3TU. School for Technological Design

STAN ACKERMANS INSTITUTE

Engineering Doctorates: the Bridge between Science and Industry

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Agenda

1. Role of 3e Cycle Engineering Programmes
2. Differences between PhD and EngD
3. The Dutch Programmes
   - History
   - Value propositions
   - Programmes Today
   - Quality Control
4. Comparison of Engineering Doctorates
5. Towards a European EngD Standard

1. Role of 3e Cycle Engineering Programmes

- 1e and 2e cycle of Bologna focus on *learning*
- 3e cycle focus on a *contribution* to the 'body of knowledge'
- PhD: the contribution is the *scientific result*
- EngD: contribution is an *innovative artefact*
- Artefact is a product, process or system. Either tangible or intangible.
- Artefact is the 'solution' to a 'problem'
- The artefact should be designed using scientific methods

2. Differences between PhD and EngD

	Scientific Research (PhD)	**Engineering Research (EngD)**
Starting point	Hypothesis	Requirements
Looking for	Truth	Practical solution
Outcomes	Knowledge	Artefact

Different approach and different attitude

Differences…

- PhD is passport for an *academic* career
- EngD for an *industrial* career

- PhD looks for *generic* knowledge:
  e.g. a theorem that holds always for a large class of systems

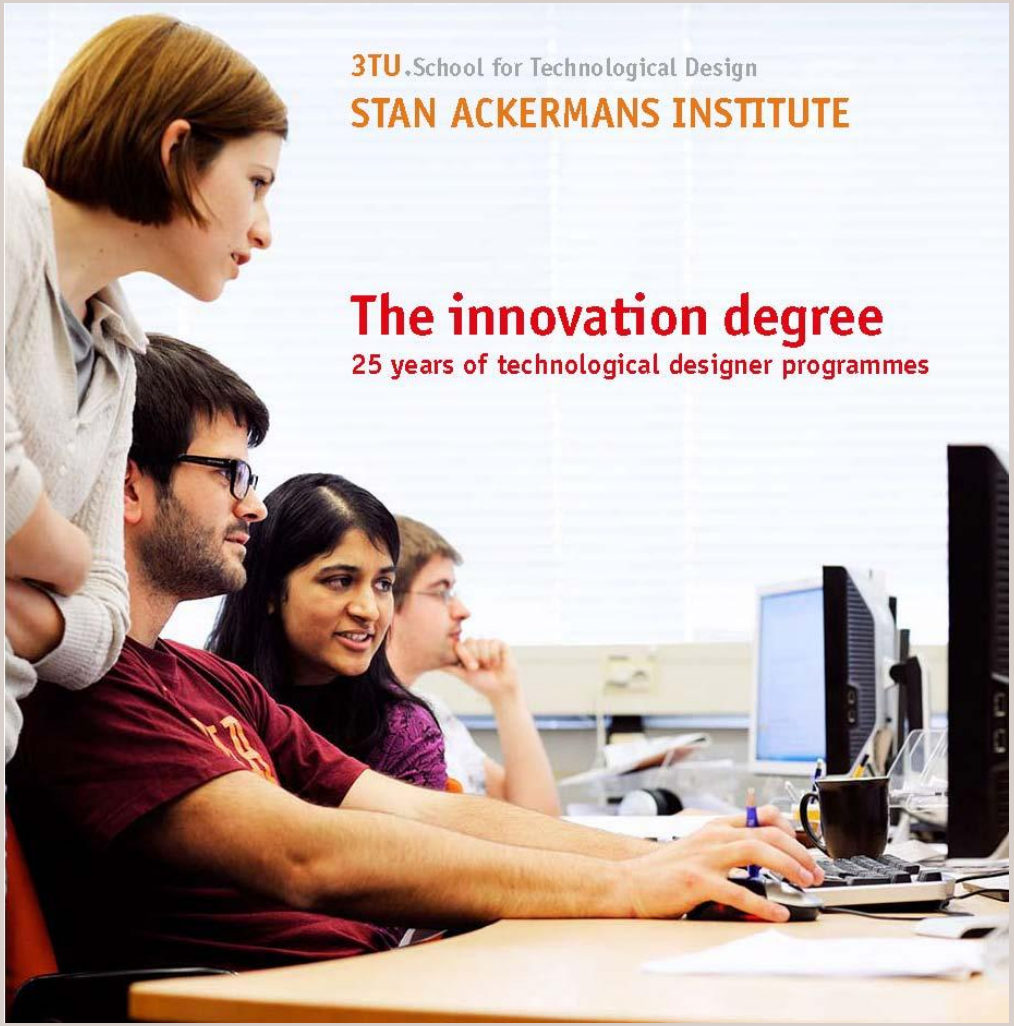
- EngD looks for a *specific* solution:
  e.g. the design of a innovative software system and a proof that it satisfies a set of requirements

- PhD seeks recognition by scientific publications
- EngD seeks recognition in succesful artefacts

3. Dutch Programmes

History:

- Started in 1986, because BSc+MSc became 4 years
- In 1997 again BSc=3 and MSc=2
- Students obtain degree:
  Professional Doctorate in Engineering (PDEng).
  Title used since 2004.
- Up to now: 3100 graduates delivered!
- Programmes in the 3 Technical Universities of Delft, Eindhoven and Twente



copy of the book: http://www.3tu.nl/en/education/sai/the_innovation_degree/

The PDEng formula

- Strongly selected master students
- PDEng students are called trainees
- PDEng trainees are employees
- Two year programme:
  - year 1: training in engineering methods and skills
  - year 2: design project in industry supervised by University staff
- Companies are paying for the innovation project (€ 5.000 per month or € 60.000 in total)
- We train top-level engineers to perform an excellent *innovation project* using state-of-the-art knowledge of the University

Value Proposition for Companies

- If you need a new *product, process or system*, let it be designed by a PDEng-trainee under supervision of a professor!
- Top-design trainees are selected from the best graduates with a masters in engineering
- Design projects are selected carefully: they must really *make a difference* to the company and they should be sufficiently *innovative* for the University

Value Proposition for Students

- Become a top-designer by '*learning and earning*'
- After graduation trainees get many job offers and have better career opportunities
- The programme gives you a career speed up
- PhD is for an academic career and PDEng for an industrial career (CTO is the ultimate goal)

Value Proposition for Universities

- The perfect way for industrial *innovation*
- Knowledge *transfer* "on the job"
- *Inspiration* from actual industrial problems
- Source of *income* !

Dutch PDEng programmes

- **Eindhoven**
  - Architectural Design Management Systems
  - Automotive Systems Design
  - Design and Technology of Instrumentation
  - Information and Communication Technology
  - Logistics Management Systems
  - Mathematics for Industry
  - Process and Product Design
  - Software Technology
  - User System Interaction
  - Smart Energy Buildings and Cities
  - Healthcare Systems Design
- **Delft**
  - BioProcess Engineering
  - BioProduct Design
  - Chemical Product Design
  - Comprehensive Design in Civil Engineering
  - Process and Equipment Design
- **Twente**
  - Civil Engineering
  - Energy and Process Technology
  - Robotics

Curriculum preparation year

- Personal skills including:
  - Project management
  - Presentation techniques
  - Social skills
  - Entrepreneurship (also 'intrapreneurship')
- Generic engineering methods:
  - Design theory
  - Mathematical modeling
  - Testing
- Advanced domain specific design techniques

Quality control

- Quality of the design *result*
  More difficult than evaluation of research!!
- Quality of the design *process*

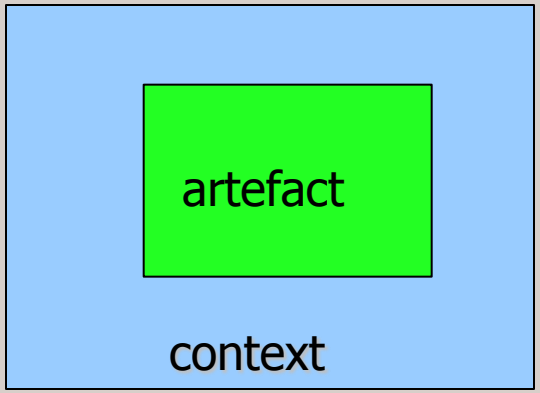
- For both *criteria* grouped per aspect were defined
- For each criterion one or more *indicators* with an *ordinal* scale were defined
- No straight jacket, but a help for evaluation committees

5 Aspects for Assessing the Design Result

1. **Functionality**
2. **Construction**
3. **Realizability**
4. **Impact**
5. **Presentation**

Each aspect has 2 or 3 indicators with an *ordinal* scale

greenfield



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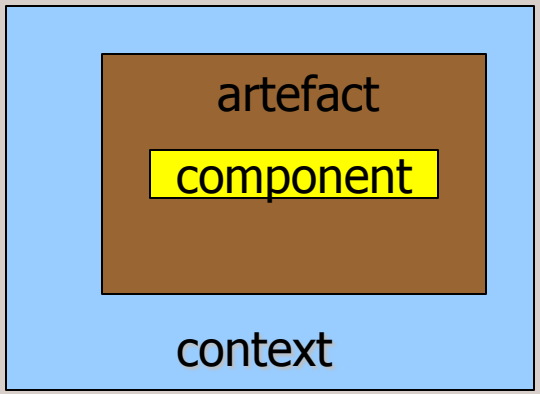

Functionality

- ***Satisfaction***;
of requirements
  1. Poor fit to the requirements
  2. Insufficient fit to the requirements
  3. More or less meets requirements
  4. Meets requirements
  5. Exceeds requirements
- ***Ease of use;***
for all stakeholders
  1. Very difficult
  .....
  5. Very easy

- ***Reusability***
  1. No reuse
  2. In same context, same scale
  3. In same context, different scale
  4. In different context, same domain
  5. In different domains

Construction

- ***Structuring;*** concerns 4 elements:
  overview, low coupling, high cohesion, clear interfaces
  1. None
  2. 1 out of 4
     ……
  5. All 4
- ***Inventivity***
  1. No surprise
  2. Surprise for laymen
  3. Surprise for professionals
  4. Surprise for supervisors
- ***Convincingness***
  1. No proof
  2. Informal proof
  3. Empirical proof based on simulation
  4. Empirical proof based on prototype
  5. Formal and empirical proof

Next 3 design aspects:

- **Realizability:**
  - *Technical*
  - *Economical*
- **Impact:**
  - *Societal*
  - *Risks*
- **Presentation;** of the artefact
  - *Completeness*
  - *Correctness*

4 Aspects for assessing Design Process

1. Organization and planning
2. Problem analysis and solution
3. Communication and social skills
4. Structure and attitude

4. Comparison with other countries

1. UK: EngD programs:
   - 4 years after (3 year) BSc; total time: 7 years
   - May be a MSc is obtained during project
   - Doctoral Training Centers 28 universities
   - Industry pays!
   - In total now ca 3500 degrees
2. France: CIFRE doctorate:
   - 3 years after (1 year) MSc+ (3 year) BSc: total: 7years
   - In an enterprise, that pays ca € 2K per month:
     total cost: € 142K

Comparison…

3. Sweden: licentiate:
   - 2 years program after (2 year) MSc+(3 year BSc); total: 7 years
4. The Netherlands: PDEng (member AEngD)
   - 2 years program after (2 year) MSc +(3 year) BSc, total: 7 years
   - Second year paid by industry ca € 60K

In all cases: total study takes 7 years!

In the Netherlands ca 10% of PDEng continues for a PhD in 2 more years

5. Towards a European EngD Standard

- Common criteria, but avoid 'one-size-fits-all'
- Academic criteria:
  - Problem description
  - State-of-the-art
  - Evidence of scientific engagement (publications)
  - Detailed description of the outcome
  - Theoretical or empirical verification
- Industrial criteria:
  - Description of industrial context
  - Analysis of impact of the projected outcome
  - Description of embedding in context
  - Evidence that outcome is innovative
  - Demonstration that outcome is fit for purpose

Some problems to be solved:

1. Not many professors have engineering experience
2. The academic reward system is based on scientific publications, not on working artefacts.
   Patents are recognizable, but for 'pure' software that is not possible in Europe
3. Developing a real working artefact, e.g. an innovative software tool, is much more work than writing a paper
4. Often industrial partners want to keep the projects secret! How to deal with that?

Europe is good in research,
but weak in innovation

EngD is thé Innovation Degree

Dutch programs are already associated with AEngD of UK, who follows us?