

# Science and engineering in transformation and the position of graduate training

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# Prefatory remarks

- My perspective: professional practices with a knowledge-producing component evolve (this might add up to transformations), while there is inertia in graduate training so that it often reflects the past (with some exceptions)
- This is how I diagnose earlier and present situations, and draw out implications by constructing scenarios of futures that might evolve
- Methodology of diagnosis plus scenario

# Example of engineering

- Traditional sectoral-defined competencies (oil, sugar, paint, electricity generation) and partly overlapping professional classifications (mechanical engineering, electrical engineering, chemical technology etc) were relevant during the main part of the 20<sup>th</sup> century, but not anymore.
- Still labels for training (not relevant to graduate research).
- ICT was the first intruder in this landscape; accommodated
- Now, two types of professional knowledge practices are important:
  - (1) sociotechnical systems engineering
  - (2) advanced technologies (materials, mechatronics, optics, bio, nano, ...)
- Recognized to some extent (e.g. Uni Twente, merger of faculties; new Bachelor Degree Advanced Technology)

# Similar developments elsewhere

- In medical & health, there is integrated health care research, and advanced biomedical research (with clinical research sitting uneasily between them).
- In agriculture, there is a broad spectrum ranging from agriculture research to rural development and nature conservation (or nature care), as well as dedicated laboratory and field research often related to molecular sciences.
- In education, social care, and psychology, the separation between the two main clusters is perhaps less emphatic, but the difference in emphasis can be seen. (E.g. the difference between designing and implementing a communication campaign and studying foundational aspects of communication in a lab.)

# A new path emerges

- A pattern linked to evolving professional knowledge practices, new institutional settings, and the global contexts of late modern societies
- This is where graduates have to find their way, eventually.
- “Why burden them with traditional PhD training (an initiation rite)?”
- Excursion: Look at evolution of universities

# What's happening already in universities?

- Internal governance changes: more directive modes (cf. New Public Management)
- (inter-disciplinary) research institutes in addition to Faculties: Centres of Excellence and Relevance (which also occur outside universities)
- Conglomerates created between universities and other research organizations (examples include Karlsruhe Institute of Technology)
- External links and interactions, importance of networks – so porous boundaries

a holding company

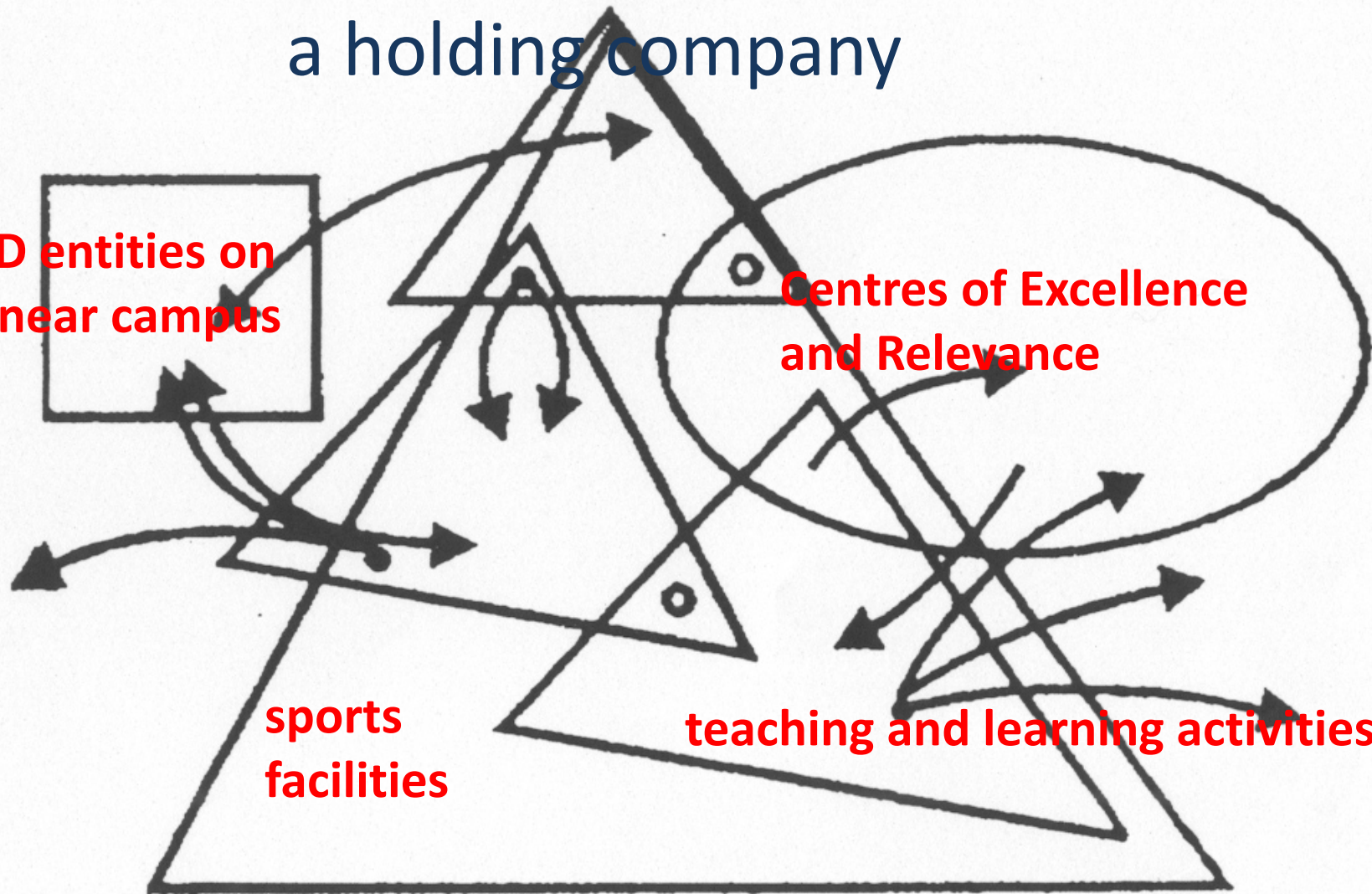
R&D entities on  
or near campus

Centres of Excellence  
and Relevance

sports  
facilities

teaching and learning activities

a university "complex"



# The new regime of Strategic Science

- Strategic Research: Basic research carried out with the **expectation** that it will produce a **broad base** of knowledge likely to form the **background** to the solution of recognized current or future practical problems (Irvine and Martin 1984)
- From early 1980s: strategic research becomes pervasive: An alliance between politicians and science policy makers and a new elite of scientists promising to contribute to wealth creation, sustainability
- Sponsors and customers for strategic research find variety of suppliers on a new “market”
- Science institutions have to adapt and evolve



# The evolving landscape

Concrete sponsor: national government  
(plus abstract sponsor: GOVERNMENT)  
ministries, advisers

Further abstract sponsors:  
**INDUSTRY, SUSTAINABILITY,  
HUMAN ENHANCEMENT**

(Changing social contract of science)

**SCIENCE as abstract sponsor**

## Markets for strategic research

universities

research groups and centres

research level

of application

local situation

The triangle in which scientists used to live had no interest in national goals and policies, except when checking funding possibilities. 'Science' justifies their relative autonomy, so is a symbolic resource (legitimation)

# A new species in the ecology of research systems: Centres of Excellence and Relevance

- Occur also outside universities (e.g. Technological Top Institutes), and when inside, are relatively independent (cf. Kokkeler, PhD Thesis)
- They move on a “market” for strategic research (as emerged under the regime of Strategic Science)
- Max-Planck Institutes and Fraunhofer Institutes converge (an “attractor” position)

# New locations for training

- Research Centres of Excellence and Relevance can and do capture the move towards advanced technology and socotechnical systems construction
- Ideal locations for graduate training, whether inside or outside universities
- If the monopoly of universities is lifted (cf. Brown and Duguid 1996), more locations (sites) are candidates for training
- Proliferation, new types of degrees (portfolio)

# Contexts and practices in flux

- Note: there are more knowledge practices, e.g. expertise, “collective experimentation” (Joly and Rip 2011) -- the latter involves lay people
- Responses of universities? Different scenarios:
- (1) add-ons to traditional graduate training, like courses on valorisation (ex. NanoNed)
- (2) allowing for variation in location and in content (cf. Research Centres for E&R)
- (3) pro-actively addressing new challenges

# New challenges?

- One challenge for graduate training is the move towards addressing so-called Grand Challenges like sustainable energy, ageing society, security, climate change, which are transformational (not just setting of priorities)
- Kuhlmann and Rip (2014) identify the need for new actor alliances including charitable foundations, and for knowledge assemblage rather than just knowledge production
- Implications for training?

## (continued)

- This might be seen as extension of sociotechnical system construction
- But without it being clear what the system can be (if “system” could be the answer at all!)
- Social innovation as an integral element
- All this may be too ambitious for graduate student training
- Other levels and forms of training?

## New challenges (2)

- Advanced technology (and similar developments at some distance from society) will be taken up and inserted in society
- Needs “social licence to operate”; the recent push for “Responsible Research and Innovation” attempts to address this
- Focus on early interaction with stakeholders and civil society actors (“co-production”)
- Unclear what this means/how to do it

# In conclusion

- I've tried to add a further level of reflection and design considerations to the work on improving graduate training, by putting it into larger, evolving contexts and identifying actual and possible "paths"
- You need not agree to my specific claims, but still recognize the importance of these broader considerations
- I neglected possible links with undergraduate training; we can explore that in the discussion