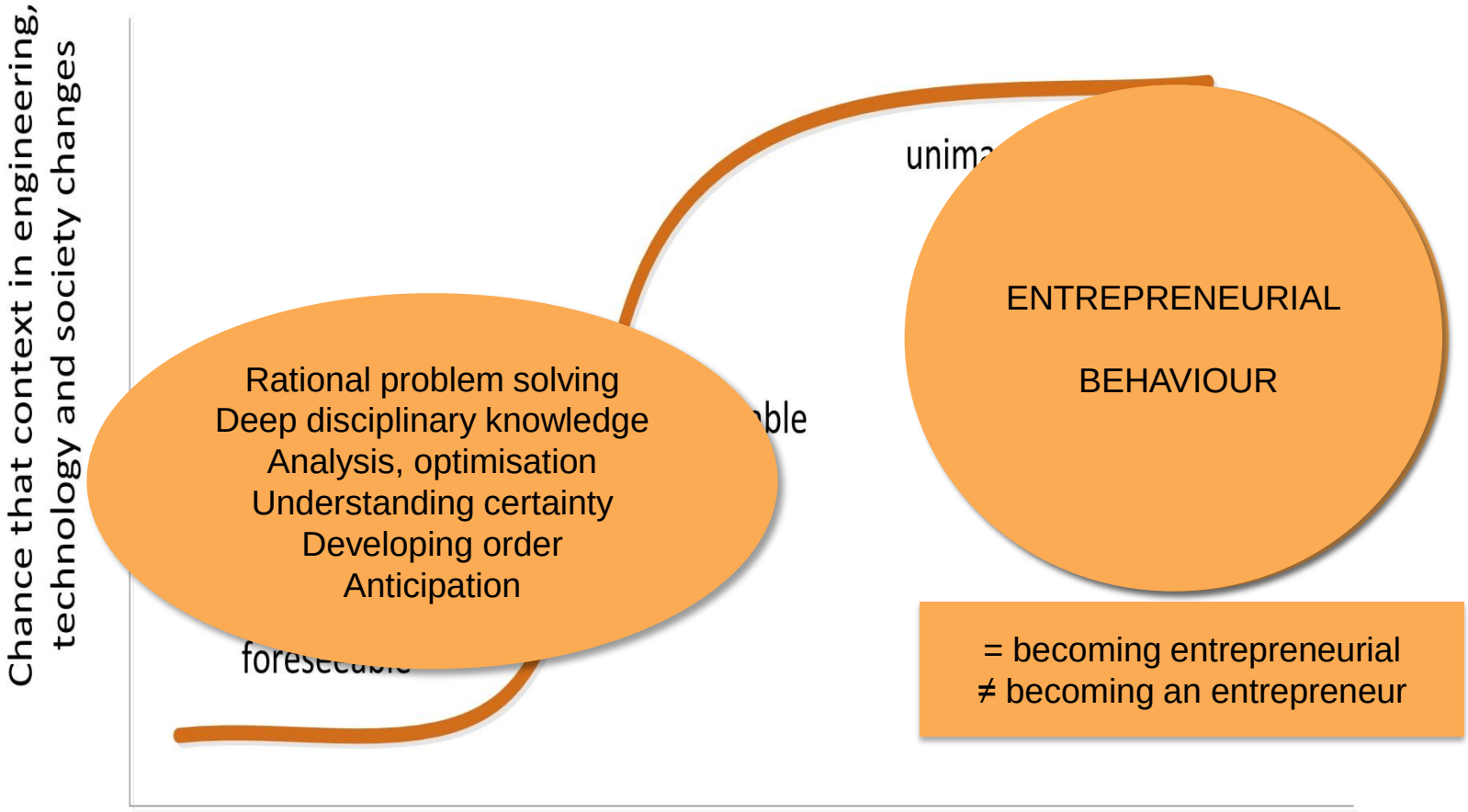
Volatile
Uncertain
VUCA world
Complex
Ambiguous

Big Data and Artificial Intelligence



Source: Futureoflife.org

VUCA World



EXPLOITATION

How and When mindset
"how we've always done"

EXPLORATION

What and Why mindset
"new ways of working"

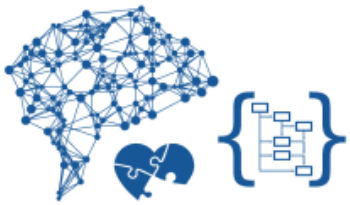
Gaining prominence in engineering

- 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

in alphabetical order

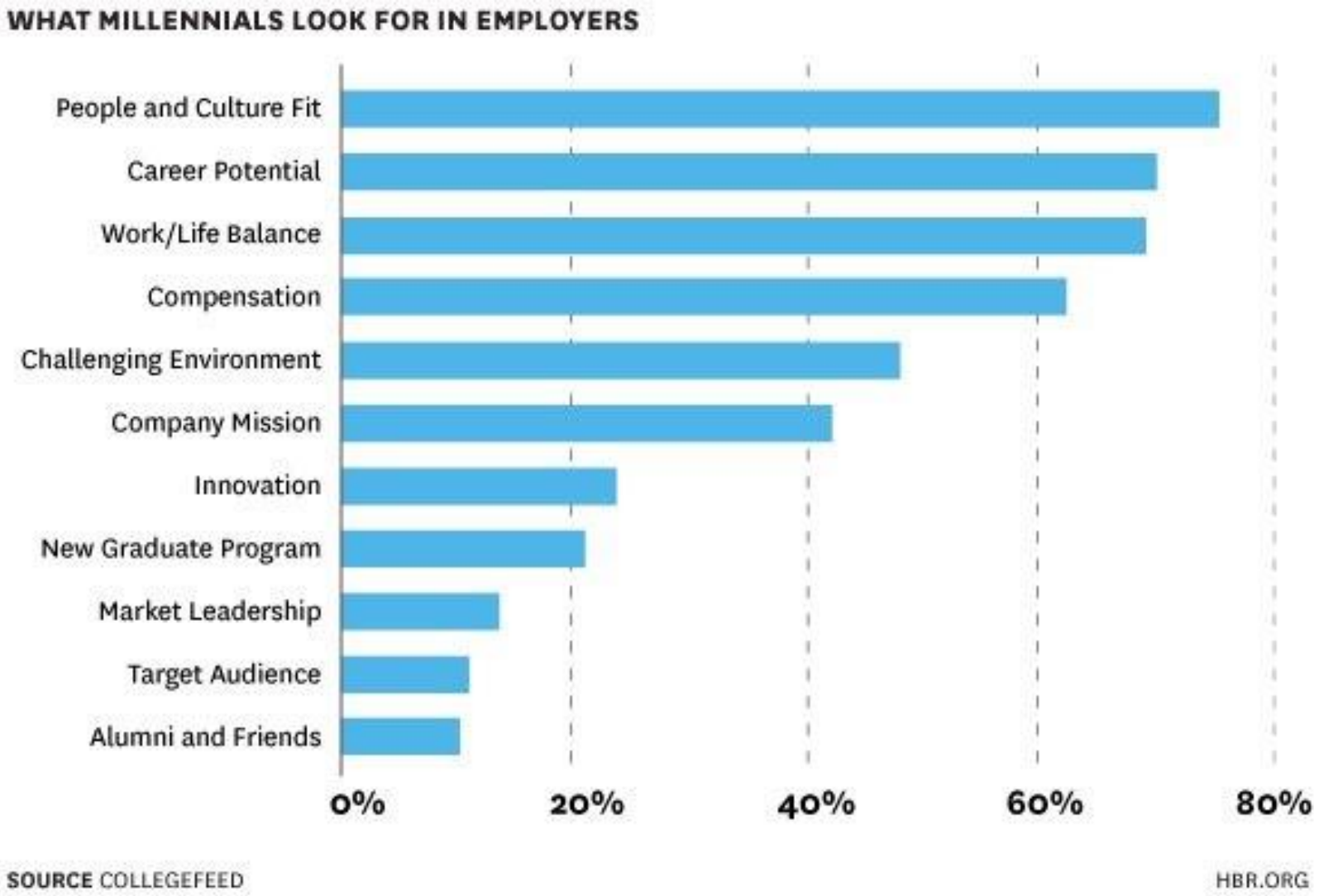
"The 10 skills you need to thrive in the 4th Industrial Revolution"

in 2020	in 2015
1. Complex Problem Solving	1. Complex Problem Solving
2. Critical Thinking	2. Coordinating with Others
3. Creativity	3. People Management
4. People Management	4. Critical Thinking
5. Coordinating with Others	5. Negotiation
6. Emotional Intelligence	6. Quality Control
7. Judgment and Decision Making	7. Service Orientation
8. Service Orientation	8. Judgment and Decision Making
9. Negotiation	9. Active Listening
10. Cognitive Flexibility	10. Creativity



Source: Future of Jobs Report, World Economic Forum

Millennials: a different breed



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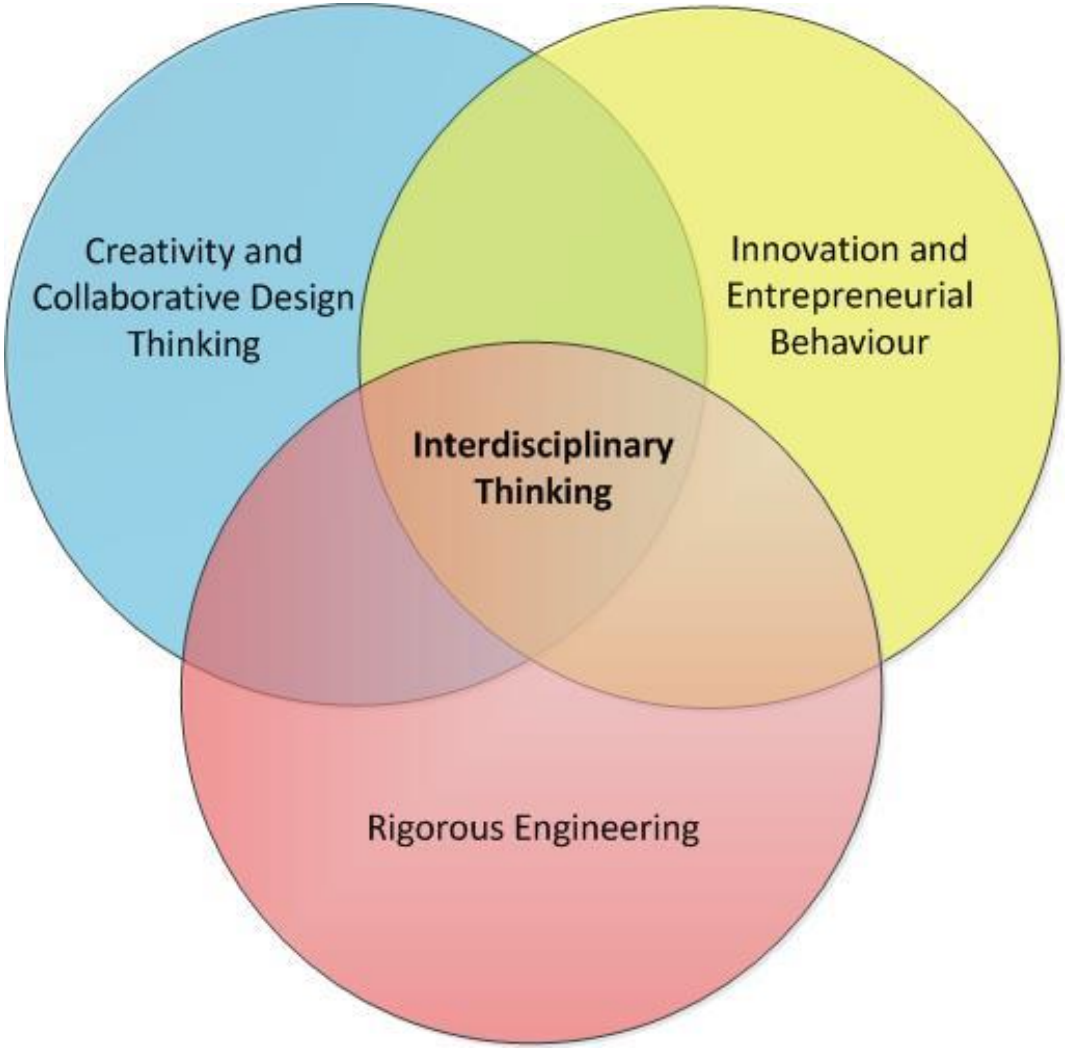
Education in 21st century

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

21st century curriculum



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

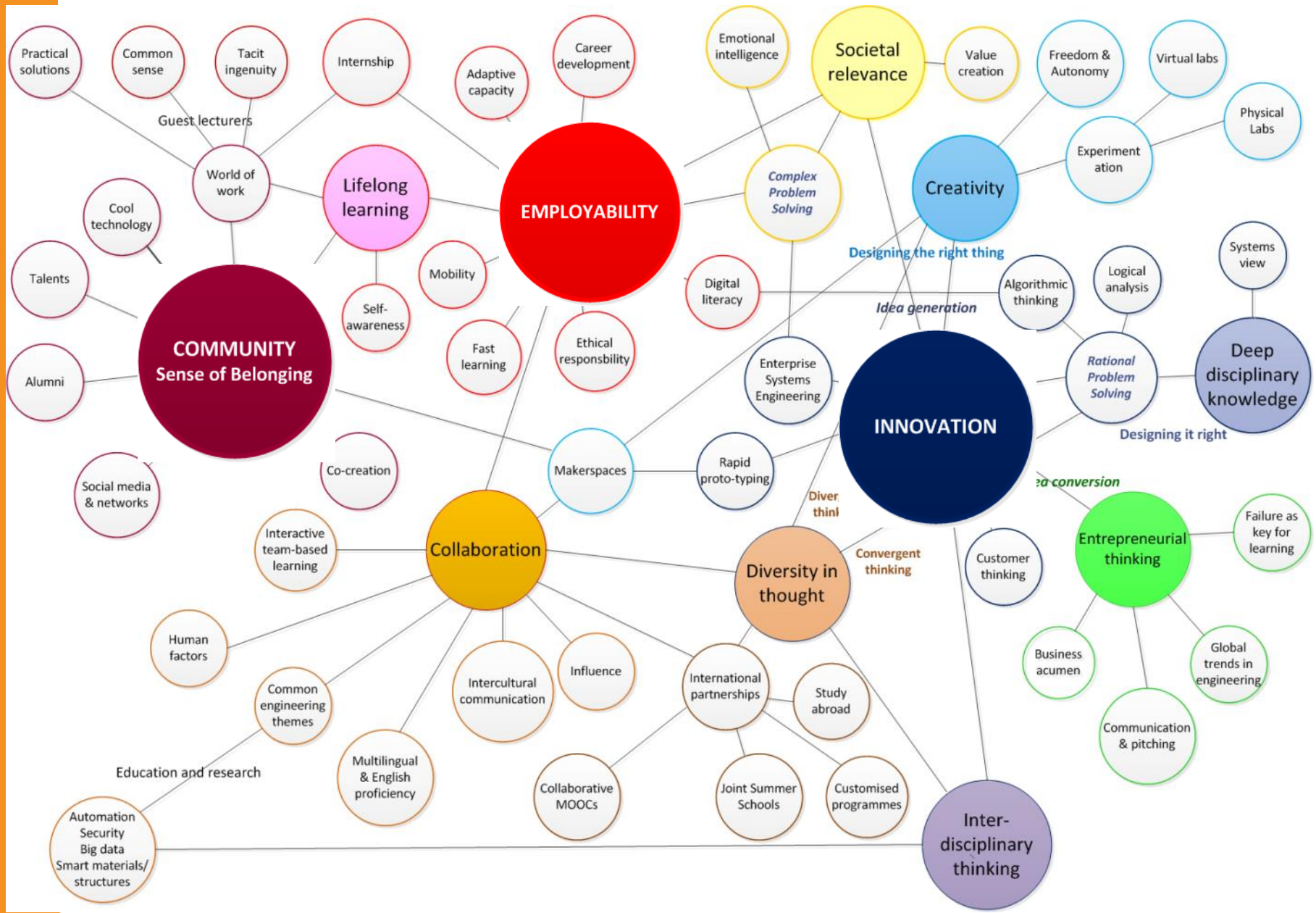
Connection industry - faculty
Continuous professional development
Understanding trends and needs
Work on real-world problems
Interdisciplinary projects
Engineering profiles
Sabbaticals

Bringing the real world into the classroom

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

Adapted from Learning Factory
www.lf.psu.edu/

Mindmap Engineering Education



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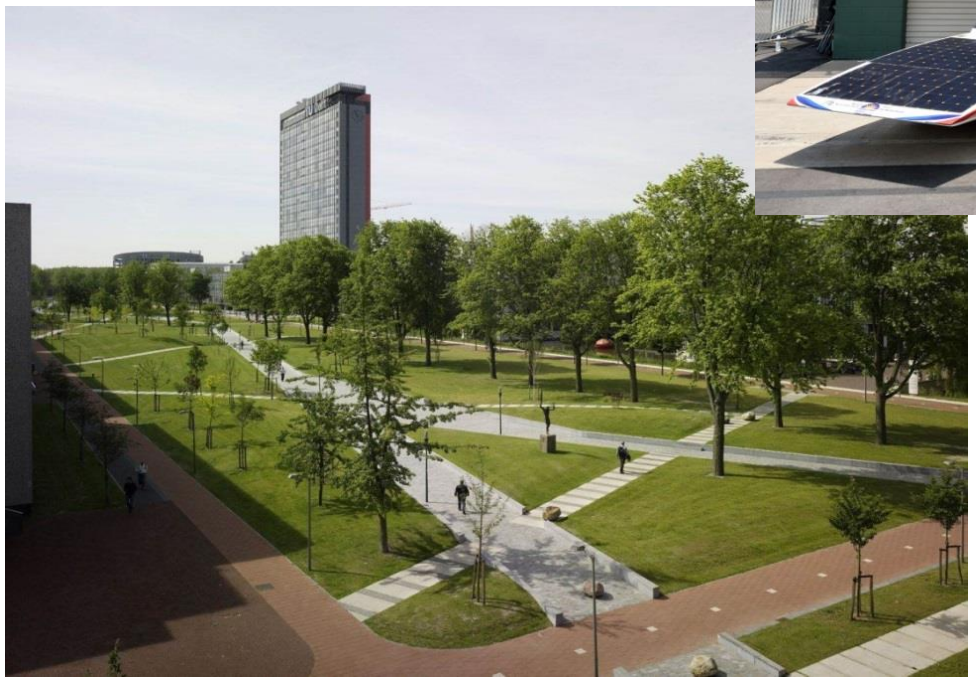
Universities of connections



Sense of belonging:
Labs and makerspaces

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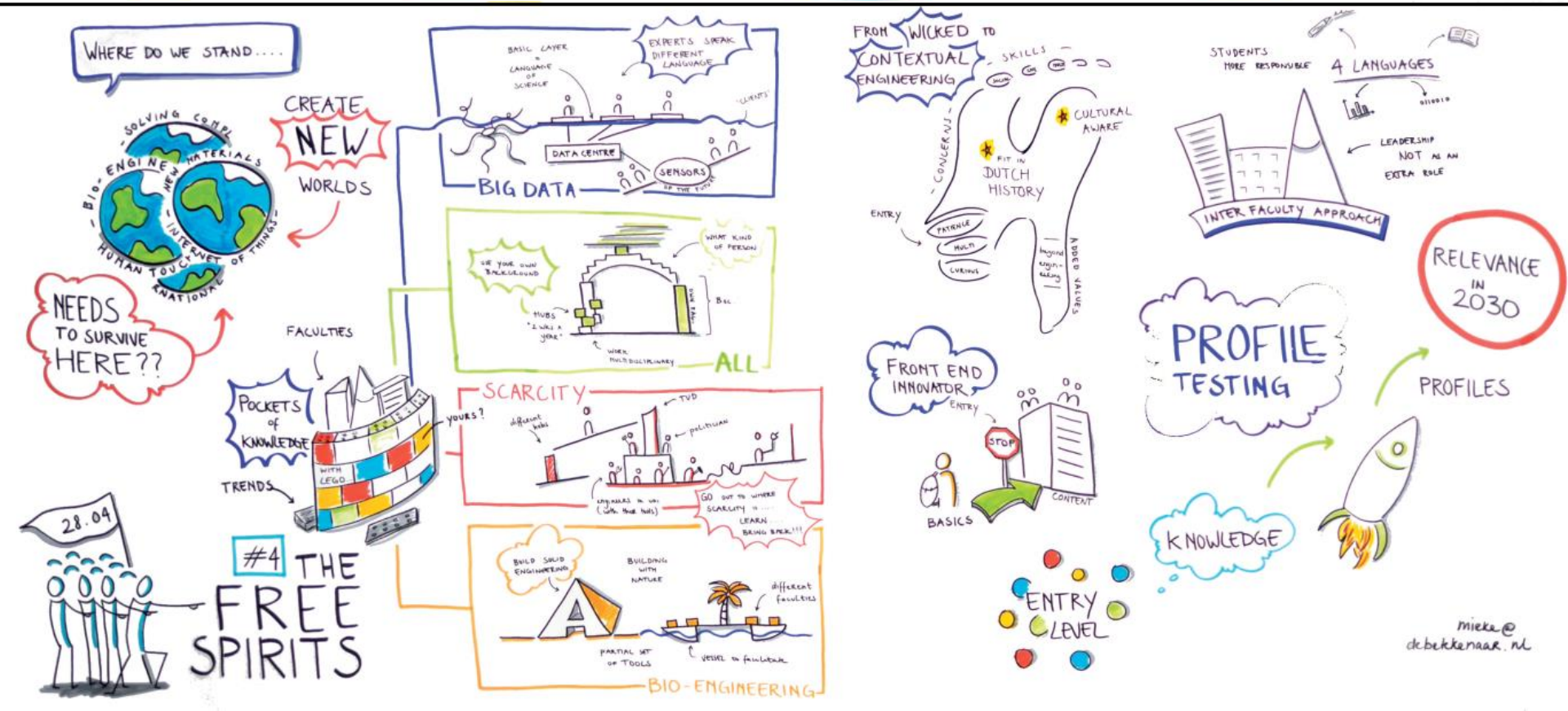
Think Tank Design Thinking

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



Think Tank tripartite concept that "wows"

I. Common engineering language across disciplines

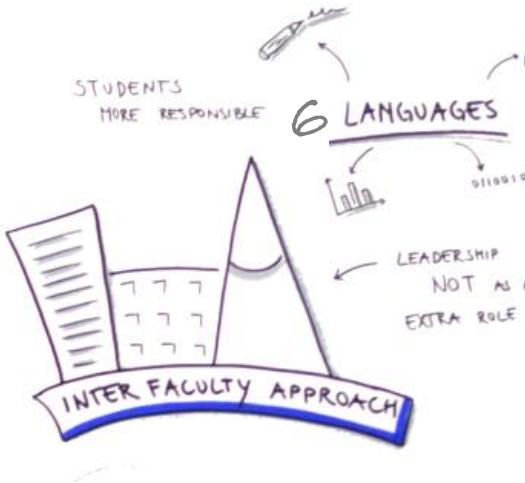
II. Profiling on top of disciplinary specialisation

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

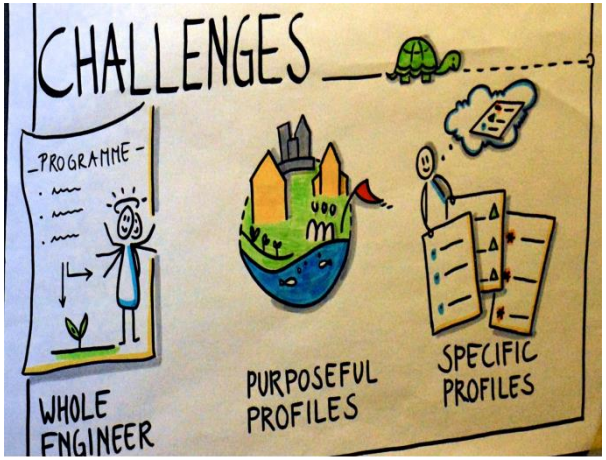
Engineering roles in particular contexts that provide opportunity for specialisation

Specialist

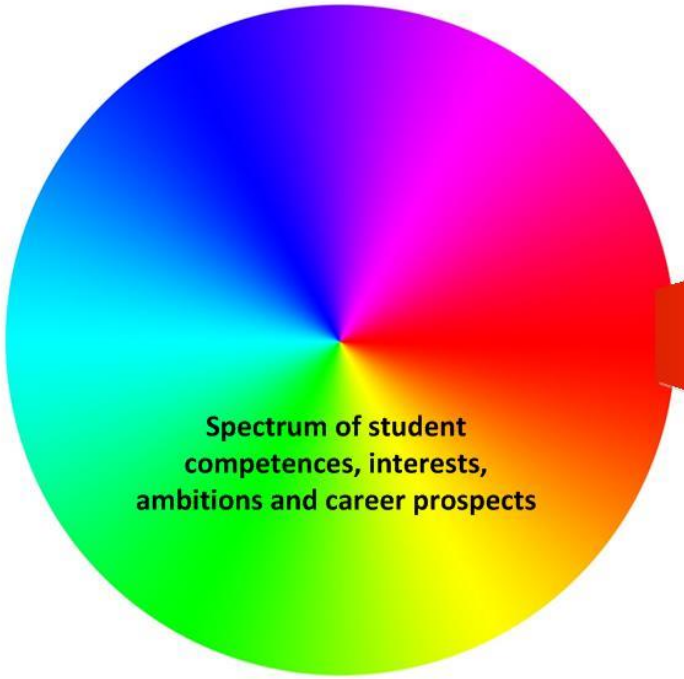
Systems Integrator

Front-end Innovator

Contextual Engineer

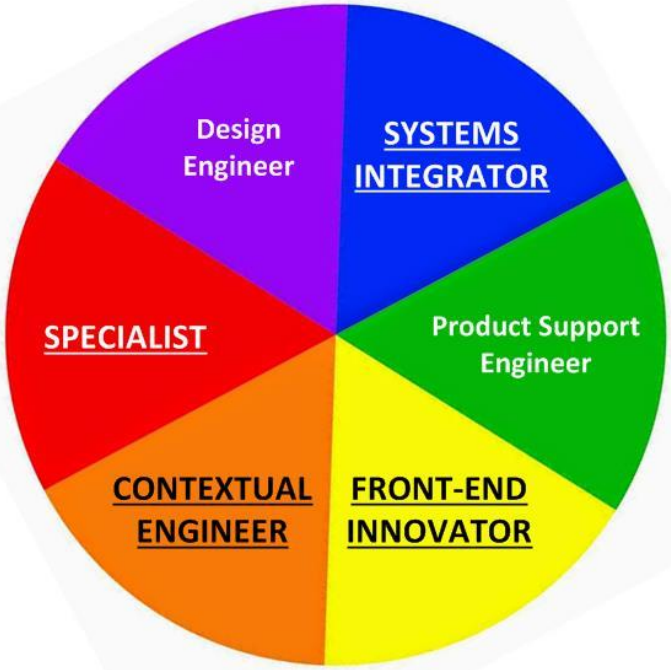


Spectrum of profiles and professional roles



Researcher /Specialist

Current common situation at research-intensive universities



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Profile: SPECIALIST

heuristic

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

required attributes

- 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

"pain and frustrations"

- Respect for other disciplines; compromising
- Language gap with non-experts

Profile: SYSTEMS INTEGRATOR

"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

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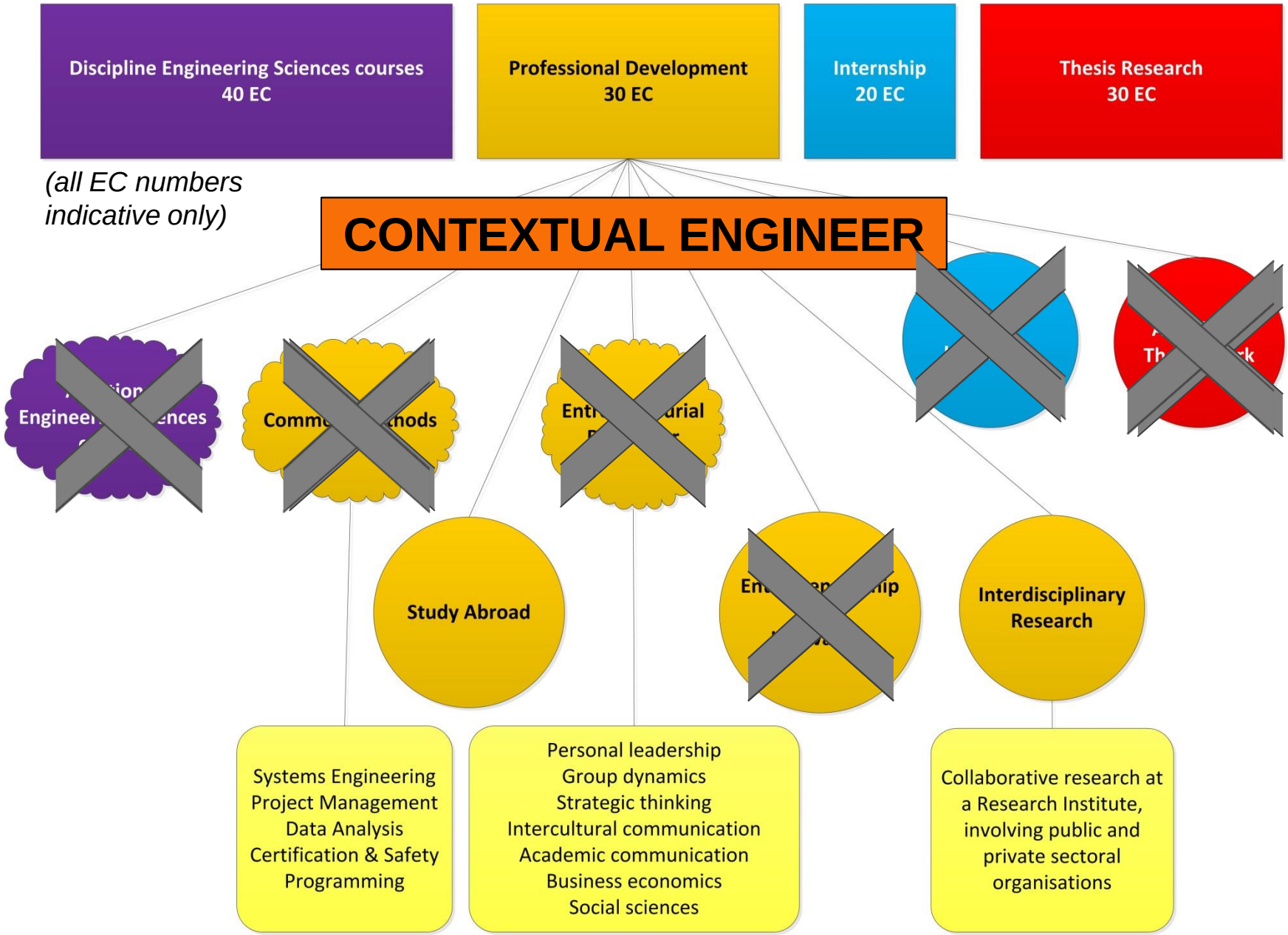
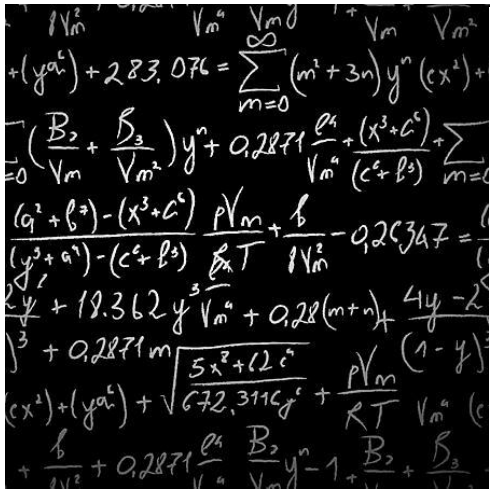
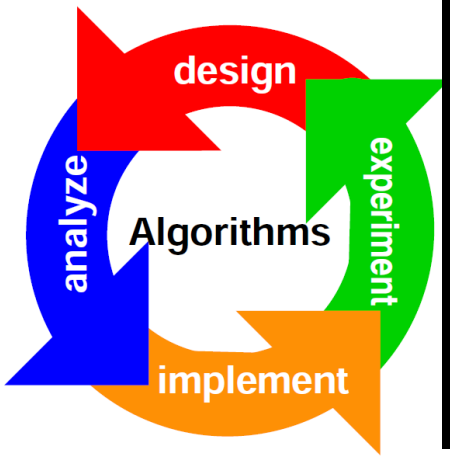
Heading for more DIY ethic in MSc



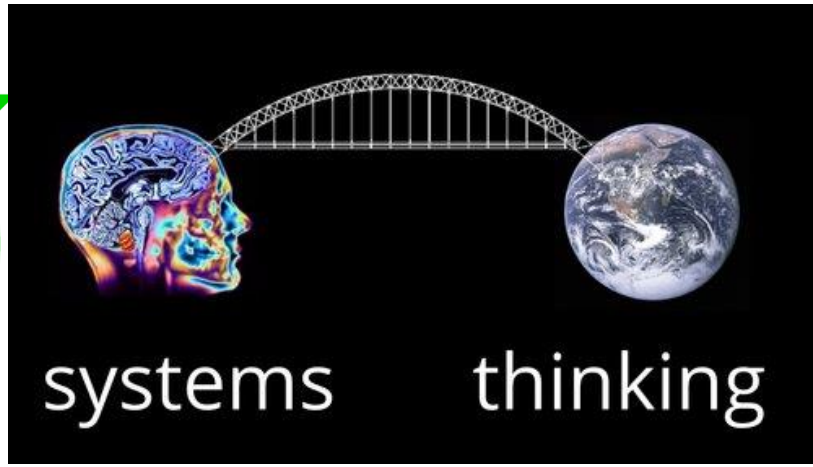
Study engineering in 2030

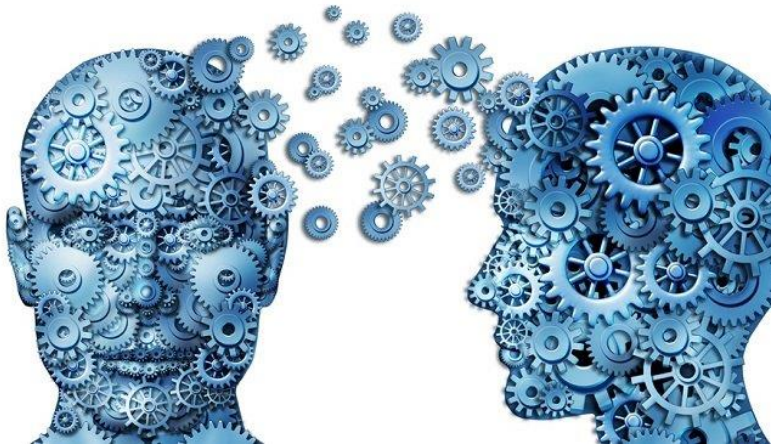


Fundamentals



www.collegeroadies.com

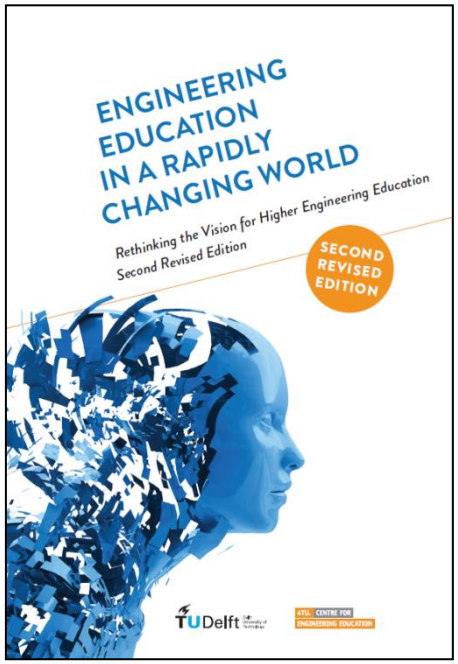


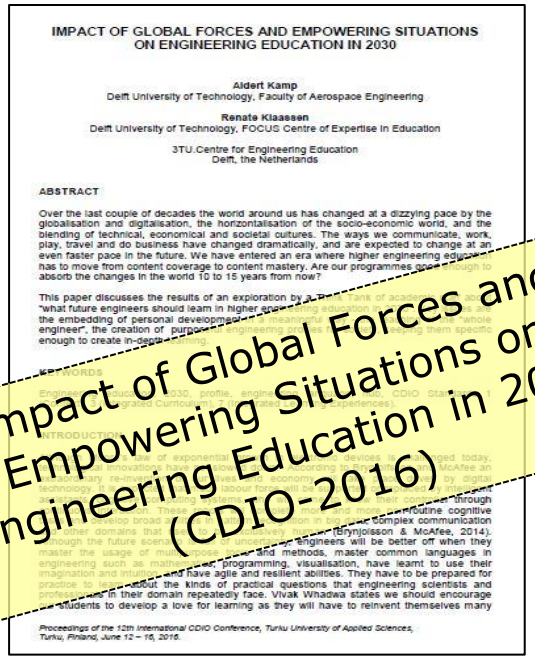


Knowledge sharing

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

Available sources




IMPACT OF GLOBAL FORCES AND EMPOWERING SITUATIONS ON ENGINEERING EDUCATION IN 2030

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ABSTRACT

Over the last couple of decades the world around us has changed at a dizzying pace by the globalisation and digitalisation, the horizontalisation of the socio-economic world, and the blending of technical, economical and societal cultures. The ways we communicate, work, play, travel and do business have changed dramatically, and are expected to change at an even faster pace in the future. We have entered an era where higher engineering education has to move from content coverage to content mastery. Are our programmes ready enough to absorb the changes in the world 10 to 15 years from now?

This paper discusses the results of an exploration by a [illegible] of academics [illegible] "what future engineers should learn in higher engineering education [illegible] the embedding of personal development [illegible] engineer", the creation of [illegible] enough to create in-depth [illegible]

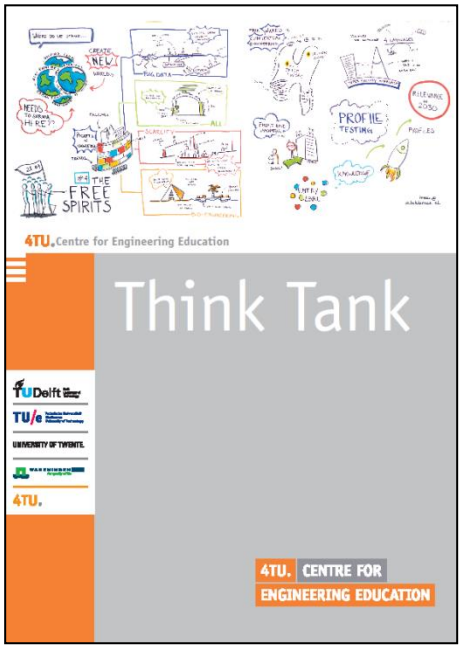
KEYWORDS
Engineering 2030, profile, engineering education, CDIO Standard 1 (Integrated Curriculum)

INTRODUCTION

[illegible] law of exponential [illegible] devices [illegible] today, [illegible] innovation [illegible] [illegible] according to McAfee an [illegible] re-invented [illegible] [illegible] by digital technology. [illegible] labour force [illegible] through routine cognitive [illegible] broad [illegible] complex communication [illegible] domains that [illegible] (Brynjolsson & McAfee, 2014). [illegible] the future scenario [illegible] engineers will be better off when they master the usage of [illegible] and methods, master common languages in engineering such as mathematics, programming, visualisation, have learnt to use their imagination and intuition and have agile and resilient abilities. They have to be prepared for practice to [illegible] about the kinds of practical questions that engineering scientists and professionals in their domain repeatedly face. Vivak Whadwa states we should encourage students to develop a love for learning as they will have to reinvent themselves many

Proceedings of the 12th International CDIO Conference, Turku University of Applied Sciences, Turku, Finland, June 12 – 16, 2016.

Impact of Global Forces and Empowering Situations on Engineering Education in 2030 (CDIO-2016)



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