# BETTER MAKE IT REAL

*Aldert Kamp*
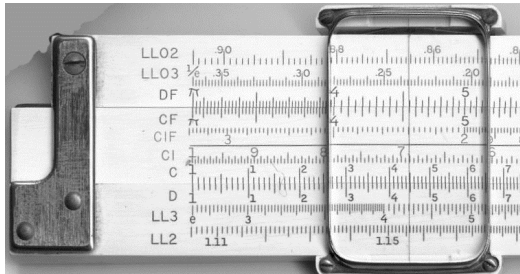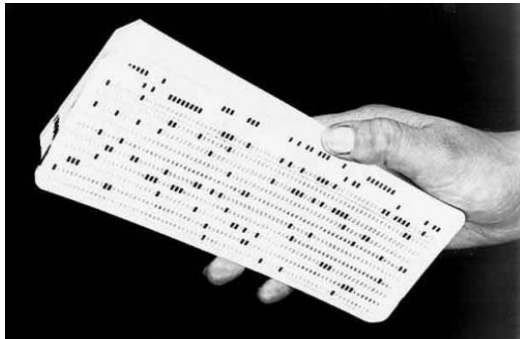
Delft University of Technology

The Netherlands
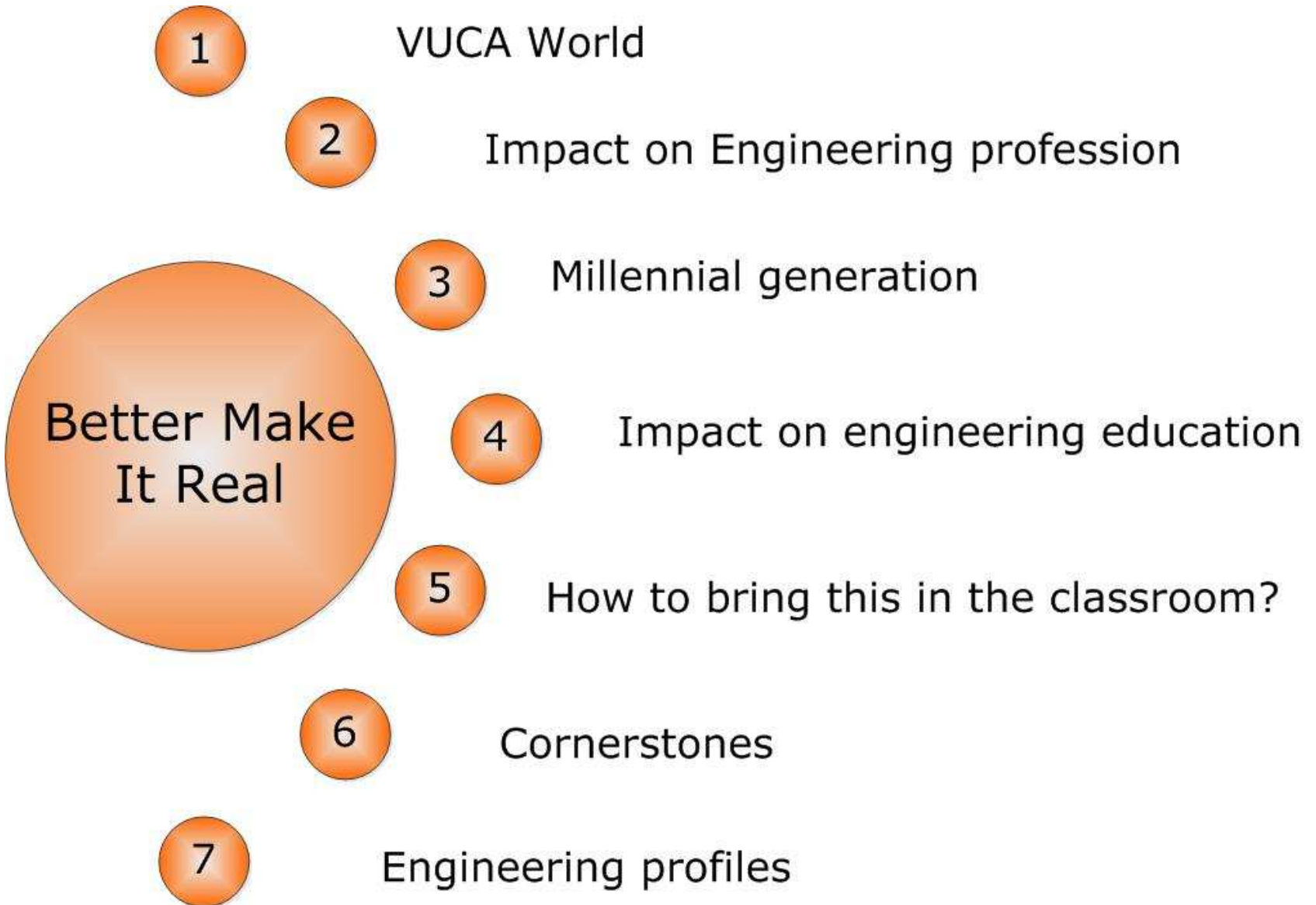
# Engineering education in 70's



© 2000 Nigel Tout

# Agenda

**1** VUCA World

**2** Impact on Engineering profession

**3** Millennial generation

Better Make It Real

**4** Impact on engineering education

**5** How to bring this in the classroom?

**6** Cornerstones

**7** Engineering profiles

# The VUCA world

Three converging forces in society

1. Globalisation and digitalisation

2. Horizontalisation of socio-economic world

3. Blending of technical, economic and societal cultures

Volatile
Uncertain
VUCA world
Complex
Ambiguous

# 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 |

# The VUCA world

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Volatile
Uncertain
VUCA world
Complex
Ambiguous

# Big Data and Artificial Intelligence

TA "Jill Watson"?

Source: Futureoflife.org
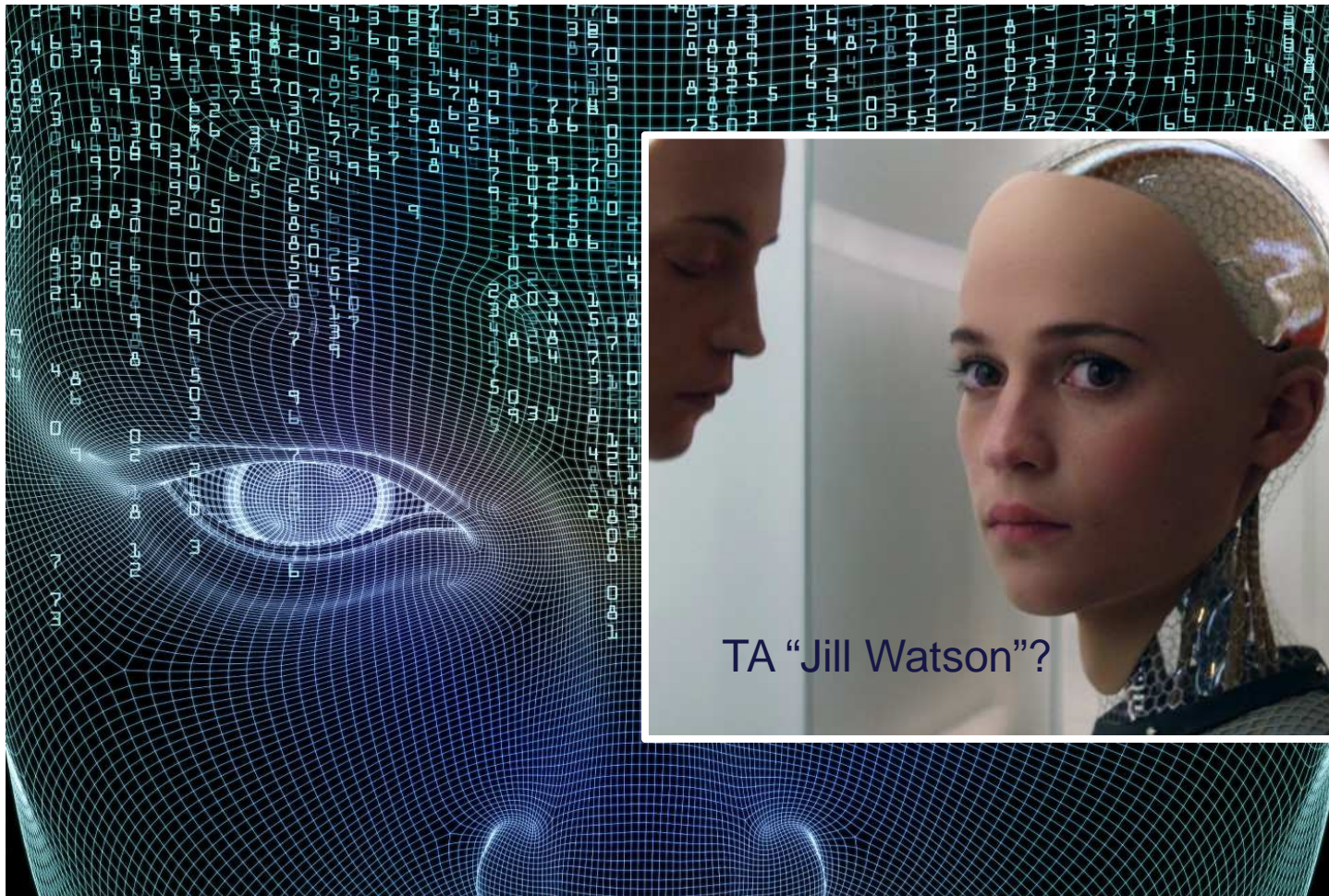
# Gaining in importance

- agility and resilience
- algorithmic thinking and programming
- business acumen
- creativity and innovation
- employability and lifelong learning
- engineering ethics
- entrepreneurial thinking
- intercultural collaboration
- mobility
- multi- and interdisciplinary thinking
- systems and holistic thinking

"The 10 skills you need to thrive in the 4th Industrial Revolution"
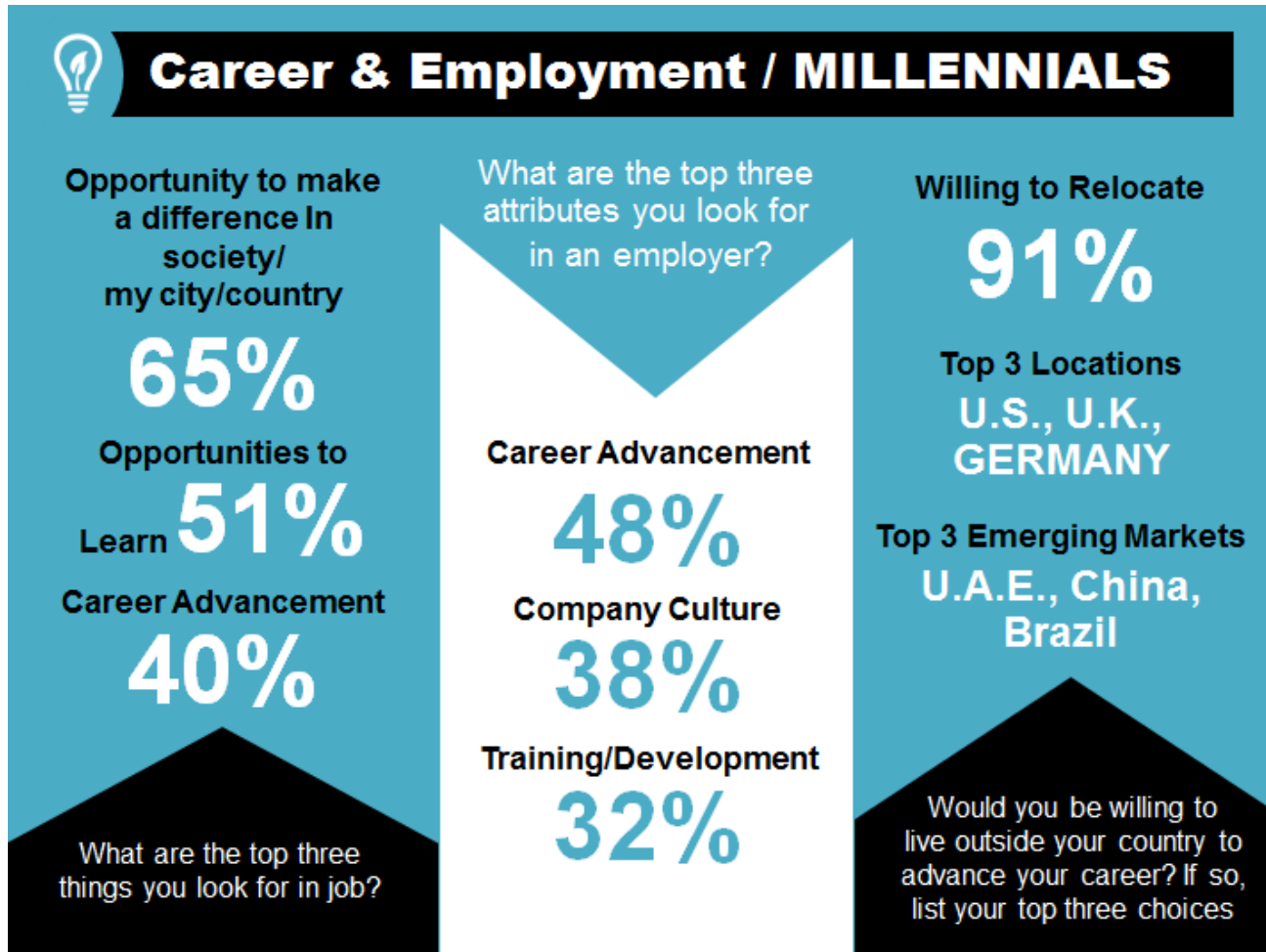
**in 2020**

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

**in 2015**

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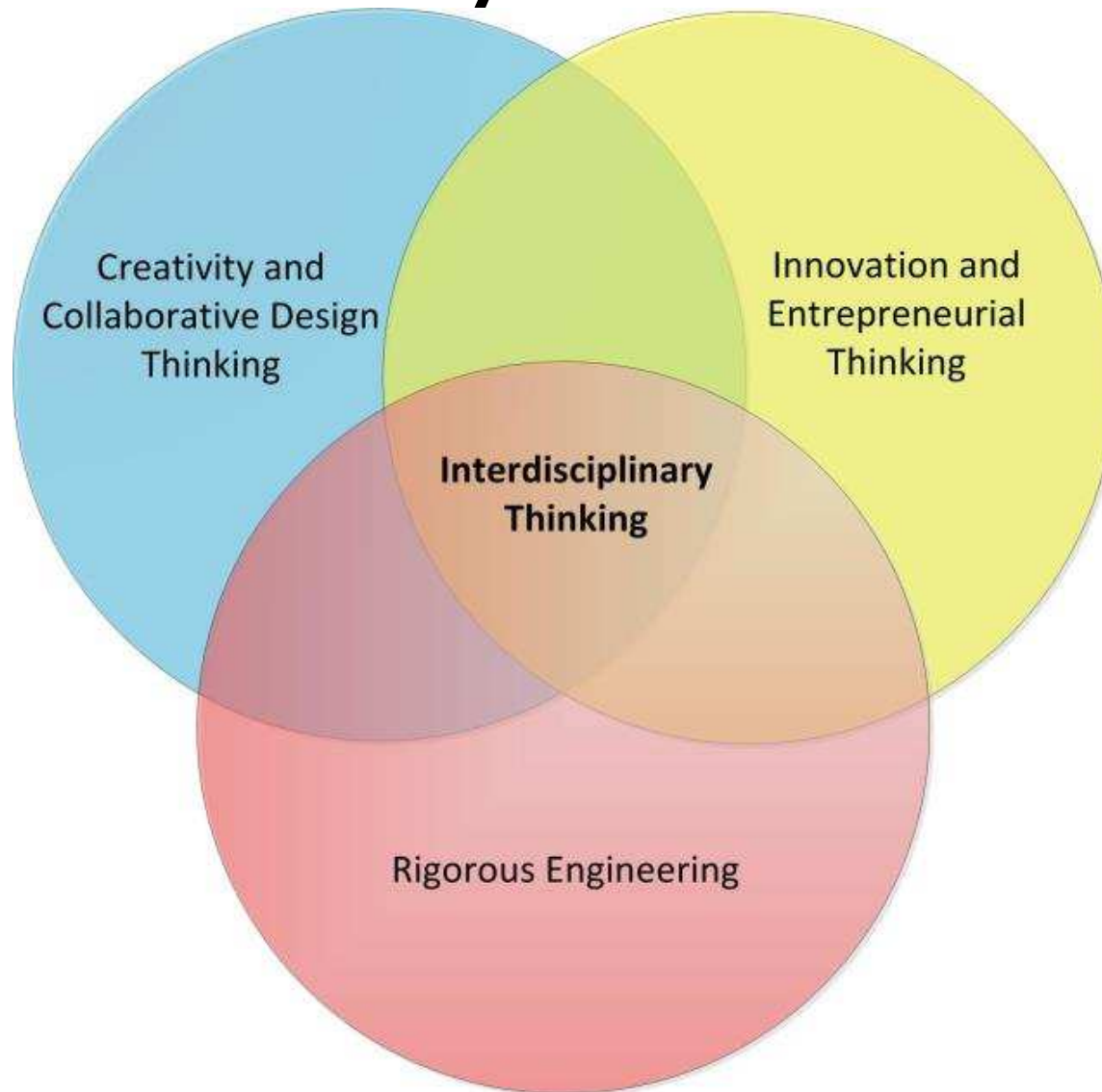9. Active Listening
10. Creativity

Source: Future of Jobs Report, World Economic Forum

# Millennials: a different breed



**Career & Employment / MILLENNIALS**

Opportunity to make a difference in society/ my city/country
**65%**

Opportunities to Learn
**51%**

Career Advancement
**40%**

What are the top three things you look for in job?

What are the top three attributes you look for in an employer?

Career Advancement
**48%**

Company Culture
**38%**

Training/Development
**32%**

Willing to Relocate
**91%**

Top 3 Locations
U.S., U.K., GERMANY

Top 3 Emerging Markets
U.A.E., China, Brazil

Would you be willing to live outside your country to advance your career? If so, list your top three choices

Source: World Economic Forum

# Education in 21$^{st}$ 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



Creativity and Collaborative Design Thinking

Innovation and Entrepreneurial Thinking

Interdisciplinary Thinking

Rigorous Engineering

**Bringing the real world into the classroom**

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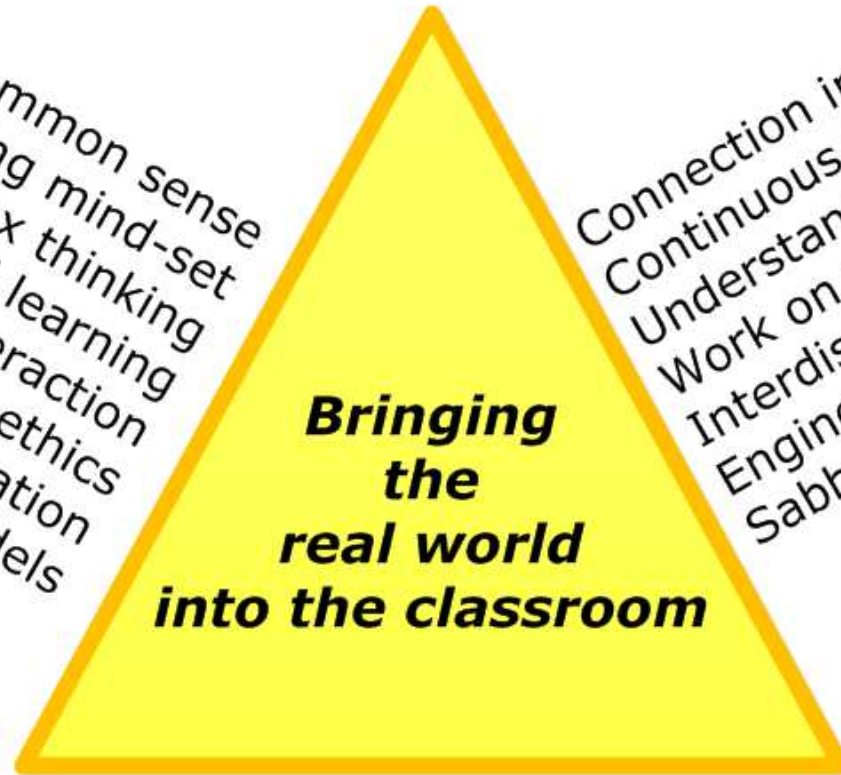
Increasing student engagement
Linking theory and practice
Labwork and makerspaces
Personal and career development
University-for-life

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

# CDIO Initiative

1. <u>an idea</u> of <u style="color:red">what</u> engineering students should learn

2. <u>a methodology</u> for engineering education reform involving 12 standards

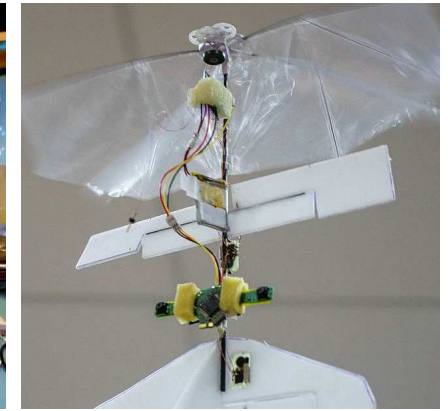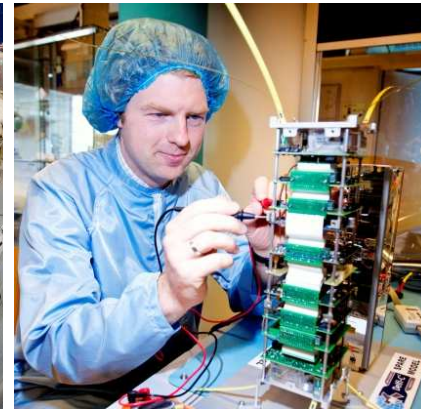3. <u>a community</u> to learn together and to share experience

**CDIO**

Conceive
Design
Implement
Operate

**CDIO Syllabus**

Technical Knowledge and Reasoning

Personal and Professional skills and attributes

Interpersonal skills: Teamwork and Communication

Conceiving, Designing Implementing, and Operating systems in the enterprise and societal context

# Mindmap Engineering Educ.
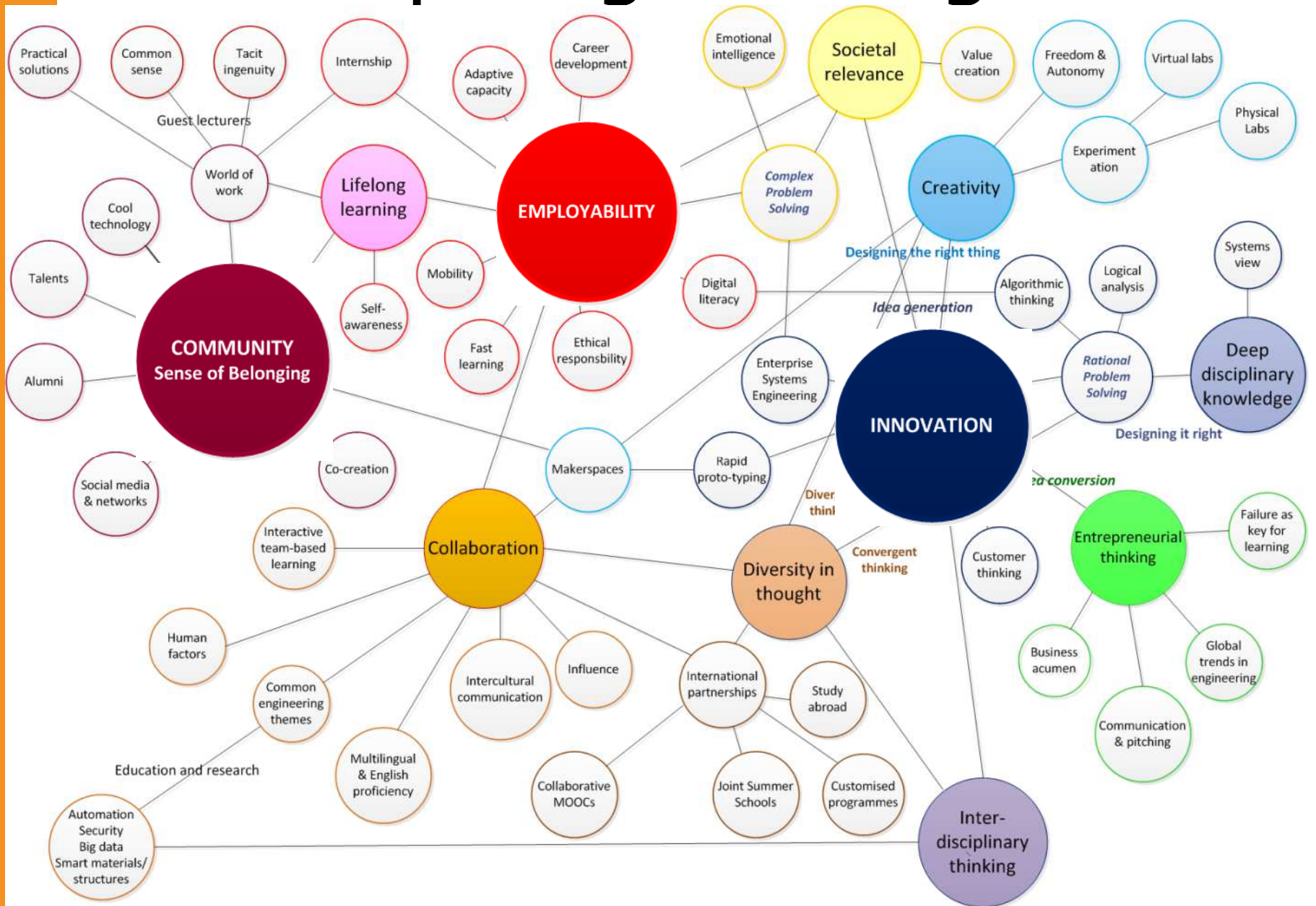
# University of connections

# Sense of belonging:
## Labs and makerspaces

# Think Tank Design Thinking
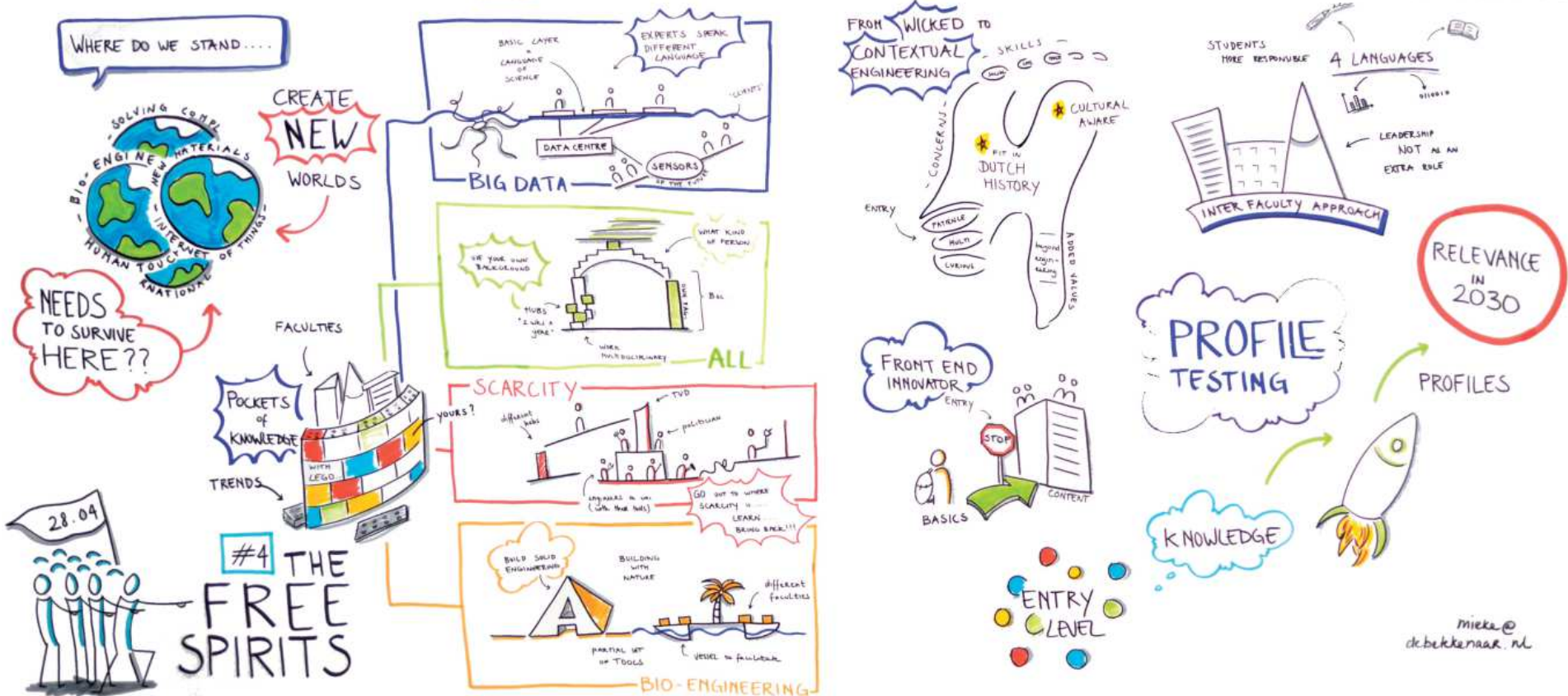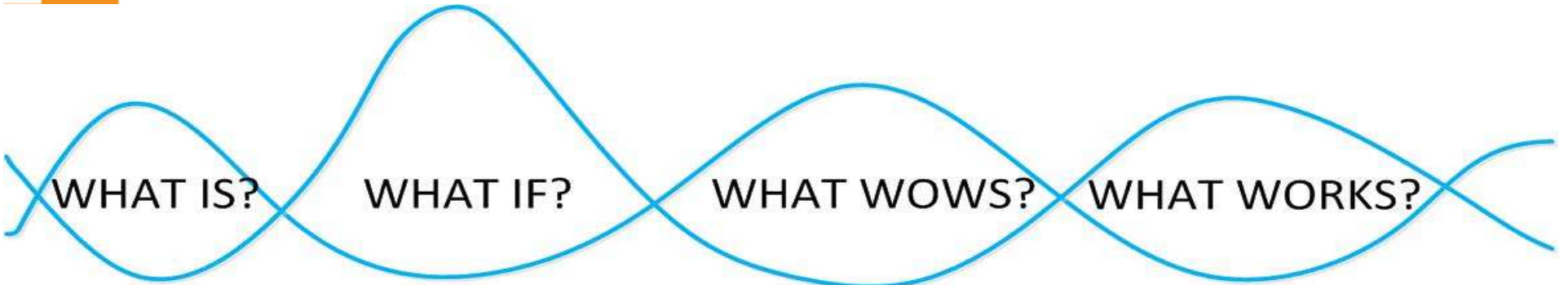
# Think Tank tripartite concept that "wows"

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 literacy
   (data analytics, algorithmic thinking)
3. Design skills
4. Academic communication
5. Engineering ethics
6. Collaborative interdisciplinary
   teamwork

STUDENTS
MORE RESPONSIBLE    6 LANGUAGES

LEADERSHIP
NOT AS
EXTRA ROLE

INTER FACULTY APPROACH
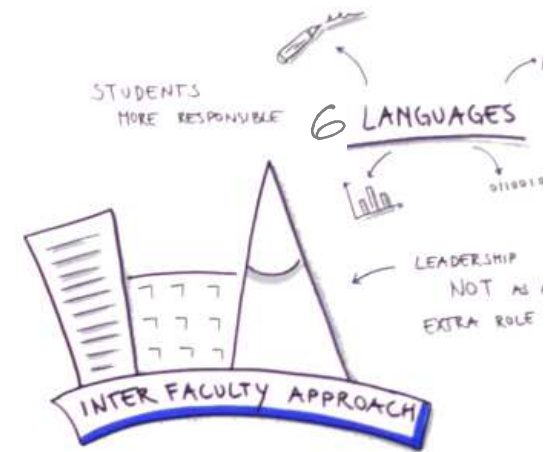
# Idea number II

## Profiles, professional roles

Engineering roles in particular contexts that provide opportunity for specialisation

Specialist

System Integrator

Front-end Innovator

Contextual Engineer
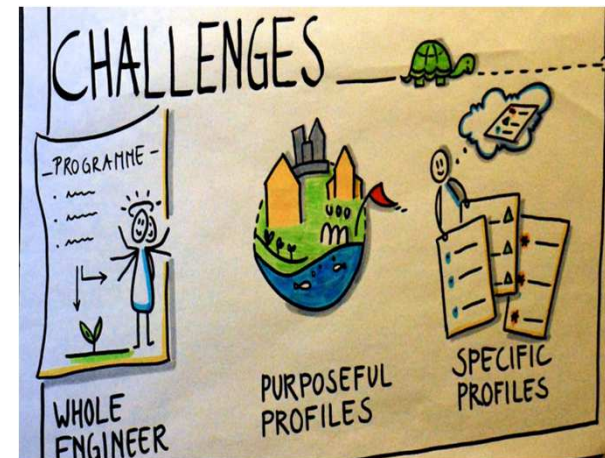
# Profile: SPECIALIST

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: SYSTEM 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

INTER FACULTY APPROACH

## <u>Hubs</u>

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
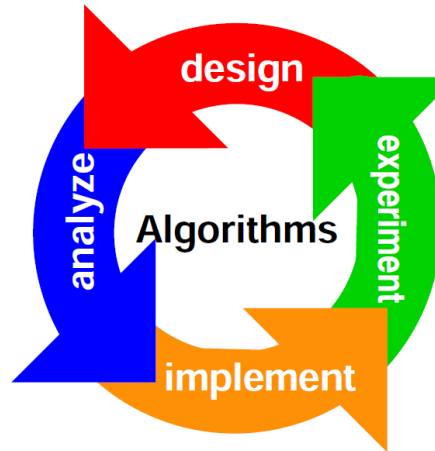
Collaboration in interdisciplinary teams

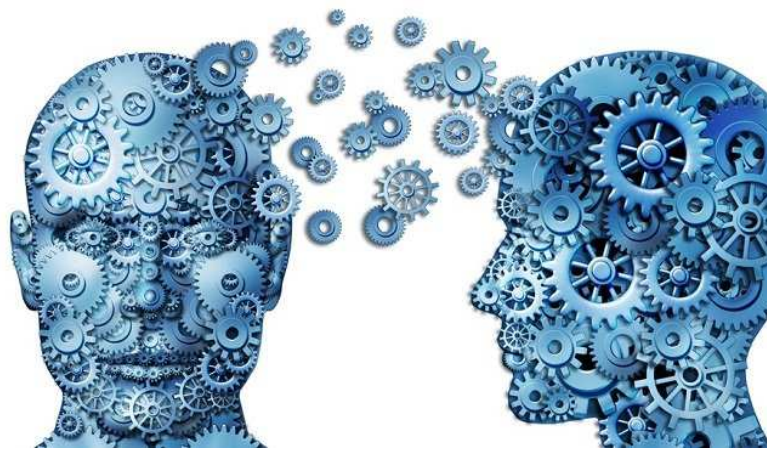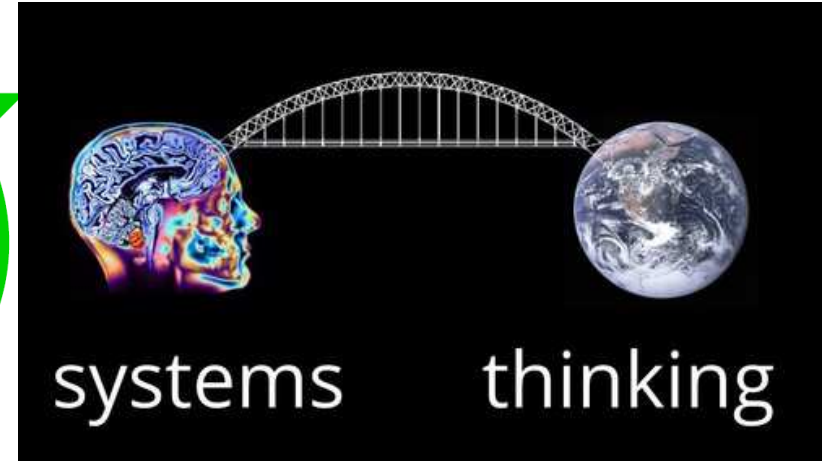Jointly with industrial business partners, customers, government agencies

# Study engineering in 2030



Fundamentals



design
analyze
Algorithms
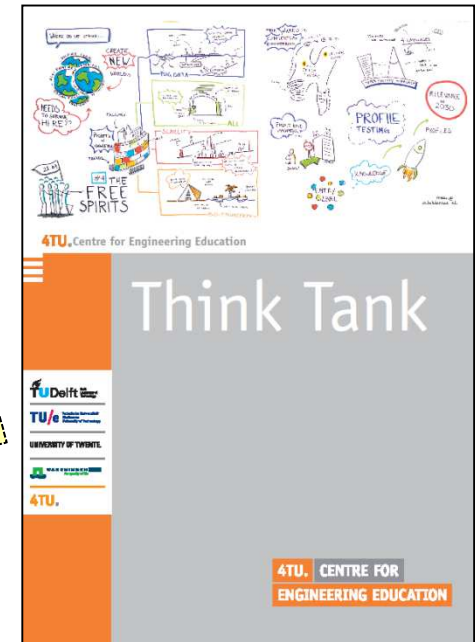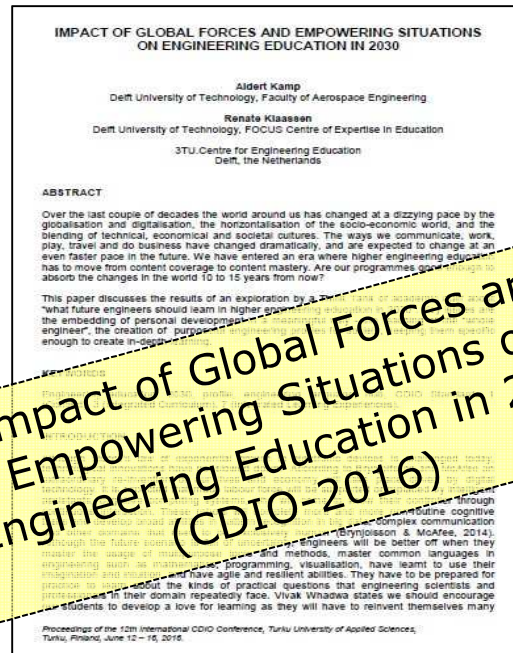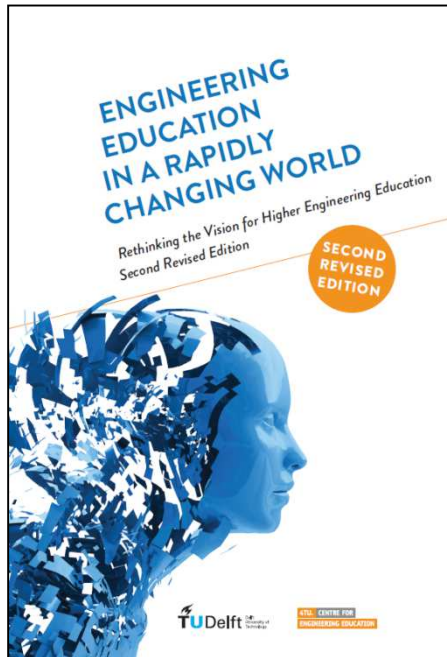experiment
implement
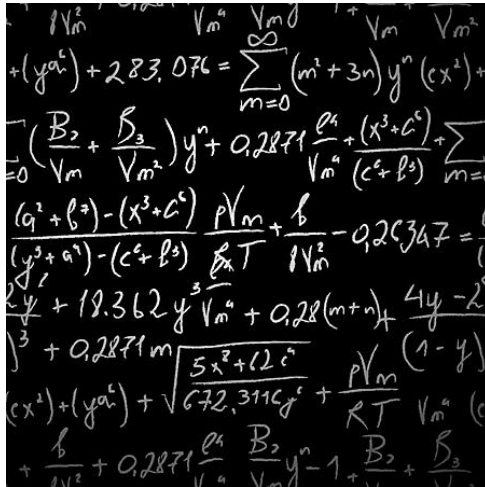
www.collegeroadies.com



systems    thinking



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 (CDIO-2016)

www.4tu.nl/cee/en/publications/vision-engineering-education.pdf

www.4tu.nl/cee/en/publications/2016-cdio-engineering-education-2030.pdf

www.4tu.nl/cee/en/publications/flyer-4tu-think-tank-def-lr.pdf

Email: a.kamp@tudelft.nl