

Critiques of Engineering Educating and the Background for Design Programs

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Challenges to engineering education

- integration of personal and organisational skills
- re-inventing engineering design competences
- emphasis to practice and domain knowledge

Institutional responses:

- ABET 2002 performance criteria
- NSF program in engineering education
- Barcellona measures for internationalisation
- several working groups and reports



Identity and uniformity?

- planning and debates of engineering education tend to replicate certain themes
- prevalent theme is the role of core curriculum distinctly providing what makes engineers competent in mastering technology
- often in critical relationship to the practical skills of engineering often not provided by the schools
- raising the question of the identity of engineers in relation to skilled craftsmen and other professions



National differences

- despite core themes national differences are observed in providing engineering competence
- German model dominates continental Europe differentiating a skilled, craftsbased engineering training from the university based engineers
- societal elite and class structures impact to a great extend and is foundational for e.g. the British system of accreditation
- while in the US the craftsbased model has transformed into a university model



Technology domains

- contrary to early 19th century visions of 'polytechnique' and 'einheitlichkeit' technology domains have changed the concept of engineering
- from construction, mechanics and manufacturing to electronics, programming and biology
- mechanics has been supplemented by component based, and control systems engineering
- management has been added as has socio-technical demands and innovation process



Science based engineering

- inspired by WWII achievements and implemented in the US engineering schools
- originating from the European technical universities and the focus on a science base
- early controversies: what would account as science?, and who was allowed to judge?
- dominance of public funding gave rise to a scientification of the disciplines of technology
- and to a disciplinary 'congestion'



Changing staff requirements

- the science based of engineering universities changed recruitment of the teaching staff
- doctoral degrees are base requirements at many universities eventually complemented with temporary staff or external lecturers from industry
- difficulties in establishing the diffusion of staff between industry and schools as wages and carrier opportunities differ
- potential conflict between education and research



Crisis for the practical engineer

- the European tradition of craftsmanship and its base in small production units was destroyed by the growth of large industry
- growing crisis for the 'zweiter Bildungsweg' and the skilled based engineering schools
- leaving the practical competences aside as the university based schools took over
- quite controversial what these practical skills were comprising illustrated by industry response



Engineers challenged

- new educations follow the growing complexity of technology
- but in some instances in-ability of engineering institutions to cope with the new technologies
- some have a historical reference to professions like pharmacists and architects
- but chemistry, IT, biotechnology and nanotechnology illustrate a new tendency
- is science at last becoming an important driver?



Paradox of engineering knowledge

Studies of engineering practice and use of knowledge tell:

- most engineers rarely use formal theory and methods explicitly
- there is a 'praxis shock' and some de- and re-learning takes place at the job
- engineers have become the 'house-maids' of industry
- 150 years of battle over the role of theory in engineering



Great expectation: science as ideology

- the 'scientification' of engineering has made research universities dominant, legitimate and stabilised the position of natural sciences
- major efforts have been made to socially construct science and research as the origins for technical development
- and to make the natural sciences become the core basis for engineering knowledge



Walking in closed circles

- growth in the number of engineering specialties and in technological knowledge has put engineering education under heavy pressure
- core curriculum demands setting the stage
- ideas of a rational structure of knowledge forming a hierarchy from the basic to the applied
- skills in communication and project management
- reform: modular structures and/or the introduction of group assignments and projects



Ideas of core disciplines

- the idea of core disciplines, with mathematics and physics as the basis
- natural science seen as the most advanced and difficult to learn
- hierarchical structure of discipline from (basic) science to (applied) technology
- staging curriculum development in a conservative and restraining way
- even setting the agenda for other disciplines and approaches to knowledge positioning them as service elements and marginal



The science - technology relation

- studies in the history of technology have shown: the science technology relation is complex and by no means linear
- but, still low impact on policy rethorics and the self-image of science
- responses in engineering education has concentrated on constructing identity between training 'rational' work processes and learning sciences in an instrumental way



Missing creativity and innovation

- the process of making technology disciplines scientific has made engineering less creative and innovative (Seely)
- a process especially dominant since the 1950'ies, but recognised as limiting since the 1990'ies
- engineering design activities have lost importance, as has the recognition of the other elements of engineering knowledge



Innovation and new perspectives

- the notion of innovation has been extended in the last decades following the new insights from innovation theory
- policy and mangement attemp to govern innovation processes has shifted focus from a technical to a broader focus on markets and users
- combining the new educations with the aggressive intrusion of business economics, innovation is not any longer mastered through engineering



Responsibility and ethics

- engineering problem solving and technology development a question of responsible practices
- a special engineering ethics has been a way of bridging social responsibility of safety and usefulness with methods and professional practices taught in engineering disciplines
- the organisational framing of engineering practice and the focus on techniques limits the impact of this perspective though it raise relevant questions



Problems and learning in focus

- pedagogic reforms surfaced during the 1970ies in the form of student projects, inductive learning principles, and problem based learning
- learning process in focus more than the content and the role of specific disciplinary knowledge
- problem seen as cooperative and communicative competences and the contact with broader demands for solutions



Cognitive and didactic approaches

- translation and transformation of knowledge from novice to expert (Patell)
- embedding of theories and methods in practical routine (Boshuisen)
- experts have cognitive maps and implicit routines established through professional experience (Schön)
- solving complex, authentic and contextualised problems in a practical skill (Erskine, Jakobsen)



History of technology approaches

- technology is the result of experimentation, stringent testing, routine and morality (Vincenti, Florman)
- engineering has its own sphere of knowledge and instruments (Ferguson, Henderson)
- technology is intertwined with science in an instrumental relation (Ihde, Latour)
- science and technology as mirror image twins (Constant)
- technical science is a unification and codification effort (Hård)



STS approaches

- science is a focused constitution of reality, punctualising certain aspects and stabilising them with methods in laboratories (Latour, Knorr Cetina)
- engineering is a heterogenous activity building on several disciplines and routines (Callon)
- knowledge and routine are closely linked and created by communities of practice (Wenger, Braun)
- technical disciplines have adopted their image from science, engineering domains are institutionally supported communities of practice



Domains or disciplines

- accept the difference between engineering practice domains and scientific (technical) disciplines
- a shift in focus from knowledge to competence
- competence is: the ability to combine knowledge, experience and contextual reflections in problem solving under organisational and other constraints
- accept and teach a heterogenous set of disciplines
- integrate technical problem-solving in science
- let authentic projects guide experience and the struggles with theories from disciplines



Traces leading to design•ing

- 20 years or more of stagnation in curriculum development at DTU (many new specialties but few improvements in engineering curriculum)
- an integrated curriculum in both STS and design engineering - but never really becoming core activities or agenda setting
- research in design was criticised for not having an empirical approach to design practice - only normative models



Staging a change

- lack of student recruitment to DTU and continued staff cuts
- discussions in industry about the lack of engineers and sceptical attitudes towards the more and more science based education and lack of creativity and practical skills
- conference about engineering education organized by industry and the engineers society introduces action plan for DTU in engineering design



The vision of design•ing

- create enthusiasm for holistic solutions by challenging and developing creative abilities – both individually and in the need and value of collaboration
- a design engineer must – in cooperation with others – take *responsibility* for future *development* and *application* of technology, as well as demands for *sustainability*, *user-involvement* and *quality*
- a design engineer must develop skills as a *technical* and *social oriented innovator* and *stage-setter* of innovation and development in industry and in society



Bridging disciplinary difference

- we have experienced the difficulties in interdisciplinary cooperation
- different research approaches: especially about what is relevant knowledge, reality and method leads to 'interesting' and demanding discussions
- engineering instrumentality creates a very crucial jump from problem statements to instrumental and normative method
- the STS tradition of observation and grounding theories complicates the use of method as 'machinery' and simplification

