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Steen Hyldgaard Christensen

Engineering in Context:
Structural, Cultural, Social, and Epistemological Tensions in Engineering Education

External PhD Dissertation
Submitted to the Faculty of Engineering and Science, Aalborg University for the PhD degree
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A Learning Trajectory
Reflective Learning through Community Building

The aim that I have been pursuing since I started my research on engineering and engineering education in 2005 has been to further the dialogue between engineering and philosophy - philosophy broadly construed. A main concern for me has been to explore ways the humanities can contribute to self-development in engineering education, partly through the appreciation of the multiple contexts within which engineers increasingly work, and partly through the appreciation of the challenges with which engineers, engineering institutions, and engineering education are currently confronted. In so doing I have been striving through a number of initiatives to create conversation spaces in terms of both national and international workshops and research projects where this dialogue between engineers, humanists, and social scientists could take place in a meaningful way. As a result I have been able to build and sustain a still expanding community of engineering education researchers across the liberal arts – engineering divide.

The point of departure for this venture is, on the one hand, the observation that engineers and engineering are key influences in the new form of the world and experience that we as human beings are creating both locally and globally, and on the other hand, the observation that engineering practices have too often been characterized by absence of self-criticism. Liberal arts practices in contrast have too often been characterized by reverence for isolated critical virtuosity. Therefore in working together across disciplinary boundaries on such topics as e.g. “how people learn engineering and are acculturated into the engineering culture”, “the nature of engineering knowledge”, “which topics should be taught, how, how much, where, and by whom”, and “the social and organizational context of engineering and engineering education” the learning process might be expected to go both ways. One of the many benefits of an “outsider” perspective is that outsiders may be able to bring in new perspectives, to maintain a greater degree of detachment, and to be in a better position to disclose taken-for-granted assumptions in engineering that are not evident for engineers but still detrimental to both engineering education and practice.

Keeping the above-mentioned aim in mind, in the following I shall give a much more concrete account of the steps in the learning experience that I have gone through since 2000 and in particular since 2005 where my research started. The extensive research networks that I have established, the projects that I have initiated and coordinated, and the books that resulted from them, which I co-edited and co-authored, constitute together with my co-authored journal articles the main pathway of my learning and knowledge making. My engagement with the above-mentioned issues therefore also constitutes the backbone of my PhD dissertation as it spawned a considerable number of research publications that eventually led me to the bold decision to submit some of them at Aalborg University in the hope that I would be able to earn a PhD degree here. The title of my PhD dissertation Engineering in Context: Structural, Cultural, Social, and Epistemological Tensions in Engineering Education indicates the problems I have been struggling with in my publications and
the link between them in my dissertation. Hence the title summarizes the scope of my research regarding the context and the challenges with which engineering institutions, engineering cultures, engineering practice, and engineering education are currently confronted at different levels. The reason for my reluctance to submit a PhD dissertation in an age of 62 years is illustrated quite accurately by a similar argument put forward in the following observation by David Labaree in his article *The Peculiar Problems of Preparing Educational Researchers*:

Doctoral students in education have already lived a life. They have spent at least some time, generally a lot of time, doing something other than being a good student. They have often pursued a career as a teacher, and along the way they have accumulated the experiences and obligations of adult life. Frequently the same age as their professors, they are not willing to be treated as kids just because they are students. One result is that they are likely to take charge of their doctoral program and make it serve their own needs instead of waiting for the program to shape them. (Labaree 2003, p. 16).

Because the coming into being of my PhD dissertation did not follow the traditional way of doing a PhD, in the following I therefore give an account of my engagement with these issues at a very concrete level, thus specifying the learning trajectory that I have traversed.

When I came across David Noble’s book *Digital Diploma Mills. The Automation of Higher Education* a certain passage in the introduction both provoked me and struck a chord in my own personal background and professional life that relates directly to the aim that I have been pursuing. Noble writes:

As a working-class, first-generation beneficiary of public higher education…I have a deep and abiding appreciation for what is at stake here in the struggle over the future of academia. I left…for the university ignorant, unaware of my world and of my place in it. There I met kinds of people I never knew existed, people who dedicated their lives to ideas, to understanding the world, to thinking critically and imaginatively about the received wisdom of our culture. This experience changed my life as it has changed the life of countless others. In the not too distant future, young people with a background like mine…will not be welcomed to the campus and into the community of this rare kind of people for a genuine education. (Noble 2002, p. xii)

As a humanist with a deep and abiding appreciation for the ideals put forward in the quote, I started teaching literature and the history of ideas in an admission program for prospective engineering students at a vocational engineering school *Vestjysk Teknikum* in 1987. My engineering colleagues there were of a totally different kind than the kind of people mentioned by Noble. They had traditionally gone through apprenticeship in a craft followed by vocational training in an engineering school, and eventually gained experience from practical day-to-day engineering work in a company, thus serving as role models for their students. Gradually I learned that there were other types of engineers coming much closer to the people mentioned by Noble. These were typically representing a more hybrid type of academic engineers with backgrounds both in engineering, the humanities or the social sciences, or both. When comparing my own background and orientation with those of my engineering colleagues it might have been easy for me, taking my own marginal position at the time into consideration, to generate a set of binary opposites. However I gradually came to think more constructively about the difference in terms of mechanisms of inclusion and exclusion, values, and practices related to a difference between occu-
pational cultures. Here I gained inspiration from C.P. Snow’s book from 1959 *The Two Cultures and the Scientific Revolution*.

Briefly put, this problematic had become acute since 1995 when *Vestjysk Teknikum* became *Institute of Business and Technology* and thus also included a business culture. At the beginning there were several power struggles and cultural clashes between engineering and business faculty members, as the latter saw themselves as higher ranking academically and therefore entitled to play leading roles in the new type of institution. This observation led me in 2000, via the international office of my institution, to apply for a European Socrates/Erasmus grant running for three years for a curriculum development project titled *Profession, Culture, and Communication – an interdisciplinary challenge to business and engineering*.

As I was the initiator and coordinator of the project, my institution received the grant and, in 2003, the nine participants representing six different European non-university Educational Institutions offering both engineering and business programs published a book with the same title as the project title. The co-editor of the book was Bernard Delahousse, IUT “A” de Lille, France. Only a few chapters were really up to the point and of some note. My own chapter was meant to be a conceptual paper but, as I see it today, it was too unfocused, eclectic and by far too long. Neither was the balance between the body text and the footnotes very good. However here and there, and in particular in some of the footnotes, my chapter struck a nerve. (In my PhD dissertation, it is positioned in an appendix not to be evaluated but to show where I started). Even though the idea behind the project was sound the project failed in many ways, partly due to the way participants were selected or rather appointed by their respective international offices, and partly due to a lack of empirical research experience and familiarity with the relevant bodies of literature by some participants including myself. Moreover there also seemed to be an apparent lack of will or capability by some participants to appropriate the idea behind the project, thus giving rise to a number of internal conflicts that were not solved competently on my part.

Despite or more precisely because of these failures, the project was a tremendous eye opener and a fruitful learning experience. Of note on the positive side was first that my future co-editors in the following two projects, Bernard Delahousse, IUT “A” de Lille, France, and Martin Meganck, KaHo Sint-Lieven, Belgium, together with Wilhelm Bomke, Fachhochschule Regensburg, Germany, decided to carry on with a new European Socrates/Erasmus project application. Second on the positive side was that I learned the nuts and bolts of book production by literally sitting beside the graphical artist making decisions for him regarding the layout of the pages, figures and the like in the book. This learning experience has been of great value for me as the editor-in-chief of three books that followed and a fourth to be published in 2013.

What later gradually developed in the following five projects that I initiated and in the four of them that I coordinated, or am to coordinate in the near future, reflects in large measure what I had learned from what failed in the first project. Of the five projects mentioned above, 1) coordinated three, 2) planned an international kick-off editorial workshop at *Massachusetts Institute of Technology* (MIT) in Boston together with Prof. Louis L. Bucciarelli, MIT for the fourth one, and 3) proposed or initiated PROCEED, which is a cross-disciplinary research effort, funded by the Danish Strategic Research Council from 2010 to 2013 by 1.54 million euro. PROCEED is coordinated by Prof. Andrew Jamison who also wrote the application. Here
I serve as a member of the management board, senior researcher and coordinator of project E titled *Integrating Contextual Knowledge into Engineering Education*. The learning trajectory that I went through may therefore be described as a multidimensional *learning by doing* experience unfolding in the following dimensions. Here I was:

- Developing much better skills in project management
- Further developing a certain talent for generating ideas for new projects and for organizing both national and international research projects and workshops
- Creating networks with leading scholars and engineers in the relevant fields of engineering studies in Europe, the United States and China, to be able to take further steps forward towards higher levels of accomplishment
- Further developing my knowledge of and skills in research methodology and theory of science by teaching a course in these issues in the 5th semester in the bachelor’s degree program in business administration of my institution. By now I have taught this course for more than 10 years, and from 2012 onward I have been asked to teach at the master's degree program in engineering in my institution
- Developing a better understanding of the peer review process and learning to review. As I was invited in 2007, 2008, 2010, and 2012 to serve as a program committee member for what later came to be called iPET, Forum on Philosophy, Engineering, and Technology, I learned the process of reviewing as my job was to validate, accept, or reject extended abstracts before the respective conferences. By 10 April 2012, I was invited to serve as a reviewer of a manuscript for *European Journal of Engineering Education*. I accepted this invitation.
- Striving hard to develop a personal style of eloquent English writing
- Getting familiar with the relevant research traditions and bodies of literature
- Learning to conduct empirical research and write scholarly articles
- Earning credibility internationally as a reliable, trustworthy, competent, hard-working and dedicated coordinator and editor-in-chief

Until I received research funding from PROCEED in 2010, I was doing my research and writing beside a full-time teaching obligation and workload. Because I was so “hungry” for this kind of intellectual work - a dream now finally coming through relatively late in my life - I was able to invest a tremendous amount of energy, time and work reading and writing and trying to catch up. Stefan Collini in his book *What are Universities for?* offers a good description of this kind of obsession:

> The kind of people who go on to do academic research tend to be natural obsessives, prone to waking up too early in the morning worrying about the paragraph they wrote yesterday, or neglecting their partners and families by going to their labs and offices at the weekend to monitor their experiments or check their footnotes. (Collini 2012, p. 135)

New inputs to the problem that I have been struggling with regarding the engineering culture in the first project were brought home to me when I met Erik Ernø-
Kjølhede. In 2002 Erik, my co-author from 2005 to 2011, came to my institution to become its director later in 2006, when the Institute of Business and Technology became Aarhus University, Institute of Business and Technology. After his departure in 2011, the institution simply became Aarhus University, Herning. Erik had earned his PhD in 2001 from Copenhagen Business School. The title of his PhD dissertation was Managing Collaborative Research: Unveiling the Microdynamics of the European Triple Helix. I gained a good deal of inspiration from this dissertation both regarding project management and the relevant theories from within sociology of science.

It did not take long before we gravitated intellectually towards each other and established a long-lasting and very fruitful working relationship on equal terms. Because of Erik’s full-time work as a director, I was acting as the driving force in our collaboration taking new initiatives, with Erik’s support, and also acting as the lead author in our writings. Simultaneously I was learning a lot from him in particular at the beginning. Our working relationship spawned our first co-authored scholarly article in 2006 in a book published at Aalborg University: Christensen, Jens; Henriksen, Lars Bo; Kolmos, Anette (eds.). Engineering, Science, Skills, and Bildung. Aalborg Universitetsforlag. Here we managed to do what I had failed to accomplish regarding the engineering culture in my first project. Our article titled Reengineering Engineers: Towards an Occupational Ideal of Bildung in Engineering Education came to serve as a point of departure for the next research project I proposed and as the next step in our future research.

Inspired by Samuel Florman’s book The Civilized Engineer and the concept of Bildung from the above-mentioned book and article, I initiated and coordinated a new European Socrates/Erasmus funded research project entitled The Cultured Engineer, which ran from 2005 to 2007. Meetings were held in Barcelona and Dublin and a final conference in Herning. Twenty-four people from 15 different European educational institutions took part. Half of these institutions were universities and the other half non-university engineering institutions. In contrast to my first project I had selected participants for this project either directly or via intermediaries but none of them were imposed as in the first experience. The book that resulted was: Christensen, Steen Hyldgaard; Meganck, Martin; Delahousse, Bernard (eds) (2007). Philosophy in Engineering. Academica, Aarhus.

The book has now been translated into Chinese to be published in China in 2012 where it is seen by Prof. Li Bocong, the Graduate University of the Chinese Academy of Sciences (GUCAS) in Beijing, as a contribution to the emerging field of Philosophy of Engineering. Li Bocong wrote:

In contrast to the situation that philosophy of technology developed slowly during the first fifty years, philosophy of engineering developed quite rapidly during the last ten years. Supporting this contention is that at the beginning of the 21st century, four books entitled philosophy of engineering or its synonym, viz. Gongcheng Zhexue Daolun (An Introduction to Philosophy of Engineering, by Li Bocong, 2002), Engineering Philosophy (by Louis L. Bucciarelli, 2003), Gongcheng Zhexue (Philosophy of Engineering, by Yin Ruyu, et al., 2007), and Philosophy in Engineering (by S. H. Christensen et al., 2007), were published during a five year span, rather than the fifty years it took for philosophy of technology to become as established. (Li Bocong 2012, forthcoming)

Erik and I contributed a chapter on tensions in engineering epistemology titled The Knowledge of Engineers. Of importance for the two books that followed was that I got in touch with Prof. Carl Mitcham, Colorado School of Mines, Golden, Colorado,
who wrote an excellent blurb for the back cover of the book and was later invited to give a key note at a conference Bildung in Engineering – A Dream in the Heads of Humanists or a simple Necessity that I organized in my institution to take place on 15 May 2007. Ninety people took part in the conference including Prof. Anette Kolmos, Aalborg University. Anette Kolmos was invited because there was a perfect match between the aim of the conference and the book Engineering, Science, Skills, and Bildung mentioned above that she had coedited together with Jens Christensen and Lars Bo Henriksen. The title of her talk was Future Engineering Skills, Knowledge and Identity. Simultaneously this was an opportunity for me to acknowledge the role she had played in getting me started.

During the conference Carl Mitcham, Bernard Delahousse, and I planned a new project to be launched at the Colorado School of Mines in April 2008. I had gained the inspiration for the title for this new project Engineering in Context from a book published in 1982 by Barry Barnes and David Edge Science in Context: Readings in the Sociology of Science. Carl Mitcham was sponsoring the workshop through the Hennebach Program in the Humanities, the John and Sharon Trefny Institute for Educational Innovation, and the International Network for Engineering Studies. Participants were to pay their travel expenses for the workshop by themselves, via their institutions.

For me, the contact with Carl Mitcham was a breakthrough which enabled me to take further steps towards more ambitious and prestigious projects. The first of these was a European-American project which was to include many of the leading scholars in the field and the second an American-Chinese-European project which was to considerably expand my network. As the “grand old man” and central gatekeeper of his fields, Carl Mitcham was in a position to achieve for me what I was striving to accomplish. When invited to participate in the European-American project Prof. Anette Kolmos informed me that Prof. Andrew Jamison would be a better choice for this particular project. For me Andrew Jamison came to be a very valuable future collaborator and we have been working together ever since. Andrew Jamison wrote a foundational chapter for the new book that resulted from the project.


In the following project, my contact with Carl Mitcham led us both to initiate, together with associate prof. Juan Lucena, Colorado School of Mines, an American-Chinese-European research project that was launched at a workshop held at Colorado School of Mines, 6-8 May 2010. This idea to include Chinese scholars and engineers had already been discussed in the context of the previous project. Long before in the early 1990s or more precisely in 1992, Carl Mitcham in tandem with an American colleague, Stephen H. Cutcliffe, the author of Ideas, Machines, and Values: An Introduction to Science, Technology, and Society Studies had engaged in
promoting STS studies and establishing collaborative networks in China. One of the key persons from China was Prof. Li Bocong, the Graduate University of the Chinese Academy of Sciences, Beijing, who then became one of my co-editors in the book that was to follow, together with Carl Mitcham and Yanming An, Clemson University, South Carolina, USA. Also this workshop was sponsored by the Hennebach Program in the Humanities, the John and Sharon Trefny Institute for Educational Innovation.

The point of departure for the workshop was the fact that, since the beginning of the 1990s, engineering activities dealing with humanitarian engineering, community development and service learning had surged within engineering communities in the US and around the world. We therefore agreed that the title of the workshop should be *Engineering and Development*. The final outcome of the project was a volume to be published in the Springer book series *Philosophy of Engineering & Technology*. The manuscript for the volume was submitted to Springer on 1 February 2012 and entitled: Steen Hyldgaard Christensen, Carl Mitcham, Li Bocong and Yanming An (eds.) (2012). *Engineering, Development and Philosophy: American, Chinese, and European Perspectives*. The book was accepted for publication by 1 May 2012. As part of a very positive and enthusiastic review Springer’s external reviewer commented:

*(High Level) Review of Engineering, Development, and Philosophy*

This collection of essays is well conceived and articulated. The essays exhibit a good balance of the themes indicated in the title. Essays that are primarily historical in nature, such as those that deal with the development of railways in China and the United States, are balanced with others that consider the economic and social costs of development, and with still others that address issues that are more technically philosophical in nature. There is also good balance of cultural backgrounds, viz. Asian, European, and American. Confucian, Buddhist, and Taoist cultural contexts are placed alongside of those that are a part of the Judeo-Christian traditions. There is also careful attention to the “universalist/contextualist” debates that are a part of ongoing social and political discussions, especially in China.

It is also apparent that the editors have done an excellent job of introducing the reader to the collection’s main debates and their implications. The preface, the general introduction, and the introductions to the three sections, are well crafted and highly informative. Abstracts tend to be crisp and appropriate to their associated essays. The editors emphasize the collaborative nature of the work: some of the essays are co-authored, even, as the editors point out, across cultural divides……

As the coordinator of the project and responsible editor of the volume, I negotiated and signed the contract with Springer. What made the coordination of this so-called ACE project so complex was that it was to be coordinated across three regions and, on top of that, the challenge of having Chinese contributions copy-edited and proof-read several times by native English speaking participants.

In the writing of the book, 36 participants representing 20 universities in the US, China, and Europe took part. My contribution to the volume was co-authoring the Preface and the General Introduction together with my co-editors. In section 2 of the book titled *Rethinking Engineering Education*, I contributed chapter 12 with Erik Ernø-Kjølhede as my co-author, titled *Socio-technical Integration in Engineering Education: A never ending Story*. Aiming at a single authored contribution in this section which could be part of my PhD dissertation, I also contributed chapter 9 titled *Academic Drift in European Professional Engineering Education: The End of Alternatives to the University?*
My last really big project started at Massachusetts Institute of Technology in Boston on 4-5 May 2012. As already mentioned, I initiated and co-organized the international editorial kick-off workshop at MIT in close collaboration with Prof. Louis L. Bucciarelli who at an early stage responded positively to my proposal and made it possible to host the workshop at MIT. As Prof. Louis L. Bucciarelli took part in the Engineering in Context project I knew him quite well. Together we planned the agenda for the workshop with inputs from Prof. Gary Downey, Virginia Tech, Prof. Carl Mitcham, Colorado School of Mines, and Prof. Andrew Jamison, Aalborg University. Finally I selected the participants for this new research project. Participants were selected from my networks in the United States, China, and Europe. I got in touch with some of the new members of my network and participants of the new research project in a workshop Engineering meets Sociology. Sociology meets Engineering held at the Graduate University of the Chinese Academy of Sciences (GUCAS), in Beijing 19-20 October 2011. Here I was invited to serve in the role of co-chair of the workshop together with Carl Mitcham and Li Bocong, and in addition I was responsible for selecting the European team of scholars and engineers to take part in the workshop.

As the chairman of the MIT workshop my job was to provide leadership well aware that the workshop had to traverse phase two and three out of four phases that I have called phases of Forming-Storming-Conforming-Performing respectively. In particular the storming phase is a critical phase. However during the workshop we collectively achieved what we were aiming at, a proposal for a publication strategy. The proposal comprised aggregating the proposed articles into three distinct volumes, with three distinct, but interrelated, themes. The themes may be described in terms of overall and specific purposes of the three volumes. These are:

- **Overall**
  1. Challenge preconceived definitions of engineering
  2. Challenge what is fundamental in engineering education
  3. Articulate alternative framings of volume I, II, and II
  4. Addressing questions of scale
  5. How do societal actors inform engineering?

- **Volume I**
  1. Understand the character, nature and diversity of engineering

- **Volume II**
  2. Where is engineering going, and where should it be going?
  3. What are alternative visions of engineering?
  4. Alternative institutional strategies for engineering
  5. What are missing basics?

- **Volume III**
  1. What are the challenges and potential solutions for engineering education?
  2. Challenge what is perceived as fundamental in engineering education
  3. Reconfiguring the structure/culture of engineering education
  4. Why do initiatives fall short?
  5. Pathways to implement change
  6. What are missing basics?
In the project I will serve in roles of coordinator, co-author, and editor-in-chief for all three volumes, assisted by an editorial board consisting of Prof. Andrew Jamison, Aalborg University; Dr. Ir. Martin Meganck, KaHo Sint-Lieven, Ghent, Belgium; Prof. Byron Newberry, Baylor University, Waco, Texas; Prof. Carl Mitcham, Colorado School of Mines, Golden, Colorado; and Senior Lecturer Bernard Delahousse, IUT “A” de Lille, France. The group will collectively review the submitted manuscripts on the basis of how well they advance the purpose of their respective volumes and meet the standards of academic quality.

The three volumes are planned to be published in the Springer book series *Philosophy of Engineering & Technology* edited by Pieter Vermaas who is also involved as an author in the project. In the project more than 40 participants from the US, China, and Europe will take part.
Research Problems, Findings, Conclusions, and Implications

As indicated by the title of this PhD dissertation *Engineering in Context: Structural, Cultural, Social, and Epistemological Tensions in Engineering Education* the focus is on context and tensions in engineering education. However as the notion of context and the way it is related to tensions can have a broad range of meanings a short definition of the relationship between them and their current use is needed. The meaning of context and its relationship to tensions in this PhD dissertation is understood to mean two different things: 1) Structural tensions refer to institutional contexts of engineering education in terms of tensions between what has been called “noble” and “less noble” engineering education institutions (Furth 1982, Teichler 2008). The tensions concern differing perceptions of what is considered the appropriate locus of educating future engineers. 2) Cultural, social, and epistemological tensions refer to tensions in the normative foundation of the engineering culture, and to tensions between technical text and social context. The latter should be seen as related to a technical core and non-technical periphery distinction in engineering curricula. My research publications should therefore be seen in the light of the following overall research question:

*What is the rationale of integrating contextual considerations in engineering curricula as put forward in legal documents and accreditation criteria, and how do differing perceptions of context as shaped by engineering culture, epistemic values and practices, and institutional loci of Danish professional engineering education enable or inhibit socio-technical integration in engineering degree programs in specific Danish engineering education institutions?*

Regarding the tensions mentioned in the title it would be misleading to think of them as something which can or should be removed by establishing a direct “feedback mechanism” between engineering practice and engineering education. Such way of thinking seem implicitly to be underlying the following question formulated by Sheppard et al. (2009, p. xviii). “Do the academy’s conceptualizations of what engineers must know and be able to do align with the new realities of professional practice”? As I see it posing the question this way is equivalent to assuming that the working of a unidirectional model of “challenges in engineering practice – responses in engineering education” could and should be put in place. However as there are numerous mediating factors between engineering practice and engineering education this kind of question inevitably needs qualification both ontologically and epistemologically. Such qualification is e.g. provided by Buch (2012 forthcoming) who instead of challenges speaks of *challenge perceptions* and relate them to a relativist ontology/epistemology as put forward in constructionism. Buch argues:

(1) The challenges should not be taken at face value. It should be recognized that the challenges are brought into existence and shaped by social events, forces and history, all of which could well have been different. Thus the con-
tingency of the shaping of challenge perception in engineering practice should be recognized.

Furthermore, it should be recognized that the responses to the stated challenges are diverse and often mutually incompatible. It is thus unproductive to reform engineering education on the basis of an un-reflected acceptance of (some of) the stated challenges.

And lastly it is mandatory to produce a more nuanced and cogent picture of the challenges to engineering practice in order to reform engineering education.

Tensions as I see them should therefore be conceived of as something similar to the workings of Hegelian dialectics. By this I do not mean to suggest that anything goes but what goes and what should be taken seriously depends on challenge perceptions through which response strategies and positions are shaped. Here lies the justification for my interpretivist perspective that I shall present in chapter 3.

In the extension of the overall and unifying research question presented above my research publications can be grouped in different ways. One way to do it is to put them all into one single category titled engineering epistemologies. Here I have chosen to group them into two main categories. These two categories are related to: 1) Academic drift in professional non-university engineering education institutions (publications a and b), and 2) socio-technical integration in Danish professional engineering education (publication c, d, e, f, g). Below the central research question for each of the two groups of my publications are presented. However I have split the second group on socio-technical integration into two subgroups – Bildung (publication c) and socio-technical integration (publications d, e, f, g ). Hence three research questions are formulated.

1. **Academic drift (Publications a and b).**

   Engineering education takes place at different levels, in different types of institutions embedded in different national systems of higher education. Systems of higher education are not stable but change over time due to institutional and structural dynamics. Examples of typical structural dynamics are academic drift in engineering colleges and vocational drift in universities. Such dynamics work to transform educational systems and to blur the boundaries between the different types of institutions. Ultimately academic drift may lead to cognitive drift of curricular emphasis towards theory and book learning. The main research question related to academic drift is: *When, why, and how does academic drift take place in professional non-university engineering education in Denmark and elsewhere, and can it be avoided?*

2. **Bildung in engineering education (Publication c).**

   **Bildung** is a normative German concept originating in literature and German philosophical idealism (epitomized in the Humboldt reform in 1810 of the German University) that has gained currency in Northern and Central Europe. The meaning of Bildung extends beyond knowledge and skills – its central meaning is formation of character and judgement in terms of self-perfection of the individual both as a person and as a professional. In Denmark the discourse of Bildung in engineering education is inscribed into a cultural change perspective. In the US, the most closely related idea is related to the idea of a liberal education, designed to prepare students for “civic life” through education in philosophy, ancient languages, mathematics,
and science. The main research question related to Bildung is: *How can the ideal of Bildung serve to better understand and critically assess current practices of identity formation in Danish professional engineering education?*

3. **Socio-technical integration** (publication d, e, f, g).
The importance of incorporating contextual issues and developing socio-technical competencies in engineering education has been widely acknowledged around the globe. High quality engineering design requires understanding of how the engineered artefact interacts with individuals, society, and the environment, both natural and manmade. In the US, the ABET EC2000 criteria for accrediting engineering degree programs incorporate context in two out of eleven program outcomes (a-k) under criterion 3. In the European EUR-ACE accreditation framework context is incorporated under the heading “Transferable Skills”. First cycle engineering students are expected to “demonstrate awareness of health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice”. The main research question here is: *How is the boundary between technical text and social context in Danish professional engineering education constituted, and how, if so, have stipulations regarding contextual issues in legal documents and accreditation criteria become aligned with engineering disciplines?*

Table 2.1. below illustrates the relationship between the above mentioned overall research questions and the way they have been linked with specific research questions, approaches, and methods in my research publications (a-g).

**Table 2.1 Problem areas, research questions, approaches, and methods related to publications a-g**

<table>
<thead>
<tr>
<th>Publication</th>
<th>Problem area</th>
<th>Research questions</th>
<th>Approach</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Academic drift</td>
<td>To what extent have academic drift taken place in Danish non-university engineering education institutions? What were the driving forces? What are the consequences?</td>
<td>Comparative case studies</td>
<td>Qualitative focus group interviews</td>
</tr>
<tr>
<td>b</td>
<td>Academic drift</td>
<td>What kind educational systems dynamics impact on European higher non-university engineering education? Are such processes inevitable and irreversible? What kind of tensions and dilemmas do they create?</td>
<td>Comparative case studies</td>
<td>A study of literatures related to comparative studies of higher education</td>
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<tr>
<td>c</td>
<td>Bildung in engineering education</td>
<td>Is there a need for an occupational ideal of Bildung in engineering education? To what extent is the engineering culture a barrier for Bildung in engineering education - in particular at the bache-</td>
<td>Review of literature</td>
<td>Theoretical analysis</td>
</tr>
</tbody>
</table>
Research Problems, Findings, Conclusions and Implications

<table>
<thead>
<tr>
<th>d</th>
<th>Engineering epistemology</th>
<th>What are the structural differences between engineering and science?</th>
<th>Review of literature</th>
<th>Theoretical analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>Socio-technical integration</td>
<td>To what extent do teachers of engineering see it as meaningful for students to work with relatively abstract philosophical concepts as part of engineering degree programs? What are, if any, the difficulties in implementing philosophical questioning into engineering curricula?</td>
<td>Ex ante event case study</td>
<td>Quantitative questionnaire survey</td>
</tr>
<tr>
<td>f</td>
<td>Socio-technical integration</td>
<td>Why has the process of implementing theory of science been characterised by doubt and hesitation resulting in a remarkable delay when compared with other degree programs like those in the humanities and social sciences? Which mechanisms have caused the delay?</td>
<td>Ex ante event case study</td>
<td>Qualitative focus group interviews</td>
</tr>
<tr>
<td>g</td>
<td>Socio-technical integration</td>
<td>In what way have boundary definition and demarcation between technical text and social context influenced the process of introducing theory of science into professional engineering bachelor degree programs?</td>
<td>Longitudinal case study</td>
<td>Mixed methods quantitative questionnaire survey qualitative interviews</td>
</tr>
</tbody>
</table>

The two actant models in Figure 2.1 and 2.2 below are meant to provide an overview for the reader. They show positions of relevant actants to be considered in relation academic drift (only valid for publication a) and socio-technical integration (Publications e, f, g). The “event” mentioned in table 2.1 above under the approaches of publications (e and f) refers to the time of the actual implementation of theory of science into Danish engineering bachelor degree programs.

**Figure 2.1. An actant model for academic drift in Danish professional engineering education in Odense and Herning**
Empirical and theoretical findings

In table 2.2 below a brief summary of the findings both from my/our empirical research and theoretical studies is presented. When compared with the research questions presented in table 2.1 the reader will notice that there is not a one to one correspondence between the research questions in table 2.1 related to the individual publications and the findings presented in table 2.2 below. The reason is that table 2.2 only presents the main findings and conclusions of publications a-g. A one to one correspondence can be found in the publications themselves.

Table 2.2. Empirical and theoretical findings in research publications a-g

<table>
<thead>
<tr>
<th>Publication</th>
<th>Findings</th>
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<tbody>
<tr>
<td>a Academic drift</td>
<td>A typology of academic drift comprising six levels was used to investigate academic drift in Danish professional engineering education. These levels are: 1) student drift, 2) staff drift, 3) program drift, 4) institutional drift, 5) sector drift, and 6) policy drift. In the national macro oriented Danish case the focus was on level 4, 5, and 6. In the two institutional examples the focus was on the entire model. It was found that in both the Danish case and in the two institutional examples – the engineering colleges in Herning and Odense - academic drift had taken place only at level 4, 5, 6. It was also found that since the 1970s there is evidence of a long term sector drift of engineering colleges towards the university sector. Moreover mergers with universities were seen by teacher respondents in Herning and Odense both as an opportunity and a threat.</td>
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<tr>
<td>b Academic drift</td>
<td>A typology of academic drift comprising four levels was used to investigate academic drift in British Polytechnics, French Instituts Universitaires de Technologie (IUTs), and German Fachhochschulen. These levels are: 1) policy drift, 2) institutional drift, 3) staff drift, and 4) cognitive drift of curricular emphasis. From the beginning the three types of institutions were established as a vocationally oriented alternative to the university. In my study of literatures related to comparative studies of higher education it was found that since the establishment of these institutions in 1965, 1966, and 1971 respectively a drift of policy by national authorities in the UK, France, and Germany can be observed as these three types of institutions were allowed to drift away from their original vocational purpose. As French IUTs were nested into universities already from start institutional drift only took place in British Polytechnics and German Fachhochschulen. In German Fachhochschulen the majority of faculty members were</td>
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</table>
professors for which reason staff drift only took place in British Polytechnics and French IUTs. However most importantly cognitive drift of curricular emphasis has taken place in all three institutions. The main finding of this study is therefore that since the early 1990s there is evidence of a blurring of boundaries between “noble” and “less noble” engineering education institutions. A distinction between academic and professional engineering degree programs still exists but the consequence of the blurring of boundaries is that professional engineering degree programs are taught in a more academic way.

<table>
<thead>
<tr>
<th>c</th>
<th>Bildung in engineering education</th>
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<td>In this theoretical study it was found that there is strong evidence both nationally and internationally of the claim that the engineering culture is rigid, too narrowly focused on technical text to the exclusion of the social context, gender troubled and characterized by a lack of professional self-reflection. From a cultural change perspective it is argued that there is a need for a new professional ideal of Bildung in Danish engineering education. The purpose of this ideal is twofold: 1) to provide future engineers with better skills in critical reflection and interdisciplinary collaboration than those of today, and 2) to make engineering more attractive as a profession to students.</td>
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<tr>
<th>d</th>
<th>Engineering epistemology</th>
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<td>The theoretical finding regarding engineering epistemology is that it is misleading to conceive of engineering merely as applied science. Engineers are the producers of a distinct body of technological knowledge in its own right. What engineers know and how they know it is determined by the sort of problems they are trying to solve. Hence practical problems and knowledge generating activities are fused into a whole in engineering practice. Despite similarities in terms of methodology, research infrastructure, experimental techniques etc. in its aim, in its center of activity, in its technoscientific and socio-technical organization, in its satisficing modes and simplifying assumptions, engineering differs significantly from science, in particular from traditional academic truth-seeking science. The social terrain in which engineers manouevre is on the whole much more complex than the social terrain in which most academic scientists manouevre.</td>
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<table>
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<tr>
<th>e</th>
<th>Socio-technical integration</th>
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<tr>
<td>The empirical findings of this ex ante case study of perceptions among faculty members in engineering degree programs in our institution regarding the relevance of philosophy/theory of science for engineering students are somewhat ambiguous. The case study was designed as an anonymous quantitative questionnaire survey. The focus areas of the questionnaire were: 1) advance knowledge of the topical issue, 2) attitudes to place, content and relevance, 3) attitudes to teaching aims, 4) expectations. Despite a mortality or attrition rate of 25% (9 out of 35 respondents did not fill in the questionnaire) which in itself is open to interpretation the overwhelming majority of respondents that filled in the questionnaire displayed welcoming attitudes toward this curricular novelty. Among respondents there was a preference for an instrumental approach in terms of research methodology as opposed to Bildung as an end in itself. Surprisingly expectations were generally positive. However the ambiguity that came in was that despite the welcoming attitudes displayed in responses to the questionnaire, engineering leadership and faculty members were several years behind the implementation schedule by 2004 as stipulated by the Danish Ministry of Education. Hence the attitudes displayed in the questionnaire could be interpreted as rather uncommitted attitudes suggestive of hidden barriers or difficulties in aligning this new topic with current priorities in the engineering degree programs in our institution.</td>
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<table>
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<th>f</th>
<th>Socio-technical integration</th>
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| This ex ante case study was a follow up on our case study in publication e. The data collection method that we used was qualitative focus group interviews among purposefully selected engineering faculty members. The purpose was to further investigate barrier mechanisms or difficulties in aligning philosophy/theory of science with current priorities in engineering degree programs in our institution. The main finding of the case study was the identification of 7 recurrent ideal typical arguments regarding the value of the above mentioned curricular novelty. These are: 1) The “no need” argument, 2) The “instrumentalize it” argument, 3) The “split it up” argument, 4) The “lack of staff qualification” argument, 5) The “keep it simple” argument, 6) The “loyal employee” argument, and finally 7) The “trade off” argument. Taken together these arguments seem to add up to an implicit argument saying: “If we can’t avoid it let’s
In the following I shall restrict myself to conclude and discuss implications of my research only within the two main areas of academic drift and socio-technical integration. The reason for this limitation is that publication c) and d) as argued at the beginning of this section may be seen as contained within those two research areas.

Conclusions and implications regarding academic drift and socio-technical integration

Academic drift.

What makes academic drift an important area of study in engineering education research is that although the phenomenon has been widely documented by historians of engineering and technology, remarkably little attention has been devoted to explaining it. The driving forces behind it changed dramatically in the mid-1960s with the onset of massification of higher education despite the fact that the set of phenomena that academic drift was meant to capture is much older and has been key characteristics of professionalization since the early beginning of professional education. A deeper understanding of the phenomenon and the more recent structural and institutional dynamics of higher technical and professional education has been developed within the field of comparative studies of higher education. However in engineering education research much more research is needed on specific engineering institutions and the various national educational systems in which they are embedded, as it seems as though we are in the midst of a process of institutional transformations both nationally and internationally. Hence understanding academic drift is important for three reasons: 1) it is important for practitioners concerned that engineering education should be relevant to practice, 2) it is important in making sense of long term trends in knowledge-production, and 3) it is important because it denotes the process whereby knowledge intended to be useful in engineering practice gradually loses close ties to practice while becoming more tightly integrated with one or another body of scientific knowledge. Hence at the center of academic drift is ultimately what I have called cognitive drift of curricular emphasis or reconstitution of engineering curricula with an emphasis on theory and book learning.

Because my institution went through a number of structural transformations from 1987 to 2012 – fragmented expansion, horizontal integration, and vertical integration - in publication a) and b) my co-author and I have been struggling to understand
the nature of academic drift and the driving forces behind it. In publication (a) we and in publication (b) I have made a contribution to the literature. In particular research on recent academic drift processes in Danish engineering colleges seen in the light of dynamics of educational systems has been sparse. We believe that what we have observed in our own backyard may serve as a mirror of what has also taken or takes place elsewhere in Danish professional engineering education. Taken at surface value it would seem that the findings of publication (a) and (b) are contradictory in the sense that the conclusion of publication (b) is more far reaching that the more cautious conclusion in publication (a). However in publication (a) we concluded what could be concluded by the time of the study, and we did not allow ourselves to speculate. However since then the process has gone even further in my own institution. Many more people are presently pursuing PhD degrees whether by inner urge or fear of losing their jobs. However to be able to conclude that cognitive drift of curricular emphasis has taken place in Danish professional engineering education a curricular analysis would have to be carried out. A curricular analysis would be able to reveal in detail whether, and if so, how Danish professional engineering degree programs have changed in recent years, and whether such changes have been influenced by the change of prime locus for Danish professional engineering education from the engineering college to that of the university.

Socio-technical integration

What makes research on socio-technical integration in engineering education important is that it is boundary work. Hence it is molded upon an implicit injunction to engineers to move beyond mere technicalities. As engineering interventions in the world often change the “big picture” dramatically over time context, contextual knowledge and contextual awareness become critical. It has not always been properly recognized among engineers that engineering work is not only technical work but also work that one way or another engage the social and cultural context. Engineering is always and inevitably a kind of social engineering under uncertainty and contingency conditions that systematically introduces risks in unintended ways. Things become aggravated as the traditional approach to engineering problem solving as it has been evidenced in publication c) fosters a sense of belonging to a technocratic culture of “the right answer”. Finally the dominant identity of engineers as “problem solvers” has been molded upon an epistemological distinction in engineering curricula between technical core and non-technical periphery. This distinction in turn has had the consequence that knowledge hierarchies have emerged which in many ways act as barrier mechanisms for socio-technical integration, interdisciplinary and international collaboration.

The introduction of philosophy/theory of science in Danish engineering education may be seen as an exemplary attempt to integrate socio-technical and contextual competencies into bachelor engineering degree programs. In our three case studies it was found that theory of science became contested area and went through a translation process in our institution where discursive strategies were mobilized by relevant constituencies to safeguard or redefine boundaries between the technical and the social in the three engineering bachelor degree programs. In particular as an illustration of the complexities related to boundary definition we noted that the implementation phase had been remarkably long (six-seven years by the time of the survey).
The main conclusion of our three case studies on socio-technical integration carried out in our own institution is that it has been difficult to align philosophy/theory of science with the epistemological paradigms in the three engineering degree programs in our institution viz. Global Management and Manufacturing (GMM), Business Development Engineering (BDE), and Electronic Engineering (EE). It matters little whether the discussion is framed as a quest for Bildung, liberal education, or philosophical questioning. The epistemologies of the three bachelor programs are different. Business Development Engineering (BDE) and Global Management and Manufacturing (GMM) can be characterized as hybrid engineering degree programs (combining social and technical science). The hybrid programs differ from the third purely technical program, Electronic Engineering (EE), as the epistemological core/periphery distinction cannot be said to uniformly follow the technical core/non-technical periphery distinction characterizing (EE). In GMM, it may even be argued that the epistemological distinction is one between the business core and the technical periphery. In BDE, marketing, business creation and business knowledge are defined as the epistemological core. However, here the epistemological core also embraces technical issues which are seen as the basis for business creation. Thus BDE is characterized by having to epistemological cores.

In Electronic Engineering the epistemology is clearly molded upon the technical core/non-technical periphery distinction for which reason a technical orientation clearly prevails. In some sense it has therefore been much easier to integrate philosophy/theory of science into the two hybrid programs by aligning this curricular novelty with business disciplines in the form of a research methodology approach whereas a satisfactory approach has not yet been found in the Electronic Engineering degree program.

In our research publications c, f, g we have made contributions to the rather sparse literature on socio-technical integration in Danish professional engineering education. Also here we believe that what we have observed in our own backyard may serve as a mirror of what has also taken or takes place elsewhere in Danish professional engineering education. However what needs to be done in future research is to change the research focus from impediments to implementing philosophy/theory of science into engineering education to a research focus on assessment of outcomes of various interpretations of philosophy/theory of science. Here identification of what socio-technical values should guide future professional engineering and hence engineering education is crucial. Without such identification it would be impossible to measure outcomes and hence determine what would count as best practices because specific parameters would be lacking.

Although overarching philosophical ideas are not made explicit in table 2.1 above and largely remain hidden in research, they have nevertheless served to underpin and guide my research and my preference for qualitative methods. In the following section I will therefore scale up to the research paradigms and methodologies that have undergirded my choice of methods in particular in my empirical research.

References


Qualitative research is a situated activity that locates the observer in the world. Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including fieldnotes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. (Denzin & Lincoln 2011, p. 3)

This section has two aims: (1) to clarify the intricate relationship between research paradigm, methodology, approach, strategy, and method, and (2) to position my empirical research publications within this intricate relationship. Regarding the first aim it has been argued in a number of articles with a particular focus on methods and methodologies in Journal of Engineering Education that methodological decisions need to be more explicitly represented in research articles and reports, and that researchers should consider a broader range of methodological issues and options (see e.g. Olds, Moskal, and Millar, 2005; Koro-Ljungberg and Douglas, 2008; Borrego, Douglas, and Amelink, 2009; Case and Light, 2011; and Borrego and Bernhard, 2011).

In particular there has been a call for more qualitative studies and mixed methods as a supplement to or as an alternative to the hegemonic positivist tradition of quantification in engineering education research. Positivists hold a deterministic philosophy centred on causality in which the focus is on the relationship between dependent and independent variables. It is therefore reductionist in the sense that the intent is to reduce the ideas into a small, discrete set of ideas to test in the form of variables that comprise hypotheses and research questions. Hence developing numeric measures of observation and studying the general laws governing the behaviour of individuals becomes paramount for positivists. Measures are systematically created before data collection and are standardized (Creswell 2009, p. 7). However mixed methods approaches raise serious questions as to whether methods can be combined because of differences in underlying paradigm assumptions. Hence the question can be raised whether a mixed methods approach refers to a paradigm of its own. Post-positivism has accommodated both quantitative and qualitative methods aimed at triangulation. Purists deny the legitimacy of such operation. The issue is subject of extended debate within the mixed methods community (Denzin and Lincoln 2011, p. 2). If paradigms are to be understood in terms of overarching philosophical systems that entail particular ontologies, epistemologies, and methodologies, one cannot easily move from one to another. The empirical research that I have conducted together with my co-author Erik Ernø-Kjølhede lies within the qualitative tradition, and we have only used mixed methods in a longitudinal case study without entering into a serious paradigm conflict. We avoided this paradigm conflict because quantification was not aimed at randomization, generalisation, prediction and control but was subsumed under the qualitative orientation of our study by providing rather simple numeric
background data which could be analysed by a simple counting procedure which did not need sophisticated statistic analysis.

A major problem regarding the methodological issues and options mentioned above is that no consistent terminology is used. Key concepts such as research paradigm (Guba and Lincoln, 1994), research design, research strategy, research approach, methodology, theoretical perspective (Koro-Ljungberg and Douglas, 2008), epistemological perspective (Chism, Douglas, and Hilson, 2008), and methods (Olds et al. 2005) tend to some extent to be “thrown together in grab-bag style as if they were all comparable terms” (Crotty, p. 3). However for lack of space I shall refrain from delving deeper into this discussion as it will take us far beyond the purpose of this section. In the following the distinction made by Crotty (1998, p. 3) will be used. Crotty distinguishes between four basic elements of any research process:

- **Methods**: the techniques or procedures used to gather and analyse data related to some research question or hypothesis.
- **Methodology**: the strategy, plan of action, process, or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes.
- **Theoretical perspective**: the philosophical stance informing the methodology and thus providing a context for the process and grounding its logic and criteria.
- **Epistemology**: the theory of knowledge embedded in the theoretical perspective and thereby in the methodology.

In my co-authored research publications (a, e, f, g) the research methodology/approach/strategy that we have used is qualitative case study. We have used three different kinds of case studies: comparative case studies, ex ante event case studies, and a longitudinal case study. Some authors have argued (see e.g. Crotty 1998, p. 5) that case study is a method thus adding to the above mentioned confusion. I disagree with them as a case study as I see it is located a level above method and because case studies imply a broad range of data collection methods subsumed under the notion of case study. My position is supported by Denzin and Lincoln (2011) who instead conceptualize case study as a strategy. According to Chism et al. (2008, p. 12) a case study is defined as an in-depth study of a bounded system. The boundaries of the case are typically defined in terms of time, space, or participants. Case studies are well suited when one wants to study a particular event, organisation, or a specific situation in depth. Creswell (2009, p. 13) defines a case study this way: “Case studies are a strategy of inquiry in which the researcher explores in depth a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time”. The case studies that we have conducted can be categorized further into three types of case studies; (1) the intrinsic case study, (2) the instrumental case study, and (3) the collective case study. The purpose of the intrinsic case study is to provide in-depth understanding of a case which is interesting in and of itself, not because it is representative of a more general phenomenon. The purpose of the instrumental case study is to provide insight into a more general phenomenon of which the case is representative, or because it is unusual and provides a useful contrast to the typical case. Finally the purpose of the collective case study is to study several cases which taken together, provide a better
understanding of a general phenomenon (Chism et al. 2008, pp. 12-13). In publications (a and b) we have used collective/comparative case studies whereas in publications (e, f, g) we have used instrumental case studies.

In the case studies we have conducted our main concern has not been randomization, generalization, prediction, and control, but to study phenomena in their natural settings, attempting to make sense of, or to interpret phenomena in terms of the meaning people attach to them. Our aim has therefore been to study and trying to understand the interpretations of respondents at a particular point in time and in a particular context to obtain a situated and rich, or even thick description of the phenomena under investigation. Key characteristics of our research have therefore been an in-depth focus on only a few or relatively few individuals or situations, a focus on the context of the study, and a recognition of our own sensibilities as an instrument of our study (Chism et al. 2008, p. 1). Generally qualitative research is characterized by the collection of textual data (surveys, interviews, focus groups, conversational analysis, observation, ethnographies). In our empirical case studies we have made use of questionnaire surveys, interviews, and focus groups as data collection methods. The research questions that we either explicitly or implicitly have addressed in our qualitative research are: What is occurring? When is it occurring? Why does it occur? How is it perceived? Is there a pattern in the occurrence? How does this particular phenomenon affect other things? (Borrego et al. 2009, pp. 54-55)

In our case studies we have studied processes and perceptions of two different sets of phenomena, namely: (1) mergers between universities and engineering colleges in Denmark, and (2) the implementation of theory of science as a curricular novelty in engineering bachelor degree programs in Denmark. Processes and perceptions of the first phenomenon have been studied empirically at two different sites including our own institution whereas we have used our own institution - our own backyard - as a site for the study of processes and perceptions of the second phenomenon. In research publication (a) we have studied mergers between universities and engineering colleges with a focus on academic drift processes in Denmark in general and as an illustration we have conducted an in-depth study of processes and perceptions of mergers in two different engineering colleges. To put our findings into a broader perspective in research publication (b) I have conducted a comparative case study of academic drift processes in three European engineering education institutions, in the UK, France, and Germany respectively. This case study was based on a study of literatures related to comparative studies of higher education.

I shall now return to questions regarding the philosophical underpinning of our research. Research paradigm/worldview/theoretical perspective have been conceptualised differently by a number of authors. Neuman (2000, pp. 63-87) for example in speaking of the meaning of methodology have organized basic methodological assumptions and ideas undergirding positivism, interpretivism, and critical social science into answers to eight basic questions: 1) Why should one conduct social scientific research? 2) What is the fundamental nature of social reality (the ontological question)? 3) What is the basic nature of human beings? 4) What is the relationship between science and common sense? 5) What constitutes an explanation or theory of social reality? 6) How does one determine whether an explanation is true or false? 7) What does good evidence look like? 8) Where do socio-political values enter into science? Guba and Lincoln (1994, p. 108) argue in favour of only three basic questions or levels of a research paradigm: 1) the ontological question. What is the form and nature of reality and therefore, what is there that can be known about it? 2) The
epistemological question. What is the nature of the relationship between the knower or would-be knower and what can be known? 3) The methodological question. How can the inquirer (would-be knower) go about finding out whatever he or she believes can be known?

Using a conceptual scheme developed by Koro-Ljungberg and Douglas, (2008) in the following I shall discuss some further aspects of our research including both ontological and epistemological aspects. The point of departure for this discussion is a comparison between research paradigms/theoretical perspectives as presented in Table 3.1 below.

**Table 3.1. Comparison between theoretical perspectives in engineering education research (Koro-Ljungberg and Douglas, 2008, p. 165)**

<table>
<thead>
<tr>
<th>Theoretical perspective</th>
<th>Post-positivist</th>
<th>Interpretivist (constructivism, social constructionism, hermeneutics, phenomenology)</th>
<th>Critical/emancipatory</th>
<th>Postmodern/poststructural</th>
</tr>
</thead>
<tbody>
<tr>
<td>View on reality</td>
<td>Single falsifiable reality</td>
<td>Multiple subjective realities</td>
<td>Multiple subjective and political realities</td>
<td>Multiple fragmented realities</td>
</tr>
<tr>
<td>Purpose</td>
<td>To find relationships among variables, to define cause-and-effect</td>
<td>To describe a situation, experience, or phenomenon</td>
<td>To produce a socio-political critique</td>
<td>To deconstruct existing “grand narratives”</td>
</tr>
<tr>
<td>Methods</td>
<td>Methods and variables defined in advance, hypothesis driven</td>
<td>Methods and approaches emerge and are to be adjusted during study</td>
<td>Methods and approaches designed to capture inequities</td>
<td>Methods and approaches generated during the study</td>
</tr>
<tr>
<td>The role of researcher</td>
<td>Researcher is detached</td>
<td>Researcher and participants are partners</td>
<td>Researcher and participants are activists</td>
<td>Researchers and participants have various changing roles</td>
</tr>
<tr>
<td>Outcome or research product</td>
<td>Context-free generalizations</td>
<td>Situated descriptions</td>
<td>Critical essays, policy change</td>
<td>Reconceptualized descriptions of the phenomenon</td>
</tr>
</tbody>
</table>

Despite the fact that there is no perfect match between our research and a single perspective our research is clearly best accommodated within the broad interpretivist perspective. The match is not entirely perfect due to our changing roles as research-
ers. We have in some instances acted in roles of detached researchers, in other instances as partners, and in a single publication (c) as activists. In this respect we have acted in roles attributed to all four perspectives. This observation is also valid for methods as we have used methods presented in the three perspectives beyond the post-positivist perspective. However as we have also used a quantitative questionnaire survey as a method of data collection – a method commonly accommodated within a positivist or post-positivist perspective – it can be argued that also regarding methods we can attribute our research to all four perspectives. However regarding positivism an important proviso was mentioned earlier.

Research publication (c) on Bildung in engineering education is concerned among other things to capture gender inequities and lack of self-criticism in engineering education and is therefore inscribed into a cultural change perspective including an activist orientation as presented in the critical/emancipatory perspective. Publication (d) which is concerned with the nature of engineering knowledge/engineering epistemology stands a bit apart from the rest in the sense that it is intended to be a contribution to the emerging discipline or perhaps more precisely the emerging interdisciplinary field of philosophy of engineering. Therefore by way of its philosophical intentions broadly construed it cannot be claimed to belong to the interpretivist perspective and neither can it be said to be a contribution to engineering education research. The method that we used in (d) is a literature review.

At the ontological level the interpretivist perspective as presented in both constructivism and social constructionism posits relativism – local and specific, individually or socially constructed realities. Constructivism posits an individual subjective reality as opposed to a socially constructed reality put forward in social constructionism. Thus what can be known according to constructivism does not simply mirror the real world; “rather, the meanings ascribed to the real world are created by individuals as they experience it” (Chism et al. 2008, p. 3). In social constructionism meaning reflects a shared sense of the world derived within a culture created through interactions between individuals. Crotty (2003) describes this shared sense of the world in the following way: “…viewing it (the world) through lenses bestowed on us by culture. Our culture brings things into view for us and endows them with meaning, and, by the same token, leads us to ignore other things” (Crotty 2008, p. 54).

Further support for this shared cultural meanings argument can be gained from the Community of Practice (CoP) framework developed by Lave and Wenger (1991). For these authors, a CoP is characterized by three key elements: a domain of knowledge, a community of people actively involved in and caring about the domain, and a shared practice. According to Jesiek et al. (2009, p. 42) “the image of concentric circles is sometimes used to describe CoPs, with core members at the centre of a community, and active members, peripheral members, and outsiders increasingly distant”. The point is that only within the boundaries of the outer circle a culture created through interactions between legitimate participants brings things into view for them and endow these things with meanings. Faculty members of a particular engineering degree program may thus be construed as a CoP. In our case studies social constructionism thus provides a better match with engineering cultures than does constructivism. The culture shared by faculty members of a specific engineering degree program should therefore not be construed as a reflection of a merely subjective reality but as a socially constructed reality sui generis.
According to Guba and Lincoln (1994) a further consequence of the interpretivist perspective is that the distinction between the ontological and the epistemological level breaks down which means that the two distinct levels are instead fused into a dyad the result of which is that reality becomes a creation of the interaction between the researcher and the participant. By way of analogy this argument also applies to both the critical/emancipatory, and the postmodern/poststructural perspectives.

The nature of knowledge so constructed consists, still according to Guba and Lincoln (1994),

of those constructions about which there is relative consensus (or at least some movement toward consensus) among those competent (and, in the case of more arcane material, trusted) to interpret the substance of the construction. Multiple “knowledges” can coexist when equally competent (or trusted) interpreters disagree, and/or depending on social, political, cultural, economic, ethnic, and gender factors that differentiated the interpreters. These constructions are subject to continuous revision, with changes most likely to occur when relatively different constructions are brought into juxtaposition in a dialectical context. (Guba and Lincoln 1994, p. 113).

An important aspect that differentiates the interpretivist perspective from positivism and post-positivism is related to participant selection or sampling. Situational theoretical perspectives generally concentrate on fewer participants who are studied in order to investigate the experiences of those participants in greater depth. The predominant way of selecting participants in the interpretivist perspective is by means of purposeful selection. In contrast to random, stratified, cluster or convenience sampling participants selected purposefully are selected “because their unique experiences or individual situations provide important insights. In some studies the outlier case is of particular interest, as the contrast with the typical case can help to conceptualize and understand specific situations” (Koro-Ljungberg and Douglas 2008, p. 166). In the research behind our co-authored research publications (e, f, g) we have been particularly concerned with the outlier case. Because of a considerable delay positioning our institution among the latest to implement theory of science into engineering degree programs our institution came to constitute an outlier case. All the more so when compared to non-engineering degree programs in Denmark. Hence our institution provided a suitable site for investigating the mechanisms at work behind the delay.

In contrast in our investigation of mergers between universities and engineering colleges (publication a) our institution came to constitute a typical case but now partly because it was among the first to merge with universities. Here it provided a suitable site for investigating systemic or structural dynamics in higher education. In this context the engineering college of Horsens came to constitute the outlier case as it did not merge vertically with a university but as the only institution merged horizontally into a polytechnic kind of institution. In this study our strategy was to create new knowledge from a general case plus two typical cases for which reason the outlier case was of less significance.

In the questionnaire survey that we conducted to be used in publication (e, f, g) the questionnaire was distributed to 35 potential respondents comprising the entire full-time teaching staff of our institution. Here we were seeking broad coverage and therefore we did not use purposeful selection of key informants. In our focus group interviews we deliberately used purposeful selection including both faculty members and local leadership.
A main difference between post-positivism and interpretivism or more broadly between quantitative and qualitative research concerns the generalizability or the external validity of the research. The concept of generalizability in quantitative studies is replaced by the term transferability in qualitative studies. According to Borrego et al. (2009) “quantitative research is focused on generalizing to the larger population independent of context, and thus there is a heavy emphasis in the research design on random sampling and statistical significance. In contrast qualitative research seeks to generalize through thick description of the specific context, allowing the reader to make connections between the study and his her own situation” (Borrego et al. 2009, p. 57). Table 3.2 illustrates the difference between quantitative and qualitative research criteria.

### Table 3.2. Quantitative and qualitative research criteria (Borrego, Douglas, and Amelink, 2009, p. 60)

<table>
<thead>
<tr>
<th>Quantitative Research Criteria</th>
<th>Qualitative Research Criteria</th>
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</thead>
<tbody>
<tr>
<td>Validity: project and instruments measure what is intended to be measured</td>
<td>Credibility: establishing that the results are credible or believable</td>
</tr>
<tr>
<td>Generalizability: results are applicable to other settings, achieved through representative sampling</td>
<td>Transferability: applicability of research findings to other settings achieved through thick description</td>
</tr>
<tr>
<td>Reliability: findings are replicable or repeatable</td>
<td>Dependability: researchers account for the ever-changing context within which the research occur</td>
</tr>
<tr>
<td>Objectivity: researchers limits bias and interaction with participants</td>
<td>Reflexivity: researchers examine their own biases and make them known</td>
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</table>

Hence to phrase the question of generalizability a bit differently the burden of demonstrating generalizability in quantitative research is placed on the researcher whereas in qualitative research the burden of identifying appropriate contexts for transferability is placed on the reader. Seen from the perspective of the quantitative researcher the use of a single case does not warrant generalization, as there is no way of knowing whether that particular case is typical. From a qualitative perspective the authenticity provided by thick descriptions of a single case makes it possible for readers to identify elements that *mutatis mutandis* can be transferred to their own situation (Borrego et al. 2009, p. 57). The overall difference between quantitative and qualitative research may be summarized into the following opposites: Post-positivist researchers strive for nomological generalizability whereas situational researchers strive for representational generalizability. (Koro-Ljungberg and Douglas 2008, p. 166).

### References

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Situating the Research
Research Identity: Discipline, Community, or Field

The purpose of this chapter is of a more personal character, namely to reflect on the specific nature of my own research identity as an engineering education researcher. In so doing in the following I shall present a rather simple conceptualization of research identity suitable for my present purpose and based on how engineering education researchers themselves conceptualize the social and intellectual organization of engineering education as a domain of research activity shaping their identity. The section therefore has three aims: (1) to clarify some relevant terminology regarding the categories related to the domain of activity, (2) to conceptualize recent exemplary developments in the United States in terms of identity and research agenda, and (3) to situate my own research, future research agenda, and identity within this conceptualization.

As indicated by the title of my PhD dissertation and the list of publications on which it is based, it should come as no surprise that the domain of my research activity is engineering education. The simple but complex question for me to raise here is: what would more precisely qualify as the locus (the home) of my research in terms of social and intellectual organization, networks, funding sources, and institutional and educational affiliation. In anticipation of what will have to be considered in the following I would describe myself as a boundary crossing humanist, or perhaps even a hybrid type of academic, teaching literature and the history of ideas in an admission program for prospective engineering students, and teaching theory of science and research methodology at the fourth and fifth semester in the business degree program of my institution, Aarhus University, Herning. Simultaneously I am doing research on engineering education. I so doing my research has until the end of the Spring semester 2012 taken place as an isolated activity within my institution, which is a subsection of Aarhus University located 90 km from Herning. However from the Fall semester 2012 I will start teaching research methodology at the master program in engineering in my institution. As a consequence the question I raised above evidently seems to have no straightforward answer.

However a crucial part of an answer is that my reference group and collaborators consist of scholars from engineering, the humanities and the social sciences located outside my institution both nationally and internationally. Creating conversation spaces and building communities with and for these people whether of a temporary or an enduring nature aiming at interdisciplinary collaboration and publication is an indication of the locus of my research. Suffice it therefore to say that this piece of information alone serves to eliminate discipline as the appropriate locus of my research.

Engineering education as a domain of activity shaping the identity of participants has been conceptualized variously by participants as discipline, community, community of practice, and field. Of less significance here is its conceptualization as tribe, hobby etc. despite the fact that my research actually started as a “hobby”. In
terms of exclusivity, discipline, community, and field may be briefly characterized this way:

1) **Discipline**: Discipline is the most exclusive of the three terms. A discipline is located in the academy (universities, colleges, etc.) and may be seen as the institutionalization of fields in training and employment units. Hence departments and graduate degree programs are key characteristics of the discipline in tandem with the disciplinary infrastructure consisting of professional societies, journals, conferences, and research centres. Claims to academic work and disciplinary knowledge are complex, shifting, and based on heterogeneous criteria. Disciplines only achieve temporary consensus and recognition.

2) **Community of Practice (CoP)**: In terms of inclusivity and flexibility CoPs are positioned between discipline and field. A CoP is based on a *domain* of knowledge, a *community* of people, and shared *practice(s)*. As opposed to disciplines located in the academy CoPs transcend institutional boundaries and therefore organisations and institutions only serve as backdrops (see Lave and Wenger 1991).

3) **Field**: Field is associated with the widest range of definitions and understandings. Field is best understood in terms of an area of activity, operation, or investigation. Many sociologists following Bourdieu see fields “as arenas or sites where agents occupy particular social positions and interact, struggling for power and resources according to context-dependent rules”. Moreover a field may be both broadly and narrowly defined. Here it will be understood in terms of an overarching catch-all reference for an area of activity (Jesiek *et al*. 2009, pp. 41-44).

In table 4.1 below the terminology and categories in engineering education as a domain of activity are presented.

**Table 4.1. Terminology and categories in engineering education as a domain of activity (Jesiek *et al*. 2009, p. 44)**

<table>
<thead>
<tr>
<th>Conceptualizing Identity as a Domain of Activity</th>
<th>Infrastructure</th>
<th>Goals and Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discipline</td>
<td>Conferences</td>
<td>Research</td>
</tr>
<tr>
<td>Community or Community of Practice (CoP)</td>
<td>Departments</td>
<td>Practice</td>
</tr>
<tr>
<td>Field</td>
<td>Degree Programs</td>
<td>Bridging Research and Practice</td>
</tr>
<tr>
<td>Other (Tribe, Hobby, Etc.)</td>
<td>Funding Sources</td>
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<td></td>
<td>Professional Societies</td>
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<td></td>
<td>Publication Outlets</td>
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<td></td>
<td>Social networks</td>
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<td></td>
<td>Tenure Lines</td>
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</tbody>
</table>

From my own epistemological perspective I see engineering education as an interdisciplinary field of research related to an expanding international or internationally oriented *community of practice* characterized by inclusivity, and epistemological and methodological breadth and flexibility. Bourdieu’s description of fields “as arenas or sites where agents occupy particular social positions and
interact, struggling for power and resources according to context-dependent rules” corresponds to my own experience from collaborating with people nationally and internationally who are or see themselves as “established” within the field. However the inclusivity and flexibility of the CoP and the “catch-all” character of the field has been a chance for me to get involved. My own contributions here have been of two different kinds, namely: (1) a number of research publications within the confines of the field, and (2) from the community of practice perspective a number of initiatives aimed at community building in terms of creating conversation spaces for meaningful dialogue and interdisciplinary collaboration between engineers and non-engineers aimed at publication in the field. The merit of this perspective as I see it is that it celebrates participants with hybrid identities and/or boundary crossing ambitions with commitments to empirical engineering education research and/or to the view that the separation between historical, philosophical, and sociological considerations is artificial and a hindrance to comprehensive understanding of engineering education. Moreover in support of the above mentioned perspective it has been seen as a challenge among a number of engineering education researchers to overcome the epistemological and methodological partiality related to the dominant positivist tradition of quantification through acceptance of multiple and diverse ways of knowing (Douglas et al. 2010).

However the rationale for conceptualizing identity as discipline is presented in a number of quotations in a study of research identities in the respective domain of activity carried out by Jesiek et al. (2009, pp. 44-45). The statements put forward in these quotations seem to suggest that a sense of belonging, ability to work continuously, and better possibilities of providing funding are crucial issues for people whose identity is located in the discipline, not necessarily to the exclusion of people with different backgrounds. However it would seem that disciplinary research within engineering education tend to display a more outspoken engineer profile. Examples are: “As someone who now lives in a department (of engineering education), I have vested interest in being a discipline”, “we have to have a home (in a discipline) or the work will only take place sporadically”, and “Ninety percent of the people in the community are living on the fringes of society. They are staff on soft money with no reward structure for them. The only way to give them a home and to gain recognition is to have a home as a discipline”.

For all the merits of a discipline it would however be a contradiction in terms for me from my own epistemological position to argue in favour of a strictly disciplinary perspective as a foundation of my research identity.

However recent calls in the United States for increased rigor in the study of engineering education suggest the emergence of engineering education as a new discipline aiming to achieve the same rigor characterizing engineering science disciplines. From 2004 onward claims about the establishment or “birth” of a new discipline have surfaced in the US with increasing regularity (see e.g. Wankat 2004, Borrego et al. 2008, Haghighi et al. 2008) not least in a report from 2006 titled Special Report: The Research Agenda for the New Discipline of Engineering Education published in Journal of Engineering Education which since 2003 had repositioned itself for this purpose. The journal now requires the following criteria to be met in articles published under its auspices (Streveler et al. 2005, p. 1).

1. Requires a high level of discipline-related expertise
2. Is conducted in a scholarly manner with clear goals, adequate preparation, and appropriate methodology
3. Is appropriately and effectively documented and includes a reflective critique that addresses the significance of the work, the process used, and what was learned
4. Has significance beyond the individual context
5. Breaks new ground or is innovative
6. Can be replicated or elaborated upon
7. Is judged to be meritorious and significant by a rigorous peer review process.

In the Special Report five research areas for the new discipline were presented and elaborated upon (Special Report 2006, pp. 259-261):

1. **Engineering Epistemologies**: Research on what constitutes engineering thinking and knowledge within social contexts now and in the future.
2. **Engineering Learning Mechanisms**: Research on engineering learners’ developing knowledge and competencies.
4. **Engineering Diversity and Inclusiveness**: Research on how diverse human talents contribute solutions to the social and global challenges and relevance of our profession.
5. **Engineering Assessment**: Research on, and the development of, assessment methods, instruments, and metrics to inform engineering education practice and learning.

The five research areas indicate the scope of disciplinary research in engineering education in the United States but due to an impressive expansion of engineering education since the early 2000s both in the United States and around the globe the five areas may be taken as general descriptors of the scope of disciplinary research in engineering education.

The five areas also provide an opportunity for me here to position a part of my own research, and future research agenda within these five areas. In particular area 1 **Engineering Epistemologies** (publication a, b, c, d, e, f, g) and area 4 **Engineering Diversity and Inclusiveness** (publication c) have been focal areas in my/our research and will also be areas to be included into my future research agenda. However publications (a and b) on academic drift with a particular focus on cognitive drift of curricular emphasis in vocationally oriented engineering degree programs cannot easily be accommodated within the disciplinary research agenda as put forward in the Special Report. These publications are better accommodated both within the field of engineering education research and within the field comparative studies of higher education.

Because the five areas seen from the perspective of the discipline seem to a great extent to be concerned with instrumentalities related to the betterment of engineering education my research as it stands are accommodated more appropriately within the interdisciplinary perspective and collaboration taking place among more hybrid identities within the field and CoP. A major benefit of the expansion mentioned above has been a substantial increase in inclusivity and flexibility, especially for
non-engineer researchers such as humanists and social scientists with broader aims and willing to stake out claims in this field of inquiry.

In closing this section it should be mentioned that many engineering education researchers in support of discipline as the locus of their research identity have raised concerns over the disadvantages of an overall lack of clarity and continued sense of ambiguity about the identity and status of engineering education research. They fear that it may lead to lack of visibility, recognition, and respect in the wider academic landscape “as well as increasing anxiety about the challenges that come with scaling up their work, building capacity, and making larger impacts” (Jesiek et al. 2009, p. 41).

References


Engineering in Context
Structural, Cultural, Social, and Epistemological Tensions in Engineering Education

Many years of reform efforts have not produced the breakthroughs we will need to find room for the new technologies and skills that are now being called for. We want to understand how students learn engineering. It is our hope that by supporting fundamental research, we can better understand how to create a more innovative, efficient, and enticing engineering curriculum that can attract a more talented, innovative, and diverse student body. We seek disruptive breakthroughs in moving engineering education out of its current mold and into new modes of thinking about engineering education. In a departure from past efforts, we are looking to transform, not reform engineering education (Borrego et al. 2008, p. 2).

The optimism put forward in the quote regarding a new beginning for not only reforming but transforming engineering education entirely by moving it out of its current mould after many years of failed reform efforts should be seen in the sobering light of a number of recurrent tensions in engineering education. These tensions are related to questions concerning: what, how much, how, when, where, engineering student should learn, and by whom, and for whom engineering should be taught. Therefore any particular configuration of responses to these questions will only - seen from a philosophical point of view - create a temporary solution which is open to critique.

Due to the inherent normativities of any configuration of responses curricular reforms are difficult to implement as they are very complex on at least five counts (International Bureau of Education, 2006): 1. They are inextricably linked to perceptions of current thinking and actions on educational concerns and reforms around the world, 2. The vision behind curriculum reform is concurrently the expression of a political and a technological agenda which is open to criticism, 3. Curriculum reform is both a process and a product, which involves a wide range of institutions, stakeholders and actors, 4. The process of constructing a curriculum is unique to each national and institutional setting. It is the complex outcome of negotiations between stakeholders to meet the perceived needs and requirements of companies, students and society, 5. Quite often the strategic goals of stakeholders collide. It is my contention that the strategic goals of stakeholders are in no small part related to narrow or broad perceptions of context. Therefore in the following I shall discuss the issue of context in some depth.

The notion of context in engineering education and practice is an object of heated debate. On the one hand claims are made that context is an artificial construct that reifies the distinction between context and content, reproducing the sense of an in-

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1 What follows is a revised and much expanded version of the part I contributed to the general introduction to: Christensen, Steen Hylgaard, Delahousse, Bernard, Meganck, Martin (eds.) (2009). Engineering in Context. Academica, Aarhus. The general introduction is titled General Introduction: The Challenges in Engineering and Society.
side and an outside. On the other hand claims are made that the distinction between technical text and social context: (1) reflects real tensions in engineering education and practice, (2) is constantly being negotiated, and most importantly (3) the outcome of such negotiations has real world consequences. The position behind my research in the field of engineering education is that context matters and has real world consequences. The relevance of context in my research is related to three different meanings of context and inherent tensions that result from them: Embedding of institutions of engineering education into higher education systems, the breadth of problem scoping in engineering problem solving, and contextual knowledge. Each in their own way dynamics and concrete decisions related to these three provinces of meanings have real world consequences.

In dealing with context however it immediately becomes clear that context is an inherently dialectical concept, since contextualizing in itself is dependent on definitions of what is perceived to be the relevant boundaries regarding both the education and the practice of engineers. Contextualizing thus unfolds its inherent dialectics in the terrain between what “is” and “ought”. In this way the quest for a re-contextualizing of engineering education and practice inevitably is a value-laden enterprise and therefore not without a certain degree of controversy. It is concerned with both what engineering “is” and what it “ought” to be. Ultimately a greater awareness and understanding of context should result in better preparation of engineers to render those contexts visible in their work, and consequently enable engineers to contribute to more socially robust and responsible endeavors.

As contexts can either create possibilities or impose limitations, differing perceptions of context also contribute to creating controversies among engineering educationalists. The following two examples may serve as an illustration of the spectrum of what is perceived to be relevant contexts of engineering education. At one end of the spectrum, a report published by the Royal Academy of Engineering (2007) Educating Engineers for the 21st Century, argues in favor of a concentration on the technical context of engineering, “Universities must continue to teach “core engineering” and not dilute course content with peripheral subject matters”. At the opposite end of the spectrum, Harvey Mudd College, California (2008), argues in favor of a widening of the context of engineering education in order “to educate engineers, scientists, and mathematicians, well versed in all of these areas and in the humanities and the social sciences so that they may assume leadership in their fields with a clear understanding of the impact of their work on society”. In the following I first address the first position, limitations imposed by context. The opposite position, opportunities created by a widening of contexts will be addressed secondly.

Limitations imposed by context

Regarding the limitations imposed by context, many observers have gone so far as to speak of a crisis in engineering education, for example McIlwee and Robinson (1992), Ferguson (1977, 1993), Florman (1987, 1996), The Institution of Engineers, Australia, (1996), Bucciarelli and Kuhn (1997), Beder, (1997, 1999), Goujon and Heriard-Dubreuil eds. (2001), Williams (2002, 2003), Copeland and Lewis (2004a, 2004b), Sheppard et al. (2009), Graham (2012), Bucciarelli (2012), to mention but a few. That there is a crisis in engineering education also appears to be the central message put forward in the initial quote by Borrego et al. (2008). A number of ar-
arguments in support of this crisis position have an ideal typical character that can be presented by one or more of the following arguments:

1. The captivity argument
2. The cultural change argument (publication c)
3. The identity crisis argument
4. The weak profession argument
5. The convergence argument (publications a and b)

Despite overlaps between some of the arguments the merit of distinguishing between them is that each argument emphasizes a specific aspect of engineering education that is claimed to be detrimental to the engineering profession.

The captivity argument put forward by Goldman (1991), Johnston et al. (1996), Holt (2001), Radcliffe et al. (2003), and Kotta (2011) suggests that the engineering profession, in regard to both engineering education and practice, has been locked in a number of social and intellectual captivities which may be interpreted as a “fundamental usurpation of the intellectual and social dimensions of engineering as an autonomous discipline” (Goldman, 1991, p.121). Intellectually engineering has been subordinated to science. Hence it has been grounded in a particular suite of epistemological assumptions related to positivism. According to the above mentioned authors the culture and discourse of science have imposed their own rigor on the academic discipline of engineering. As a result of the way these have been adopted by engineers their authority and influence have become almost absolute. The positivist mindset in engineering have therefore fueled reductionism and technological determinism. In the words of Kotta (2011, p. 24) “Reductionism holds that the analysis of different parts of the problem can fully explain the system. In technological determinism emphasis is placed on the impact technology has on communities as opposed to the role communities play in co-constructing technology”. According to this argument such tenets lead engineers to the belief that science and engineering are objective and able to exclude human values from influencing the exoteric work taking place within engineering disciplines. In the extension Kotta (2011) argues that engineering science disciplines are sustained by a high degree of individual competitiveness. Furthermore she argues that engineers tend to be overly concerned with order and certainty, tend to be adverse to ambiguity, and somewhat provocatively also claims that engineers tend to have a rather narrow range of interests (Kotta 2011, p. 25). This means that issues of meaning and social impact tend to be rejected or ignored because scientific methodology, the structure of hypothesis, proof, validation, publication, and critique are embedded in a scientific culture that serves engineers well. This culture serves them well in allowing them to speak with the “voice” of the “disinterested scientist” (Guba and Lincoln 1994, p. 112) and in terms of providing better funding opportunities and better opportunities of enhancing individual prestige.

Socially engineering practice has become captive and subordinated to a managerial agenda driven by the market. Engineers exercise their power only within that mandate. By internalizing the interests of either the company or the client, engineers thus become captive to the social process of technological action. For Goldman, technological action is a social process in which engineers participate rather than something which engineers do. Goldman’s argument fundamentally questions the
characterization of engineers as the primary agents of technological change. Moreover according to Johnston et al. (1996, p.1)

the result has been a serious limitation in engineers’ capacity to examine the social meanings and effects of their work and to self-consciously reflect upon their practice and professional identity.

The cultural change argument is concerned with what is claimed to be a lack of diversity in the engineering culture. Especially in feminist research, the social norms of the engineering culture have been much debated in recent years, for example by Hacker (1981), Carter & Kirkup (1990), McIhwee & Robinson (1992), Tonso (1996, 2006), Copeland & Lewis (2004a, 2004b), Faulkner (2007), Grimson & Roughneen (2009). Increasingly, a shift in the way the underrepresentation of women is understood and explained has been advocated. Instead of problematizing what could be seen as the qualifications lacking in women, the very culture of engineering is seen as the problem. Particularly, the dominant masculinity in engineering faculties and in the profession has been called into question. The main concern of this argument is that it makes it difficult to attract female students to degree programs that will initiate them into this kind of culture, but it also makes it difficult to tap engineering talent from diverse cultural backgrounds. A dominant motivation for female students to enroll in engineering degree programs appears to be that they have excelled in mathematics and physics courses prior to their decision to enter into an engineering degree program, whereas the motivation of male students is predominantly an experience with and an inner urge to tinker. Here lies a major challenge in future engineering education. However, this is only one aspect of the cultural change argument. More broadly, diversity in general is identified as the major challenge (Grimson & Roughneen 2009).

The identity crisis argument has been developed forcefully by Williams (2002) in her mighty analysis of the engineering profession. She shows how the division of labor has destroyed the identity of the engineering profession. Williams argues:

What engineers are being asked to learn keeps expanding along with the scope and complexity of the hybrid world. Engineering has evolved into an open-ended Profession of Everything in a world where technology shades into society, into art, and into management, with no strong institutions to define an overarching mission. All the forces that are pulling engineering in different directions – toward science, toward the market, toward design, toward systems, towards socialization – add logs to the curricular jam. (Williams, 2002, p.76).

Williams provides an illuminating description of the tensions in engineering education resulting in what she describes as a curricular jam. In the extension Heywood (2004) argues that inevitably the engineering profession will develop into a plethora of grades, types and levels as technology has by far outgrown any single occupation. In terms of education, Williams continues that this

means that the trend toward cramming more and more into the engineering curriculum runs in exactly the wrong direction. Few students will want (to) commit themselves to an educational track that is nearly all-consuming. What we now call engineering education should be lowering the threshold of entry, mixing itself with the larger world rather than trying to keep expanding its own world. Students are trying to do this mixing on
their own, but in too many cases they are trying to pour new educational wine into old institutional containers. (Williams, 2003, p.4).

If the result of the present situation is the education of engineers to very narrow specialisms, with a set of narrowly defined skills and competencies for pre-established jobs, then this kind of hyper-professionalism, runs exactly contrary to Braslavsky’s (2002) analysis of future educational demands where she stresses the importance of “educating active, rigorous and flexible individuals, rather than skilled workers for pre-established jobs”. For Williams, the curricular response should be a convergence between the technological and liberal arts educating the engineering student both for life and flexible employment (see publication e, f, g, regarding some of the impediments for such venture). William’s argument is closely linked to what I have called the weak profession argument but with a different angle on the issue. According to Williams,

only a hybrid educational environment will... prepare students for handling... life in a hybrid world”. Williams argues “the convergence of technological and liberal-arts education is a deep, long-term, and irreversible trend. Students need to be prepared for life in a world where technological, scientific, humanistic, and the social issues are all mixed together. Such mixing will not take place if students have to decide from the outset that they are attending an “engineering school” as opposed to a “non-engineering school. (Williams, 2003, p.4).

Williams further argues that if engineering schools only attract “faculty members and students who gravitate toward the technical problem-solving approach, then those students have an education that does not prepare them well for life experience”. As pointed out by Heywood (2004), Williams' argument bears strong resemblances to some of John Henry Newman's core ideas regarding the value of liberal education put forward in his famous book “The Idea of a University”. For Newman, the university is a hybrid educational environment which serves to educate students for life by means of “collegiality”, “enlargement of mind” and “acquisition of a philosophical habit of critical thinking”. Williams, like Newman, is concerned with a hybrid approach to learning focused on habits of thinking, skills and competencies not primarily with a focus on content.

The weak profession argument quite often appears in two different versions, either as explicitly or only implicitly stated. In comparison with strong professions, such as medicine and law, the engineering profession may be described as a weak profession or a quasi profession for a number of reasons such as e.g. its heterogeneous knowledge base when compared to medicine, the length of education needed to practice engineering. Mitcham (2008) for example has argued in terms of the philosophical weakness of engineering as a profession:

One can distinguish between two kinds of professions. Strong professions, such as medicine and law, rest on the formulations of ideal goals that are also well embedded in the professional curriculum and practice. Weak professions, such as military and business, either lack such ideal goals or only weakly include the relevant specialized knowledge in a professional curriculum and practice. The (somewhat intentionally provocative) argument here will be that engineering had more in common with weak than with strong professions.
The weak profession argument however need not as in Mitcham’s analysis be explicitly stated but may be only implicitly stated in term of desiderata for the engineering profession. This is the case in a number of position papers and reports (see e.g. The Millennium Report 2008, The Engineer of 2020, Grasso and Burkins 2010). To establish engineering practice as a true learned profession “similar in rigor, intellectual breadth, preparation, stature and influence to law and medicine, with extensive postgraduate education” it is argued in The Millennium Report that the engineering community should strive to establish engineering practice as a culture more characteristic of professional guilds than corporate employees (Duderstadt 2008, p. V, and 2010, p. 22). Moreover in “The Engineer of 2020” (National Academy of Engineering, 2004), the section titled “Our Image and the Profession” presents us with an optimistic picture of the aspirations of the engineering profession, one of which is to gain leadership and broad acknowledgement in society. “By 2020 we aspire to engineers who will assume leadership positions from which they can serve as positive influences in the making of public policy and in the administration of government and industry.”

However positive many of the ideals put forward in the “Visions of the Committee”, they nevertheless are in stark contrast to the observations made by Holt (2001). Holt speaks of the weakness of the engineering profession in terms of the inescapable condition of engineering in all ages; that is, patronage… First the patron or client establishes the intention, deciding on particular grounds what shall be done. Second, the patron provides the wherewithal to accomplish that purpose… Decisions about the market for engineered products, at once declaring opportunity and justifying commitment, are thus removed from engineering itself. It is the patron who energizes professional work towards a specific goal, not what the engineer might know or can do. (Holt, 2001, p.498).

The point I want to make in outlining this argument is that there is another tension in engineering education. In aspiring for engineering leadership, should engineering educators primarily endeavor to educate technocrats or should they also aspire to educate public engineering intellectuals by means of supplementary science, technology and society (STS) studies for at least a limited number of philosophically minded engineers? Some might dismiss this as merely wishful thinking. However Bijker called for STS scholars to become public intellectuals (Bijker, 2003). As some engineers also have an STS degree, this might be the basis of a new kind of engineering public intellectual and hence a new form of engineering leadership. This approach also supports the identity problem issue for engineers discussed above. Bijker argues

that STS needs to make a further step and actively contribute to democratizing this technological culture: to show to a broad array of audiences – politicians, engineers, scientists, and the general public – that science and technology are value laden, that all aspects of modern culture are infused with science and technology, that science and technology do play key roles in keeping society together, and that they are equally central in all events that threaten its stability. It is therefore necessary that science and technology, in their explicit and implicit forms, be subject to political debate. (Bijker, 2003, p.444).

This perspective is also linked to another tension within higher education generally, namely what should be the aims of the university. This tension was addressed by
Wolff (1969) when he discussed what he termed the ideal type of the university of professions. He fundamentally questioned whether the university should serve as a training camp for professionals. Basically Wolff directed his criticism against the ideal type of the university of professions towards (1) its lack of autonomy, and (2) its lack of intellectual inquiry and critique. Today, when changes in the social distribution of knowledge production, academic capitalism and managerialism have undermined the autonomy of the university, Wolff’s first criticism appears dated whereas I would argue that his second criticism is still valid. Delanty (2002) makes a similar point in speaking of cultural and technological citizenship and the way they should be linked. Delanty’s argument thus lies in the extension of Bijker’s call for public STS intellectuals and Wolff’s call for intellectual inquiry and critique. Delanty says that

the domains of education and intellectual inquiry and critique relate to cultural citizenship, and the domain of research and professional training relate to technological citizenship. The fulfillment of these two kinds of citizenship is the social responsibility of the university. To find ways of linking these roles and cognitive frameworks into a communicative understanding of the university seems to be what the university needs to achieve today if it is to be able to take on the task of becoming one of the key institutions in the public sphere and in which citizenship is brought forward to new level. (Delanty, 2002, p.9).

What I have called the **convergence argument** differs from the four previously mentioned arguments in the sense that it does not summarize the shared views of a number of authors into an argument. Instead it promotes the idea that overall conclusions from a number of studies within the field of comparative studies of higher education point in the same direction. Pressures of massification of higher education from the 1960s onward and counter pressures of credentialism, modulated by a number of external factors such as e.g. new public management and the so-called Bologna Process are key issues here. These pressures are part of structural/systemic/institutional dynamics that work to transform educational systems in more cost-efficient ways. As a result they give rise to academic drift in and of non-university institutions, and vocational drift in universities or institutions similar to universities. Academic drift is commonly understood to refer to a long-term tendency of non-university higher educational systems, institutions, study programs, faculty and the student body to strive for an upward movement in the direction of an institutional setting or curriculum that resembles that of the university as the epitome of prestige. Such developments seem to suggest a convergence or a blurring of boundaries between “noble” and “less noble” educational institutions. Hence “less noble” vocationally oriented institutions strive to merge with universities and/or imitate the values, practices, and research of “noble” academically oriented institutions. I have taken the liberty to call this kind of convergence an argument well aware that this is a too strong claim to make. However the point I want to make is of an epistemological and cognitive nature. Harwood (2010) captures the point saying:

‘Academic drift’ (or ‘academicization) is a term sometimes used to describe the process whereby knowledge which is intended to be useful gradually loses close ties to practice while becoming more tightly integrated with one or other body of scientific knowledge…..It is surprising, therefore, that although the existence of this process has been widely documented, remarkably little attention has been given so far to explaining it (Harwood 2010, pp. 423 - 414).
As Harwood notes it is quite surprising that such overarching systemic dynamics have tended to go unnoticed among engineering educators as they play an important role in the way engineering curricula are constituted.

Opportunities created by a widening of contexts

The crisis position as presented by the five ideal typified arguments presents a relatively pessimistic picture of the present context of engineering as residing almost entirely under the aegis of business and engineering disciplines. This is the bad news, however the good news is that engineering education is becoming increasingly more socialized (Williams, 2003). This means that engineering is becoming engaged with the pressing concerns of society, a fact which is likely to create optimism and new opportunities. Engineering educationalists and faculty members of engineering degree programs are becoming more aware of the social responsibilities which should be highlighted in engineering education, not least because of the current accreditation criteria. Hence a more positive counterpoint to the crisis position is that globalization, humanitarianism, sustainable development, green development, climate change, renewable energy, infrastructure etc. are beginning to become quite prominent issues in engineering practice and education. Accordingly there is more to engineering education than the crisis position would have it. Moreover, “re-contextualizing” initiatives have occurred particularly in the US where specific programs on “engineering in context” have been promoted, for example at the University of Virginia.

The university describes its “Engineering in Context (EIC)” program as providing engineering students with a culminating (capstone) experience in which they apply the engineering knowledge and skills they have acquired to address realistic problems in a multidisciplinary team environment. It emphasizes the importance of context (cultural, organizational, regulatory, environmental, economic, political,…) in identifying and defining problems, and the potential benefit and impact of engineering solutions. EIC capstone teams receive the financial, instructional and infrastructural support to bring a proposed solution from problem definition to final design and prototype testing. (University of Virginia, 2007).

At the Colorado School of Mines and a number of other engineering schools in the US, the context of engineering has been widened to embrace the humanitarian context. Degree programs in “Humanitarian Engineering” have been established to help contribute to humanitarian relief work. This type of program demonstrates that the context of engineering is not entirely resident under the aegis of business as Williams argues.

Despite the marginal status of such programs it is noteworthy that this kind of endeavor is motivated by traditions of human idealism departing from “an ethical vision for the use of science and technology (initially in the form of medicine) to benefit human beings who may have previously been harmed by technology (at first in the form of military weapons)” (Mitcham et al. 2009). The opposite side of the coin points to a contextual dialectic. The profession and practice of engineering have historically evolved within a military context in “tandem with activities sponsored by military agencies and purposes”. This dialectic corresponds to what Wolff called the ideal type of university acting as a social service station (Wolff, 1969), an ap-
proach which he criticized from the historical perspective of the war in Vietnam and the student unrest of the 1960s. From this perspective Wolff argued

surely it should be obvious that the academy must make its own judgement about the social value of the tasks it is called upon to perform. Even if the federal government wants war research or political stability studies or offer training, the professors and students of the university may decide that the government is wrong and that its desires should be resisted. (Wolff, 1969, p. 40).

In current discussions of engineering education the global context is a major concern. However the meaning of globalisation is not always made explicit for which reason perceptions of globalization move swiftly between “is” and “ought” (Newberry, 2005). Globalization has both a descriptive and a normative meaning. Newberry argues that educational programs that seek to develop a global perspective must endeavor to develop and convey a suitable normative meaning of globalization,

if we give credence – as I do – to the assertion that there are serious, pervasive, and persistent problems and inequities that are potentially created or exacerbated via the current process of globalization, then simply providing our students with “global skills”, skills desired by employers in order to bolster their competitiveness in the global marketplace, may not be sufficient from a moral point of view. (Newberry, 2005, p.12).

Evidently the normative meaning of globalization relates to the lives and motivations of engineers and the meaning and aspirations they attach to their life and work. According to Newberry such moral concerns relate to the education-for-life perspective in engineering studies. However the skills and competencies to be acquired by engineering students to become globally competent practitioners of their profession relate to the mode of collaboration in engineering practice. More specifically, they relate to working with people from different cultures in interdisciplinary, multidisciplinary or international contexts. According to Downey et al. (2006) these skills and competencies depend critically on the ability to work effectively with people who frame and define problems differently, including both engineers and non-engineers. This kind of collaboration has increasingly become a normal condition of engineering practice.

Interactions with people from other countries are valuable because they are most likely (a) to draw boundaries around problems in different ways and (b) to judge problems to have distinct implications for their lives and careers. The key benefit in the ideal of learning to work productively with other cultures thus involves going beyond recognizing that engineering problems can be solved in different ways and mean different things to people holding different perspectives. (Downey et al. 2006, p.4).

The good news is that educational initiatives based on these premises, laid down by Newberry and Downey et al., are currently gaining momentum in Australia, Europe, Latin America, and the United States. Moreover they have a strong resonance within accreditation criteria for engineering degree programs both in the US and in Europe.
Post-neoliberal engineering-for-development initiatives

It is precisely the groundswell of anti-development thinking, oppositional discourses that have as their starting point the rejection of development, of rationality, and the Western modernist project, at the moment of purported Washington consensus and free-market triumphalism, that represents one of the striking paradoxes of the 1990s. Ironically, however, both of these discourses - whether the World Bank line or its radical alternative – look to civil society, participation, and ordinary people for their development vision for the next millennium.

(Mohan and Stokke 2000, p. 247)

Post-neoliberal engineering-for-development initiatives

As indicated in the previous section the normative meaning of globalization relates to the lives and motivations of engineers and the meaning and aspirations they attach to their life and work. However this normative meaning should not been conceived of as an entirely subjective construction but rather as a reflection of competing ideologies and approaches that have emerged in the wake of globalization since the early 1990s. Simultaneously these meanings and approaches reflect different epistemologies and perspectives on development.

Among the most important ideologies of globalization are what may be termed market globalism, social justice globalism, and restorative justice globalism. Market globalism as an expression of a hegemonic neo-liberal agenda is characteristically promoted by the United States and sees globalization as primarily a process of expanding the free market and lowering international trade barriers, both to some degree preserved by U.S. military power. Social justice globalism is more typically promoted by European countries and stresses the extent to which globalization is a political process that promotes human rights and international law. To the extent that military force plays any role it must be exercised through the United Nations or some other multilateral mechanism. Restorative justice globalism takes the notion of restorative justice from the domestic sphere, where it refers to a focus on the needs of victims, offenders, and engaged communities instead of attempts to satisfy abstract legal principles, and extends this to international affairs. China, for instance, tends to see globalization as a process in which to reaffirm long-denied sovereignty and to redress historical injustices.

It should come as no surprise that there are also various anti-globalization ideologies. Manfred Steger (2009), for instance, uses the term “jihadist globalism” to refer to struggles against both market globalism and social justice globalism in the name of allegedly Islamic values and beliefs perceived by adherents to be under attack by forces of secularism and consumerism. This is simply reflecting the fact that any globalism opposes itself to others and thus constitutes at once both an anti- and a pro-perspective on globalization as a whole.

In dealing with meanings of globalization for engineers I shall mainly focus on post-neoliberal engineering-for-development initiatives that seek to incorporate so-
cial justice goals and ways in which context and contextual knowledge have been dealt with within these initiatives. According to Trent Hamann (2009) neoliberal governmentality is rooted in entrepreneurial values such as competitiveness, self-interest and decentralization. Its central aim is

the strategic production of social conditions conducive to the constitution of Homo eco-

nomicus, a specific form of subjectivity with historical roots in traditional liberalism. However, whereas liberalism posits “economic man” as a “man of exchange”, neoliberalism strives to ensure that individuals are compelled to assume market-based values in all of their judgments and practices in order to amass sufficient quantities of “human capital” and thereby become “entrepreneurs of themselves. Neoliberal Homo economicus is a free and autonomous “atom” of self-interest who is fully responsible for navigating the social realm using rational choice and cost-benefit calculation to the express exclusion of all other values and interests. Those who fail to thrive under such social conditions have no one and nothing to blame but themselves.

(Hamann 2009, p. 38)

Neoliberal governmentality thus celebrates the empowerment of the individual, the down-sizing of government, and the decentralizing of state power to smaller localized units. The neoliberal mode of governance promotes the self-regulating free market. Citizens who pursue the common good along traditional lines, striving to enhance civil society and social justice, are redefined as customers striving in this capacity to maximize their self-interest vis-à-vis the public (Steger and Roy 2010, p. 12).

Post-neoliberal engineering-for-development initiatives focused on community development are in strong opposition to the neo-liberal agenda. However, as Giles Mohan and Kristian Stokke (2000) have indicated in the quotation at the beginning of this section, it should be noticed that the move towards conceptualizing global engineering-for-development initiatives in terms of “community development”, “participatory development”, and “empowerment” or the other way around can be deceptive, since it has produced a high level agreements between actors and institutions of the new “left” and the new “right”, although for quite different reasons. This is an indication of diversity but also of tensions between commercial, professional, and hybrid approaches in engineering education to development and their inherent epistemologies. The three contending approaches and their inherent epistemologies may be characterized this way:

1. **The business strategy.**
   Aimed at optimizing local and national competitiveness and profit in the global knowledge economy, and secure economic conditions for welfare by focusing on the market system, companies’ demand for competencies, employability, management and technical innovation. Epistemologically speaking non-technical knowledge here predominantly takes the form of integrating business knowledge and business disciplines into engineering curricula.

2. **The professional/academic strategy.**
   Aimed at improving living conditions and secure social welfare nationally and globally through technological solutions with a focus on macro-ethical responsibilities in relation to humankind and nature. Here the emphasis lies on engineering virtues, professionalism, solutions that work and “doing
service” to humanity by enriching technological solutions. Non-technical knowledge integration quite often takes the form of an endeavor to restructure undergraduate engineering as an academic discipline, similar to other liberal arts disciplines in the sciences, arts, and humanities. Strong emphasis is put on professional mastery with the goal of preparing students for lifelong learning rather than employment as an engineer immediately after graduation at bachelor level.

3. The hybrid strategy.

The point of departure of this strategy is the disintegration and proliferation of technological knowledge and the emergence of techno-science. The aim is to produce new knowledge and engage with the community. Non-technical knowledge takes the form of 1) increased context sensitivity and a concern to increase the breadth of problem-scoping in engineering problem-solving, and 2) integration of contextual knowledge and understanding into engineering curricula with an emphasis on social responsibility and a strong focus on cultural context.

In recent years there has been an explosion in global-development-engineering initiatives in engineering education in the United States and elsewhere driven by a broad range of goals including addressing basic human needs, working to end poverty, providing students with cross-cultural design experience in preparation for careers in the globalized economy (Riley 2007). Similarly engineering-for-development initiatives that seek to incorporate social justice goals have emerged in engineering communities around the globe (see e.g. Riley 2008, Baillie and Catalano 2009, Catalano 2007). According to Donna Riley (2007) a broad array of models have been employed for this purpose, both curricular and co-curricular models. These models have been employed in collaboration with foreign governments, educational institutions or non-governmental organizations. Moreover entrepreneurial, sustainable, appropriate technology and/or community based approaches to design have been applied. These initiatives seek to imagine new models of interactions with indigenous people and local cultures able to counteract adverse effects of development interventions more effectively (Nieusma and Riley 2010).

Since the beginning of the 1990s engineering activities dealing with humanitarian engineering, community development and service learning have surged within engineering communities in the US and around the world. According to Juan Lucena et al. (2010) and Carl Mitcham and David Muñoz (2010) it was the involvement of other professions in humanitarian relief such as Doctors Without Borders (1971), Reporters Without Borders (1985), and Lawyers Without Borders (2000) that prompted engineers to take up the challenge leading to the establishment of a number of groups in France in the late 1980s, Spain (1991), Canada (2000), Belgium (2002), Denmark and others, under some national form of the name “Engineers Without Borders”. Simultaneously there has been a growing interest among engineers in trying to address the challenges of sustainable development.

According to Lucena et al. (2010) the convergence of three historical key events stimulated a growing interest in humanitarian relief and sustainable development in the US (Lucena et al. 2010, p. 40).

- The globalization of US engineering education
Globalization has been recognized within engineering education in the US and elsewhere both as a new business need and as a professional or social responsibility concern (see e.g. Downey and Beddoe 2011). Simultaneously it has been included among the ABET (Accreditation Board of Engineering and Technology) EC2000 criteria. Under criterion 3 the global context is reflected as a requirement for engineers to obtain “the broad education necessary to understand the impact of engineering solutions in a global and societal context”.

One example of a course that seeks to meet this ABET requirement is the “Engineering and Global Development” course offered at Smith College’s Picker Engineering Program. Its objectives and pedagogy are designed to enable engineering students to (Riley 2006, p. 51):

- Design and build technology systems for use in developing countries
- Apply knowledge of appropriate technology and its critique to design
- Critically analyze issues related to the use of technology in developing countries
- Demonstrate understanding of the limitations of technology in addressing problems of development

In this course specific attention and critique is centered on the “expert” model.

Similar courses or programs may be found in many other places across the USA. The University of Colorado at Boulder for example offers a program in Engineering for Developing Communities with a similar mission “to educate globally responsible students who can offer sustainable and appropriate technology solutions to the endemic problem faced by developing communities worldwide (including the US)”.

The crucial question is whether these initiatives have succeeded. As suggested by the term “voluntourism” voluntary work among engineering students might sometimes entail incentives for tourism in exotic places making their projects “hit and run” style development projects without any real value for beneficiaries. Actual contributions to the development process of a country only happen when engineers or prospective engineers are truly alert to the importance of contextual sensitivity and listen to the desires of those they are attempting to serve (Parsons 1996).

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Academic drift in Danish professional engineering education. Myth or reality? Opportunity or threat?

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Academic drift in Danish professional engineering education. Myth or reality? Opportunity or threat?

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This article examines whether and, if so, to what extent academic drift can be said to have taken place in Danish professional engineering education. If the answer is affirmative, what were the driving forces behind it and what are the consequences – if any? First, a theoretical and conceptual framework for the discussion is introduced. This is followed by a case study of institutional change in higher education in Denmark, with a particular emphasis on two institutional examples, the two previously independent engineering colleges that recently merged with universities. The two examples are based on data gathered in interviews with teachers and management in these two engineering colleges (now both part of a university). In conclusion, based on the findings the questions posed in the title of this article are addressed and possible benefits and drawbacks of increased academisation of professional engineering education are discussed.

Keywords: professional engineering education; academic drift; driving forces; higher education; education policy; mergers in the higher education sector

Introduction

Neave (1979, pp. 156–157) has pointed to a set of objectives for higher education that professional engineering schools in Europe were originally created to fulfil. In professional engineering education they would thus apply to, for example, the former British polytechnics, French IUTs, Danish engineering colleges, German Fachhochschulen, Dutch Hogeschools, etc. The objectives are characterised by their work orientation and orientation towards the needs of the local community and industry for a skilled workforce to boost growth and competitiveness in the regional economy. They would also apply to a broad range of study programmes in higher professional education in Europe at the bachelor’s level such as, for example, nursing and other health education programmes, social work, teacher training, economics and business administration, information technology and other non-academic vocationally oriented degree programmes (Kyvik 2009, p. 4). The objectives mentioned by Neave are as follows:

- Meeting the demands for vocational, professional and industrially based courses.
- The creation of a separate sector of higher education outside the universities.

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• Greater public control to ensure continued responsiveness to social and economic demands of the locality.
• Increased standing of vocational and professional education.

However, it is a well-documented phenomenon that there is a tendency for non-university institutions in higher education to strive for the academic status, recognition and/or the rights associated with university institutions such as research and higher degrees (Neave 1978, 1979, Labaree 1997, 2006, Morpew and Huisman 2002, Kyvik and Skodvin 2003, Apesoa-Varano 2007, Kyvik 2007, 2009, Jónasson and Jóhannsdóttir 2010, Leith 2010). For better or worse, for the non-university, professional higher education institutions this tendency represents a shift from the above-mentioned vocational objectives towards more theoretically oriented academic values and attitudes. Hence the term ‘academic drift’—originally coined by Burgess (1972) to describe this phenomenon. Academic drift is commonly understood as an overarching concept that refers to a long-term tendency of non-university higher educational systems, institutions, study programmes, faculty and the student body to strive for an upward movement in the direction of an institutional setting or curriculum that resembles that of the university as the epitome of prestige (Jónasson 2006).

So far Danish engineering education has been characterised by a binary system of engineering education in which engineering colleges rival universities. As a result there are two tracks at the bachelor’s level: 1) a professional, practice-oriented track including an internship in a company; 2) an academic, more theoretically oriented track without an internship. Each track leads to a bachelor’s degree in engineering and gives the possibility to study for an academic Master’s degree.

This article is concerned with recent developments in Danish professional engineering education (track 1). Therefore, the concept of academic drift is understood to mean the efforts by constituencies in engineering education to seek what they perceive as better opportunities and higher status for themselves in terms of prestige, institutional progress and development of staff and students to be able to compete in a highly competitive market for engineering labour and higher education. The aims of better opportunities and higher status are supposed to be achieved by making degree programmes more academic by: 1) changing the locus of professional engineering education to that of the university; 2) embracing academic values, practices and research in general; 3) changing the balance in degree programmes between theory and practice towards more theory. Recent institutional changes in Danish professional engineering education seem to confirm this pattern as four out of previously five independent Danish engineering colleges since 2006 either have merged with universities or have entered into close association with a university. The rationales for and driving forces behind these mergers and close associations have been different but the mergers and close associations have not per se been intended to change the aim, scope and content of the professional engineering degree programmes themselves. Thus, although the five previously independent engineering colleges are now in different institutional settings, the same ministerial order still applies to the professional (non-research based) engineering degree programmes at all the colleges. The overall purpose of the programmes, their overall content, the funding of the programmes, the required teacher qualifications, the interplay with businesses etc. are consequently still as they used to be. In that very overall sense, nothing has changed.

Hence, on the face of it, the institutional changes cannot as such be said to have led to an increased emphasis on, for example, research and research-based teaching as this is no requirement in professional Danish engineering degrees. However, too sweeping conclusions should be avoided based merely on the institutional changes themselves. Academisation may also work in more subtle ways than what is reflected in overall guidelines and official rules and regulations. A more thorough examination of a set of relevant parameters is therefore needed in order to assess the possible academisation impact of recent institutional changes on Danish professional engineering
education. The following section presents a theoretical perspective and the conceptual framework that was used to investigate these parameters in the following Danish institutional case study and the ensuing two examples of engineering colleges that have recently merged with a university.

Theoretical framework and the typology of academic drift

Even though a number of perspectives (e.g. institutional theory (Morphew and Huisman 2002), human capital economy (see Williams 1985), convergence theory (see Neave 1978), manpower planning (see Neave 1978, Williams 1985), widening participation, quality assurance (see Jónasson and Jóhannsdottir 2010)) regarding the transformative dynamics in higher education have been adopted they are usually not synthesised into a coherent theoretical framework. An effort to create a more coherent perspective has been made by Labaree (1997) and further developed by Jónasson (2006). Labaree characterises his approach as the ‘credentialing perspective’. The mechanism at work according to this perspective can be summarised in this way:

The credential account implies that public policy initiatives and the demand for a skilled workforce should be seen as external modulating or facilitating factors rather than as primary causal mechanisms. Thus students (according to this account the primary consumers of education), along with their aspirations for educational credentials, are interpreted as a substantial driving force behind educational expansion. The academic faculty, on the other hand, having a similar aspiration for status, affect the internal structures of institutions and of the system, partly as a response to institutional growth and partly as a method to gain status, which leads to the academic drift that we witness.

(Jónasson 2006, p. 4)

According to this account, academic drift works bottom up with students, staff and institutions as the key driving forces modulated by policy initiatives as, for example, harmonisation of higher education in Europe (the Bologna Process), by procedures and criteria for accreditation of degree programmes and by manpower planning considerations, etc. The following will combine the credentialing approach with a typology of ‘academic drift’ as presented by Kyvik (2007). Kyvik’s typology comprises six levels of academic drift. These are: 1) student drift; 2) staff drift; 3) programme drift; 4) institutional drift; 5) sector drift; 6) policy drift.

The nationally or macro level oriented Danish case that is presented below will mainly deal with levels 4, 5 and 6 of the typology. In the two more locally or micro level oriented institutional examples, following the national case, the focus will be on the entire model. The drift mechanism at work at each level will be expounded as the findings are presented in the following sections.

Recent developments in Danish professional engineering education

In recent years, a significant degree of institutional, sector and policy drift has taken place in professional non-university engineering education in Denmark. Policy drift should thus be seen in the light of two legal acts endorsed by the Danish Parliament in 2000 and 2007 to first create so-called centres of higher education (Danish Parliament 2000) and a few years later these centres were transformed into so-called university colleges (Danish Parliament 2007). Both of these acts intended to include engineering colleges in the new multi-disciplinary education institutions, which first the centres for higher education and later the university colleges were supposed to be. However, the responses from engineering colleges to these intended changes in the institutional landscape have been very diverse due to a variety of local circumstances and conditions. The official policy has given rise to both unintended vertical mergers with universities, an intended horizontal merger of a non-university institution into a large non-university multi-disciplinary educational conglomerate and cases with a postponement of mergers until 2015. This development
clearly indicates a drift of policy by state authorities. On the one hand, this drift of policy may be interpreted as a failure by state authorities to monitor institutions and to stick to their policy due to strong institutional pressures and lobbyism by local political and industrial constituencies. On the other hand, it may also be interpreted as a lack of an adequate policy regarding professional engineering education; thus, creating doubt and hesitation in engineering colleges regarding the appropriate institutional response to policy.

It would, however, be misleading to generally conceive of these change processes uniformly as academic drift. At first sight, only the vertical mergers with universities could be suspected to have led to academic drift in the student body, staff and programmes towards academic values, practices and research. However, from the mid-1970s until 2006 no less than five Danish engineering schools had previously merged with universities. Today, three types of institutional settings for Danish professional engineering education have emerged as the outcome of these change processes:

(1) The university (four Danish universities offer professional engineering education in six locations).
(2) A non-university institution termed university college chiefly offering teacher training, nursing, early childhood and social education. One such university college presently offers professional engineering degrees in two locations.
(3) A so-far unchanged independent institutional setting, the engineering college, destined by Act of Parliament to merge with university colleges by 2015. There are two remaining independent engineering colleges in Denmark – one of which has an application pending with the Danish Government for a merger with a university. This application was accepted by the government in January 2011. At the time this article went into press, the merger, however, has not gone through as it also needs the approval of opposition parties in the Danish Parliament. This approval is necessary as the two remaining engineering colleges are required by Act of Parliament to merge with university colleges by 2015 as described above. The government’s 2011 acceptance of the merger application is thus concrete evidence of clear policy drift since the very same government proposed the piece of legislation in 2007 demanding a merger of the two remaining engineering colleges into university colleges. Political negotiations are ongoing.

It appears that the result of these recent developments has been institutional disintegration and confusion in Danish professional engineering education. However, the crucial question is whether mergers between professional engineering colleges and universities constitute a long-term trend, reducing the present institutional confusion to a temporary phenomenon, and thus likely to end up overruling the Act of Parliament adopted in 2007, stipulating that the two remaining Danish engineering colleges must merge with university colleges by 2015. It could be argued in the affirmative, not least due to the fact that professional engineering education is increasingly under pressure both from above and from below. From above, a growing demand for engineers with a Master’s degree capable of solving increasingly complex and increasingly interdisciplinary work assignments may be expected. The last decade has also seen a relative increase in the Danish production of engineering Masters compared to engineers graduating with a professional bachelor degree (who still make up the majority of Danish engineering graduates). (Frandsen and Harnow 2011). From below, the pool of skilled craftsmen for whom professional engineering education was originally created is diminishing due to transformations in the occupational structure and the industrial paradigm. In the words of Frandsen and Harnow (2011, p. 88):

The fact that there is a larger proportion of students enrolled directly from upper secondary school and less with a vocational background is due to a general change in the educational pattern resulting in a preference for upper secondary school instead of apprenticeship in a craft.

[authors’ translation]
In any case, the result is declining enrolments of engineering students with craftsman-like backgrounds and increasing enrolments of students with upper secondary school backgrounds.

The following gives a brief account of the fragmented landscape of institutional settings for professional engineering education, the institutional strategies that served as the driving forces behind the fragmentation and the governmental policies by which the driving forces were modulated.

At the beginning of 2006, Denmark offered engineering education in four out of then 12 universities (professional and/or academic engineering degrees) and in five engineering colleges (professional degrees only). From the mid-1970s and up to 2006, five engineering colleges had merged with universities: the colleges in Helsingør (Elsinore) and Haslev merged with the Technical University of Denmark (and were closed down in connection with the mergers) and the engineering colleges in Aalborg and Esbjerg merged with Aalborg University. Finally, the engineering college of Sønderborg merged with what is now called the University of Southern Denmark. Hence, at the beginning of 2006, there were three universities offering bachelor level professional engineering degree programmes: the Technical University of Denmark, Aalborg University and University of Southern Denmark and one university offering only academic Master’s degrees (Aarhus University). The five independent engineering colleges were Copenhagen Engineering College, Odense Engineering College, Aarhus Engineering College, Herning Institute of Business and Technology and Vitus Bering in the town of Horsens. As the outcome of three different institutional strategies adopted by these five engineering colleges, the recent and current institutional situation for engineering colleges can be characterised this way:

(1) Mergers with universities. In 2006 the Institute of Business and Technology in Herning became Aarhus University, Institute of Business and Technology. Business, language and engineering degree programmes were affiliated together to the Faculty of Social Science at Aarhus University in Aarhus. Odense Engineering College became the University of Southern Denmark, Faculty of Engineering. The main motives for wishing to join the universities was to increase the competitiveness of the colleges vis-à-vis the universities by joining them, to strengthen the knowledge base of the college by joining forces with academic engineering education and research in the universities and to gain access to offering Master’s degrees.

(2) Mergers into a conglomerate type of multi-disciplinary non-university institution; the university college. In 2008 Vitus Bering, Horsens became part of VIA University College. Vitus Bering had favoured the idea of merging into this multi-disciplinary type of non-university institution from the beginning of parliamentary work (shortly after the turn of the millennium) to create university colleges in Denmark. The university college was to be a new form of educational, vocationally oriented bachelor level institution based on merging institutions offering professional bachelor’s degrees oriented towards jobs in the public welfare sector, such as teaching, child care, social work, nursing, and as the sole type of institution oriented towards business, the engineering colleges. The main reason for Vitus Bering’s support for the idea behind the conglomerate university college was that, in addition to offering engineering degrees, it was hosting a technical school offering both upper secondary education as well as training in the crafts. For this reason, a consolidation of the professional engineering degrees at the bachelor level and the vocational orientation via the inclusion in a non-university university college was considered an appropriate strategic response. Merging with a university undoubtedly would have necessitated a splitting up of Vitus Bering as it is unlikely that the technical school could have obtained ministerial approval to follow the engineering college into a university – whereas it was a possibility to follow the engineering college into a university college. Quite interestingly and paradoxically, and adding further to the picture of institutional confusion in Denmark, only two years after the merger, in 2010, the university college decided to separate the technical school activities from the university college and these activities are now destined to merge with the commercial secondary school in Horsens.
(a school offering upper secondary education and vocational training for the retail sector and for general office work).

(3) Continued independent status as a non-university institution for professional engineering education – but with an expiry date. Copenhagen Engineering College and later Aarhus Engineering College (Aarhus originally followed the second strategy above) have both followed a dual strategy by trying to lobby for either continued independence as an engineering college or to seek university collaboration or inclusion. The motive for this is similar to the motives for other engineering colleges to seek university collaboration or inclusion – professional synergy. Presently, strong collaborative ties have been established between Copenhagen Engineering College and Aalborg University and between Aarhus Engineering College and Aarhus University. In summer 2010, Aarhus Engineering College thus applied for a merger with Aarhus University. This was accepted by the Danish government in January 2011; however, as explained above, the application is still pending and political negotiations are ongoing at the time this article went to press. According to the Act of 2007 founding the new Danish university colleges, both the Engineering Colleges in Aarhus and Copenhagen must thus by 2015 merge with university colleges and not with the universities with which they are now closely associated. It is, however, the strategy of both engineering colleges to seek to avoid mergers with university colleges as they have very little in common with the almost entirely public sector-oriented university colleges in terms of professional orientation and have instead a great deal of common ground with the universities offering engineering education.

To create an overview of this complex institutional situation, Table 1 summarises the mergers of Danish professional engineering education institutions from the mid-1970s to the present, indicating the year of the merger. It also shows the strong links between the Engineering College of Aarhus and Aarhus University and between the Engineering College of Copenhagen and Aalborg University. Even though it is of minor importance for the present purpose, for the sake of completeness, also incorporated in the table is the so-called and now closed ‘Danish Academy of Engineering’ (another Danish peculiarity in engineering education offering only academic bachelor’s degrees in engineering), previously located in Lyngby near Copenhagen and with a subsidiary in Aalborg. The two branches of the academy merged with universities in 1974 and 1995 respectively.

**Modulating factors**

At the level of political governance the institutional strategies and initiatives leading to the development summarised in Table 1 have been modulated by neo-liberal new public management ideas

<table>
<thead>
<tr>
<th>University Colleges</th>
<th>Engineering Colleges</th>
<th>Universities</th>
<th>Engineering Academies</th>
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<tbody>
<tr>
<td></td>
<td>Helsinge (1995)</td>
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<td></td>
<td>Haslev (1997)</td>
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<tr>
<td>Heming (2006)</td>
<td>Aarhus University</td>
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Table 1. Merging professional engineering education institutions from the mid-1970s to the present.
regarding rationalisation of the public sector, leading to a push for larger and larger institutions of higher education in Denmark (Fitzsimons 2002, Drechsler 2005, Dunn and Miller 2007, Koch 2008, Lund 2008). A second modulating factor has been a national government strategy to prepare Denmark for handling the challenges of the global economy (Danish Government 2006). The Danish Government’s so-called globalisation strategy has a strong focus on education and research. One of the ambitious goals of the globalisation strategy is that 50% of a youth cohort should complete higher education (Ministry of Science, Technology and Innovation 2010, p. 22), which has also been translated into a need for larger and larger higher education institutions.

A third modulating factor is the attempt by the European Commission to create transparency in European higher education by gradually implementing a common scheme of curricular cycles $(3 + 2 + 3)$ throughout the EU member states. This process is commonly referred to as the Bologna Process. Moreover, struggles between the Danish Ministry of Education (responsible for non-university higher education) and the Ministry of Science, Technology and Innovation (responsible for the universities) have been an important modulating factor. The Ministry of Education has thus openly been an opponent of mergers between colleges of engineering and universities. There are two main reasons for the Education Ministry’s opposition: 1) it would entail a loss of power as engineering colleges would need to be transferred to the Ministry of Science, Technology and Innovation; 2) it would weaken the attempt to build a university college sector as a new player in Danish tertiary education to rival universities, which was the ambition with the adoption of the Act of 2000 on centres of higher education and the Act of 2007 on university colleges.

Two institutional examples of mergers between engineering colleges and universities

To examine whether there has been a drift towards academic values, practices and research in bachelor level professional engineering degree programmes, one small and one relatively large engineering college by Danish standards have been selected for further examination. These are Herning Institute of Business and Technology, which in 2006 was one of the two smallest engineering colleges in Denmark, and Odense Engineering College, which was a relatively large engineering college. In 2006, Herning Institute of Business and Technology merged with the second largest Danish university, Aarhus University, and Odense Engineering College merged with the University of Southern Denmark, which is a medium sized university by Danish standards and a good deal smaller than the University of Aarhus.1

The data collection method that was used in the case study of two institutional examples consisted of two different semi-structured focus group interviews in each institution, based on Kyvik’s typology: one interview in each institution with three engineering teacher respondents. In Odense, the three teacher respondents were selected as representatives of three different degree programmes out of a total of 11 degree programmes. In Herning, the three teacher respondents were selected as a total representation of all three degree programmes. A second interview in each institution was carried out at the managerial level. In Herning, the heads of two different degree programmes were interviewed. In Odense, four managers were interviewed, including the Director of Education at the Faculty of Engineering (former rector of Odense Engineering College) and the heads of three different engineering degree programmes. In the interviews at the managerial level, the focus was on: 1) the rationale of the merger; 2) policy drift; 3) sector drift; 4) institutional drift; 5) programme drift. In the interviews with teachers, the focus was on: 1) staff responses to the merger; 2) student drift; 3) staff drift; 4) programme drift. In the interpretation of the dataset, the two institutions were examined for both differences and similarities. In what follows, the findings are synthesised and structured according to Kyvik’s typology of academic drift.
Student drift

According to the credentialing perspective (Labaree 1997, Jónasson 2006), an important driving force behind educational expansion leading to academic drift processes is assumed to be a demand-pull from students seeking educational credentials of the highest prestige to enhance their opportunities in the labour market and their social standing in society. However, none of the 12 respondents in the interviews was able to confirm this demand-pull assumption of academic drift regarding professional engineering education. On the contrary, it would appear both from the previous general Danish case and the institutional examples that the recent mergers have been explicitly driven by a supply-push assumption based on the ability to offer Master’s degree programmes in engineering. Students, in fact, appear to have been remarkably passive in triggering the merger processes in both institutions. However, *ex post* and in terms of enrolment, students’ response to the mergers have been contradictory among the two institutions. In Odense the enrolment of professional degree engineering students has been almost unaffected, whereas in Herning the intake has almost doubled. Somewhat paradoxically, the university status is used by respondents as part of the explanation for both the stagnating intake in Odense and the success with recruiting more students in Herning. In Odense, the view that ‘we have become invisible’ after the merger is a shared perception among respondents, which serves as part of the explanation for the stagnation. A respondent from Odense expresses this view metaphorically: ‘we have become 12 pages in a 200 page catalogue’. According to this perception, being only a small part of a big offering of degree programmes in the larger university setting has made separate marketing and recruitment work for the professional engineering degree programmes increasingly difficult in Odense. Quite the opposite perception prevails among management respondents in Herning. According to them, the new university status has made the institution more visible and is therefore seen as an important reason for the increase in student enrolment and as a valuable asset for the marketing of the institution. Without attaching explanatory power to geography, it should be mentioned that there was already a university in Odense before the merger, whereas in Herning there was none. Herning is a university subsidiary, 90 km away from its mother university in Aarhus, whereas the original Engineering College in Odense is situated only a few kilometres away from the university’s main campus.

Staff drift

Following Kyvik’s (2007) argument, staff drift would be caused by staff members with academic aspirations and/or an academic self-perception. As an academic orientation differs from the practice-based and industrial and utilitarian orientation of professionally educated engineers in terms of reflectivity, critical orientation, regard for theory and orientation towards research staff members characterised by an academic orientation will tend to push their institutions towards academic values, practices and attitudes. Not surprisingly, however, the identities of engineering teacher respondents both in Odense and Herning are characterised by a predominantly industrial and utilitarian orientation. Their primary reference group is their teaching colleagues in professional engineering degree programmes and, second, professional peers and industrial leaders in the locality. They all take pride in being engineering teachers and share a strong commitment to educate engineers who are able to meet the demands of local industry and capable of working internationally. In that respect, Herning respondents resemble those in Odense. In Odense, a teacher respondent expressed the fear that increased emphasis on theory in professional engineering education might backlash in the sense that: ‘such a new breed of academically trained engineers would simply not be able to live up to the expectations of industry’. Moreover, teacher respondents both in Herning and Odense see their practical experience and tacit knowledge as crucial for the formation of students’ professional engineering identity: ‘You have a clear sense
of being respected by students when you have gained practical experience from real day to day engineering work’ says a respondent from Herning. A respondent from Odense puts it this way: ‘The ability to translate theory into practice’ distinguishes the experienced engineering teacher from the mere theoretician. In Herning, a respondent emphasises the value of practical experience and the key role of engineers as practical doers this way:

In conversations among faculty members in business degree programmes a typical question is: What is your educational background? In contrast a typical question among staff members in professional engineering degree programmes is: Where have you been working, and what were you doing?

In terms of funding, there is a strong sense of shift of focus from education to research, particularly in Odense and, to a lesser degree, in Herning. Especially in Odense, there is a growing fear that this shift of focus is creating a division and tension between what is seen by respondents as institutionally higher ranking academic ‘A’ engineering faculty members teaching and doing research and institutionally lower ranking professional ‘B’ engineering faculty members who only teach. Among the so-called B faculty members, formerly highly esteemed teachers now see their position in the institutional hierarchy and their earlier prestige reduced and their teaching workload gradually increasing. In conclusion, it might therefore be said that teacher respondents cannot be said to have driven their institutions towards academic values, attitudes and practices. Somewhat paradoxically, this is in spite of the fact that, in Odense, one of the teacher respondents has a PhD and is presently – but with some hesitation due to strong ties to his teaching colleagues – considering pursuing a research career there. In Herning, one teacher respondent has a PhD and is currently practising as an active researcher and another teacher respondent in Herning is presently studying for a PhD. Both in Herning and in Odense, however, a common characteristic of all teacher respondents is that their focus and goals have hitherto been almost entirely on teaching for professional engineering practice in industry. This dataset thus does not warrant the conclusion that there has been a transformative trickle down of academic values, attitudes and practices into professional engineering degree programmes among the teaching staff. The values and attitudes of teachers are instead chiefly attached to their industrial and utilitarian orientation and identity.

Regarding educational credentials for the teaching staff, they have remained the same. Neither in Herning nor in Odense has it become a requirement for continued employment that faculty members should hold or pursue a PhD or a Master’s degree (Danish teachers of professional bachelor’s degrees in engineering have traditionally had a background of practical experience as an engineer combined with a professional bachelor’s degree in engineering). However, in Herning a management respondent says: ‘In principle today the formal requirement for teachers in professional engineering degree programmes is a Master’s degree’. This requirement, however, is based on overall guidelines from the accreditation agency, the Danish Institute of Evaluation (EVA) and applies to professional engineering degree programmes in general, regardless of the type of institution offering the degree.

**Programme drift**

Professional engineering degree programmes would be drifting if they start departing from their original vocational, professional and industrial goals. Research and research-based teaching, new and more theoretically oriented curricula, new degree structure and new entrance criteria for engineering faculty members would be examples of elements of programme drift. Overall, there is relatively little concrete evidence of this in interviews. As a teacher respondent in Odense observes: ‘I don’t believe that students would notice any difference between the previous Odense Engineering College and the present Faculty of Engineering at the University of Southern Denmark’. This statement indicates that the substance of professional engineering degree programmes has been largely unchanged after the merger. Similar statements can be found in the data from Herning.
However, respondents also state that curricular adjustments have taken place in professional engineering curricula, both in Herning and Odense. To some extent, depending on the priorities of the individual teacher, attempts have been made both in Odense and Herning to supplement textbooks with research articles in some courses and some respondents link that to the new university status. However, there seems to be no straight line in this matter as one of the respondents from Herning dismisses such an endeavour arguing that: ‘Research articles are difficult reading for students, and students don’t easily get to the point. They can only digest them in small bits. Learning by doing is better’, whereas in contrast, another Herning respondent requires from students’ project work that ‘each project should refer to at least two scientific articles’. To put these observations into perspective, it should be mentioned that theory of science since 2001 has become a compulsory ingredient in all degree programmes at the bachelor’s level in Denmark; a requirement that was expected to be fully implemented by 2004 (see Christensen and Ernø-Kjølhede 2008, 2009, Hussman and May 2009). The aim of theory of science was that: ‘Students should be offered an opportunity to qualify their professional specialty by seeing it in a broader and more general perspective’ (Ministry of Education 2000). In 2006, the EVA formulated the following accreditation criterion (criterion 15 out of a total of 40 accreditation criteria) for professional engineering degree programmes: ‘Research methodology and theory of science must be part of the professional degree programme in order to enable students to follow and apply R&D results in their field of specialization’ (Danish Institute of Evaluation 2006a,b). Regarding the implementation of theory of science, both in Odense and Herning, it has been difficult to align this academic ingredient with professional engineering education. In both institutions, implementation has therefore been delayed considerably because of doubt regarding the value of the ingredient and lack of sufficient knowledge about the subject. A teacher respondent in Odense says it this way: ‘The students’ perception of theory of science is that it is an issue that is “nice to know” and not so much an issue that you “need to know”’. The overall conclusion that may be drawn from the interviews, therefore, is that respondents state that educational goals and means of professional engineering degree programmes have largely remained the same after the mergers, both in Odense and Herning; even though degree programmes have of course been adjusted and updated. But it is argued that such adjustments would have taken place anyway. An important factor in this respect is that professional engineering degree programmes are still governed by the same executive orders (e.g. Executive order no. 527 of 21 June 2002) as before the university mergers. There has, however, been pressure towards an increasing degree of academisation to get professional engineering degree programmes accredited from the above-mentioned central accreditation criteria, as defined by EVA. This has, however, been part of a general trend within all professional education at the bachelor’s level in Denmark and it therefore cannot be said that the defining elements of programme drift seem to have been met. There are signs that programmes are moving in the direction of more theory and that research articles are becoming more prominent as teaching material. However, in the two institutional examples no research, research-based teaching, new curriculum, new degree structure or new entrance criteria for engineering faculty members have been implemented in any significant measure as a direct outcome of the mergers with universities.

Institutional drift

If engineering colleges merge with universities they by definition meet the criterion for institutional drift. The rationale for the merger in both Odense and Herning is, briefly put:

(1) To be able to offer Master’s degree programmes in engineering to attract students. In a highly volatile and competitive market for higher education, this is seen as an important part of the institutional survival and development strategy.
(2) To be able to carry out research to meet the requirements of research-based Master’s degree programmes.

(3) To be able to offer PhD-projects for gifted students and staff.

(4) To obtain better opportunities for funding of research than the existing (related to engineering colleges) opportunities for funding of purely educational development.

(5) To help increase the general level of education among employees in the region.

(6) To help increase the knowledge intensity of local companies.

Sector drift

As has been shown in the Danish institutional case above, there is ample evidence for claiming that sector drift is a clear and strong tendency in professional engineering education in Denmark. This tendency finds unequivocal support from the respondents in both Odense and Herning. Respondents, both at managerial and staff level, see the inclusion of professional engineering education in the university sector as necessary and natural due to the need for professional development. The fact that Danish engineering colleges are constrained to be merely teaching institutions and only allowed to offer bachelor engineering degree programmes is seen as a serious impediment for professional long-term development of faculty members and degree programmes and thus as an impediment for competitiveness in the market for higher education. This constraint has made it difficult for institutions and faculty members to be part of R&D projects: ‘We were not able to participate in research activities and we shared the fear that we would not be able to obtain opportunities for staff development. Whether this situation has improved after the merger is debatable... In any case it was a case in point for the rationale of the merger... The previous situation couldn’t be sustained in the long run’, says a teacher respondent in Odense.

A management respondent in Herning supports this argument by saying: ‘As I see it the sector as a whole has a viable model at the Technical University of Denmark which has been able to offer both professional engineering degree programmes and academically oriented Master degree programmes within one institutional setting’.

In Odense a teacher concludes: ‘Our position is that only universities should be allowed to offer any kind of engineering education whatsoever’.

Symbolic drift towards the more prestigious university label has also been an important aspect of the mergers as implied by a respondent in Herning: ‘Marketing wise it would be simply fantastic if the name of our institution changed to Aarhus University’.

A teacher respondent in Odense also gives an impression of the value of the university label:

I believe even though many colleagues wouldn’t admit it that it is more prestigious to be an employee at a university..... this is not to say that professional engineering education has become better or worse. Evidence for such claims can only be provided in the long run.

Policy drift

Policy drift, as used here, refers to a gradual shift in the views of state authorities regarding the purpose, terms and conditions of professional engineering education. On the face of it, it is undeniable that policy drift has taken place when compared to the intentions of the Danish parliamentary Acts of 2000 and 2007. These Acts were intended to include the engineering colleges in the new university colleges, yet only one out of five colleges has followed this intention and the two colleges examined here have even obtained governmental approval to merge with universities; in spite of not only the intentions of the parliamentary Acts but also strong opposition from the Ministry of Education, under which the two colleges were previously. However, the drift is ambiguous as the aim of professional engineering degree programmes are still the
same, the programmes are governed by the same legal documents and executive orders from the Danish Government and accreditation criteria are as before the mergers. The official mission of professional engineering education has thus been unchanged even though the programmes are presently offered by three different types of institution in Denmark (university, university college and engineering college). What has been witnessed in recent years is perhaps not so much policy drift but rather policy failure or policy inconsistency. Failure to outline a clear, national policy for professional engineering education institutions and failure to stick to this policy. Yet seen from an overall point of view, the conclusion must be that there has been some degree of policy drift due to the fact that parliamentary Acts stipulate a direction for engineering colleges, which only to a small extent has been implemented in practice.

Figure 1 summarises the actors, their positions and motives during the period leading to the merger of the two engineering colleges with universities. This overview is given in the form of an actant model. It has been found that, in the two institutional examples, there is evidence of academic drift in three out of Kyvik’s six forms of drift. It may also be concluded that there is evidence of a long-term sector drift (since the 1970s) of engineering colleges towards the university sector. It therefore can be said that academic drift in Danish professional engineering education is a reality – but in some respects it is perhaps also a myth.

Conclusion

What is presented in this article should only be considered a preliminary and partial conclusion in an investigation of academic drift in Danish professional engineering education. A final and more comprehensive conclusion would have to include more institutions and more actors (students, industrialists and politicians have, for example, not been interviewed for this study) and it would also have to be based on a more detailed curricular analysis. In the conclusion of this article, the limitations in the research design and the internal and external validity of the data in terms of their credibility, authenticity and transferability are therefore first discussed (Guba and Lincoln 2000).
Second, a summary of the findings is presented regarding the respondents’ perception of benefits and drawbacks of the university mergers for professional engineering education. Third, an avenue for future research is suggested.

A clear limitation in the research design is that students were not included in the investigation, as the data have led to the questioning of the validity of the ‘credentialing perspective’ for professional engineering education. To fully refute this perspective, it is not sufficient to conduct research among staff; a survey of students would also be needed. However, it is not a prime concern in this article to use the empirical data to falsify the theoretical framework but to use it for analytical purposes in the study. The prime concern herein is to study the perceptions of managers and teaching staff in professional engineering colleges that have recently merged with universities. Due to the data control procedure that has been applied, it could be argued that the internal validity of the data in terms of their credibility is high. It is also believed that the respondents in each institution present an authentic, multi-faceted picture of how they have experienced the merger process in their respective institutions and that these pictures are all the more credible as they have a relatively high degree of resemblance. Regarding the external validity of the data and findings in terms of their transferability, there is no reason to doubt that similar findings could not also be found nationally and internationally in other professional engineering institutions that have recently merged with universities – or will do so in the near future.

The subtitle of this article posed the question: ‘Academic drift... opportunity or threat?’. Whether such drift is perceived as either an opportunity or a threat naturally depends on who is asked and whose perspective is adopted. In this article, the perspective is that of management and teacher respondents in two former engineering colleges, now part of a university. To give a partial answer to the opportunity or threat question, Figure 2 presents a summary of the respondents’ perception of opportunities/benefits and threats/drawbacks for professional engineering education after their mergers with universities.

Evidently, academic drift is both an opportunity and a threat for professional engineering education and it entails both benefits and drawbacks. Figure 2 suggests that merging professional engineering education with the university creates a number of potential tensions, such as, for example, tensions regarding teaching quality, the importance and value of research for teaching, the balance between theory and practice, etc. Whether benefits and opportunities outweigh threats and

<table>
<thead>
<tr>
<th>Opportunities and benefits</th>
<th>Threats and drawbacks</th>
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<tbody>
<tr>
<td>1. The higher prestige of the university</td>
<td>1. Overspecialisation and isolation</td>
</tr>
<tr>
<td>2. Focus on research and development of cutting edge knowledge</td>
<td>2. Individual status competition instead of collaboration</td>
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<td>4. A broad array of disciplines and degree programmes within the faculties of the university</td>
<td>4. Lack of flexibility</td>
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<td>5. Offers education to the highest level</td>
<td>5. Only publication counts as measure of quality</td>
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<td>6. Research based teaching</td>
<td>6. Shift of focus from education to re-search</td>
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<td>7. More intellectually stimulating environment</td>
<td>7. Creating a division between A and B faculty members</td>
</tr>
<tr>
<td>8. The ability to offer Master’s degree programs in engineering</td>
<td>8. Diminishing value of practical experience</td>
</tr>
<tr>
<td>10. Building of research capacity</td>
<td>10. Lack of interaction between researchers and teachers</td>
</tr>
<tr>
<td>11. Easier access to relevant R&amp;D networks nationally and internationally</td>
<td>11. Decreasing enrolments of students with a craftsman-like background</td>
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<tr>
<td>12. Easier to increase student enrolment</td>
<td>12. Volatile student enrolments</td>
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<tr>
<td>13. Professional development of faculty members</td>
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Figure 2. Respondents’ perceptions of opportunities/benefits and threats/drawbacks for professional engineering education after merging with a university.
drawbacks depends on the concrete context in which any given engineering degree programme or educational institution is embedded. It could be argued that, by nature, professional and academic engineering degree programmes do not sit well together if located in the same institution. However, concerning the two institutional examples examined in this article, respondents are not in doubt. Four years after their merger, respondents unanimously claim that opportunities and benefits clearly have outweighed threats and drawbacks.

A next step for future research is to conduct a curricular analysis in professional engineering degree programmes. This would include a systematic review of legal documents, reports, accreditation criteria and procedures regulating engineering curricula. A curricular analysis would be able to show in detail whether and how Danish professional engineering degree programmes have changed in recent years and whether such changes have been influenced by the change of prime locus for Danish professional engineering education from engineering colleges to universities. Furthermore an expansion of the present study on a European scale, also embracing other types of professional education together with what has been suggested as a next step for future research, might be able to provide valuable insights as to the dynamics of higher education in general and as to engineering education in particular.

Note

1. The figures, in terms of student populations, indicate the relative size of the institutions in question. By 2011, Aarhus University totalled a population of nearly 40,000 students whereas University of Southern Denmark by October 2010 totalled a population of nearly 21,000 students. By 2010 Institute of Business and Technology at Aarhus University had a total population of 2200 full- and part-time students. Of these, 355 were full-time students from the institution’s three professional engineering bachelor degree programmes. By 2010 Odense Engineering College, now Technical Faculty of University of Southern Denmark, had a total population of 1415 full-time students enrolled in 11 professional engineering bachelor degree programmes.

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Chapter 9

Academic Drift in European Professional Engineering Education
The End of Alternatives to the University?

Steen Hyldgaard Christensen

Abstract: In this chapter it is argued that insights from comparative studies of higher education are essential to develop an understanding of educational systems dynamics impacting on professional engineering education. Usually such structural dynamics tend to go unnoticed among engineering educators. The chapter is organized the following way: After a theoretical framing of the argument three examples of institutional transformations and cognitive shifts that have taken place in similar types of professional non-university engineering education institutions in Great Britain, France and Germany, from the massive expansion of higher education in the 1960s to the present are discussed. More precisely academic drift processes in British Polytechnics, French Instituts Universitaires de Technologie (IUTs), and German Fachhochschulen will be examined and compared. In reviewing the relevant literature the following questions will be considered: 1. What do we know about the processes whereby the engineering curriculum has been constituted? 2. Are such processes inevitable and irreversible? and 3. What kind of tensions and dilemmas do they create? It is argued that a particularly powerful and coherent set of values and attitudes characteristic of universities may also be seen as lying at the heart of non-university higher education institutions causing them to drift towards the university or imitate them as implied in the subtitle.

Keywords: vocational non-university engineering education, academic drift, vocational drift, mergers, driving forces, structural dynamics.

Introduction

The point of departure for this chapter is a personal reflection on the institutional transformations that my own institution – Aarhus University, Institute of Business and Technology - seen from the point of view of the original vocational engineering school Vestjysk Teknikum, has gone through over the last two and a half decades as indicated by the tripartition of its present name. It has puzzled me that, in spite of the local and situated character of the institution’s strategic decisions regarding the way to go at different points in time, the institution nevertheless since its establishment in 1987 seems either consciously or unconsciously to have followed a general pattern of transformations of non-university higher education institutions in Europe since the 1960s.

This general pattern of transformations may be seen as related to my own institution in the following way: 1. Fragmented expansion. Under the name Vestjysk
Teknikum the engineering education institution was established as a small subsidiary of the larger Horsens Teknikum in 1987 in an area characterized by a lack of post-secondary higher education traditions and institutions. 2. **Horizontal integration.** As the first of its kind the institution gained independence by merging with a business school in 1995, thus becoming Institute of Business and Technology. 3. **Vertical integration.** In 2006 Institute of Business and Technology merged with Aarhus University under the name *Aarhus University – Institute of Business and Technology* and became part of the faculty of social science at Aarhus University. By 2011 when this volume went into press, the name simply became *Aarhus University, Herning*. What happened in my own institution is a clear-cut example of academic drift caused by institutional and structural dynamics. Presently these dynamics are also causing other engineering colleges in Denmark to merge either horizontally into large multi-profession institutional conglomerates or as the dominant trend with universities. In the following, examples of such processes taking place in Europe will be scrutinized from the perspective of comparative studies of higher education.

The notion of academic drift was originally coined by Tyrrell Burgess in 1972 to describe dynamics of change in higher education since the massive expansion of student enrolments in the 1960s (Burgess 1972, Pratt and Burgess 1974). However the set of phenomena it was meant to capture is much older and has been a key characteristic of processes of professionalization since the early beginnings of professional education. Elite status pretensions and continued strive for vertical distinctions have always acted to push educational requirements in a more genteel and theoretical direction and to make them less narrowly vocational (Collins 1979). Discussing academic drift in professional engineering education today is still important for two reasons. One reason is that it relates to historically rooted, though still ongoing, processes whereby the engineering curriculum has been/is constituted. The second reason is that it relates to struggles over the appropriate place or locus for educating engineers for engineering practice. In many cases these struggles have been affected by structural dynamics that have not yet attracted sufficient attention among engineering educators.

On the one hand academic drift at a curricular level encompasses a cognitive dimension. From this perspective, academic drift refers to a tension between practice-oriented and science-oriented curricula. It thus refers to the process whereby knowledge derived from practical engineering work experience and intended to be useful for industrial practice gradually loses its close ties to practice. Instead engineering knowledge becomes increasingly theoretical and oriented towards engineering disciplines, including mathematics and natural science. Regarding the extensive use of mathematics in engineering problem solving Brosan (1992) argues: “All too often parts of such courses are concerned with playing advanced mathematical tricks which are not concerned with what a man has to do in industry; little if any time is given to alternative formulations of the same basic problem!” (Brosan 1972, p. 45). Hence science-driven curricula reflect an approach to problem solving in which science is regarded as the single most important element in the solution of practical problems. Conversely practice-driven curricula do not imply that no use is made of theories, laws, concepts etc., from the basic sciences. Instead they are regarded as just one resource among many for the solution of practical problems (Harwood 2006). Historically this transition marks a shift of orientation in engineering educa-
tion from a perception of engineering as an “art” concerned with creative engineering design to a perception of engineering as a “science” concerned with scientific methodology and rigor (Heymann 2009).

On the other hand academic drift also encompasses an institutional dimension. From this perspective, it refers to the question concerning the appropriate locus for educating professional engineering students for engineering practice. More precisely academic drift here refers to a tension between what is considered “noble” and “less noble” institutions (Furth 1982, Teichler 2008), and accordingly to a tension between narrow vocational training and broad professional or research-oriented academic education (Burgess 1978). Academic drift in this dimension is thus meant to capture a long-term tendency of non-university higher educational systems, institutions, study programs, faculty and the student body to strive for an upward movement in the direction of an institutional setting or curriculum that resembles that of the university as the epitome of prestige (Jónasson and Jóhannsdottir, 2006). In the historical perspective adopted here, it would seem that this process has been enhanced by a dialectic of forces in the sense that academic drift has been a driving force in non-university higher education institutions whereas vocational drift has been a driving force in universities. Both processes started in the 1970s and gained further momentum in the 1990s. As a result the boundaries between the two types of institutions have become increasingly blurred (Kyvik 2009, Kehm and Teichler 1995, Teichler 1996).

In these intertwined processes of cognitive shifts and institutional transformations, status and funding have played a prominent role (Harwood 2006). The status question has been a prominent factor in the history of engineering education in Europe since the 18th century. As to funding Seely (1993, 1999) offers an illuminating example. He has shown that the vast increase in US federal funding of engineering research related to what came to be called the military-industrial complex in the wake of World War II and the Cold War period was the decisive factor for a major paradigm shift in engineering education in the United States. This paradigm shift tilted the balance in engineering curricula towards academisation and engineering disciplines. This paradigm shift also had a pervasive impact on both professional and academic engineering curricula in Europe. In 1991 Herbert Simon noted that in the United States there was also a “contagious effect” of such development in business schools and medical schools:

My initial views were that engineering education needed less vocationalism and more science. As I began to understand the trends in the stronger engineering schools, I saw the same things that were happening to them were happening to the new model business education: science was replacing professional skills in the curriculum. I looked a little further, and saw the same thing going in medicine. More and more, business schools were becoming schools of operations research, engineering schools were becoming schools of applied physics and math, and medical schools were becoming schools of biochemistry and molecular biology. Professional skills were disappearing from the curricula, and professionals possessing those skills were disappearing from the faculties.

(The quotation is from Skoie 2000, p. 415)

In the extension of the contagious effect of academisation noted by Herbert Simon academic drift also refers to a structural dimension. In this dimension academic drift operates across the entire non-university higher education sector to transform educational systems. In many European countries there has been a sequence of structural
transformation since the 1960s starting from university dominated systems, over
dual and binary systems to unified systems of higher education, with stratified sys-
tems like the French as an exception. Here academic drift spans a variety of fields
such as for example engineering, agriculture, nursing and other health care pro-
grams, social work, business administration and information technology. Therefore
at this level the term implies that there is a macro-structure of higher education and
that individual institutions are not self-sustaining entities. Institutions are embedded
in common frameworks of societal expectations, regulatory frameworks, and co-
operative or competitive linkages (Teichler 2004, 2008, Jonasson 2006, Kyvik
2009). Understanding the driving forces behind academic drift at all three levels is
therefore important for professionals concerned that higher education should be rel-
evant to their practice.

Some critics have complained that academic drift has made engineering educa-
tion increasingly irrelevant to actual needs. For some of them the issue is how to
bring engineering education closer to industrial needs. For others the decline in
graduates' design skills has been a key concern. However such concerns inevitably
imply a number of more complex and intricate questions. These are: what processes
work to transform the engineering curriculum over time? How are research priorities
set? Who has a say in the kind of staff that are appointed? And finally: which factors
tend to encourage academic drift and which factors work against it (Harwood 2006,
p. 70)?

**Theoretical framework**

According to Kyvik (2009) European non-university institutions of higher education
seem to a great extent to have gone through three different though overlapping phas-
es of transformations since the 1960s. Formulated in an ideal typical fashion, these are:

1. **Fragmented expansion** aiming at differentiation and diversification by means
   of geographical and institutional decentralization. As a result dual systems of tertiary
   education became established with a clear division between universities and the col-
   lege sector. In this model the college sector is fragmented into many small and spe-
   cialized professional schools that offer short-cycle 2- or 3-year vocational courses.
   Each of the schools has distinct vocational cultures and is subject to different public
   regulations.

2. **Horizontal integration** aiming at field contraction, authority unification, insti-
   tutional de-differentiation, program coordination, and regionalization. The outcome
   of this process may be characterized as a gradual transition to a binary model where
   the college sector came to be organized in comprehensive vocational multi-
   profession colleges, sometimes termed polytechnics, beside the university sector.
   The college sector now becomes subject to a common system of regulations.

3. **Vertical integration** aiming at academisation, field coupling, student mobility,
   structural convergence, network building and organizational integration. The out-
   come of this phase is characterized by a gradual transition to a unified system of
   tertiary education. In unified systems, both traditional academic studies as well as
   vocational programs are offered within universities. Unified systems have been cre-
   ated in three different ways: by upgrading polytechnics, by merging traditional uni-
In order to discuss academic drift processes in a European context, I have selected three institutions offering professional engineering education for further examination: British Polytechnics, French Instituts Universitaires de Technologie (IUTs), and German Fachhochschulen. I have the following questions in mind: 1. What do we know about the processes whereby the engineering curriculum has been constituted? 2. Are such processes inevitable and irreversible? and 3. What kind of tensions and dilemmas do they create? The choice of institutions has been dictated by four considerations. First, all three institutions are examples of institutions that emerged in Europe in the 1960s and early 1970s and were expected to prepare engineering students for professional practice in a more direct manner than universities. Second, they all challenged the autonomy of universities and their conception of knowledge for its own sake. Third, they have been selected as the three institutions each in their own way have served as ideal typical cases of drift processes in comparative studies of higher education (see Kehm and Teichler 1995). Finally they have been selected as the United Kingdom, France and Germany represent three historical reference models of higher education – the Oxbridge, the Napoleonic, and the Humboldtian. These reference models constitute the historical initial conditions for the shaping of engineering education and the different status and roles attributed to engineers in the three countries.

In the following the focus is on the tensions that were latent in the three institutions already from their establishment in the 1960s and early 1970s. In this period a transition from elite to mass higher education took place. The new types of institutions were created to deal with increasing numbers, a more diversified student body and a rapidly growing need for manpower in advanced industrial societies (Slantcheva-Durst 2010).

For lack of space I shall refrain from a lengthy theoretical discussion of the various interpretations of the notion of academic drift. However to be able to compare the three institutions four dimensions of academic drift will be needed: policy drift, institutional drift, staff drift, and cognitive drift in curricular emphasis (see Neave 1978, 1979, for further elaboration see Jónasson 2006 and Kyvik 2009). I first give a brief presentation of each of the three institutions focusing on the phases of transformations they went through, if any, and the tensions that were latent in the institutions from their establishment. Next I discuss in which dimensions, if any, academic drift in the three institutions took place and what kind of new tensions and dilemmas followed from these drift processes.

By using perspectives and theoretical frameworks from comparative studies of higher education, we might be able to better understand some of the forces and obstacles that engineering educators are confronted with at a structural level in their effort to swing the educational pendulum back towards engineering practice (Sheppard et al. 2009). Moreover using a comparative perspective would also make it possible to be able to better estimate the likelihood of success in attempting to reverse the process of academic drift.
Three institutions of professional engineering education in the United Kingdom, France, and Germany

British Polytechnics

The so-called British Polytechnic experiment may be seen as an ideal type of institutional and cognitive transformations in engineering education related to all three phases in Kyvik’s phase model. By means of horizontal integration British Polytechnics were created in 1965 as a separate sector different from, but supposed to be equal in status to, the traditional university. The creation of this institutional novelty marked a transition from a dual system to a binary system of higher education. In 1992 British polytechnics were upgraded to university status. With the upgrading a transition from the binary system to a unified system of higher education took place and the British binary experiment can be said to have come to an end (Pratt 1997).

What makes the British binary policy so fascinating is that one of its purposes was to prevent academic drift. In 1965 Secretary of State Anthony Crosland, who was the architect behind the binary policy, warned against academic drift saying: “For more than a century, colleges founded in the technical college tradition have gradually exchanged it for that of universities. They have aspired to an increasing level of work, to a narrowing of student intake, to a rationalization of course structure, and to a more academic course content” (Pratt 1997, p. 12). With the objectives of the new type of institution it was intended to put an end to the academic drift tradition. The objectives were set out by Crosland and justified in his speeches at Woolwich and Lancaster Polytechnics in 1965 and 1967. Here he said that the binary policy was aimed at fulfilling four main objectives (Neave 1979, p. 147):

a. That the purpose of the polytechnics was to meet the increasing demand for vocational, professional and industrially based courses which the universities could not supply.

b. That a separate sector outside the universities but in the higher education system be created.

c. That greater public control should be brought to bear upon the new establishments to ensure their ensued responsiveness to the social and economic demands of the locality.

d. That vocational and professional education needed greater standing if the international competitiveness of England and Wales was to improve.

As pointed out by Neave (1979, pp. 156-157) implementing the binary policy was not as easy as Crosland originally had imagined. The objectives appeared to be ambiguous and gave rise to a number of unresolved questions which eventually led to “policy drift” by the British Government and, as a result, to the upgrading of polytechnics to university status in 1992. Some of these unresolved questions related to a-d were: a. Demands by whom? By the government? By students? By the economy? b. Should there be some degree of mobility between the sectors with students passing from the non-university sector to the university sector? How large should the proportion of university staff be in polytechnics? c. How precisely to handle the problem that close supervision by local and central authorities had not previously prevented drift in curricular emphasis, and did not automatically ensure sensitivity to
social demands or the needs of the locality? d. Increased standing in relation to what? To university education? To general secondary education?

However taken at surface value and interpreted in terms of curricular thrust, the above-mentioned objectives are nevertheless characterized by a strong work orientation and orientation towards the needs of the local community and industry for a skilled workforce to boost growth and competitiveness in the regional economy.

Already in 1980 the Finniston report commented on deficiencies in engineering education in British polytechnics. These deficiencies were related to an observed cognitive drift of curricular emphasis. According to Pratt (1997) among criticisms of engineering education was the harsh observation “that it was unduly scientific and theoretical; that newly-graduated engineers lacked awareness of “real life” constraints; that they were oriented too much towards research and development work and were not interested in working in production or marketing functions” (Pratt 1997, p. 114).

From its inception the British binary policy created a number of tensions. First among them was the tension between institutions belonging to the “autonomous” tradition as opposed to those belonging to the “service” tradition. Burgess (1978) formulated the tension in the following way. Institutions in the service tradition seek to place the knowledge they have at the service of society. Indeed they believe that human knowledge advances as much through the solution of practical problems as through pure thought... In seeking to serve it takes on very serious difficulties. In the first place there is the question of service to whom? Is it the student who is to be served, society as a whole, the government?... Can the institution serve more than one? The autonomous tradition settles this by asserting the priority of the discipline.

(Burgess 1978, p. 46)

Already in 1974 Pratt and Burgess noted that many of the polytechnics were seeking to escape from public control by striving to become autonomous institutions like universities (Pratt and Burgess 1974, p. 173). Moreover, in 1979 Neave illuminated the inherent problems in the service tradition mentioned in the quote. Neave (1979) noted that polytechnics generally failed in distinguishing between student demands and the demands of industry and the economy (Neave 1979, p. 147).

A second tension was of a social nature. In the original Oxbridge model, elite schooling was for the upper classes focused on the development of leadership. What counted was the development of character, not the mastery of “skills” or of vast bodies of knowledge. The curriculum was therefore dominated by classical history, literature, and philosophy. There was a disdain for “technical subjects like science and certainly the economic and managerial subjects that might prepare captains of Industry” (Grubb 2004, p. 6). Contrary to this tradition the aim of polytechnics was to educate personnel for technical middle-level positions. Crosland described the kind of students that polytechnics would be catering for in the following way:

Perhaps they left school early, perhaps they were late developers, perhaps they were first generation aspirants to higher education who were too modest at the right moment to apply to a university, perhaps they had started on a career and thought that a technical college course would more directly improve their qualifications for doing it.

(Pratt and Burgess 1974, pp. 5-6)
Crosland’s description clearly indicates that what he had in mind was “working class students” and that an important purpose of British polytechnics would be to offer these students a second chance of higher education. However, somewhat paradoxically, the social tension in the emerging binary system of higher education was transformed into a tension in polytechnics between categories of students. Here a tension arose between part-time students, evening students, sub-degree level students on the one hand, and degree students, post-degree students on the other. The overall consequence was that there was a rapid expansion of the academic potential of polytechnics causing the original vocational orientation and student clienteles from industry to suffer. The final upgrading of polytechnics in 1992 and the transition from a binary to a unified system of engineering education coincided with the transition from industrialism to post-industrialism. This has led Kyvik (2009) to conclude:

In many ways, the binary model should be seen as a metaphor for the old class society, where the class a person was born into was decisive for his or her social status, cultural taste, and income. In the same way, the binary divide between universities and colleges would preserve a socially constructed and socially institutionalized division between noble and less noble higher education institutions.

(Kyvik 2009, p. 204)

It appears to be the irony of history that the institutional bottom-up strategy leading to institutional drift of polytechnics and to their final upgrading in 1992 to university status has had the adverse effect that polytechnics have now become the second division of the university sector. Pratt (2002) characterized the new situation in the following way:

They can point to the maintenance of vocationally oriented degree courses, to their many part-time courses, and to greater access than old universities to student from lower socio-economic groups, 34 per cent against 20 per cent. Some have a growing research reputation. Yet they appear at the bottom of most league tables, gain only a few per cent of the research assessment exercise funding, and are struggling to attract applicants. In many respects, they are the second division of the university sector.

(Pratt 2002, p. 1)

After this somewhat sketchy presentation of British polytechnics I shall now turn to the French IUTs where the tensions were of a different kind.

French Instituts Universitaires de Technologie (IUTs)

French IUTs were established in 1966 to provide short cycle 2-year course programs equivalent with the French university first cycle (2+1+1+1) (Lamoure and Rontopoulou 1992). Their aim was to train skilled, middle-level graduates to assume “technical functions in productions in applied research and the services” as formulated in the founding decree of January 1966 (van de Graaff 1976, p. 195). More precisely the aim was that graduates should be more narrowly specialized than an engineer but with a broader education than a technician.
The creation of IUTs was an attempt by the French Ministry of Education to create a new kind of institution better suited than the traditional university to cater for the new cohorts of post-secondary students (van de Graaff 1976). The Ministry of Education therefore wanted to introduce more flexible but still highly selective admission procedures, new objectives and pedagogies and open up the university to the world surrounding it. As argued by Reichert and Smith (2009), in France “the celebrated ideal of free access and provision for all coexists with a cherished culture of selectivity that seems to be held in equally high public esteem and is not as neutral to socio-economic origins as true meritocracy would imply”. This ambivalence dates back to the Napoleonic reform of higher education in France in the wake of the French Revolution in 1789 (Reichert and Smith 2009, p. 45).

The creation of IUTs as selective institutions was therefore no exception. Selectivity came in as a **numerus clausus**. IUTs were only allowed to admit students up to a prescribed capacity. Beside the traditional **Baccalauréat** (or Bac), there were three other possibilities for admission aiming at attracting high-calibre students: 1. Acquisition of equivalent training in industry, 2. Completion of a diploma that would grant access to university studies, and 3. Obtaining validation of professional experience or previous learning (Mikhail 2008, p. 76).

The creation of IUTs may be interpreted as an attempt by the French Government at horizontal integration of technical and administrative fields and fields of service provisions related to the primary, secondary and tertiary sectors of the French economy (Bernard 1973). However, in the end the advent of IUTs added further to a fragmented and stratified system of engineering education in France. Engineering education came progressively to rest on four pillars consisting of two binary structures in which each pillar corresponded to a distinctive set of administrative arrangements. One binary structure was established for long study programs including universities and the **Grandes Écoles**. Another binary structure was established for short study programs including IUTs associated with universities, and STS (**sections de techniciens supérieurs**) which were run by the **lycées**. The **lycées** were in charge of two of the four pillars, namely the STS as already noted and the **classes préparatoires** for admission into the highest ranking institutions in the French educational system, namely the highly selective but less research-intensive elite institutions, the **Grandes Écoles** (Jallade 1992, Giret 2011).

A key concern of the responsible Ministry of Education regarding the separation of universities and **Grandes Écoles** was a concern related to the overall rationality of the French educational system. A major problem was that it led to a waste of intellectual potential to the detriment of France’s international economic competitiveness and research reputation. First and most importantly, the most gifted students were drawn into the less research-intensive but highly prestigious **Grandes Écoles** depriving the research system of these talents. Second the universities were not selective and they therefore had to cope with massification on their own (Witte et al. 2008, p. 224). This problem was related to a legal aspect of the **Bac**. In France as opposed to other European countries, the **Bac**. confers a legal right to students who have obtained it to be enrolled in the university without restrictions (Jallade 1992, p. 134).

Turning to the IUTs the autonomy and accountability of IUTs fell under the remit of the Ministry of Education. Since 1968 a high degree of pedagogical, scientific, administrative, and financial autonomy had been assigned to IUTs. To this day however this autonomy has remained a subject of conflict with the university (Mikhail 2008, p. 75). Beside the Ministry of Education and the university there was a
substantial involvement on the part of the private industry and the trade union. This tripartite involvement created an uneasy position regarding function and status. The trade union in particular stressed the need for better “research opportunities for the staff and the creation of sufficient additional teaching posts so that most of the temporary staff can be regularly employed” (van de Graaff 1976, p. 201).

The vocational type of qualification offered by IUTs was conceived to be terminal leading to the Diplôme Universitaire de Technologie (the DUT). Intensive school-like teaching and learning methods were therefore introduced in IUTs as a pedagogical innovation (see Jallade 1992). Courses were made mandatory as a general rule, attendance at courses was to be monitored and students could be dismissed for absenteeism. Evaluation of students was not a terminal one but was taking place currently and finally added up to the DUT. IUT students were therefore expected to attend at least 32 contact hours per week, over an academic 2-year training averaging 30 weeks per year, to which a further six to ten weeks of apprenticeship experience was to be added, as opposed to the university norm of 12 hours per week in 26 weeks (Jallade 1992).

As observed by Quermonne (1973) with regard to IUTs “the staffing ratio and the special educational methods in IUTs have been so designed that students entering employment on leaving them have received an education combining the necessary technical skills with an adequate general training” (Quermonne 1973, p. 226). Regarding the general education mentioned at the end of the quotation such general training would be of a more non-utilitarian nature and would therefore be expected to be more academically inclined. It might therefore be argued that the IUTs already from start had been charged with a dual responsibility which would later in 1999 be reemphasized for short-cycle programs during the so-called Bologna process, namely: to train graduates for employment as well as prepare them for further studies (Slantcheva Durst 2010).

This dual responsibility gave rise to a tension. Although the courses were designed as terminal courses, van de Graaff (1976) noted that already in 1976 more than one third of IUT graduates went on to higher education. Since then the proportion has been steadily increasing, indicating an institutional identity problem, a clear mission drift of IUTs and a policy drift by the French Ministry of Education (Ratouly 1975, Reichert and Smith 2009, p. 47).

Regarding the composition of the teaching staff of the IUTs, this was from start the remit of the Ministry of Education. According to van de Graaff (1976) national policy was aiming at a symmetrical, tripartite composition of the teaching staff. One third should be drawn from higher education, one third from the lycées, and finally one third from industry representing the relevant professions. Here national policy failed. Instead this requirement gave rise to a number of tensions. First it led to a sharp division between secondary personnel mainly from technical secondary education and higher education personnel from universities. As secondary personnel did

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1 These figures are based on personal communication with Bernard Delahousse, former teacher and head of the International Office at IUT "A" – Lille 1; actually they vary from one IUT department to the other, especially industrial departments vs. business ones.

2 To be more precise, this symmetrical dimension did not apply to the personnel composition properly speaking, but to the quota of teaching hours delivered by each category, i. e. a third of the total contact hours over the 2 years was to be taught by university personnel, a second third by teachers from the lycées and the last third by engineers or executives from the professions.
not possess the proper credentials for university employment they could in a formal sense only be temporarily assigned to IUTs. A second tension was that if and when university personnel wanted to become involved in the IUTs they deliberately had to sacrifice all possibility of university promotion as promotion would depend on their research productivity for which there was neither sufficient time due to a high teaching workload nor facilities in the IUTs (van de Graaff 1976, p. 201).

When the Bologna Process was launched in 1999 by the European Commission to create transparency in European higher education by gradually implementing a common scheme of curricular cycles (3+2+3) throughout EU member states, it came as a shock for higher education in France as the French degree structure was not attuned to the new system (see Malan 2004, Witte et al. 2008, Mikhail 2008). Even though the diploma (the DUT) offered by the IUTs was equivalent with the first French university 2-year cycle, it could not be considered equivalent with the proposed new first 3-year cycle leading to a bachelor’s degree. Therefore as argued by Witte et al. (2008, p. 218) the change of degree structure was an opportunity for policy makers and other stakeholders to reconsider institutional identities and the distribution of roles and status between the institutional types in the system. As a consequence a process of curricular drift in IUTs towards la licence professionelle started.

The licence professionelle (bac+DUT+1) is equivalent with the new French vocational bachelor degree which was introduced in 2000-2001. The licence professionelle is conferred by universities along with IUTs (Malan 2004, p. 294). The development of IUTs and the connections to more advanced levels of engineering education might be interpreted as a process that in many ways resembles what Neave (1979) has called “curriculum inversion”. This concept is understood to mean that practical vocational education comes first in all engineering courses and degree programs no matter what kind of institution offers them to ensure the employability of candidates to be followed later by more advanced theoretical studies.

German Fachhochschulen

When German Fachhochschulen started operation in 1971 the historical point of departure was the inertia and resistance to change in the German university system which was still to a high degree committed to the core values of the Humboldtian University. To be sure, its core values “autonomy”, “unity of teaching and research”, “unity of all knowledge”, and “scholarly life in solitude and liberty” were still kept alive after the reconstruction of the German university in the wake of World War II (Rau 1993). These values were seen as the sound core of the German university after the damaging effects of the Nazi period. However, as argued by Rau, the Humboldtian values only appealed and apparently still do to a tiny fraction of students, those namely “who are interested in a research career or those who are in a position simply to enjoy a liberal education”. According to Rau the majority of students cannot be adequately served this way. They need and want “a vocational orientation, often look for social, political or ecological meaning in their studies, and are often rather bored by the kind of teaching which is delivered at the university” (Rau 1993, p. 40).

To accommodate the vast increase in student numbers in the 1960s it was assumed that expenses for higher education in Germany, as well as in France and the
UK, could not increase to the same extent as the growth in student numbers. Therefore structural changes were needed in order to serve the new types of students and the needs of the labor market in a more cost efficient way (Teichler 1996).

In Germany the advent of Fachhochschulen in 1971 should therefore be seen as a policy response to the need for structural change. The change marked a transition from a dual system of higher education to a binary system. The binary system was created by means of horizontal integration of former engineering schools (Ingenieurhochschulen) and higher vocational schools (höhere Fachschulen). The latter were predominantly representing economic and applied social science areas. The binary divide applied to engineering education in much the same way as the binary divide in the UK. Universities and Fachhochschulen should complement each other regarding their education of engineers and the professional qualification of their graduates. The underlying concept was that Fachhochschulen were different in nature but were supposed to be equal in status to the universities. According to Taurit (1993, p. 23) the role of the universities was:

- To preserve the unity of science, the variety of disciplines, and the autonomy of faculty members and institutions.
- To ensure the unity and equivalence of research and teaching, to educate future generations of researchers, and to build strong communities of professors and students.
- To be the only institutions with the exclusive right to award Doctoral degrees. However in engineering degree programs universities had a right to award both Dipl. Ing. and Dr. Ing.

The research of universities was therefore characterized by a strong focus on fundamentals related to engineering disciplines but could also be engaged in applied research. In contrast the profile of Fachhochschulen was characterized by the following seven features:

- Practical orientation
- Short terminal courses for direct employment leading to the engineering diploma and title Dipl. Ing.
- School-like teaching methods including periods of internships in companies
- Emphasis on teaching
- Courses attuned to the demands of the labor market
- Partnerships with predominantly small and middle-sized companies in the region
- Applied development and research

Student admission was mainly based on two different routes. Taurit (1993) estimated that in 1993 half of the students were admitted via the Abitur from the Gymnasium plus half a year of practical training. The remainder of students were admitted via extensive practical experience acquired through three years of apprenticeship in a craft. The vocational orientation of Fachhochschulen was further reflected in requirements for staff employment. Professors were required to have 3 to 5 years of
practical experience in industry after their doctoral degree. According to Teichler (1996) in 1991 on average 84% of regular academic staff were professors.

Like the policy behind British polytechnics German higher education planners were concerned to create a stable system able to resist the pressures of academic drift from the “less noble” sector. The merit of a stable system would be its ability to counterbalance “the trend that too many want to become “chiefs” and too few want to remain “Indians’”” (Teichler 1996, p. 128). In 1996 Teichler noticed confidently that the Fachhochschulen seemed to have achieved this goal. However with the benefit of hindsight it has fascinated me that Teichler, a keen educational observer of structural changes, has been proven wrong. Academic drift had not been prevented once and for all.

Already from start there were a number of tensions in German Fachhochschulen. First among them was the degree structure. The German Dipl. Ing. is below the master degree, but above the bachelor degree. To begin with, the study for the engineering diploma was planned to take three years, but from the 1980s the duration of the courses increased to between four and a half and five and a half years (Grose 2000). This meant that the degree structure came out of tune when compared with the bachelor, master and doctoral degree system. A second tension was that Fachhochschule graduates were not entitled to become master and doctoral candidates due to the terminal nature of their courses. If they wanted to study for a master or a doctoral degree they would have to complete a university degree in toto (Teichler 1996, p. 126). A third tension was related to the teaching workload of faculty members and professors (18 hours per week) and the possibility of doing research. In this tension was also included the question of salaries. Salaries were on average 20% lower than the salaries of university professors. Finally, even though on average 84% of faculty members in Fachhochschulen were professors, they were not allowed to train their future faculty members and professors. These tensions would appear to be unsustainable in the long run. Furthermore since the reunion of Germany after the fall of the Berlin Wall in 1989 and the Iron Curtain it was also an enormous challenge to integrate the educational systems of East and West Germany.

As a result of the Bologna process starting in 1999, the unification of degree structures (3+2+3) took place both in Germany and France. However the prime concern of the reforms was to harmonize the two first cycles. In the UK the new bachelor, master, doctoral degree structure was not new but already existing. In Germany this process went further than in any other European country. As a result, the final outcome in Germany was that the gap between the two types of institutions in the binary system eroded from 1999 to 2004. From 2004 onward both Universities and Fachhochschulen were able to offer both academic research-oriented programs and professionally- or practice-oriented programs. This development may be interpreted as a de-institutionalisation of degree types in the sense that both types of bachelor and master degrees could be offered in both types of institutions. With the erosion of the binary divide between universities and Fachhochschulen Germany came very close to a transition to a unified system of engineering education (Witte et al. 2008, p. 222, Vogel 2009). Contrary to Teichler’s expectations in 1996, academic drift can be said to have destabilized and eventually almost abolished an apparently stable binary system.
Dimensions of academic drift in the three institutions

To be able to briefly summarize and compare academic drift in British polytechnics, French IUTs and German Fachhochshulen, an operational definition of academic drift will be needed. Here I draw on my introduction, and in addition I draw on Neave (1979, p. 155). The main difference between my conceptualization and Neave’s is that what I have termed staff drift serves as the exclusive definition of academic drift in Neave’s conceptualization. Neave in turn draws heavily on Pratt and Burgess (1974). Given this relationship, it should therefore come as no surprise that British polytechnics as an ideal typical case of academic drift live up to the operational definition. In the following I shall therefore concentrate mainly on French IUTs and German Fachhochschulen with an eye to recent mergers of Danish engineering colleges and universities.

Table 9.1 Operational definition of academic drift

<table>
<thead>
<tr>
<th>Dimensions of academic drift</th>
<th>Administrative locus</th>
<th>Definition</th>
<th>The three institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Policy drift</td>
<td>Central Administration</td>
<td>Inadequately defined objectives, failure to enforce policy, reluctance to monitor implementation of policy, and to intervene at an institutional level</td>
<td>British polytechnics, French IUTs, German Fachhochschulen</td>
</tr>
<tr>
<td></td>
<td>Regional Administration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Institutional drift</td>
<td>Individual institutions or institutional type</td>
<td>Reorganization of course structure along academic lines, attempt to seek parity with the university sector, re-definition of institutional objectives by institutions themselves</td>
<td>British polytechnics, German Fachhochschulen</td>
</tr>
<tr>
<td>3. Staff drift</td>
<td>Faculty members and departments in the individual institution or type of institution</td>
<td>Emphasis on advanced work, less significance attached to part-time students, or to recurrent education, increasing emphasis on academic values, practices, and research, and failure or lack of will to recruit experienced “practitioner” personnel</td>
<td>British polytechnics, French IUTs</td>
</tr>
<tr>
<td>4. Cognitive drift in curricular emphasis</td>
<td>Curricular content, the teaching context or situation</td>
<td>Increasing emphasis on abstract theoretical knowledge, gradual reduction in emphasis attached to experience based practical knowledge, move away from a utilitarian approach to an approach focused on engineering disciplines</td>
<td>British polytechnics, French IUTs, German Fachhochschulen</td>
</tr>
</tbody>
</table>

A common characteristic of the three institutions was that their objectives were similar, namely:

- Meeting the demands for vocational, professional and industrially based courses of a terminal nature
To train middle-level technical personnel for employment in small and middle-sized companies
The creation of a separate sector of higher education outside the universities.
Greater public control to ensure continued responsiveness to social and economic demands of the locality.
Increased standing of vocational and professional education.

However their attempts to seek parity with the university and to adopt academic values, practices and research were of different kinds. In any event these attempts, partly or wholly successful as they were, came to constitute a departure in terms of curricular emphasis from the above-mentioned objectives.

All three institutions were created from scratch. British polytechnics were upgraded to university status in 1992. In Germany the gap between universities and Fachhochschulen narrowed down or simply eroded from 2001 to 2004 as the outcome of the Bologna process. In contrast French IUTs were nested into universities already from start. Yet a different attempt to seek parity with the university would be merging engineering colleges with universities. This attempt has been the dominant trend in Denmark since the mid-1990s. In Denmark professional engineering colleges - former so-called Teknika - were created in the early 20th century and were from start nested into technical schools for the crafts. In 1962 Danish Teknika gained independence from the supervision by the technical school leadership and became part of a binary system of engineering education (Frandsen and Harnow 2011). The following figure illustrates the development of Danish professional engineering education institutions from the early 1970s to the present (See Christensen and Ernø-kjølhede 2011, p. 290).

In the table a lack of year indicates that only an informal and loosely defined association with a university has taken place presently. However it also indicates that a future merger is likely to take place with the respective university. The end of structural reforms in professional engineering education is destined by an act of the Danish Parliament to be completed no later than by 2015.

Table 9.2 Merging Danish professional engineering education institutions from the mid-1970s to the present

<table>
<thead>
<tr>
<th>University Colleges</th>
<th>Engineering Colleges</th>
<th>Universities</th>
<th>Engineering Academies</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Kristians (2006)</td>
<td></td>
<td></td>
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<tr>
<td>Holbæk (1997)</td>
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<tr>
<td>Hillevig (1995)</td>
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<tr>
<td>Esbjerg (1965)</td>
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<tr>
<td>Copenhagen</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Odense (2000)</td>
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<td></td>
</tr>
<tr>
<td>Herning (2006)</td>
<td></td>
<td>Aarhus University</td>
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</tr>
<tr>
<td>Aarhus</td>
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</tbody>
</table>

(Based on Frandsen et al. (2011, pp 149-152)).
In the table it is noteworthy that the only institution that merged horizontally into a polytechnic type of institution presently seems to have regretted its decision and now wants to merge vertically with a university instead.

In French IUTs academic drift took place in dimensions 1, 3 and 4. What triggered the drift process was the emergence of a changing pattern of education among entrant students, causing a mission drift by IUTs as the majority of students went on to higher education. Mission drift therefore took the form of a drift away from the original vocational and terminal nature of the course. A contributing factor here was the selective admission of only high-calibre students. The acceptance of the mission drift of IUTs by the French Ministry of Education may be seen as a clear example of policy drift. In dimension 3 academic drift took place as the originally planned tripartite recruitment of faculty members could not be fulfilled. Neave quotes Jean Capelle (senior civil servant under De Gaulle) for saying: “Disillusion with the IUTs set in when they slipped from the hands of men who practiced commercial and industrial affairs as part of their daily life… Instead they have turned into talking shops (institutions bavardes) – sub-universities run by a surplus of students from doctoral seminars or under the aegis of university chair holders” (Neave 1979, p. 151). The quotation, which of course in itself is no valid evidence, indicates that increasing emphasis was put on academic values, practices and research. Finally drift in dimension 4 set in during the Bologna process where the degree structure became gradually attuned to the bachelor level (Bac + DUT + 1), therefore causing the two-year courses to drift towards the three-year licence professionelle.

As I have shown, the German binary policy attaching different roles and status to universities and Fachhochschulen was relatively stable from the early 1970s until 1999 when the Bologna Process started. In itself there was nothing in the Bologna Process that indicated that the binary system could not be sustained after the harmonization of degree structures. However, in addition to the Bologna Process, the current German reform agenda is concerned with the introduction of market-oriented, competition-based academic self-governance by hierarchical structures and powerful management positions like in many other European countries (Vogel 2009, p. 1). Moreover, as argued by Witte et al. (2008) the policy formulated by German state actors and advisory bodies started to drift “as the state actors and advisory bodies’ perception that Fachhochschulen were doing a better job than universities in providing relevant higher education at moderate cost to large numbers of student, certainly contributed to their willingness to narrow the status gap between universities and Fachhochschulen” (Witte et al. 2008, p. 225). As a result there is clear evidence of academic drift in dimension 1. The de-institutionalization of degree types is evidence of institutional drift and a blurring of institutional boundaries in dimension 2. In dimension 3, it would be difficult to speak of academic drift related to recruitment of staff and the professorate in Fachhochschulen as Fachhochschule professors are tenured academics with years of experience outside academia. However there is a difference between university professors and Fachhochschule professors. University professors “insist that defining their own standards, applying their own scientific judgement, and making decision about their own affairs on the basis of criteria that reflect the inner logic of the academic world”. These values form an integral part of their professional identity and are deeply rooted in the Humboldtian principle of “solitude and freedom” (Vogel 2009, p. 1). Contrary to that Fachhochschule profes-
sors regard managerial and market-oriented reforms as aligned with their professional identity.

Regarding cognitive drift in curricular emphasis – dimension 4 – there is clear evidence of cognitive drift in curricular emphasis. The original terminal nature of the curriculum has been changed and adapted to a new degree structure and the need by students for higher educational credentials to be able to compete in the job market. However Fachhochschulen may still be devoted to their professional mission, the difference is that they implement this mission in a more academic mode than before (Jónasson 2006). Moreover Fachhochschule professors, according to Vogel (2009), perceive their substantial teaching obligation as a prime threat to their professional identity. This is an indication that research and in particular applied research would better fulfill their normative professional ideal and therefore might be expected to have spill-overs to the teaching function in the sense of gradually shifting away from being work-based to being text-based instead. Jónasson (2006) has argued that in general “the new combined institution assumes to all intents and purposes the character of the higher-prestige institution” (Jónasson 2006, p. 9). However Fachhochschule professors do not have an individual obligation to be research-active. The research obligation rests only with Fachhochschulen as an institution. The current ambition of Fachhochschulen is to improve their research conditions and to obtain the right to award doctoral degrees (Vogel 2009, p. 5). To the extent that Fachhochschulen succeed in fulfilling this ambition a number of tensions and dilemmas is likely to occur.

Kyvik and Skodvik (2003) have argued that a new type of tensions and dilemmas related to status and funding is likely to emerge when non-university institutions are trying to emulate university values, practices and research. In so doing, it has been evidenced in the same type of institutions in Norway that they gradually became entangled in the following eight tensions and dilemmas related to allocation of resources and recruitment of staff (Kyvik and Skodvin 2003, p. 205):

- Allocation of resources – R&D versus teaching
- Distribution of R&D resources – quality criteria versus need for developing research skills
- Distribution of R&D resources – institutional versus individual rights and obligations
- Research-based teaching versus dissemination of advanced knowledge
- Recruitment of staff – research abilities versus professional experience
- Distribution of R&D resources – specialization versus breadth
- Vocational and regionally oriented research versus discipline oriented research

Building research capacity in former non-university institutions implies that both faculty members and students should be acquainted with the scientific culture, scientific methods and developments within their field. Moreover building research capacity also relates to the question of research-based education. In 1998 the Danish Ministry of Science, Technology and Innovation listed 5 interpretations of research-based education indicating the scope of the concept: 1. Instruction in research methodology given by active researchers, 2. Instruction given by active researchers within their research area, 3. Instruction given by researchers, 4. Instruction given in institutions governed by researchers and in which the course material has been developed by researchers, and 5. Instruction given in institutions which are under supervision of research institutions and in which the course material is developed by researchers. (Skoe 2000, p. 412).
Institutional control of R&D versus the staff’s own preference

Conclusion

In 2006 Jónasson (2006) argued that a combination of academic drift and the effect of credentialism might be used to predict the convergence of institutions and systems of higher education under conditions of further expansion of higher education. A summary of his argument would also serve as a summary of the overall argument that I have been trying to advance in this chapter. In the three institutions examined here two main drivers of structural change may be observed. On the one hand, there has been a general trend since the 1960s towards quantitative expansion and massification of higher education. On the other hand, massification has been countered by structural transformations and diversification of national educational systems. The prime objectives of structural transformations have been: 1. to ensure that higher education contributes to the economy, 2. to accommodate increasing numbers of an increasingly diversified student body in more cost-efficient ways, and 3. to take enrolment pressures away from the university. Furthermore structural dynamics have become increasingly complex as they have moved beyond the nation state to a trans-national level. Even though the increase of engineering student enrolments might appear to have been relatively smaller than elsewhere in the educational system, professional engineering education has nevertheless been affected by the above-mentioned structural dynamics, but in various ways as it has been shown.

At a descriptive level, Kyvik’s phase model captures a general pattern of institutional transformations in the non-university sector. As it has been argued in this chapter British polytechnics and German Fachhochschulen have developed in accordance with the model whereas French IUTs differ from it. Whether institutions fit the bill or not may be due to historical initial conditions which have been described in the three historical reference models of higher education. However what is lacking in Kyvik’s phase model is a causal mechanism which would be able theoretically to provide a causal explanation of the above-mentioned structural transformations and the functioning of academic drift. Such framework for causal theorizing has been elaborated by Jónasson (2006). Jónasson has termed his approach the credentialing perspective. The credential account implies

that public policy initiatives and the demand for a skilled workforce should be seen as external modulating or facilitating factors rather than as primary causal mechanisms. The students (according to this account the primary consumers of education), along with their aspirations for educational credentials, are interpreted as a substantial driving force behind educational expansion. The academic faculty, on the other hand, having a similar aspiration for status, affect the internal structures of institutions and of the system, partly as a response to institutional growth and partly as a method to gain status, which leads to the academic drift that we witness.

(Jónasson 2006, p. 4)

According to this account structural transformations of institutions and educational systems take place in three steps. First, students in search of credentials to be able to better compete in job markets drive educational expansion. Second, academically
inclined faculty members on the one hand and institutional leadership on the other with similar aspirations for individual and institutional status are looking for an opportunity to revamp internal institutional structures along academic lines, thus creating a push for structural change of the educational system. For institutions this means that they would be more competitive in the market for higher education as the credentials they award are more attractive to larger numbers of students than those offered by institutions with less prestige. It also means that they would be better able to attract high-calibre students thus allowing themselves to be more selective. Third, the constant push created in the first two dimensions is modulated by policy initiatives and manpower planning considerations. According to this perspective the Bologna Process should not be seen as a causal mechanism but rather as an opportunity for policy makers and other constituencies to reconsider institutional identities and the distribution of roles and status between the institutional types in the system.

I shall now return to the three questions that were posed in the abstract, namely:

1. What do we know about the processes whereby the engineering curriculum has been constituted? 2. Are such processes inevitable and irreversible? and 3. What kind of tensions and dilemmas do they create? To answer the questions in the inverse order the third question has already been dealt with at the end of the previous section. The eight tensions and dilemmas presented here may be seen as of a general nature. They almost inevitably will arise when former non-university institutions try to emulate academic values, practices and research. Regarding the second question I tend to share the view put forward by Jonasson (2006). According to him academic drift is a primary characteristic of long-term educational development of non-university institutions and higher education systems. It should therefore be seen as an irreversible process and a natural part of the trajectories of educational institutions and systems. Generally transformations take place in moments of opportunity provided by external state, public, private or transnational agencies. However the void after the transformation of institutions may need filling by a new type of short-cycle institution and the process can go on once again. Regarding the first question it has been shown how the three institutions came into being with a clearly defined mission and a clear vocational emphasis in the curriculum that eventually was exposed to cognitive drift. However here we should be more cautious to generalize as pendulum movements between theory and practice historically have been seen many times in engineering education as demonstrated by Harwood (2006) and Heymann (2009).

In 1979 Neave (1979, p. 157) pointed to a particularly powerful and coherent set of academic values and attitudes that worked against the objectives set for the three institutions. It is not unlikely that these values and attitudes will continue to exert their influence in professional engineering education as pressures for higher credentials is steadily increasing. The elements of this value system are the following:

1. That higher education is based upon a concept of personal autonomy.
2. That higher education is distinguished by its grounding in research.
3. That dissemination of knowledge requires the academic to work at the cutting edge of his/her chosen field – at the boundary of discovery.
4. That staff should be of the highest quality, such quality being judged in terms of scholarly performance.
5. That institutes of higher education cannot develop effectively if, at the same time, they have to attend to the demands of non-degree students.
6. That students, if they are to derive the fullest benefit from higher education, must be full-time.

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Chapter 11

Reengineering Engineers
Towards an Occupational Ideal of Bildung in Engineering Education

Steen Hyldgaard Christensen and Erik Ernø-Kjølhede

Abstract: This chapter argues the need for a new occupational ideal of Bildung for engineers. The purpose of this ideal is twofold: 1) to provide future engineers with better skills in critical reflection and cross-disciplinary collaboration than those of today, and 2) to make engineering more attractive as a profession to students. To justify the relevance of a new ideal of Bildung in engineering education, to identify its normative foundation, and to argue the case for a change in engineering syllabi, we will discuss four questions: 1) What are the main characteristics of the engineering culture and the engineering ethos? 2) How can the ontological and epistemological basis of engineering be described? 3) To what extent is the engineering culture a barrier for Bildung in engineering studies—especially at the undergraduate level? 4) How can this barrier be overcome? As a parallel to obligatory courses in “Philosophy of Science” in university science education, we also propose a new, metadisciplinary course in “the historical, philosophical, and ethical foundation of engineering” for students at engineering colleges.

Introduction

It is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. This is the engineer’s privilege

(Whinnery, 1965:V)

The engineering culture has almost become a myth and it is an intriguing topic for researchers all over the world. It has in particular been studied by engineers themselves and by researchers from the social sciences and the humanities. They all seem to agree that engineers believe in a relatively uniform engineering culture common to all engineering domains. Among others, Leonardi (2003) observes that the engineering culture is astonishingly coherent, pervasive, and persistent. What it means to be an engineer is apparently as self-evident for the engineer as for everyone else. Among social scientists, the engineering culture has been interpreted in terms of a coherent and pervasive ideology – which we could call “the mythos” of engineering culture. Especially in feminist research, the social norms of the engineering culture have been much debated in recent years (Hacker 1981, Carter & Kirkup 1990, McIlwee & Robinson 1992, Copeland & Lewis 2004). Increasingly, a shift in the way women’s underrepresentation is understood and explained has been advocated.
Instead of problematizing what could be seen as the lacking qualifications of women, the very culture of engineering is seen as the problem; especially, an apparent dominant masculinity in engineering faculties and in the profession has been called into question. Accordingly, this shift can be described as a shift from a deficit model to a cultural change model; a perspective, which we share.

Relevant as it may be, this approach nevertheless misses important facets of the engineering culture as it only questions the environment of science, engineering, and technology in the perspective of equity and diversity. It does not address the instrumental rationality, which often tends to reduce engineering to one-dimensional thinking at the expense of critical and broader social, human, environmental, and ethical reflection. The focal norms in feminist research on engineering culture are not norms derived from the technological practice of engineering, but broader social norms underlying the social division of labour. These norms are reinforced and perpetuated in the engineering culture in such a way that they may work to exclude, alienate, and isolate women who become, by definition, the outsiders.

As an extension of the cultural change perspective, this chapter views the following elements as important constituents of the engineering culture: the epistemic values of engineering, the norms derived from technological practice, the ontology, the epistemology, and the instrumental rationality of engineering. We believe that this conception of the engineering culture will allow for a more comprehensive discussion of engineering, competence, and Bildung. The chapter addresses four main questions: What are the main characteristics of the engineering culture and the ethos of engineering? How can the ontological and epistemological basis of engineering be described? To what extent does the engineering culture work as a barrier for Bildung in engineering studies - especially at the undergraduate level? How can this barrier be overcome?

We take our point of departure in the definition of “occupational culture” offered by van Maanen and Barley (1984). Their definition is a two-step definition containing a social and a cognitive component. The social component is defined by the concept of an “occupational community”:

An occupational community is a group of people, [1] who consider themselves to be engaged in the same sort of work; [2] whose identity is drawn from the work; [3] who share with one another a set of values, norms and perspectives that apply to but extend beyond work-related matters; and [4] whose social relationships meld work and leisure.

(Our numbering; van Maanen & Barley 1984:287).

The cognitive component is defined by the concept of “work culture”, which is “the things a person must know to be a member of a given group” (op. cit.:308). In our view, the cognitive component can in brief be interpreted as the epistemic culture of engineering (Knorr-Cetina 1999, Bucciarelli & Kuhn 1997). Our definition of the occupational community of engineering also applies to engineering faculties in universities and other institutions, i.e. engineering colleges and polytechnics, the latter being our primary focus of interest. Throughout this chapter, we thus distinguish between the more “theoretically oriented” academic engineer who graduated from a university, and the more “practically oriented” engineer with a bachelor’s degree who chiefly graduated from other institutions of higher education. This distinction between “academic engineers” and more “practically oriented engineers” is found in varying degrees in many countries. In Denmark, for instance, it is very clear. In
Denmark, the ministerial responsibility for academic degree courses in engineering (BSc, MSc, PhD) is thus located in the Ministry of Science, Technology and Innovation, whereas the more practically oriented engineering degree courses (BSc) are the responsibility of the Ministry of Education. Throughout this chapter, it holds that if this distinction between academic and more practical orientation is not specifically mentioned, we speak of engineering in general.

In the final chapter, our intention is to argue the case for an occupational ideal of Bildung in engineering education that is linked to the above definition of “occupational culture”. In our view, “occupational Bildung” is thus seen as an additional component to van Maanen and Barley’s definition of occupational culture. Thus, we define occupational Bildung as the ability to reflectively transcend occupational culture in the direction of the common good. The purpose of making way for an occupational ideal of Bildung in engineering education is to increase the professional quality and the attractiveness of the profession. It is beyond the scope of this chapter to discuss the concept of occupational Bildung in greater detail, but for further elaboration see, e.g. Børsen Hansen et al. (2000: 135-140).

What Are the Main Characteristics of the Engineering Culture and the Ethos of Engineering?

These, then, are what I take to be the main elements of the engineering view: a commitment to science and to the values that science demands— independence and originality, dissent and freedom and tolerance; a comfortable familiarity with the forces that prevail in the physical universe; a belief in hard work, not for its own sake, but in the quest for knowledge and understanding and in the pursuit of excellence; a willingness to forgo perfection, recognizing that we have to get real and useful products “out of the door”; a willingness to accept responsibility and risk of failure; a resolve to be dependable; a commitment to social order, along with a strong affinity for democracy; a seriousness that we hope will not become glumness; a passion for creativity, a compulsion to tinker, and zest for change.

(Florman, 1987: 76).

This is the credo of a civilized, reflective, and distinguished engineer as presented in the two books “The Civilized Engineer” (1987) and “The Introspective Engineer” (1996) by Samuel C. Florman. His “engineering view” summarizes an ethos for the engineering culture and presents the engineer as a scientist invoking the claim of expertise and paying his tribute to the norms of science. However, one may ask if this is a true picture or if it is rather a rosy myth of the engineering culture? In the first part of this section we shall give an account of “the myth” of the engineering culture. In our view, this myth is a strong integrator but also a strong segregator— a potential source of cultural conflicts (Workman, 1995). In the second part of the section, we take a critical look at engineering culture from the perspective of the sociology of science.

McIlwee and Robinson (1992) and Leonardi (2003) provide a suitable framework for discussing the mechanisms through which the engineering culture integrates its members and maintains its coherence. The approach of McIlwee and Robinson is founded both in conflict and interactionist theory of cultural reproduction. The focus of the conflict approach is on power relations that allow the values of some groups to become dominant. In this perspective, not only the values, norms, and styles of
Reengineering Engineers: Towards an Occupational Ideal of Bildung in Engineering Education

discourse, but also the relations of power behind them are to be conceived as mechanisms of cultural reproduction. According to the interactionist approach, culture manifests itself through daily activities and interactions. From this perspective, culture is “impression management”, the function of which is to create an impression on others and advocate adherence to a certain set of values. This impression is created through forms of talk, styles of interaction, and modes of dress that signal belief in these values.

In the eyes of McIlwee & Robinson, the engineering culture consists of norms and values regarding “correct engineering practice”. This practice is defined by male engineers and is created and maintained through daily patterns of interaction in the workplace and in the training grounds of engineers (universities, colleges etc.). It is an ideology based on three major components; 1) The centrality of technology and the role of engineers as developers, producers, and protectors of technology. 2) The acquisition of organizational power as a sine qua non for the success of an engineer. 3) That the interest in technology and organizational power is presented in an appropriate form – a form closely linked to the male gender role.

Like any other “occupational community”, engineers share an interest in solidifying their power and prestige. This is achieved by defining an ideological relation to work focused on technical knowledge, which in its abstract form is monopolized by the engineer. An important part of this ideology is the display of the fascination with tools, machinery, and gadgets. In the engineering culture, “the good engineer” is not only technically competent in his area. He is supposed to be “obsessed” with technology. This ideology is an important means through which engineers rise into management and it is also a way of expanding the occupational boundaries of engineering. A vital part of the “impression management” of an engineer is to display the image of a forceful, competitive, technically oriented person with hands-on experience. To be perceived as an engineer is to look, talk, and act like an engineer– a behavioural style closely linked to the male gender role (McIlwee and Robinson, 1992).

Especially the interactionist approach is from our perspective interesting since the conflict approach, unveiling the mechanisms of power of an expansionist ideology, is flawed in as much as the technological component to all intents and purposes remains a black box and the set of norms therefore too simplistic. For further elaboration on the norms and values of the engineering culture, we turn to an approach put forward by Leonardi (2003). Leonardi points to five characteristics of what he terms “the mythical engineer”. Leonardi’s five characteristics are derived from an extensive literature review and he furthermore claims to have found, in his own research, empirical support of the relevance of these characteristics (2003:102). In toto, Leonardi’s characteristics have the status of a Weberian ideal type, by which is understood that, in order to give the cognition unique means of expression, certain features of the phenomenon are formalized and comprised into an ideal type, which empirically is not, or only rarely, found in its pure form. For our purpose, we interpret these characteristics as norms. In Leonardi’s account, the focus is thus not whether the above myth portrays the reality of the engineering day-to-day practice, “but rather how that myth intersects with the ways engineers interact with others” (Leonardi 2003:27).

In Leonardi’s account, the engineering culture consists of five characteristics (norms):
The Maverick
The Expert
The Macho
The Technophile
The Non-Communicator

In our view, this normative concept of “being a real engineer” can be seen as quite parallel to the normative concept of “being a real man”. Briefly put, the five norms stipulate:

1. A real engineer is an individualist, a tinker by nature who works independently (the Maverick norm).

This norm is associated with the engineer’s craft orientation. A high value is attributed to the ability to think practically and work skillfully. Engineering work is centred on the solitary engineer tinkering with technology, often giving rise to stereotypes and the image of a “nerd”. Usually, engineers spend long hours at work, establishing a close relationship to the technologies they are creating. As a consequence of the high value put on the technical and practical applicability of their work, engineers often understand themselves as autonomous individuals.

2. A real engineer should be in possession of the expertise to know the right answer (the Expert norm).

The relationship between science and engineering is an often debated topic. Within the profession, engineers frequently see themselves as a kind of scientists. They enter their profession through “the portals” of science. Although technical craft work occupies most of the time in engineering, engineers often display an ethos of expertise by pronouncing the science of their work. In engineering education, hands-on experience and prowess at scientific engineering talk are highly valued. As an expert invoking the discourse of science, the engineer alone claims the right to do engineering and make design and implementation decisions. As Workman (1995) observes, corporate engineering departments often have problems communicating with other departments because engineers insist on their expertise in technical matters and are unwilling to accept the relevance of other points of view.

3. A real engineer should be dominant, aggressive, and competitive (the Macho norm).

The creation of a culture of “the right answer” is linked to masculine ideals of showing strength. Male dominance, possessiveness, aggressiveness, gender-role rigidity, and a constant need for respect are seen as basic tenets of the engineering culture. Competence in engineering depends on how well the image of an aggressive, competitive, and technically oriented person is presented; display of technical self-confidence and hands-on competence being important criteria for success in the engineering culture.

4. A real engineer should be dedicated to technology (the Technophile norm).
As pointed out by Weizenbaum (1976), a certain degree of compulsion or even “obsession” characterizes the relationship between the engineer and the technology. Being in command of technology and being the creator of technological advancement in society are strong components in the way engineers view themselves. In a broader perspective, the engineering culture stresses the importance of technology over personal relationships and even over formal abstract knowledge (Robinson & McIlwee, 1991).

5. A real engineer should communicate with engineers only on essentials and in technical style— but with others “less is better” (the Non-Communicator norm).

Poor performance in oral and written communication is generally a conspicuous element in engineering education coupled with explanations of engineering studies focusing elsewhere. It is well-documented that an intimate relationship with technology and an omission of interpersonal interactions in daily work may prevent engineers from working and communicating effectively with others; a corollary of which is that it becomes difficult for engineers to understand other people’s ways of thinking, as put forward by Workman (1995).

The first part of this section has discussed the social norms and values of the engineering culture, focusing on mythical and ideological aspects. It has been argued that the cultural change perspective of feminist research is fruitful, but too narrowly focused on the disablement of women. In our perspective, aspects of the engineering culture such as the above can in fact be said to disable both men and women. Thus, we argue that the above myth of the engineering culture is in itself a threat to the engineering profession. If and when this myth intersects with actual engineering practice, it makes it difficult to cooperate with engineers and makes it difficult for engineers to transcend this myth. In contemporary society, it certainly also makes it difficult to attract students to degree courses that will initiate them in this culture—if Leonardi’s five characteristics are anything to go by.

As an alternative approach to Leonardi and McIlwee & Robinson, is it possible to conceive norms in engineering in another way and on this basis suggest an intellectual ideal of Bildung for engineers? In the second part of this chapter, we change perspectives as we will now take a look at engineering from the perspective of the sociology of science. We believe that this perspective can offer inspiration to building a new framework for reflections on Bildung in engineering education.

Sociology of science and engineering

An important concept in the sociology of science is the idea of a unified community of scientists held together by a set of scientific norms—much in line with the idea discussed above of engineers as a coherent group. Scientists are supposedly integrated through their adherence to these norms.

To create a basis for comparisons with engineering, our point of departure is Robert K. Merton’s classic norms of science from 1942 (1973). The Mertonian norms are habitually referred to by the acronym CUDOS (admiration/prestige) and constitute Merton’s original ethos of science:
COMMUNISM: Research results are public property and should be accessible to all. Researchers should see themselves as contributors to the scientific community’s common knowledge base. Research presses forward by building on past achievements and through co-operation. Therefore, results must be published in full as soon as possible.

UNIVERSALISM: The evaluation of research results should be based entirely on impersonal criteria and be without any form of prejudice against nationality, gender, race, personal characteristics, etc., or against a person’s scientific reputation.

DISINTERESTEDNESS: Researchers should be emotionally detached from their field of study and pursue truth with a completely open mind. Furthermore, research results should not be influenced by extra-scientific interests (e.g. political, economic, or religious).

ORGANIZED SCEPTICISM: Researchers are obliged to be critical not only towards the work of others, but also towards their own work. Possible sources of error, doubts, and weak spots in the research should be presented openly and the researcher should be his or her own fiercest critic.

More than 60 years after its original publication, it is easy to point to considerable flaws in Merton’s ethos of science. The most well-known alternative to the Mertonian norms are the counter-norms suggested by Ian Mitroff (1974). Mitroff lists 6 norms and contrasts them with those of the Merton school (in brackets). The work of Barber (1952) is included in the Merton school:

1. Rationality and non-rationality (rationality, Barber 1952)
2. Emotional commitment (emotional neutrality, Barber 1952)
3. Particularism (universalism, Merton, 1942)
4. Solitariness (communism, Merton 1942)
5. Interestedness (disinterestedness, Merton 1942)
6. Organized dogmatism (organized scepticism, Merton 1942)

Mitroff did not claim that his counter-norms should displace those of the Merton school. What he maintained was that all the above norms exist alongside each other and that it depends on the situation which of the norms takes the upper hand. In research on what Mitroff terms “well-defined problems”, he concludes that the classic norms are likely to be dominant. Such problems can be formulated in clear language and there is consensus among researchers as to how they should be dealt with. Thus, research on well-defined problems is essentially of an impersonal nature, whereas “ill-defined” problems are difficult to catch, there is disagreement on their solution and, moreover, the problems are likely to be more closely linked to the private property-oriented, emotional, subjective, and particularistic counter-norms.

Other ways of framing the norm discussion in science is to look at it in institutional terms and in terms of Modes 1 and 2 (Gibbons et al, 1994). Institutions and the modes are to some extent related according to Gibbons et al. They associate Mode 1-research (academic, truth-seeking research) with disciplinary research in universities. In Mode 1, they argue, there is a “provisional consensus among the relevant set of practitioners” denoting “a way of seeing things, of defining and giving priority to certain problem sets” (1994:22). In Mitroff’s terms, Mode 1-research thus chiefly addresses “well-defined problems”. Furthermore, the quality of knowledge produced in Mode 1 is evaluated and legitimated by a group of discipli-
nary experts acting as gatekeepers in the scientific prestige hierarchy. According to this line of argumentation, Merton’s norms are likely to remain of some consequence in disciplinary university research.

The institutional affiliation of Mode 2-research is less clear-cut. In mode 2, research takes place in many settings, both in universities, other institutions of higher education, government research organizations, and private undertakings. A characteristic of Mode 2 is its “transdisciplinary” nature and the fact that it is carried out in the context of application. On the face of it, this would from the outset seem to make Mode 2 linked primarily to private companies and government laboratories, considering their emphasis on practical application, “transdisciplinarity”, and socioeconomic goals. Yet, such emphasis may also be characteristic of some activities in universities as well and, consequently, a clear-cut distinction is not possible. Hence, Mode 2 emphasizes blurring of institutional differences, blurring of the boundaries between disciplines, and between basic and applied research. In terms of practical research work, this leads to a blurring of what constitutes the research problem, what the main priorities in solving it should be, and what the best research methods are to deal with the problem. Returning to Mitroff, Mode 2-research thus generally addresses “ill-defined problems”. Subsequently, in Mode 2, quality criteria cannot easily be located within the domains of a scientific discipline; they are fluid and dependent on context and on practical applicability, which would indicate that Mitroff’s norms are likely to have a larger impact than the CUDOS-norms in Mode 2.

The Mertonian norms represent an understanding of science rooted in academic research. In contrast, Ziman (1994, 2000) has suggested a set of norms that he claims to be characteristic of non-academic (typically industrial or government laboratory) research. Ziman’s norms are summarized in an acronym as well: PLACE. The acronym suggests that scientists working in non-academic research should carry out “Proprietary, Local, Authoritarian, Commissioned and Expert work”. These norms can be seen as reflecting the thoughts of Mitroff in that they too represent counter-norms to those of Merton. Ziman uses his norms to highlight the existence within science of a two-track-system with different communities adhering either to PLACE-norms (or Mitroff norms) or to academic norms like those of the Merton school. Furthermore, each set of norms is indicative of fundamentally different career patterns for researchers. Merton-style norms are associated with individual careers in pursuit of personal scientific reputation and prestige (CUDOS). PLACE-norms, on the other hand, are associated with organizational careers entailing a much closer identification with and feeling of common destiny with the researcher’s place of work. The PLACE-norms consequently imply a more collectivist attitude.

The reason for including a discussion on the ethos of science in this chapter is to provide inspiration for a new framework for reflections on occupational Bildung in engineering education. In this perspective, the point we would like to make based on the discussion on scientific norms constitutes a bit of a paradox. As we see it, the counter-norms of science as conceived by Mitroff and Ziman in fact give a more precise description of the norms prevailing in daily engineering practice than does much of the ideology of the engineering culture as, e.g. portrayed in Leonardi’s norms mentioned above. In our interpretation, engineering may in general thus be conceived as a Mode 2-activity taking place in a broad range of organizational settings and often with ill-defined criteria of quality – very much along the lines of Ziman’s PLACE-norms.
In terms of Bildung, we furthermore believe that the norm of "organized dogmatism" presented by Mitroff is crucial when approaching engineering education and engineering culture from a cultural change perspective. Changing this norm into a Mertonian norm of organized scepticism allowing for metadisciplinary and critical reflections is thus, in our view, a highly important element in arguing the case for a new occupational ideal of Bildung in engineering education.

How Can the Ontological and Epistemological Basis of Engineering Be Described?

The differences between the direct design of the artisan and the design drawing of the engineer are differences of format rather than differences of conception. In both cases the design starts with an idea—sometimes distinct, sometimes tentative—which can be thrown on the mind’s screen and observed and manipulated by the mind’s eye….Thus, far from starting with elements and putting them together systematically to produce a finished design, both the artisan and the engineer starts with visions of the complete machine, structure or device.

(Ferguson, 1993:5).

According to Ferguson, the core of engineering is “design”. To be able to discuss engineering competencies—the black box in much feminist research on engineering—the engineering practice has to be opened as regards its ontological and epistemological aspects. In this section, we briefly discuss the characteristics of engineering practice to be able to reflect upon the match or mismatch between engineering practice and engineering education.

Engineering practice is complex and diverse and consists of so many specialties that it may seem futile to try to find a common denominator. The organizational setting is also very diverse: from SME-enterprises to large, publicly funded research institutions. Engineers, thus, pursue very different kinds of carriers. Engineers design the heavy machinery of production, redesign household appliances, work to get people to the moon, design advanced weapons systems, schedule the dispatch of vehicles and raw materials to be processed, etc. (Bucciarelli & Kuhn 1997). However, there are of course also important common denominators. The ideology of engineering as being “science-centred” is the point of departure. The fact that engineering is based on science does, nevertheless, not automatically lead to the conclusion that engineering is “science-centred” (Davis, 1998, Vincenti, 1990). At the epistemological level, especially two kinds of knowledge characterize engineering work—pragmatic and scientific knowledge. As pointed out by Pentland (1997), engineering knowledge has traditionally been based on pragmatic criteria. A crucial difference between “pure” scientific knowledge and “mere” pragmatic knowledge is that scientific knowledge is believed to be independent of the particular interests or biases of the individual producing this knowledge. It is supposed to be objective and value-free (cf. Merton’s CUDOS-norms above). Quite opposite, pragmatic knowledge is subjective and value-laden (cf. Mitroff’s counter-norms and the PLACE-norms above). The claim that something works indicates that it works well enough for the present purpose, but that this purpose may vary as to time and observer. Mertonian scientific truth, on the other hand, is believed to transcend time, space, and culture.

Ferguson (1993), Bucciarelli and Kuhn (1997) have argued that the search for academic respectability—the transformation of engineering from a practical art to a
symbol-manipulating “science” – has weakened the engineer’s skills and distanced academic engineering from the employer’s needs. Unlike scientists, engineers have always been involved in practical matters, in making things and making them work. Even though mathematical or scientific analyses are important tools in engineering, successful practice depends on trial-and-error, local and contextual knowledge (Whalley & Barley 1997). In this respect, the nature of engineering knowledge differs from the more non-contextual nature of “Mode 1”-scientific knowledge as argued above.

As observed by Whalley and Barley (1997), engineering work is technical, not only because engineers use esoteric techniques and instruments, but because machines and systems are the ultimate objectives of engineering. Maintaining and improving existing machines and systems and designing new ones remain the core of engineering. To be able to manipulate physical objects to achieve practical ends, engineers must be in possession of an extensive body of contextual knowledge of materials, technologies, and techniques (Vincenti, 1990). Contextual knowledge is largely particularistic. It is tacit knowledge acquired through practice and difficult to verbalize. Contextual knowledge resides in the practitioner’s ability to find and interpret subtle cues where outsiders see no information. In this sense, engineering resembles a craft. The hallmark of craftspeople is their ability to find creative solutions and to render skilled performances based on an intuitive feeling of materials and techniques. Donald A. Schön (1983, 2001) speaks of “knowing in action” to describe the contextual knowledge and “artistry” of the engineer. This “artistry” is undertaken spontaneously without antecedent reasoning. A second facet of this “artistry” is “reflection in action”, originated by a surprise problem, which does not fit into the category of “knowing in action”. The engineer reflects in the middle of an action to make corrective interventions and adjustments by restructuring strategies of action, theories of phenomena, and ways of framing the problem (Wright, 2004). Accordingly, it seems justifiable to speak of the “reflective practitioner” (Schön, 1983). In our interpretation, this concept summarizes the instrumentalism of professional reflectivity.

As to the ontological aspects of engineering, Bucciarelli and Kuhn (1997) argue that engineering work takes place within two different “worlds”: the “object world”-encompassing a “mental world” – which, for reasons of brevity, we do not address-and the “social world”. Bucciarelli and Kuhn make three interesting points. Their first point is that the core of engineering is design (supported by Ferguson (1993), Whinnery (1965), Davis (1998), and Vincenti (1990)). Accordingly, engineering is not “science-centred”, but “design-centred”. Their second point is that the tendency to portray engineering as an applied science or as “science-centred” neglects the fact that engineering is a social process taking place in a social world. Their third point is that there is a mismatch between actual engineering work and engineering education; a point we address in the next section.

According to Bucciarelli and Kuhn, the “object world” is the domain of thoughts and actions in which engineers take part when working on any specific aspect or subsystem of the design. This kind of work consists of the engineer’s intensive interaction with the object of the design and involves different aspects: feasibility studies, computer programmes, theoretical and experimental work, data on the properties of materials, reliability analyses, etc. These aspects are not ends in themselves, but means to the engineering objective of “hardware” (Whinnery, 1965). Thus, work in the object world is first and foremost the esoteric work within a discipline. Disci-
disciplinary tools are brought to bear in a thought process, which is likely to be inaccessible to people from other disciplines, let alone a layman.

As engineering design is embedded in a larger context - a “social world” - the design process can be conceived as a social process as well. A complete design is not in the hands of a single individual. To proceed, engineers have to take into consideration legal restrictions and standards, performance requirements set by customers, they have to negotiate with others in the company, etc. Different worlds intersect the generation of work, which is fundamentally social and process-oriented — contrary to the above discussion on the mythical norms/characteristics of engineering (cf., e.g. Leonardi on the norms of Expert and Non-Communicator). No overriding instrumental strategy is at hand to reconcile and synthesize the diverse design interests. At the beginning of the design process, the performance requirements set by the customer is the basis of the layout of performance specifications, but even these requirements are subject to change. It is impossible to uphold these specifications within an ongoing process of modification, clarification, negotiation, and joint interpretation (Bucciarelli & Kuhn 1997:213). In this way, specifications, which seem clear at the outset, are challenged by the very design process. The design process is thus a process of discovery to uncover ambiguities, confusions, and contradictions.

Unlike the value-free constraints of scientific laws, other constraints are normative by nature, thus negotiable, e.g. codes of ethical conduct, environmental restrictions, costs of production, limitations in time, etc. Some of these constraints are more flexible than others, but they are all subject to a plethora of interpretations. In the “social world”, design can therefore be conceived as a process of communication, negotiation, and consensus. No single engineer, no scientific law, no technical imperative, and no normative constraint can dictate the design in its totality (Bucciarelli & Kuhn 1997:214). This totality is the synthesis of Bucciarelli & Kuhn’s ontological worlds. Briefly put, the epistemological values attached to the ontological worlds may be seen as utility (the object world) and consensus (the social world). (The epistemological value of Bucciarelli & Kuhn’s mental world - which for reasons of space we do not address - can briefly be characterized as innovation).

The way we see it, this excursion into the subtle realms of epistemology and ontology has very concrete consequences for the education of engineers as to improving the fit between engineering practices and engineering education. Firstly, as engineering is “design-centred”, engineering education should be “design-centred” as well. This means a better integration in daily teaching of often disjointed, narrowly defined, and frequently very time-consuming course modules such as, for instance, maths, physics, and chemistry, which do not reflect the open-ended character of the design process. Secondly, as engineering is embedded in a social context, engineers must learn to deal with that context and learn to see the legitimacy of contextual problems. Finally, engineering educators must be able to “read” the changing conditions of engineering in order to make adjustments in the syllabus or to design new degree courses to cope with the challenges of the global knowledge economy. In our view, this requires metadisciplinary knowledge, which much engineering education – especially of the practice-oriented kind – does not presently provide in a sufficient quantity.

To What Extent Does the Engineering Culture Work as a Barrier for Bildung in Engineering Studies – Especially at the Undergraduate Level?
Aspiring engineers’ first year or so at university is mainly spent taking mathematics and science courses. These are typically taught in authoritarian ways, with the apparent intent of getting students to think, speak, and act in terms of the theories and methods dispensed. The authority and hierarchy of knowledge presented are rarely open to question. Critical reflection on the historical settings of theory development or the modern contexts of its use is, if not openly discouraged by faculty, ultimately devalued by the students as a waste of time and energy. In this respect, the content of the students’ coursework is very narrowly defined; but in another respect, the content can make claim to universal importance.

(Bucciarelli & Kuhn 1997: 214-215)

As argued above, a conspicuous barrier to the Bildung of engineers is the (myth of) social norms and values of the engineering culture as, e.g. portrayed by Leonardi’s characteristics (2003). Given that values and norms such as these – regardless of whether they are primarily myth or reality – in fact do influence the discourse on engineering and the engineer’s self-image, they serve to make the engineering profession immune to internal and external criticism (dogmatism); they stereotype and stigmatize the engineer, thus rendering the engineering profession less attractive to both male and female students. This is problematic for several reasons, but perhaps most importantly because the diminishing attraction of engineering as a profession represents a huge problem for companies and society as argued in numerous government reports and statements by business executives. We thus contend that the weakened appeal of engineering to contemporary students is linked to the diminishing attractiveness of the (myth of) the engineering culture.

As observed by Bucciarelli and Kuhn (1997), engineers often have relatively few ideas about the history and the social construction of their own culture, its premises and limitations (see also Florman 1968, 1976, 1987, 1996, Goujon & Hériard DuBreuil 2001). This kind of knowledge is considered an unnecessary luxury or even a waste of time. It is also often argued that engineers lack an appropriate theoretical framework allowing them to observe and reflect upon their own culture from different meta-level perspectives, e.g. sociological, historical, ethical, philosophical, pedagogical, and didactical perspectives, resulting in insufficient skills of self-reflection, interdisciplinary cooperation, and adjustment to changing conditions. Moreover, if not supplemented with other types of rationality in an educational context, the instrumental rationality of engineering creates a barrier to deep learning (Copeland & Lewis, 2004).

As pointed out by Bucciarelli & Kuhn (1997) and by Børsen Hansen et al. (2000), the socialization of the neophyte via the authoritarian pedagogy of “the correct answer” in maths and science courses at the bachelor’s level creates a wrong impression of the core of engineering and stimulates the sense of belonging to a culture of “the right answer”. Traditionally, these courses have been conceived as rites of initiation serving as a weed-out mechanism for students deemed unfit for the profession. In addition, especially in the non-university education of engineers, a long-standing tradition in the recruitment of teachers has been the high value attached to the combination of a craftsman-like background, a bachelor’s degree in engineering, and practical experience from a career as an engineer in a company. In this way, the teacher serves as a role model for students, mastering the tacit knowledge and “reflective practice” of his profession. This criterion of employment has proven its worth over time, but in the context of occupational Bildung for the
knowledge society, a faculty of teachers with chiefly this kind of background has a number of shortcomings. To some extent, this tradition of recruiting engineering teachers fosters traditionalism and a culture of “the right answer”, which naturally contributes to creating a lack of reflectivity both in the organization of the syllabus and in the planning of courses. This traditionalism is rooted in the lack of an intellectual tradition of extensive and reflective reading coupled with a lack of metadisciplinary reflections. As a consequence of this traditionalism, it is difficult for many engineering colleges to analyze and cope with the problems of a declining number of students by, e.g. changing pedagogy, by changing the syllabus, or by creating new specialties or new study programmes that meet both the needs of companies, society, and students.

In their study “Working with men to change the culture of engineering”, Copeland and Lewis (2004) report some interesting features from Australian universities: 1. Interest in engineering itself is not an important factor in students’ choice to study engineering; in particular, this applies to male students. 2. A pattern among male students of a strong background in mechanical and/or electrical tinkering coupled with a lack of awareness of the relevance of this background for success in engineering. 3. A very high workload and an overcrowded curriculum coupled with a corresponding pride in working long hours as a sign of toughness. 4. A pressure on students to pass exams at the expense of engaging in deep learning. 5. A “weed-out” system whereby those deemed unfit for the profession are weeded out via an overwhelming pace and load and a fiercely competitive environment. 6. A curriculum focused on technical concerns at the expense of the broader social, human, environmental, and ethical context of engineering. Leonardi’s characteristics described above can thus find a good deal of support in Copeland and Lewis’ findings. In our view, Copeland and Lewis’ observations can be summarized in three points, which are also valid in the practice-oriented education of Danish engineers and most likely in many other countries as well:

- 1) An unclear and indeterminate motivation to become an engineer
- 2) An overcrowded curriculum and a corresponding curriculum pace focused too narrowly on technical concerns
- 3) A curriculum lacking clear focus and containing too many disjointed courses, e.g. mathematics, physics, finance, management, business economics, statistics, etc.

As we see it, the syllabus of the practice-oriented education of engineers thus has to be reconsidered with regard to its practical applicability and its centre of focus. In this, the aim would be:

- 1) To focus the syllabus on “the design process” and to connect disjointed elements to design as the centre of engineering in an open-ended way
- 2) To reduce the time consumption of disjointed courses in order to make space for individual studies and deep learning processes, and to make space for discussions on the broader social, human, environmental, and ethical context of engineering
How Can the Barriers to Bildung in Engineering Education be Overcome?

We need more and better qualified engineers. Universities and other institutions of higher education have to improve their profile and to be more successful in selling engineering studies. The description of the education must be better in order to make the qualifications and competencies of an engineer perfectly clear to companies. The number of engineering students has to increase. This will require a development of the degree programmes so that they will attract young people and meet the current needs of companies.

(Danish Ministry of Science, Technology and Innovation et al. 2005:6; our translation)

Above, we have argued that engineering as a knowledge domain – in particular the way it is taught in engineering colleges- has few mechanisms for reflective critique and for the consideration of knowledge and ways of knowing that go beyond or call into question the domain’s present definition of itself. We, therefore, share the cultural change perspective of feminist research and the attempt to change this culture to make it more attractive to prospective students. If study programmes in engineering placed greater emphasis on reflective critique and wider societal aspects of engineering, we believe that this would not only contribute towards increasing the professional qualifications of graduates, but also make the engineering profession more attractive to students in general – both male and female.

The recommendations in the above quote stem from a report by the Danish Ministry of Science, Technology and Innovation, the Danish Ministry of Education, the Confederation of Danish Industries, and the Society of Danish Engineers. These recommendations may be interpreted as representative of a general crisis in Danish engineering education. This is, however, not just a Danish phenomenon, but is well-documented in international research on engineering and engineering education. The image problems of engineers, a seemingly diminishing quality and relevance of their education, the male bias, and the declining number of engineering students all require a rethinking– or reengineering- of the engineering education as to its ideals of Bildung and engineering competencies. Another facet of this is the observation made by Troelsen (in Børsen Hansen et al. 2000:65) that the education of prospective scientists and engineers has to be seen in a wider context of interests. Troelsen mentions four factors, to which we would like to add a fifth and very important one—the global context of education. Hence, the context of interests for educating engineers can be seen as:

<table>
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<tr>
<th>Societal interests</th>
<th>: Education to citizenship</th>
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<tr>
<td>Occupational interests</td>
<td>: Education as investment</td>
</tr>
<tr>
<td>Academic socialization</td>
<td>: Education to membership</td>
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<tr>
<td>Education as identity work</td>
<td>: Education as self-actualization and self-development</td>
</tr>
<tr>
<td>Globalization of the labour market</td>
<td>: Education to cosmopolitanism</td>
</tr>
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These five elements are important parts of the new occupational ideal of Bildung for engineering education that we propose. Another important part is reflection and critical thinking. Reflection and critical thinking are of course wide concepts deserving a separate discussion. Suffice it therefore here to refer to Barnett (1997), who mentions eight forms of reflection. In our interpretation, however, Barnett’s third
form of reflection—critical reflection—may be seen as the overarching concept. Based on Barnett, critical reflection can be broken down into seven sub-forms of reflection:

- 1) Reflection on disciplinary competence
- 2) Educational reflection
- 3) Reflection as a meta-competence
- 4) Reflective practitioner
- 5) Reflection as self-realization
- 6) Reflection as social formation
- 7) Societal reflection

See Barnett (1997) for further elaboration. It may be argued that some of Barnett’s instrumental kinds of reflection already exist in much engineering education (1, 4, and 5). However, to implement critical reflection as an ideal of occupational Bildung for engineering education, emphasis should in future also be put on 2, 3, 6, and 7.

As engineering practice is both a technical and a social process aiming at creating growth and value for companies and society in general, engineers should in our opinion be able to

- Consider the impact of engineering on nature and society
- Reflect upon the utility, beauty, and goodness of their work
- Reflect upon the truth of theories, the validity of assumptions, and the correctness of calculations

This view has its point of departure in the European philosophical tradition and implies a conception of engineering as a goal-oriented, practical, and intellectual activity aiming at utility, but with important aesthetical, ethical, and epistemological components. This view also necessitates the adherence to a scientific norm, which we believe should find its proper place in the education of engineers: Merton’s norm of organized scepticism. Putting more emphasis on organized scepticism in engineering education would provide a platform for meta-disciplinary reflections. Undertaking organized scepticism requires equipping engineering students with a sociological and philosophical framework, which would make engineering open to internal and external criticism, and it would also go a long way towards meeting the recommendations mentioned in the initial quotation. This is the core of our argument in favour of reengineering engineers through the formulation of a new ideal of occupational Bildung in engineering studies.

As to practice-oriented Danish engineering study programmes at the bachelor’s level, the objective of metadisciplinary reflection is in fact put forward in Executive Order no. 527 of 21 June 2002 from the Danish Ministry of Education. The objective is very clear:

Practice-oriented engineering studies at the bachelor’s level are complete professional engineering degrees which qualify the students to undertake occupational functions both in a national and an international context in which they are able to

1. put technical research results, scientific and technical knowledge into practical use in development projects and in solving technical problems
2. critically acquire new knowledge within relevant engineering domains
3. solve engineering tasks independently  
4. plan, realize and control technical plants, and in doing so, to include societal, economic, environmental and work environmental consequences in the solution of technical problems  
5. fulfil a role in management and cooperative relations with people with other educational and cultural backgrounds.

Furthermore the education should qualify the students for further studies.

(Our translation).

This executive order is indeed very ambitious. It contains an ideal of Bildung that to a certain extent is convergent with the ideal advocated above. Points 2, 3, 4, and 5 thus explicitly emphasize a number of formative and reflective components. Unfortunately, as argued above, there is much evidence that in general the ambition of the executive order is not met in the actual education of engineers in practice-oriented engineering studies at the bachelor’s level – not just in Denmark, but in a great number of countries.

Furthermore, it should come as no surprise that issuing an executive order is in itself not enough if we are to change the culture of engineering education towards creating more reflective and “cultured” engineers. As a parallel to courses in the “philosophy of science and ethics” at the universities, we would therefore like to propose the introduction of a new obligatory course in practice-oriented engineering studies at the bachelor’s level. The course should be on the historical, philosophical, and ethical foundation of engineering. The introduction of such a course would aid the fulfilment of the intentions of the above executive order. Such a course would thus serve:

- As a uniting framework for all engineering domains  
- As a bridge between engineering, social science, and the humanities  
- To strengthen the critical, reflective, and socially responsible dimension of engineering  
- To understand, reflect upon, and transcend the engineering culture in its function as an internal integrator and an external segregator  
- As a framework for improving interdisciplinary collaboration  
- To promote the formation of a historically founded engineering identity  
- To make engineering studies more attractive to prospective students—especially women

A course on the historical, philosophical, and ethical foundation of engineering should in our view be a combination or a selection of the following elements:

- The sociology of the professions  
- The history of engineering and the ideals of Bildung in engineering education  
- The myth of the engineer in literature, public opinion, and the self-image of engineers  
- The reality of engineering work in contemporary society  
- The pedagogy and didactics of engineering education  
- The philosophy of engineering
The philosophy of technology
Ethical aspects of engineering in an organizational, national, and global context
Interprofessional and intercultural communication
Forms of knowledge: how to get it, apply it, and criticise it

If the introduction of such a course is preceded by a revision of engineering syllabi to integrate maths, physics, and chemistry more closely with the various specialties of the degree course in question—another important improvement in our view—this should make sufficient room for the course we propose in the otherwise overcrowded syllabi of most degree programmes in engineering. To ensure the education of more qualified engineers and to attract more students to engineering education, we thus propose to reengineer education programmes in favour of more integrated, design-centred syllabi with a strong focus on educating critically reflective engineers.

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Chapter 5

The Knowledge of Engineers

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Abstract: In this chapter, we discuss the nature of the knowledge of engineers. We offer a sociologically informed description of the epistemological features and the social context of technological knowledge production in engineering practice. Our main focus is on the structural differences between science and engineering. Thus one of our aims is to determine where engineering can be said to have its proper centre and the consequences this may have for an epistemology of engineering. In our view, it is misleading to conceive of engineering merely as applied science. Engineering as we see it is both a cognitive and a practical enterprise. This conception is based on two main arguments: (1) a controversial, arguing that within a context of application, engineers are the producers of a distinct body of technological knowledge in its own right, and (2) a non-controversial, arguing that engineering is a practical enterprise concerned with the immediately pressing needs of companies and the society in which it takes place. To justify this conception of engineers and engineering we address three questions: 1) What are the structural differences between science and engineering? 2) What are the sources of problems in technology and how are these linked to the epistemological categories of knowledge and the knowledge generating activities in engineering practice? 3) How can the ontological “worlds” in engineering practice be described?

1. Introduction

The function of the scientist is to know, while that of the engineer is to do. The scientist adds to the store of verified, systematized knowledge of the physical world; the engineer brings this knowledge to bear on practical problems. (The New Encyclopaedia Britannica, 1982 15th edition vol. 6: 860)

Technological knowledge…appears enormously richer and more interesting than it does as applied science. (Vincenti 1990: 4)

The two quotations leave us with a logical disjunction. On the one hand, engineering has a body of knowledge of its own - on the other it has not. The different conceptions of engineering in the above quotes indicate the need for an ongoing discussion on the epistemology of engineering. In the literature on epistemology and philosophy of science, the knowledge of engineers, positioned as it is somewhere between craft and science, has been somewhat neglected (Hendricks et al. 2000, Barley and Orr 1997, Vincenti 1990). Moreover, in an educational context there seems to be a lack of epistemological and philosophical reflections in engineering
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studies especially at the undergraduate level. In our opinion, this is damaging for the image and academic respectability of prospective engineers (Hyldgaard Christensen and Enne-Kjølhede 2006).

Although epistemological reflections have not been the stimulus, research on the interaction of science and technology has been considerably furthered by a growing political and scientific concern for technological innovation as a stimulus to economic growth (Pinch and Bijker 1987). In macro level approaches, economists have been concerned with the study of radical or basic innovations – their nature, preconditions, emergence, diffusion, and their economic impact (Sørensen and Levold 1992). At the micro level, organizational theorists and business analysts have been concerned with the innovation strategies of industrial companies and their abilities to innovate to be able to guide companies in their market strategies. Policy orientation seems to be an important motivation for this type of research. Unfortunately, in spite of important merits, these studies tend to “black box” the internal dynamics of technological change.

In a review of literature on the science-technology distinction and industrial innovation, Faulkner (1994) summarizes the science-technology debate from its inception until its demise in the early 1980s. A special concern in the early debate was to challenge the linear model of the science-technology relation – which still haunts economic models of technological change. Strange as it may sound, an important consequence of the linear model is that engineering has no knowledge base of its own. Science is the “springhead” of technological change, portrayed as path breaking, original and risky; technology in comparison becomes straightforward and routine. Hence, in this interpretation, the knowledge base of engineering is the scientific method and the knowledge of the causal laws of nature accumulated in the natural sciences, which are brought to bear on practical problems. According to Laudan (1984) this conception rests on the widely-held and often unspoken assumption that technological knowledge is essentially tacit making it inaccessible to scholarly study. According to this assumption, the line of arguments is that technological knowledge is rarely articulated; when articulated it is largely in a visual form different from the verbal and mathematical form of science. As a visual form of knowledge it is inaccessible to scholarly study with its focus primarily on the analysis of texts and logical structures (Laudan 1984).

From the 1970s and onward, the science and technology debate has been superseded by a more exclusive concern with technology itself. In the early debate, the general tendency was to stress the blurring of the boundaries between science and technology, whereas the later debate has tended to stress the distinctiveness of technological knowledge. This “revisionism” is largely due to scholars of technology, in particular historians of technology.

Assuming a blurring of the boundaries between science and technology (Pinch and Bijker 1987), the technological turn within social studies of science (Woolgar 1991) and the emerging programme of social construction of technology (SCOT) has produced a different approach to understanding the nature of engineering knowledge. In the constructivist approach, technological practice is conceived of as a locus of strategic action (Callon 1986) in which engineers act strategically to redefine both technology and society. In the course of action, both new knowledge and novel social relations are created.

In order to conceive of technological change and innovation in terms of individual action, constructivists are micro level oriented. Their focus is on
“representational practices susceptible to relativism” (Woolgar 1991:27). The display of ideals of masculinity in engineering culture is an example of such “representational practices” illustrating the persuasive abilities of male engineers and the power mechanisms of the engineering culture (Hyldgaard Christensen and Ernø-Kjølhede 2006). At the micro-level of technology the focus of constructivists is on the persuasive abilities of individual scientists and engineers; “their strategies to gain support of their choices of problems, solutions, and design criteria; and their effectiveness in connecting their research efforts to what other people see as a desirable future” (Sørensen and Levold 1992:14). We share the view of SCOT that technology is socially constructed and the constructivist assumption that “power mechanisms” both within science and engineering can be analysed fruitfully by means of key concepts such as actor-network, translation and translation centers etc. (Callon, Law and Rip 1986). Moreover we share with constructivists the assumption that the “locus of objectivity” both within science and engineering lies in a socially “prescribed set of rituals and behavioural norms” (Constant 1984).

However, we hold that, from a philosophical point of view, an instrumentalist epistemology in the sense of the philosophy of pragmatism (see chapter 10 for a thorough account of pragmatism) provides a more fruitful approach to the knowledge of engineers than does constructivism. As a corollary of this, we argue that engineering knowledge can thus be justified as to the extent that it works. This is a core idea of pragmatist epistemology. Establishing that and how it works and not necessarily explaining why it works is hence a key to understanding the nature of engineering knowledge. It is, however, beyond the scope of this chapter to enter into a lengthy discussion of the constructivist approach. For further reference, see e.g. Barnes and Edge (1982), Bijker, Hughes and Pinch (1987) and Laudan (1981).

In this chapter, we draw on literature from all of the above approaches. We intend to do three things in the following: first, to use science as a heuristic model for a comparative analysis of engineering; second, to explore the central concern of engineering epistemology, i.e. how the growth of knowledge in engineering is related to technological progress, by examining the relationship between problem generators in technology, categories of knowledge and knowledge generating activities in engineering practice; third, to discuss from the point of view of ontology the kind of realities and entities dealt with in engineering practice and the corresponding epistemological categories of knowledge. To be able to do this, we address three main questions: 1) What are the main structural differences between science and engineering? 2) What are the key sources of problems in technology and how are these linked to the epistemological categories of knowledge and the knowledge generating activities in engineering practice? 3) How can the ontological “worlds” of engineering practice be described?

A few introductory remarks are needed. As we see it, there is a close relationship between the concepts of technology, technological change and engineering and we therefore make little effort to distinguish between them in the following. However, we distinguish between engineering practice and engineering science. When we speak of engineering in general we refer to the former. We also use the term knowledge in its broadest sense in this chapter. Here knowledge thus encompasses what is usually conceived of as knowledge, expertise, skills, competencies and information etc. What we intend, is to base our epistemological reflections on an analysis of the dynamics of technological change at the micro-level. In doing so we
shall ignore the social and economic causes of such change as well as the effects of technology in the wider social environment.

2. Structural Differences between Science and Engineering

We acknowledge that there are a lot of similarities between science and engineering. However, in this section, we will focus on the major structural differences between science and engineering. When embarking on a comparison of science and engineering from a general perspective, the initial problem one faces is: what to compare? Faulkner (1994: 431) argues that, at a general level, scholars of modern technology of whatever philosophical bent they may be seem to agree that technology can be distinguished from science in three closely related areas: 1. in its purpose or orientation, 2. in its sociotechnical organization, and 3. in its cognitive and epistemological features. We would like to change her model slightly. Thus our basis of comparison is: 1. Centre and purpose of activity, 2. Normative foundation, 3. Epistemological breadth and complexity. These are the three aspects we focus on below.

1. Centre and purpose of activity of science vs. engineering

It is too easy merely to claim that science is concerned with facts and knowing why and engineering is concerned with artefacts and knowing how. However, as artefacts play an important role in the laboratory knowledge machinery of science and as knowing why is also an important element of engineering science, (there are of course several other elements; the most central ones are addressed below), this is not a crucial difference. An illuminating difference pertains to the different aims and goals of traditional academic science and engineering. According to this difference, the aim of science is to further the growth of knowledge driven by curiosity to increase understanding whereas that of engineering is to further technological progress for purposes external to engineering (e.g. economic growth, comfort of life etc.).

However, we proceed on the hypothesis that the structural differences between science and engineering are located at another level. In our view, design is the central activity that defines engineering and distinguishes it from science. The focus on design is a view we share with e.g. Ferguson (1993), Bucciarelli and Kuhn (1997) and Dym (1994). Dym has defined engineering design as “the systematic, intelligent generation and evaluation of specifications for artefacts whose form and function achieve stated objectives and satisfy specified constraints” (Dym 1994: 17).

Contrary to engineering, the centre and purpose of science has traditionally been the accumulation of institutionally certified knowledge published in the scholarly paper. Although this traditional purpose is in transition with the advent of so-called “mode 2 science” (Gibbons et al. 1994) or post-academic science (Ziman 1998), we would argue that the accumulation of institutionally certified knowledge is still at the centre of science as a system. Simon (1996: 1, 4) has phrased this as follows: “The central task of a natural science is to make the wonderful commonplace: to show that complexity, correctly viewed, is only a mask for simplicity; to find pattern hidden in apparent chaos….The engineer, and more generally the designer, is concerned with how things ought to be – how they ought to be to attain goals, and to
In science, the knowledge accumulated in search of the “truth” is thus supposed to be an end in itself whereas knowledge in engineering serves as an instrument in the production of useful artefacts.

The hierarchical structure of technological practice also distinguishes technology from science. Thus engineering design with its focus on synthesis is the predominant, discriminating feature compared to science. An important characteristic of a technological project is thus its “decomposability” (Constant 1984). A technological project can typically be decomposed into a hierarchy of specialist groups and into a hierarchy of specialist knowledge domains. When e.g. a wind turbine, a car or a bridge is to be constructed, the overall design concept is “decomposed” into the major components of the system, specific problems and subproblems, specialties and disciplines – “the technoscientific organization”. The decomposition of the technological project is structured in a way that allows for maximum interaction and coordination between specific groups – the “sociotechnical organization”. Design then, is characterized both in its sociotechnical and in its technoscientific aspect at the micro-level by integration and synthesis rather than by what constitutes the centre of science – the analysis of problems and sub-problems at the front of a scientific specialty. However, it may also be argued that the ethical dimension constitutes an element of its own right in engineering design practice as presented in chapter 12.

In a historical study of aeronautics focussed on engineering epistemology Vincenti (1990: 9) offers an illuminating illustration of what “decomposability” means as to the design of aeroplanes. Vincenti argues that his model is valid in general for devices that constitute a complex system. The complete design process takes place at five levels and can be conceived of as an iterative process that takes place up and down and horizontally throughout a hierarchy consisting of five levels:

1. Project definition – translation of some usually ill-defined military or commercial requirement into a concrete technical problem for level 2. 2. Overall design – layout of arrangement and proportions of the airplane to meet the project definition. 3. Major-component design – division of project into wing design, fuselage design, landing-gear design, electrical-system design etc. 4. Subdivision of areas of component design from level 3 according to engineering discipline required (e.g. aerodynamic wing design, structural wing design, mechanical wing design). 5. Further division of categories in level 4 into highly specific problems (e.g. aerodynamic wing design into problems of planform, airfoil section, and high-lift devices)."

Not only at the micro-level is engineering far more heterogeneous than science. Both as to institutional settings and as to economic and social constraints at the meso-level, the degree of complexity is higher in engineering than in science. Sørensen and Levold (1992) thus argue that scientists usually manoeuvre in a social terrain which is much simpler than that of engineers.

2. Normative foundation of science vs. engineering

To create a basis for comparison our point of departure is Robert K. Merton’s classic norms of science from 1942 (1973). The Mertonian norms are habitually referred to by the acronym CUDOS (referring to the Greek “kyddos”: glory, fame, renown) and constitute Merton’s original ethos of science: Communism, (research results are public property) Universalism (evaluation of research is based entirely on impersonal criteria) Disinterestedness (researchers should be emotionally detached
from their field of study) Organized Scepticism (researchers must be critical towards the work of others and their own work). (See e.g. Hyldgaard Christensen and Ernø-Kjolhede 2006, for a more thorough discussion of these norms).

The Mertonian norms represent an understanding of science rooted in academic research. In contrast, Ziman (1994 2000) has suggested a set of norms that he claims to be characteristic for non-academic (typically industrial or government laboratory) research but which we also find to be a useful description of engineering norms. Ziman’s norms are summarized in an acronym as well: PLACE. The acronym suggests that scientists working in non-academic research should carry out “Proprietary, Local, Authoritarian, Commissioned and Expert work”. Ziman uses his norms to highlight the existence within science of a two-track-system with different communities adhering either to PLACE-norms or to academic norms like those of the Merton school. Furthermore, each norm-set is indicative of fundamentally different career patterns. Merton style norms are associated with individual careers in pursuit of personal scientific reputation and prestige (CUDOS). PLACE norms on the other hand are associated with organizational careers entailing a much closer identification with and feeling of common destiny with the individual’s place of work. The PLACE norms consequently imply a more collectivist attitude. As we see it, the PLACE norms in fact give a useful description of the norms prevailing in daily engineering practice. In our interpretation, engineering may in general thus be conceived as an application oriented knowledge activity taking place in a broad range of organizational settings, drawing on a variety of knowledge forms, catering to a great number of interests and often doing so guided by ill-defined criteria of quality; very much along the lines of Ziman’s PLACE norms.

3. Epistemological complexity and breadth of science vs. engineering

If we position forms of knowledge along a continuum of craft based skills, design based competencies and scientific knowledge (Barley and Orr 1997) a taxonomy of the categories of knowledge used in engineering (Vincenti 1990, Faulkner 1994) would indicate that the epistemological complexity and breadth is wider in engineering than in science. This is not equivalent to claiming that engineering is more difficult than science: only that engineering in its epistemological features is more heterogeneous than science. Picking up on the above discussion of CUDOS vs. PLACE norms, a fruitful parallel may be drawn to concepts introduced by Nowotny, Scott and Gibbons (2001). They speak of “weakly contextualised knowledge” and “strongly contextualised knowledge”. Weakly contextualised knowledge is produced in relative separation from its surroundings and its application, which has a lot in common with the underlying idea in the CUDOS norms of independence of the knowledge producer. Strongly contextualized knowledge on the other hand is produced in close interaction and dialogue with its surroundings and with a high regard for possibilities of application — thus having a lot in common with the underlying idea in the PLACE norms of dependence of the knowledge producer. The knowledge of engineers and technology as a phenomenon is clearly strongly contextualised and dependent on its surroundings. Indeed, using another term borrowed from Nowotny, Scott and Gibbons, engineering knowledge needs to be “socially robust” meaning that it is capable of not only fulfilling technical standards in their own right; it also has to be immediately useful in terms of being capable of
passing the test of the market; i.e. fulfil needs among users at a price and in a form that makes it attractive compared to other alternative solutions to fulfilling that need.

The contextual character of engineering knowledge also allows for epistemological liberties which are usually denied scientists. Thus routines and heuristics, e.g. rules of thumb based on experience play an important role in engineering problem solving. These cannot be justified theoretically but are justified only as to the extent that they work. This epistemological liberty is closely related to different modes of “satisficing” in engineering and science (Constant 1984). The term satisficing refers to the question of “good enough” which is differently defined in science and engineering. Thus “good enough” in engineering reflects a number of specified constraints and simplifying theoretical assumptions which serve as the basis for the solution of a practical problem. Constant argues that the reason for this difference is obvious. Science explores the environment “vicariously” or indirectly by means of experiments typically in laboratory settings whereas engineering explores the environment directly by means of tests of artefacts. “Technological artefacts are subject to direct environmental elimination in ways that scientific theories are not: planes crash, engines explode, wheels fall off, Toasters go berserk” (Constant 1984:35). Epistemologically speaking, we may say that engineering is aiming at controlling nature whereas the aim of science is to gain knowledge about nature. Engineering knowledge therefore traditionally allows for “overdesign” - “if it breaks, make it bigger” - and a degree of legitimate, simplifying assumptions which differ from what is acceptable in science. Put a bit differently, we may say that engineering fundamentally aims at closing discussions by solving problems in specific ways. Academic science, in contrast, ultimately aims at opening discussions - and creating new ones - through adding new, preferably general perspectives to problems in order to expand the general knowledge base.

3. Sources of Problems in Technology, Epistemological Knowledge Categories and Knowledge Generating Activities in Engineering Practice

It is a commonplace that all research must start from a problem. Research can be successful only if the problem is good; it can be original only if the problem is original. But how can one see a problem, any problem, let alone a good and original problem. (Polanyi 1967: 21)

In our view the central concern of epistemology is the problem of the growth of knowledge. This is also the central concern of engineering epistemology. However engineering epistemology is particularly concerned with the question of how the growth of knowledge is related to technological progress (Vincenti 1990, Laudan 1984, Constant 1984). Polanyi’s observation that the growth of knowledge must start from a problem is a key to understanding the nature of the knowledge of engineers. What engineers know and how they know it is thus determined by the sort of problems they are trying to solve. Engineers spend most of their time dealing with practical problems. Some of these problems are trivial and routine and some of them complex and risky. Engineering knowledge both serves and grows out of this occupation. Accordingly, practical problems and knowledge generating activities are fused into a whole in engineering practice. For purposes of analysis we shall follow the hint given by Polanyi above and separate the discussion of the sources of
problems from the discussion of the epistemological knowledge categories and the knowledge generating activities in engineering practice.

1. Sources of problems in technology

In examining how problems get posed within engineering practice, Laudan (1984) has identified five sources of problems or problem generators that may eventually lead to cognitive change. It should come as no surprise that there is a strong disagreement among scholars of technology as to the number and kind of the basic sources of problems. Since the inception of this debate, attempts of identification have been an ongoing concern of engineering epistemology, as presented most notably in the works of Vincenti (1990) and Constant (1984). We believe that four of Laudan’s five problem generators are basic in the sense that they are related to an obvious internal logic of technological progress (Laudan’s fifth generator “problems given directly by the environment” will not be dealt with here as we believe the internal technological logic is lacking within this category).

Laudan’s four basic problem generators are:
1. **Functional failure of current technologies.**
   Functional failure occurs when a technology is subject to an increasing set of demands or when applied in a new and different context. Problems of implementation may serve as an illustration of this category. Technologies are usually implemented because they are needed and not mainly because they work successfully.

2. **Extrapolation from past technological success rather than actual technological failures.**
   This category of problems refers to cumulative improvement problems, typically problems of how to improve the speed, the capacity, the size, the cost efficiency etc. within an existing technology. Attempts to increase the capacity of wind turbines by increasing the size of the component parts is e.g. largely stimulated by the internal dynamic of technology itself.

3. **Imbalances between related technologies in a given period.**
   When specific technologies or devices are coupled into technological systems the effective operation of a particular technology may be impeded by the lack of an adequate complementary technology, typically creating bottleneck situations for the entire system. Usually, these situations are characterized by a strong economic pressure to overcome the imbalance. The coupled evolution of computer software, hardware and networks may serve as an illustration of this type of problem generator.

4. **Potential rather than actual technological failures.**
   This category of problems is based on scientific anticipation of future functional failure of a device or a system under more stringent conditions. Constant (1984) speaks of presumptive anomaly. This type of problems occurs when scientific theory predicts that the conventional technology will fail under some projected conditions or that an alternative technology would do better. Constant (1987: 226) illuminates this problem generating mechanism through an example from the history of aeronautics:

   By the late 1920s aerodynamic theory suggested three conclusions: (1) that with sufficient thrust, well-streamed aircraft should be capable of approaching the speed of sound; (2) that conventional propellers could not operate efficiently at such speeds; (3) and that gas turbine compressor and turbine components designed in accordance with aerodynamic theory should be capable of significantly higher efficiencies than previously thought possible. [our numbering].

This made way for the turbojet revolution.
Problem generators thus stimulate the development of new or extended technologies, which in turn call for new or extended knowledge. An important criterion of selection within the specific traditions of engineering practice is “likelihood of solution” (Laudan 1984). According to this criterion, the selection of problems hinges on the social or economic utility assigned to the problems by society at large which is to say that the selection of problems hinges on the contextual relevance of the problems.

2. Epistemological knowledge categories and knowledge generating activities in engineering practice

As we see it, the activities that generate new knowledge in engineering practice are linked to the above problem generators in different ways. Such activities are motivated and conditioned not only by design but by production and operation as well. Moreover, knowledge generated by scientists is combined with and interpenetrate knowledge generated by engineers. Studies of innovation (Faulkner 1994, Gibbons and Johnston 1974, Senker 1993) are helpful here. These studies have chiefly been concerned with the extent and character of knowledge flows from public sector research into industrial innovation. Faulkner (1994) has synthesized both the broader and the more detailed categorizations of knowledge of a number of innovation studies into a composite typology of knowledge used in innovation. In our opinion this typology gives a useful description of the knowledge components in engineering design practice. Its main value is a clear distinction between knowledge categories of design, production and operation. Unfortunately, the typology has little to say as to knowledge generating activities. These are to be deducted from the typology.

Faulkner’s typology characterizes knowledge in terms of three taxonomic dimensions: 1. Specific types of knowledge. 2. The object or activities with which they are associated (product, R&D, etc). 3. Broad distinctions in the character of knowledge (tacit, specific, etc.) As to the first dimension which is quite complex, see Faulkner (1994: 447). The second dimension of the typology concerns the object of the knowledge in question: 1. The natural world. 2. Design practice. 3. Experimental R&D. 4. The final product. 5. Knowledge itself. The third dimension describes a tripartite distinction between knowing as understanding, knowing as holding information, and knowing as holding skills. More specifically this tripartite division distinguishes between knowledge as: 1. Understanding – information – skill. 2. Tacit – articulated. 3. Complex – simple. 4. Local – universal. 5. Specific/contingent – general/meta-level. We believe this to be a useful framework for epistemological reflections on engineering practice. For a thorough discussion of knowledge and learning see chapter 8.

As to the knowledge generating activities in engineering practice, Vincenti (1990) has also provided a helpful approach in spite of a less detailed categorization of knowledge. An advantage of Vincenti’s perspective compared to that of Faulkner (1994) is that it is historical. According to Vincenti (1990), the main categories of knowledge generated by engineers are: 1. Fundamental design concepts. 2. Criteria and specifications 3. Theoretical tools. 4. Quantitative data. 5. Practical considerations. 6. Design instrumentalities. All of these categories of knowledge refer to the problems to be solved within engineering design practice. However, as Vincenti conceives of engineering design as an art that increasingly makes use of
already established as well as developing scientific knowledge, only a part of the knowledge is generated in the design shop. Thus the knowledge generating activities can be described under the following eight headings: A. Transfer from science. B. Invention. C. Theoretical engineering research. D. Experimental engineering research. E. Design practice. F. Production. G. Direct trial. To a great extent, knowledge within A and C is generated by the research activities of scientists and engineers in academic institutions and industrial and government research laboratories. However, this is far from claiming that science is the sole source and that engineering is essentially applied science.

Summing up this section, the main conclusion we wish to make refers to what we termed a controversial argument in the abstract. First we have made clear that the interaction between science and technology is different from the broad analogies presented by constructivists (e.g. Barnes 1982). Second it has become equally clear that it is misleading to conceive of engineering essentially as applied science; an outstanding example of which is Bunge (1966). Third we have shown that a distinct body of knowledge in its own right grows out of engineering practice in its course of action.

4. The Ontological “Worlds” of Engineering Practice

“We may view technology as a spectrum, with ideas at one end and techniques and things at the other, with design as a middle term. Technological ideas must be translated into designs. These in turn must be implemented by techniques and tools to produce things”(Layton 1974: 37-38.)

From within any specific tradition of engineering design practice we would argue that three domains of activity can be abstracted: (1) technology and the production of artefacts (2) knowledge and knowledge generation, and (3) definition of purposes and functions and negotiation of constraints. Ontologically speaking, the entities of these three domains of activity refer to different kinds of reality. Thus we would argue that the entities of the three domains of activity are located in three different ontological “worlds” which we term (1) the object world, (2) the conceptual world, and (3) the social world. Engineering practice then is concerned with the synthesis of these three worlds. This view is informed by the work of Bucciarelli and Kuhn (1997), Ferguson (1993) and Vincenti (1990). The case we want to make is that in arguing this way it becomes clear that technology may be conceived of as a social construction, a point of view which we share with constructivism.

At the epistemological level, the tripartite ontological division in our view corresponds to a rough distinction between three broader categories of instrumental knowledge, (1) skills and craft based practical knowledge, (2) design based theoretical knowledge, and (3) action oriented social contextual knowledge. To phrase it in a different way, we may say that the three categories of knowledge corresponding to the above distinction are: (1) tacit knowledge, (2) descriptive knowledge, and (3) prescriptive knowledge (Vincenti 1990: 198).

In our interpretation of Bucciarelli and Kuhn (1997), two essentially different ontological “worlds” are conflated into what they term the “object world”. We would like to make a distinction between a “conceptual world” and an “object world”. According to this interpretation, “the conceptual world” is the domain of conceptual and visual thinking in which engineers engage when working on the
overall design concept or any specific aspect or subsystem of the design. Ferguson (1992) strongly emphasizes this aspect of engineering in the title of his book “Engineering and the mind’s eye”. Design is made essentially in the mind. According to Ferguson, “the mind’s eye” not only reviews the contents of a visual memory but also forms such new or modified images as the mind’s thoughts require. It is a conceptual process in which simplified models must be devised to permit decomposition and calculation. Import from science at this ontological level is largely an import of texts and concepts. A major part of engineering information is recorded in a visual language that permits the “readers” of technologically explicit and detailed drawings to visualize the forms, the proportions, and the interrelationship of the elements that make up the object depicted. In this language, designers explain to producers what they want them to construct. The kind of knowledge in question is thus largely descriptive. Hence, work in the conceptual world is first and foremost the esoteric work within a specific tradition of engineering practice or within a discipline of engineering science. Disciplinary tools are brought to bear in a thought process, which is likely to be inaccessible to people from other disciplines let alone a layman.

Work within the “object world”, on the other hand, consists of the engineer’s intensive interaction with the “hardware” of the design. As observed by Whalley and Barley (1997), engineering work is technical, not only because engineers use esoteric techniques and instruments, but because machines and systems are the ultimate objectives of engineering. Maintaining and improving existing machines and systems and designing new ones remain the core of engineering. To be able to manipulate physical objects to achieve practical ends, engineers must be in possession of an extensive body of contextual knowledge of materials, technologies and techniques. Contextual knowledge is largely particularistic. It is also tacit knowledge acquired through practice. Contextual knowledge resides in the practitioner’s ability to find and interpret subtle cues where outsiders see no information. In this sense, engineering resembles a craft. The hallmark of craftspeople is their ability to find creative solutions and to render skilled performances based on an intuitive feeling of materials and techniques.

As engineering design is embedded in a larger context - a “social world” - the design process can be conceived of as a social process as well. A complete design is not in the hands of a single individual. To proceed, engineers have to take into consideration legal restrictions and standards, performance requirements set by customers and they have to negotiate with others in the company etc. Different worlds intersect, generating work which is fundamentally social and process oriented. No overriding instrumental strategy is at hand to reconcile and synthesize the diverse design interests. At the beginning of the design process the performance requirements set by the customer is the basis of the lay out of performance specifications, but even these requirements are subject to change. It is impossible to uphold these specifications within an ongoing process of modification, clarification, negotiation and joint interpretation (Bucciarelli and Kuhn 1997: 213). In this way, specifications which seem clear at the outset are challenged by the very design process. The design process is thus a process of discovery to uncover ambiguities, confusions and contradictions.

Unlike the allegedly value free constraints of scientific laws, other constraints are normative by nature, thus being negotiable, e.g. codes of ethical conduct, environmental restrictions, costs of production, limitations in time etc. Some of
these constraints are more flexible than others, but they are all subject to a plethora of interpretations. In the “social world”, design can therefore be conceived as a process of communication, negotiation and consensus. No single engineer, no scientific law, no technical imperative and no normative constraint can dictate the design in its totality (Bucciarelli and Kuhn 1997: 214). The totality is a result of the synthesis of the work within the three ontological worlds.

4. Conclusion

In this chapter we have attempted to outline an epistemology of engineering practice. Thus we have discussed the basic questions of epistemology: What is engineering knowledge all about? How can it be characterized? How do engineers get it? How can it be justified? And how do engineers use it? These are the sort of questions we have tried to answer although not all of them have been explicitly formulated. (Questions as to how to evaluate and criticize the knowledge of engineers have been outside the scope of our intentions).

In a comparison with traditional academic and post-academic science, we have argued that, within a context of application, there are major structural differences between engineering and science; both traditional, academic truth-seeking science (“mode 1”) and transdisciplinary, post-academic applied science (“mode 2”). We acknowledge that there are a lot of similarities between engineering and science e.g. methodology, publication in scholarly journals, experimental techniques etc. However, in its aim, in its centre of activity, in its technoscientific and sociotechnical organization and in its satificing modes and simplifying assumptions, engineering differs significantly from science, in particular from traditional academic science. Thus engineering is, generally speaking, a far more heterogeneous enterprise than both of the above kinds of science, and the social terrain in which engineers manoeuvre is on the whole more complex than the social terrain in which most academic scientists manoeuvre.

In examining the link between sources of problems in technology, solutions and knowledge generating activities in engineering practice, we have used an implicit heuristic. We have in fact used the Popperian distinction between “the context of discovery” and “the context of justification” although its direct analytical value may be arguable. This distinction, however, can also be used to highlight an important difference between science and engineering in the sense that a prime focus of science may be said to be on “discovery” in the sense of breaking new ground whereas “justification” in the sense of designing and making something work for a specific purpose is a prime concern of engineering. Our main conclusions concerning the link between sources of technological problems and knowledge generation towards their solution is thus that it is misleading to conceive of engineering essentially as applied science and that a distinct body of knowledge in its own right grows out of engineering practice in its course of action.

In the final section of this chapter, we discussed the ontology of engineering. We distinguished between three ontological worlds, the object world, the conceptual world and the social world. Based on the discussion in this section, we would like to conclude by arguing that the key to understanding the nature of engineering knowledge is to see it as a synthesis of the engineer’s work within these three ontological worlds.
References


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Epistemology, ontology and ethics: ‘galaxies away from the engineering world’?

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Philosophy of technology/philosophy of science has recently become part of the curriculum of engineering degree programmes in Denmark. However, to what extent do teachers of engineering see it as meaningful for students to work with relatively abstract philosophical concepts such as epistemology, ontology and ethics as part of engineering degree programmes? And what, if any, are the complexities and difficulties in implementing philosophical questioning into engineering curricula? Do teachers tend to see philosophy of science as a kind of 'Trojan horse' – an unwelcome idea that will defocus engineering degree courses and steal time from more important subjects? Or do they see it as a necessary and welcome addition to engineering curricula that will result in more qualified and free-thinking engineering graduates? Subsequently these issues are discussed in the light of findings in an empirical case study carried out by the authors at their Institute.

Keywords: philosophy of science; platforms and rationale; professional self-reflection; Bildung; engineering didactics; barrier mechanisms

Introduction

Is it relevant and meaningful for engineering students and teachers to engage in philosophical questioning and is philosophy of science a natural part of the curriculum for students of engineering? Moreover, what is the aim and rationale of such a venture? These are fundamental questions currently facing Danish institutions of engineering studies. Relatively similar metadisciplinary discussions are also found in other countries related to, for example, concepts such as 'liberal education' in engineering studies (Steneck et al. 2002) and 'engineering ethics' (Didier 2007). To examine these questions in a Danish context, we have carried out a questionnaire-based case study among teachers of engineering at our Institute. Before embarking on the study (discussed later) we need to address what initiated the discussion on introducing philosophy of science in engineering studies in Denmark? In 1999, a UNESCO World Conference entitled ‘Science in the Twenty-First Century: A New Commitment’ was held in Budapest. In Section 4 of the preamble of the ensuing ‘Declaration on Science and the Use of Scientific knowledge’ the declaration states: ‘Science curricula should include science ethics, as well as training in the history and philosophy of science

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and its cultural impact’. The UNESCO declaration also includes engineering science: ‘We seek active collaboration across all the fields of scientific endeavour that is the natural sciences such as the physical, earth and biological sciences, the biomedical and engineering sciences, and the human sciences’.

In 2000 as an immediate outcome of the UNESCO declaration to which Denmark had subscribed (Fink et al. 2003, p. 7), preparatory measures were taken by the Danish Government to implement philosophy of science courses into higher education. Accordingly, in 2000 the Danish Ministry of Education sent out a letter to the universities outlining 10 basic and overall principles regarding the aim and extent of the philosophy of science in bachelor programmes. The aim of introducing the philosophy of science was defined as follows: ‘students should be offered an opportunity to qualify their professional specialty by seeing it in a broader and more general perspective’ (Ministry of Education 2000). The letter also stated that philosophy of science courses were expected to be implemented in all university degree programmes by 2004. In practice, this intention has been interpreted as binding for non-university bachelor programmes too, which is, for example, reflected by the fact that the Danish Evaluation Institute also uses it as a criterion for accreditation of non-university bachelor programmes. However, the concrete implementation has been left to the institutions of higher education themselves allowing for differences as to the pace, content and way in which philosophy of science has been implemented in degree programmes. The Danish Institute of Evaluation in connection with an accreditation process in 2006 formulated the following criterion concerning professional (practice-oriented as opposed to academic) engineering degree programmes: ‘Research methodology and philosophy of science must be part of the degree program to enable students to follow and apply R&D results in their field of specialization’ (The Danish Institute of Evaluation 2006). To be accredited institutions of engineering education were obliged to document that this criterion and 39 other criteria were met. Like the above ministerial 10 basic principles from 2000 this criterion is also relatively loosely defined and how to meet the criterion is open for interpretation. The loose definitions are also found in other official documents, such as ministerial orders concerning degree programmes, which have accordingly resulted in a good deal of variance between institutions and between degree programmes. Highly specific guidelines have thus not been issued by the Danish education authorities. In practice, this has also meant that discussions at the level of the four Danish Universities and three other institutions of higher education offering engineering studies (93 bachelor degree programmes in 10 different cities) have been uncoordinated and very different as to the content and priority they were given. Contact with colleagues in all the above seven Danish educational intuitions have thus revealed a great deal of variance as to when and how philosophy of science was/is to be implemented in the various degree programmes. This picture is also blurred even more by the Danish institutional set-up in engineering education. Danish engineering education has two tracks at the bachelor’s level: (1) a professional, more practice-oriented track including an internship in a company and (2) an academic, more theoretically oriented track without an internship. Each track leads to a bachelor’s degree in engineering and gives the possibility to study for an academic master’s degree. The four universities offer both practice-oriented and more academic degree programmes (in seven different cities), whereas the three other non-university engineering education institutions offer only practice-oriented degree programmes (in three cities) – making for differences within the same institution. Thus, no clear-cut institutional differences may be found as to the implementation process. Neither can we point to significant differences between the practice-oriented and the more academically oriented degree programmes. In both types of programme there has typically been a good deal of difficulties and disagreements concerning the form, content and duration of the philosophy of science element to be incorporated in the degree programme. However, as to the time aspect of the implementation process the more academic programmes have generally been faster in meeting the deadline, whereas in the professional,
practice-oriented programmes there has typically been a delay of two or three years in the implement-
uation (supposed to have taken place by 2004). In general, however, it may be said that in most programmes, be they practice-oriented or more academic, the process of implementation is still ongoing in terms of course design, place and duration. A few programmes had in fact not even begun the implementation process by autumn 2008.

At our Institute it was decided that each degree programme would be given individual freedom
to decide upon its own implementation process. In the business and language programmes at our Institute the ministerial recommendation was followed by almost immediate action and philosophy of science was fully implemented in the curricula by 2004. In the engineering programmes, however, philosophy of science courses were still in the process of being implemented in spring 2007 where our data were collected. Currently (autumn 2008) the implementation process is still ongoing.

In the Danish context, it can also be argued that the discourse of Bildung has been invoked as a justification of philosophy of science courses in higher education (Gustavsson 1998, Sjöbjerg 2005, Hansen et al. 2000, Johansen 2002, Christensen et al. 2006, 2007). The purpose is to create a broader outlook and increase the reflexive awareness (Fisher et al. 2006) of students. This entails making students understand how concrete actions carried out by engineers are linked to the overall development of technology and society. This requires an understanding of the nature and dynamics of the technological trajectories in which engineers are engaged including their own position and role in them. Philosophy of science courses may be conceived of as a first step to enhance this kind of ‘reflexive awareness’. At the same time this kind of endeavour would constitute a Socratic element of professional self-reflection in engineering education.

The questionnaire survey

To investigate the above issues our case study examined a sample of engineering teachers’ attitudes towards the relevance and scope of philosophy of science courses for engineering students. The data were collected in an anonymous questionnaire survey. The questionnaire was distributed to 35 potential respondents comprising the entire full-time teaching staff of our Institute’s three BSc engineering degree programmes in electronics, business development and global management and manufacturing (part-time teachers not included). Twenty-six respondents filled in the questionnaire – one respondent, however, only partly; 16 respondents are engineers, four hold degrees in business studies, five in science and one in psychology. The three bachelor degree programmes at our Institute are all so-called professional or practice-oriented programmes, which means that they include an internship in a company.

The set of data collected in the questionnaire survey is obviously too small and too particular to be of any statistical significance. However, we were not aiming at statistical significance and generalisation. We were aiming to construct a case study that despite its obvious limitations can provide interesting insight into how our respondents view the importance, relevance, scope and problems of implementing philosophy of science into engineering curricula. We also believe the study may be useful as a mirror for reflection to other educational institutions facing similar changes to their curriculum. Our case study can thus serve as an exemplar which we on the one hand cannot claim to be typical, but which we on the other hand have no reason to believe is atypical of what can be found elsewhere.

The questionnaire was written in a relatively general language with a view to avoiding special-
ized philosophical terminology and with the intention to thoroughly explain questions and terms expected to be unfamiliar to the respondents. Nevertheless, a respondent wrote a spontaneous and illuminating comment to our questionnaire on the relevance and scope of philosophy of science
courses for engineers: ‘The issue [philosophy of science in engineering] and the way in which it is presented is some galaxies away from my world for which reason I haven’t answered a number of questions. A more extensive oral presentation might have been able to compensate for my engineer’s handicap’.

The focus areas of the questionnaire were:

- Respondents’ advance knowledge of philosophy of science and their personal interest in the issue (questions 7 and 8)
- Attitudes to the place, content and relevance of philosophy of science in engineering curricula (questions 9, 10, 11, 12 and 3)
- Attitudes to teaching aims for philosophy of science in engineering (questions 14 and 15)
- Expectations of the impact of implementing philosophy of science in engineering degree programmes (question 16)

Questions 1–7 were related to background information about the respondent in order to look for indications of possible variations in the answers according to gender, age, the respondent’s own education, which degree programme the respondent is chiefly attached to, etc. However, no significant differences were found (the amount of data is of course also very small for such a purpose).

**Respondents’ advance knowledge of philosophy of science and their interest in the issue**

**Question 7  ‘Have you previously been engaged with philosophy of science?’**

There were no questions to measure the respondents’ understanding of the concept of philosophy of science as it was assumed that the respondents in their capacity as teachers of higher education would have a pre-understanding of the concept. However, as the above quotation shows this may have been an unwarranted assumption. Only half the respondents also claimed to be in possession of advance knowledge on the issue. This is perhaps a reflection of the fact that philosophy of science is a new subject in the Danish engineering curriculum and therefore not yet established in the minds of half the teachers.

**Attitudes to the place, content and relevance of philosophy of science in engineering curricula**

**Question 11  ‘Please indicate on a scale from 1 to 5 the relevance of the below mentioned issues for philosophy of science courses in engineering studies’**

This question intends to combine four issues in order to separately measure respondents’ attitudes to each of these issues.

(1) a Socratic element of professional self-reflection, dimension A–B–G,
(2) core areas of philosophy of engineering, dimension C–D,
(3) a core area of philosophy of technology, dimension E,
(4) engineering ethics, dimension F.

These four issues may be used by the reader as a general framework for understanding and interpreting the data. However, a detailed data analysis along these lines concerning question 11 would by far transcend the allotted number of pages for this article. It is suffice therefore to say that responses to question 11 show that the overwhelming majority of respondents in fact express a positive attitude to the combination of topics we have suggested for philosophy of science courses in engineering studies. On the face of it, this positive attitude should make it relatively easy to implement such courses in the engineering degree programmes the respondents are attached to.
### Question 11

<table>
<thead>
<tr>
<th>Scale</th>
<th>A: Engineering roles and identity</th>
<th>B: Engineering culture and norms</th>
<th>C: The design process as a technical and social process</th>
<th>D: Knowledge generation and forms of knowledge in engineering work</th>
<th>E: The importance of technology and its impact on society</th>
<th>F: Ethical problems in engineering</th>
<th>G: Requirements of interdisciplinary and intercultural collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Irrelevant</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2. Minor relevance</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Subtotal X 1 + 2</td>
<td>6</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3. Some relevance</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>4. Relevant</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>5. Very relevant</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Subtotal Y 3 + 4 + 5</td>
<td>19</td>
<td>16</td>
<td>23</td>
<td>23</td>
<td>25</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

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However, as previously argued, at the time the survey was carried out (spring 2007) the philosophy of science courses had not yet been fully implemented in the degree programmes but were still on the drawing board.

**Question 12.** ‘How would you evaluate the relative importance of research methodology and philosophy of science respectively?’

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To learn research methodology is more important than philosophy of science.</td>
<td>17</td>
</tr>
<tr>
<td>2. To learn philosophy of science is more important than research methodology.</td>
<td>0</td>
</tr>
<tr>
<td>3. Research methodology and philosophy of science are equally important.</td>
<td>7</td>
</tr>
<tr>
<td>4. Neither research methodology nor philosophy of science is important.</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

Not surprisingly, the responses show that the main priority of the respondents is the more instrumental concept of research methodology rather than perhaps somewhat more lofty concept of philosophy of science.

**Question 13.** ‘In your opinion, how broad and deep should the learning objective of philosophy of science courses be defined?’

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Philosophy of science courses should not be a part of engineering curricula.</td>
<td>2</td>
</tr>
<tr>
<td>2. Philosophy of science courses should be small and limited and should be implemented only to meet governmental requirements.</td>
<td>9</td>
</tr>
<tr>
<td>3. Philosophy of science courses should be major courses that should supply engineering students with conceptual tools and theoretical frameworks in order to make them capable of reflecting broadly and critically on the engineering role, engineering work and the impact of technology in society.</td>
<td>4</td>
</tr>
<tr>
<td>4. Philosophy of science should not only be a part of engineering curricula. Philosophical reflections should penetrate all courses and activities in engineering studies. Philosophy of science conceived this way should contribute to redefining and refocusing engineering curricula.</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
</tr>
</tbody>
</table>

Roughly speaking, the group of respondents are divided in the middle as to the role they see for philosophy of science in engineering curricula.

**Attitudes to teaching aims for philosophy of science in engineering**

**Question 14.** ‘As to the teaching aim of philosophy of science courses which of the two options would you prefer?’

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Philosophy of science should be a course aiming at Bildung as an end in itself.</td>
<td>10</td>
</tr>
<tr>
<td>2. Philosophy of science should be instrumentalised as a tool for courses in research methodology.</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>
That the majority is in favour of the instrumental approach is to be expected as was also seen in question 12. We had in fact expected the majority to be even larger – bearing in mind the inherently instrumental nature of engineering.

**Question 15. ‘What should be the learning outcome for engineering students after having completed a course in philosophy of science?’**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The student should have acquired basic knowledge of key concepts and theories.</td>
<td>10</td>
</tr>
<tr>
<td>2. The student should be able to independently apply key concepts and central theories.</td>
<td>12</td>
</tr>
<tr>
<td>3. The student should be able to critically and independently apply, reflect and theorise on key concepts and central theories.</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

We may conclude that the majority of respondents in our case study wish to see philosophy of science courses instrumentalized as a tool for project work and courses in research methodology. Furthermore, their level of ambition as to the learning outcome can be characterized as middle-range: engineering students in their third year of study should be able to independently use the key concepts and central theories. That the student should also be able to critically and independently reflect and theorise on the key concepts and central theories of the discipline is only perceived as a desired goal by a small minority. In our opinion this would also be a somewhat overambitious and unrealistic goal.

**Expectations of the impact of implementing philosophy of science in engineering degree programmes**

**Question 16. ‘Can you briefly summarize your expectations as to philosophy of science courses?’**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive – can advance the academic level of engineering degree programmes</td>
<td>18</td>
</tr>
<tr>
<td>Neutral – will not change anything but we have to integrate it in the curriculum</td>
<td>5</td>
</tr>
<tr>
<td>Negative – waste of time. Steals time from more useful activities</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
</tr>
</tbody>
</table>

The overwhelming majority of respondents have positive or neutral expectations to the impact of philosophy of science courses in engineering degree programmes. Only one respondent has negative expectations. On the face of it, this seems to be good news for educators around the world faced with the task of implementing philosophy of science courses in engineering programmes. However, it has to be noticed that not responding to our questionnaire survey is also a kind of answer open for interpretation. Nine out of 35 potential respondents did not fill in our questionnaire. The reasons for which we can of course only speculate about. If we were able to establish that our questionnaire study’s overall positive attitude towards implementing philosophy of science in engineering curricula was paralleled by concrete initiatives and actions to implement philosophy of science courses in the degree programmes in question the overall result of the case study would gain more credibility. However, if we compare the process of implementation in the three engineering degree programmes with the process of implementation of philosophy of science courses in the business and language degree programmes at our Institute, it has to be noted that the implementation process in the three engineering programmes has been a lot slower and
characterized by a good deal of hesitation and doubt as to how philosophy of science could and should be implemented in the curriculum. A pertinent question therefore is: given the relatively positive attitude towards philosophy of science courses in engineering which our questionnaire survey has shown, what possible mechanisms in the three engineering programmes may help to explain the seemingly paradoxical time lag between the ministerial recommendation of 2000 and the lack of full implementation by Spring 2007? These mechanisms were not manifested in the questionnaire survey as it was not designed for that purpose, but these mechanisms, we would argue, may be observed in daily practice at our Institute and they have also been discussed in the literature on sociological aspects of engineering.

Mechanisms working as barriers for the implementation of philosophy of science courses in engineering studies

In order to understand why the process of implementing philosophy of science into degree programmes has been slower and more complicated in engineering studies than in the business and language programmes at our Institute, we argue the case that engineering education at an overall structural level should be conceived of as an arena of conflicting contextual demands where strategic goals collide. To navigate in this arena is difficult. Internal and external pressures on engineering education create frustration among faculty members who are working hard to design what they perceive to be a future-oriented curriculum. Their immediate concern is to make the curriculum appealing to students, to meet the needs of companies locally and globally, to help society prosper and ensure future student enrolments in order to survive as a degree programme (Christensen et al. 2009). Other stakeholders of engineering education might question both the seemingly instrumental and narrow definition of the engineering curriculum and of stakeholders by soliciting conflicting claims. Thus some authors have argued that future engineers will have to face up to a long-term convergence between technical and liberal education (Williams 2002). Some argue that this convergence is necessary in order to provide future leadership for engineers (National Academy of Engineering 2004, Heywood 2007, Grimson et al. 2008). Given the tremendous impact of engineering and technology on society, culture, environment and the life and health of ordinary people, it might be expected that engineering education would become an arena where strategic goals of a broad range of stakeholders collide. This is advocated by Williams (2002, p. 70): ‘What engineers are being asked to learn keeps expanding along with the scope and complexity of the hybrid world. Engineering has evolved into an open-ended Profession of Everything in a world where technology shades into society, into science, into art, and into management, with no strong institutions to define an overarching mission. All the forces that are pulling engineering in different directions – toward science, toward the market, toward design, toward systems, toward socialization – add logs to the curricular jam’.

It is often argued (Goldman 1991, Bucciarelli and Kuhn 1997, H. Christensen et al. 2007) that engineers lack a metadiscourse allowing them to observe and reflect upon their own culture and education from metalevel perspectives, e.g. sociological, historical, ethical, philosophical, pedagogical and didactical, resulting in insufficient skills as to self-reflection, interdisciplinary cooperation and adjustment to changing conditions in general. In other words, precisely the elements which the introduction of philosophy of science courses in engineering curricula are supposed to compensate for.

A mechanism we would claim might work as a barrier for the implementation of philosophical questioning into engineering curricula has been identified by Goldman (1991), Johnston et al. (1996) and Holt (2001). They argue that engineering education and engineering practice have become captive to two major discourses which have had constitutive effects in engineering – both education-wise and practice-wise. The two captive discourses mentioned by Johnston et al. are (1)
the discourse of engineering science and (2) the discourse of commerce and science. According to Johnston et al. (1996, p. 1) ‘the result has been a serious limitation in engineers’ capacity to examine the social meanings and effects of their work and to self-consciously reflect upon their practice and professional identity’.

As to the discourse of engineering as a science, Simon (1996, pp. 111–113) argues that in the search for academic respectability, engineering design as an artificial science was gradually extolled from engineering curricula. Engineering schools thus gradually became applied science schools of physics and mathematics… The consequence of this has been pointed out by Bucciarelli and Kuhn (1997) and Hansen et al. (2000). According to their observations the socialisation of the neophyte engineer via the authoritarian pedagogy of ‘the correct answer’ in math and science courses at the bachelor’s level creates a wrong impression of the core of engineering (usually defined as problem solving (Koen 2003)) and stimulates a sense of belonging to a culture of ‘the right answer’ in line with what is often found in the natural sciences which operate in a more decontextualized environment.

As to the second discourse mentioned by Johnston et al., the discourse of commerce and science, the focus of this discourse may be characterized by a narrowly defined focus on company needs in which utility, applicability, profitability and innovation are the main concerns and in which the role and identity of the engineer are closely tied to the competitive needs of the company reducing the engineer’s role to that of the salaried employee. Accordingly this approach does not embrace a societal perspective and the role of the engineer does not embrace the role of the concerned citizen or the role as a public trustee. Moreover, especially at the practice-oriented bachelor’s level of engineering education, a long-standing Danish tradition in the recruitment of teachers has been the high value attached to the combination of a craftsman-like background, a bachelor’s degree in engineering and considerable practical experience from a career as an engineer in a company. In this way, the teacher serves as a role model for students, mastering the tacit knowledge and the instrumental ‘reflective practice’ of his profession. This criterion of employment has proven its worth over time, but in the context of philosophy of science teachers with chiefly this kind of background have a number of natural shortcomings in terms of the ability to engage in reflexive meta-discourse on engineering didactics – such as the discussion on reasons and methods for implementing philosophy of science in engineering degree programmes.

In their study ‘Working with men to change the culture of engineering’, Copeland and Lewis (2004a, 2004b) identified additional, cultural mechanisms which make it difficult to find a place in the curricula of engineering studies for courses aiming at creating vocational/occupational Bildung – such as philosophy of science. Copeland and Lewis report some interesting features from Australian universities: (1) interest in engineering itself is not an important factor in students’ choice to study engineering; in particular, this applies to male students. (2) A pattern among male students of a strong background in mechanical and/or electrical tinkering coupled with a lack of awareness of the relevance of this background for success in engineering. (3) A very high workload and an overcrowded curriculum coupled with a corresponding pride in working long hours as a sign of toughness. (4) A pressure on students to pass exams at the expense of engaging in deep learning. (5) A ‘weed-out’ system whereby those deemed unfit for the profession are weeded out via an overwhelming pace and load and a fiercely competitive environment. (6) A curriculum focused on technical concerns at the expense of the broader social, human, environmental and ethical context of engineering.

The time lag in the implementation of philosophy of science courses at our Institute and elsewhere in Denmark may thus also be explained by an already existing overload and the resulting practical difficulty in making room for this kind of course coupled with an educational culture that is alien to relatively abstract and non-concrete subjects such as philosophy of science. To make room for philosophy of science also means that some core engineering topics have to be left out. To go from non-committal good intentions and an overall welcoming attitude to binding
practical implementation has thus also been slow in the making of our case study. An increased and more coherent curricular focus is likely necessary to make space for studies of the broader social, human and ethical context of engineering. However, this is a discussion that tends to bite its own tail: to create acceptance of the need for increased curriculum focus requires discussions among faculty which are to all intents and purposes related to an understanding of philosophy of science; and to implement philosophy of science into curricula for students requires increased curriculum focus. Breaking this cycle has proven to be hard in our case study.

Conclusion

Our study has highlighted a seeming paradox: on the one hand, a relatively positive attitude among faculty as to the relevance of philosophy of science in engineering curricula and on the other hand, lacking concrete actions of implementation among the very same faculty. However, the difficulties of implementation are perhaps not so surprising given the barriers outlined earlier. The biggest surprise is therefore the generally positive attitude among the respondents in the study. This could of course be written off as a consequence of the establishment of an institutional discourse on philosophy of science at our Institute – established through our questionnaire survey – which has made respondents more positive to philosophy of science when filling in the questionnaire than before. It is a well-known fact that there may be differences between people’s attitudes ex ante and ex post gaining knowledge of a phenomenon. However, we believe that this cannot explain in full the rather surprising positive attitudes found in our survey which is also due to the fact that we were very conscious of formulating the questionnaire in a neutral way. We believe that the positive attitudes are an indication of a more general phenomenon, that is, that although the contemporary culture of engineering is still to a large extent rooted in a relatively narrow technical/applied science approach there is also openness towards discussions of broader issues among our respondents. We were, for example, surprised to see that 40% were in fact in favour of Bildung as the ultimate aim of philosophy of science courses.

It therefore seems reasonable to conclude that our respondents see philosophy of science as an unwelcome intrusion or a kind of ‘Trojan Horse’ in the curricula of their degree programmes. On the contrary it seems that the general attitude is that philosophy of science may help improve the studies. How to go from attitude to action is, however, the major challenge, raising the pertinent question: Who should teach philosophy of science to engineering students, engineers or philosophers? Engineering teachers are likely to have the legitimacy among students but most likely to lack the qualifications. Academics trained in philosophy of science on the other hand may have the formal qualifications but are likely to lack legitimacy among students and to lack the ability to put theories into a relevant, practical engineering context. Consequently, for a successful implementation of philosophy of science courses into engineering curricula such courses should ideally be taught as a collaborative effort of teachers rooted in engineering disciplines and teachers rooted in the relevant philosophical specialties. Furthermore, as our case study shows, it has to be recognized by engineering educationalists teachers and students that given the history and culture of engineering it takes time to successfully implement philosophy of science courses in engineering degree programmes.

References

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Chapter 6

Implementing Liberal Arts in Engineering Education in Denmark

Abstract: Some authors have argued that future engineers will have to face up to a long term convergence between technical and liberal education. This development is seen in Denmark where liberal education in the form of philosophy of science has recently become a compulsory part of the curriculum of degree programs. However, the process of implementation in engineering degree programs, in particular in practice-oriented engineering degree programs, has been characterized by a good deal of doubt and hesitation resulting in a remarkable delay when compared to degree programs like those in the humanities and social sciences. In this chapter we discuss the mechanisms which might have caused the delay on the basis of the findings of an empirical case study carried out at our Institute. We first investigate attitudes among engineering faculty toward the aim and scope of philosophy of science in engineering education. Second, we discuss overall principles regarding the delivery of philosophy of science courses in engineering and suggest guiding principles regarding skills and competencies to be acquired by students. Finally we suggest a pedagogy that may enhance learning.

Key words: global challenges, philosophy of science, platforms and rationale, the arguments of engineers, skills and competencies, general complexity of curriculum reform

Introduction

Some authors, e.g. Beder (1997, 1999), Williams (2002), Christensen et al. (2006), and Hyldgaard Christensen et al. (2007), have argued that future engineers will have to face up to a long term convergence between technical and liberal education to meet the needs of the future labor market where purely technical competencies are increasingly becoming insufficient. Other authors have argued that convergence between technical and liberal education is necessary to provide future leadership for engineers (National Academy of Engineering, 2004; Heywood, 2007; Grimson et al., 2008). All derive their arguments from key developments in the global knowledge economy. Devon and Liu (2002) have presented a short and instructive list of trends of the global knowledge economy which translate into challenges for engineering education (see also National Academy of Engineering, 2004):

1. People become increasingly interconnected and geographically mobile. National economies become more and more interdependent
2. Information is a new currency
3. Decentralisation of power, reduction of hierarchy, and increasing complexity
4. Globalization of economy, workplace and culture, including international standards (ISO)
5. Strengthened influence of multinational corporations which increasingly operate as transnational players
6. Functionalizing of relationships – the extent to which we know and relate to people only as an extension of our work
7. Diversification of relationships; multicultural and multinational teams become the norm
8. Continuous change in technology and organizational structures

Not only engineering education but society in general has to deal with these global megatrends to predict and plan for skills gaps in the workforce. However, a much debated consequence of these “new realities” is that the role and purpose of higher education is increasingly becoming linked with an instrumental “employability” agenda to meet the needs of the economy and ensure future competitiveness of companies. Some critics see this as a “downgrading” of higher education to merely training graduates for jobs rather than (also) educating them for life by improving their minds, stimulating their intellectual orientation and broadening their horizon (Harvey, 2000).

According to Steiner (1998, p. 2) one of the engineering educator’s dilemmas in a globalised world is the problem of teaching engineering certainty under uncertainty and contingency conditions. This means that when engineering students gradually become acclimatized into the engineering culture and the paradigm of their field of technology they must simultaneously learn “to depart from...[their]...professional paradigm, to exceed its bounds, to look beyond its borders both for problems and solutions”. This critical self-reflection is made difficult by the fact that a rapid and exponential growth of knowledge in all engineering fields leads to a high degree of specialization in engineering curricula which is likely to be a narrowing factor (McCowan & Knapper, 2002). Steiner’s observation suggests that degree programs that are largely focused on technical content in a limited technological field and on inculcation of a specific professional culture and epistemic paradigm are insufficient as engineering work takes place in increasingly diverse social and technical contexts; engineering problems thus often cut across not only different technological fields but also fields within the social and humanistic sciences, for example. From a global macro level to a local micro level, consideration of social issues will therefore impact on both engineering education and practice in the future. At the macro level major social issues include depletion of natural resources by population increase, political and economic conflicts between nations and peoples, concerns regarding intellectual property, cultural diversity, moral/religious repercussions and national security. At the micro level engineers will increasingly work in project teams across disciplines, professions and (national) cultures, necessitating the development of a broader range of professional/personal/interpersonal skills and competencies (US National Academy of Engineering (2004)).

In Europe these new requirements have been acknowledged and outlined under the heading of “transferable skills” within the EUR-ACE framework. The EUR-ACE framework was launched in 2006 in order to establish an accreditation system of engineering education on a continental scale (see EUR-ACE, Doc. A1-en Final, November 17, 2005 and Doc. C1-en Final, November 17, 2005). “Transferable skills” is one out of six categories of criteria regarding knowledge and skills which have to be satisfied to obtain accreditation of an engineering degree program. The six categories of criteria apply at different levels of complexity to both first cycle
and second cycle programs. In the United States the above developments are mirrored in and reinforced by the ABET 2000 criteria (Accreditation Board of Engineering and Technology). These criteria are an ambitious attempt to improve the level of accredited engineering programs in the US. It is, however, important to notice that both the ABET 2000 criteria and the EUR-ACE criteria are concerned with skills and attitudes and not with curriculum content. McCowan and Knapper (2002) have translated the ABET 2000 criteria in the following way which is similar to the “transferable skills” requirements of the EUR-ACE criteria:

- Improve communication skills
- Increase design content in curriculum
- Develop lifelong learning skills
- Increase societal understanding and sense of social responsibility
- Increase understanding of management and business issues
- Increase understanding of environment and sustainability
- Increase awareness of health and safety issues
- Improve team skills
- Broaden knowledge of other disciplines

In the US the teaching of a number of the above skills and competencies are traditionally referred to as “liberal education”. Both in Europe and in the US the responsibility for teaching such skills to engineering students is generally left to academics trained in the humanities and the social sciences (Steneck et al., 2002). In the light of the above observations of global megatrends, the aim of this article thus is to discuss at an institutional level some of the complexities and didactic/pedagogical problems in implementing liberal education into engineering curricula in Denmark. In Denmark liberal education under the heading of philosophy of science has become high on the agenda since 2000. In 2000, the Danish government recommended the inclusion of philosophy of science courses in degree programs at the bachelor’s level. Since then the process of implementation has been characterized by a slow pace in engineering education where it has taken longer to implement than elsewhere such as in the humanities and the social sciences. We have been wondering what kind of mechanisms have caused this time lag?

The Platform and Rationale for Implementing Philosophy of Science into Engineering Studies in Denmark

Before embarking on our case study let us look into what at all initiated the discussion on introducing philosophy of science in engineering studies in Denmark? In 1999, a UNESCO World Conference entitled “Science in the Twenty-First Century: A New Commitment” was held in Budapest. In section 4 of the preamble of the ensuing “Declaration on Science and the Use of Scientific knowledge” the Declaration states: “Science curricula should include science ethics, as well as training in the history and philosophy of science and its cultural impact”. The UNESCO Declaration also includes engineering science: “We seek active collaboration across all the fields of scientific endeavor that is the natural sciences such as the physical, earth and biological sciences, the biomedical and engineering sciences, and the human sciences”.

In 2000 as an echo and immediate outcome of the UNESCO Declaration to which Denmark had subscribed (Fink et al., 2003, p.7), preparatory measures were taken by the Danish Government to implement philosophy of science courses into higher education. Accordingly, the Danish Ministry of education in 2000 sent out a letter to the universities outlining 10 basic and very overall principles regarding the aim and extent of philosophy of science in bachelor programs. The aim of introducing philosophy of science was defined as follows: “Students should be offered an opportunity to qualify their professional specialty by seeing it in a broader and more general perspective” (Ministry of Education, 2000). The letter also outlined that philosophy of science courses were expected to be implemented in all university degree programs by 2004. However, the concrete implementation was left to the universities themselves allowing for differences as to the pace, content and way in which philosophy of science was to be implemented in degree programs. The Danish Institute of Evaluation (EVA) in connection with an accreditation process in 2006 formulated the following criterion concerning professional engineering degree programs: “Research methodology and philosophy of science must be part of the degree program in order to enable students to follow and apply R&D results in their field of specialization” (The Danish Institute of Evaluation, 2006). To be accredited, institutions of engineering education were obliged to document that the above EVA criterion among 39 other criteria were met. Like the above ministerial 10 basic principles from 2000 this criterion is also relatively loosely defined, and how to meet the criterion is open for interpretation. The loose definitions are also found in other official documents, such as in ministerial orders concerning degree programs, which has accordingly resulted in a good deal of variance between institutions and between degree programs. Very specific guidelines have thus not been issued by the Danish education authorities. To put the Danish initiative into perspective it should be mentioned that in the US the platform for discussions on philosophy/liberal education in engineering studies is the ABET criteria and, as a further example, the American Society for Engineering Education. In Denmark, the situation is different in the sense that the platform for such discussions is governmental executive orders which serve to regulate a broader range of studies both at universities and other institutions of higher education. Illuminating as to how liberal education is facilitated in the US is a White Paper from the Liberal Education Division of the American Society for Engineering Education, in which Steneck, Olds and Neeley (2002) present an extensive set of valuable general guidelines and broad standards for the engineering education community to use in implementing ABET’s criteria 2000. Such valuable guidelines have not been discussed or issued in Denmark. However useful the US White Paper may be in defining the aim, scope and ways to assess the outcome of liberal education it nevertheless raises a number of pertinent questions as to the concrete implementation of liberal education in engineering degree programs inasmuch as a number of concrete contextual constraints can be expected to play a crucial role.

As such broad standards and guidelines are lacking in Denmark in practice this has also meant that discussions at the level of the 7 Danish Universities and other institutions of higher education offering engineering studies (93 bachelor degree programs in 10 different cities) have been uncoordinated and very different as to the content and priority they are given. Contacts to colleagues in all 7 Danish engineering education institutions have thus revealed a great deal of variance as to when and how philosophy of science was/is to be implemented in the various degree pro-
grams. This picture is also blurred even more by the Danish institutional set-up in engineering education. Danish engineering education has two tracks at the bachelor’s level: 1) a professional, more practice-oriented track including an internship in a company, and 2) an academic, more theoretically oriented track without an internship. Each track leads to a bachelor’s degree in engineering and gives the possibility to study for an academic master’s degree. The four universities offer both practice-oriented and more academic degree programs (in 7 different cities) whereas the three non-university engineering education institutions offer only practice-oriented degree programs (in 3 cities) – making for differences within the same institution. Thus no clear-cut institutional differences may be found as to the implementation process. Neither can we point to significant differences between the practice-oriented and the more academically oriented degree programs. In both types of program there has typically been a good deal of difficulties and disagreement concerning the form, content and duration of the philosophy of science element to be incorporated in the degree program. However, as to the time aspect of the implementation process the more academic programs have generally been faster in meeting the deadline whereas in the professional, practice-oriented programs there has typically been a delay of two or three years in the implementation (supposed to have taken place by 2004). In general, however, it may be said that in most programs, be they practice-oriented or more academic, the process of implementation is still ongoing in terms of course design, place and duration. And a few programs had in fact not even begun the implementation process by autumn 2008.

At our Institute it was decided that each degree program was given individual freedom to decide upon its own implementation process. In the business and language degree programs at our Institute the ministerial recommendation was followed by almost immediate action and were fully implemented by 2004. In the engineering degree programs, however, philosophy of science courses were still in the process of being implemented in spring 2007 where our data was collected. Currently (autumn 2008) the implementation process is still ongoing.

In the following we thus set out to discuss on the basis of the findings of an empirical case study some of the difficulties and didactic problems at an institutional level in defining and implementing philosophy of science in engineering studies in Denmark. The methodology we used is semi-structured focus group interviews carried out in 2007 with 3 faculty members in each focus group representing the three BSc engineering degree programs at our institute. We first investigate attitudes among engineering faculty toward the aim and scope of philosophy of science in engineering education. Second, we discuss overall principles regarding the delivery of philosophy of science courses in engineering and suggest guiding principles regarding skills and competencies to be acquired by students. Finally, we suggest a pedagogy that may enhance learning.

The Focus Group Interviews

The data which was recorded from 3 focus group interviews each of a duration of 2 hours have been fully transcribed and subsequently analyzed as a whole. In our analysis we concentrate on what is said rather than on who said what from which degree program. In this way we guarantee the anonymity of the respondents. The interviews focused on 7 themes regarding respondents’ attitudes toward:
1. aim, scope and value of philosophy of science in engineering studies at the bachelor’s level
2. the place of philosophy of science in the engineering curriculum and the trade-offs to be dealt with in the curriculum design
3. obsolescence of technological knowledge and the trade-offs between broad and specialized skills and competencies in engineering studies
4. international, interdisciplinary and inter-professional collaboration and the significance of engineering culture
5. roles of engineers in society
6. teaching social responsibility in the engineering curriculum
7. stakeholders in engineering education

Based on the responses related to the 7 themes we were able to identify what the respondents believed would be core characteristics of future engineering work and accordingly focal concerns of practice-oriented engineering degree programs. All respondents thus believed that interdisciplinary skills, broadmindedness and ability to think independently would be essential features of future engineers. The knowledge, skills and competencies needed would be:

- Solid, basic knowledge of the natural sciences
- In-depth knowledge of the engineer’s own field of technology
- The ability to solve problems creatively
- Good language skills and other skills needed in international relations
- Good skills in written and oral communication (lacking presently according to respondents)
- The ability to work in teams and networking capabilities
- Business knowledge and market orientation
- Entrepreneurial skills and competencies

(for comparison see Yrjänheikki & Takala (2001)).

Of the above 7 themes guiding the interviews, themes 1-3 are mainly concerned with didactic/pedagogical issues whereas themes 4-7 refer to a Socratic element of professional self-reflection and hence the prospects of re-contextualizing engineering studies.

Based on our analysis of respondents’ attitudes regarding the 7 above themes, we below reconstruct responses in the form of ideal types of arguments which illuminate complexities in implementing philosophy of science in engineering degree programs. These ideal types of arguments allow a partial understanding of the time lag as to the implementation of philosophy of science in engineering degree programs at our institute. In the ideal typical arguments there is a clear resonance of the above profile of future engineers. We have termed the ideal type arguments regarding the rationale and scope of philosophy of science as follows:

1. The “no need” argument.
2. The “instrumentalize it” argument.
3. The “split it up” argument.
4. The “lack of staff qualifications” argument.
5. The “keep it simple” argument.
6. The “loyal employee” argument.
7. The “trade-off” argument.

In the following we present these ideal typical arguments followed by a number of typical quotations to illustrate our interpretation:

Ideal type arguments regarding the rationale and scope of philosophy of science in engineering degree programs

<table>
<thead>
<tr>
<th>The “no need” argument.</th>
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| The argument: Practice-oriented engineering degree programs at the bachelor’s level at our institute have been very successful in meeting the needs of companies which is an ongoing concern in all engineering studies. It is thus relatively easy for engineering graduates from our institute to find work due to the fact that they have acquired the skills and competencies which make them readily useful in companies. The success owes to the fact that both students and engineering teachers work in a close cooperation with companies. Students have assignments with companies regarding their project work including their final project. The goal of their education is to educate broad minded and independently thinking engineering graduates who are able to cooperate with others in order to creatively solve engineering problems in companies. To divert attention from this goal by introducing philosophical questioning of what engineers are doing and why they are doing it would be a mistake that might jeopardize what has been achieved so far.

Examples: “The type of engineer that we educate is supposed to work in a company. He should be able to put things together and make them work. He is not supposed to question philosophically what he is doing and why he is doing it”.
“...We educate people who are able to take an independent stand be it at a technical, economic, device or company level. It is sound engineering wisdom to know how these things relate to each other. However, I don’t think that such knowledge builds on or relates to philosophy of science. It rather relates to the professional core of engineering”.
“Our students have a very good reputation indeed in the local companies. Quite often we receive mail from companies that wish to hire our students or ask if we have students who will complete their study within a short time in order to offer them employment. This quality stamp on our education therefore allows us to conclude that we currently teach our students the qualifications which are requested by companies”.

<table>
<thead>
<tr>
<th>The “instrumentalize it” argument.</th>
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| The argument: As the core of engineering is practical problem solving; all activities in engineering studies should ideally aim at enhancing the student’s competence in this area. Philosophy of science would be a positive novelty in engineering studies if interpreted and instrumentalized as research methodology. In this way it will be meaningful for the students in making them better aware of how to formulate a problem, how to use different methodologies and research techniques in the data gathering process and how to analyze and validate the data. In making them better at solving problems by teaching them how to work in a structured way, they will become better engineers.

Examples: “Philosophy of science for me thus designates a structured way of working. Hence what Socrates and Plato said in the past would largely be irrelevant”.
“...Taking diploma engineering studies which are not wildly academic as a point of reference, I think that some of these abstract concepts, especially the methodological part of philosophy of science, simply may help the students to become better at solving problems”.
“In my opinion the purpose of the governmental decision to implement philosophy of science in degree programs is to make the students more conscious about their own perception of the world in order to better understand how such perceptions influence their analyses and … results, that is to say the quality of their analysis and results. I think that there is a need here to be more conscious”.
“In my opinion it is beyond dispute that it will be extremely difficult to aim at Bildung in many engineering studies. Engineers do not think along these lines. It has something to do with the engineering mode of thinking. Engineers do not seek knowledge just for the sake of knowledge in order to be able to discuss it in the lunch room…….Our students are put into a context in which they are supposed to produce useful
Implementing Liberal Education in Engineering Studies in Denmark

The “split it up” argument

The argument: Implementing philosophy of science in the form of research methodology as a separate course module into a practice-oriented 3 ½ year engineering degree program would be risky business. There is a risk of making such courses both too time-consuming thus stealing valuable time from more important issues in a tightly packed curriculum and of wasting time by entering into philosophical and methodological subtleties which nobody understands and which is of no use in practical day-to-day engineering problem solving. Ideally, philosophy of science should only be taught when needed and requested in connection with the students’ project work. In this way it would be both relevant and meaningful for students and teachers. Another way to do it would be to consciously label what we are doing already regarding philosophy of science in the curricula of engineering degree programs.

Examples: “In my view it is not wise to make philosophy of science an independent module. Ideally it should be taught when needed in specific engineering disciplines or problem areas. In doing so, it would not have the negative side effect of increasing the pressure to remove vital engineering topics”.

“When summarized into a few tangible elements, you might say that we already teach the subject without clearly labeling this activity as philosophy of science. Thus the subject is taught but not as an identifiable course module.”

The “lack of staff qualifications” argument

The argument: As practical engineering problem solving does not hinge on philosophy and the ability to engage in meta-disciplinary reflections as important parts of the engineer’s toolbox, most engineers are not trained to be sensitive to the more intellectual and philosophical aspects of engineering. Accordingly, most engineering teachers cannot be expected to be familiar with the concept and scope of philosophy of science. Therefore they have to be taught the subject. In order to gain legitimacy, implementation of philosophy of science courses must be supported by engineering faculty members. Otherwise it won’t work.

Examples: “In principle I believe that one has to start with the engineering teachers. If they don’t understand what it [philosophy of science] is, it simply won’t work.”

“I believe that the most important kind of Bildung takes place during the engineering study. However, it might appear that this kind of Bildung is wrong in the sense that it is building on a culture and a set of norms, which are imposed upon the students without the students being conscious of it…. This imposition, so to speak, takes place at an unconscious level”.

The “keep it simple” argument

The argument: As philosophy of science in general and philosophy in particular are perceived to be abstract, difficult and peripheral by engineering students, the likelihood of success will depend on three pedagogical preconditions: 1. The teacher should be capable of using a straightforward and simple vocabulary in order to convincingly bridge the gap between engineering and philosophy for the engineering students, 2. Suitable examples from engineering practice and project work should be provided in order to demonstrate the practical applicability of meta-disciplinary reflections, and 3. The subject should be taught at a very basic level. Otherwise the students will lose their motivation and simply skip it.

Examples: “It also depends on which pedagogical approach is chosen...the students have to be able to see the practical applicability... If the students are unable to comprehend that universe, they simply skip it...We have tried that many times before”.

“You are getting at a higher level of abstraction... that is to say you are supposed to get an insight into how other people think which for me is a fine intention...however I believe that it will be extremely difficult for the students to cope with”.

“We all agree that engineers should be able to cooperate with people from other professional and national cultures. In that context the concept of Bildung might be relevant. I think Bildung is o.k. if you can teach it at an extremely basic level”.

The “loyal employee” argument

The argument: Questions of personal responsibility are of minor importance for the engineer as patronage is essential in two ways in engineering. First, the patron establishes the intention, and decides on particular grounds what engineers have to do. Second, the patron provides the means to accomplish that purpose. It is the patron who energizes professional work towards a specific goal, not what the engineer might know or can do. As engineers are dedicated to their work and loyal to their patron, ethical concerns for engineers are largely related to the choice of patron. When the patron is chosen, ethical problems are usually located at a higher level within the organization. For this reason philosophical engagement with
engineering ethics and the responsibilities of the engineer as a citizen are largely irrelevant in practice-oriented engineering degree programs.

Examples: "The responsibilities of the engineer as a citizen, that’s a difficult one!.....You ask whether they [the students] are supposed to take part in the public debate on technology. You have simply gone totally astray”.

“I fail to see that this is our job”.

“They simply live and breathe for the companies, in which they are hired and in which they work. I personally feel likewise”.

“If you work in a company you equally well serve as a citizen. There is a connection between those things. Speaking of ethical concerns such as: In which companies do you want to work, what do you want to do and how do you want to do it, what is the overall strategy of the company? Does it fit with your personal strategy and ambition? These concerns also mean that you act as a citizen”.

“In principle we don’t discuss the responsibilities related to citizenship with our students. However, we do discuss ethical concerns, which in itself represents a societal perspective. Of course we do not possess the tools needed in order to be able to discuss ethics at an abstract and philosophical level but we discuss such concerns at a level a step higher up than ordinary common sense”.

The “Trade-off” argument.

The argument: In a tightly packed, practice-oriented engineering degree program, trade-offs have to be made when proposals of implementing new topics are put on the agenda. Trade-offs should be made in favor of strengthening the skills and competencies which serve to enhance the immediate employability of engineering graduates. To the extent that philosophy of science courses enhance the immediate employability of engineering graduates, it should be implemented and other important topics left out. To do so would be sound engineering judgement in a situation where a number of constraints has to be taken into consideration in order to design a future oriented engineering curriculum.

Examples: "Which new topics should be incorporated and which ones should be removed? At the moment the curriculum is tightly packed....with courses which we have selected very carefully and which have proved their practical value in a company context. If additional courses are to be incorporated into the engineering curriculum they must relate to the engineering mode of working. They should not be constrained to merely philosophical reflections”.

“If we have come to the conclusion, that we don’t believe in the value of a specific course module, we simply skip it for the benefit of something more useful”.

The seven ideal typical arguments show that attitudes amongst engineering faculty members towards the incorporation of philosophy of science in the curricula are ambiguous. The “no need” argument on the one hand shows that there is a good deal of skepticism toward philosophy of science. Other arguments, however, show that underneath the skepticism there is also a welcoming attitude and that engineering faculty is trying to come to terms with the new subject. Taken together the seven arguments therefore show that philosophy of science/liberal education is not yet a well-established concept in the minds of engineering faculty members at our Institute.

In order to understand at an overall institutional level why the process of implementing philosophy of science into degree programs has been slower in the making and more complicated in engineering studies than in the business and language programs at our institute, a number of concrete ambiguities have to be mentioned which have resulted in a relatively low involvement among constituencies at our institute:

1. The governmental requirement of making philosophy of science a compulsory part of all degree programs at the bachelor’s level did not originate in a proposal from the engineering community.

2. The official regulation of the philosophy of science component in engineering degree programs has been unclear, thus leaving ample space for doubt and hesitation.
3. No specific guidelines have been issued as to content, place and duration.

4. No collaboration between constituencies has taken place, resulting in a lack of concrete decisions as to the implementation process.

5. The rhetoric and expectations of engineering constituencies have differed significantly from those of the humanities and the social sciences.

We would argue that the ambiguities mentioned in number 1, 4 and 5 clearly indicate that discussions of philosophy of science have brought to the surface a difference between the value systems of different professional cultures at our institute which has proven difficult to bridge to the detriment of implementation. Contacts to colleagues in other educational institutions offering engineering degree programs in Denmark reveal that the above picture is more or less the same.

To move beyond what we have established so far we discuss in the following section overall principles regarding the delivery of philosophy of science courses and suggest guiding principles regarding skills and competencies to be acquired.

Discussion of Guidelines Regarding the Aim and Scope of Philosophy of Science

Executive order no. 527 of 21 June 2002 from the Danish Ministry of Education stipulates that:

“Practice-oriented engineering studies at the bachelor’s level are complete professional engineering degrees which qualify the students to undertake occupational functions both in a national and an international context in which they are able to

1. put technical research results, scientific and technical knowledge into practical use in development projects and in solving technical problems
2. critically acquire new knowledge within relevant field of engineering
3. solve engineering tasks independently
4. plan, realize and control technical plants, and in doing so, to include societal, economic, environmental and work environmental consequences in the solution of technical problems
5. fulfill a role in management and cooperative relations with people with other educational and cultural backgrounds.

Furthermore the education should qualify the students for further studies”.

(Our translation).

Even though executive order 527 has not been instrumental in discussions of philosophy of science, it nevertheless has resemblances to the ABET 2000 criteria. It thus provides opportunities for defining and strengthening the role of liberal education in practice-oriented engineering degree programs. Thus the term philosophy of science may be slightly misleading in the sense that traditional, de-contextualised courses of philosophy of science undoubtedly would be useless in order to achieve the skills and competencies put forward in the executive order. If not related properly and consistently to the engineering context, i.e. the engineering mode of working and thinking and the context in which engineering work takes place, philosophy of
science would most likely be a waste of time in an already tightly packed engineering curriculum. In the following we thus try to define the aim and scope of philosophy of science in engineering curricula in terms of skills and competencies that meet both official Danish requirements, i.e. research methodology and philosophy of science and some of the wishes of engineering faculty members as presented in our data analyses. Attempting to be realistic in defining the scope of philosophy of science at a bachelor’s level, we have left out a number of important issues regarding the historical and intellectual dimension of engineering. Accordingly we would recommend that the following limited number of learning objectives of philosophy of science in terms of skills and competencies should be met (for further elaboration see Steneck et al., 2002).

A. Research methodology
   • Ability to make a well planned research design for the data collection of an empirical investigation within technical science or social science
   • Ability to analyze quantitative and qualitative data
   • Ability to present data and draw conclusions accurately and fairly, based on the use of critical reasoning

B. Philosophy of science
   • Ability to identify the philosophical foundation of the research paradigm used when making a research design
   • Ability to describe and discuss the strengths and weaknesses of a scientific worldview
   • Ability to describe and discuss how engineers produce and use knowledge with particular emphasis on the strengths and weaknesses of scientific methods and engineering design processes

C. International, interdisciplinary and inter-professional collaboration
   • Ability to identify and discuss how differences in cultural backgrounds have bearings on problem definitions of both engineers and non-engineers
   • Ability to identify and discuss the value systems and working habits of other national, regional and ethnic cultures
   • Ability to identify and discuss the value system and working habit of the engineering culture
   • Ability to identify and discuss the value systems and working habits of other professional cultures
   • Ability to negotiate and find common ground between different ways of defining problems, value systems and working habits

D. Ethical reasoning
   • Ability to identify stakeholders in an engineering problem/solution
   • Ability to identify and analyze moral problems and dilemmas at the micro, meso and macro level

As to assessment, clear criteria for the range of skills and abilities, as well as the knowledge to be acquired in the relevant part of the curriculum should be provided, and clear feedback against these criteria should be given (for further elaboration see
Harvey (2000)). Defining the aim and scope of philosophy of science in terms of skills and competencies instead of content allows for a more flexible curriculum design. Undoubtedly some of these skills and competencies are already taught without being clearly labeled. A compulsory requirement in Denmark for accreditation of engineering degree programs is that philosophy of science in engineering curricula must be identifiable as a separate course unit. It therefore cannot be entirely “split up” although this to some extent is both feasible and desirable. Thus a division between a basic course common to all engineering degree programs and separate course units related to the specific design spine of the individual degree program is feasible and allows us to define the boundary between the two in a flexible way. We would argue that a prerequisite for success in teaching philosophy of science for engineering is the provision of, 1) opportunities for training the skills of comprehensive research design related to either technical science or social science (without conducting the actual research), 2) opportunities of creating projects in which the students work in multidisciplinary and multicultural teams, 3) opportunities to document the results in papers/reports, 4) opportunities of collaboration between faculty members from engineering, the humanities and social sciences.

As to curriculum design and pedagogy, McCowan and Knapper (2002) and Bordogna et al. (1993) suggest that the current emphasis on reductivism in engineering studies should be replaced by a more holistic approach. The current approach in which the curriculum is designed to present the students the set of topics engineers “need to know” creates the impression that engineering education is a collection of isolated courses which have to be learned before the students are “allowed” to frame an engineering problem. Instead of this “bottom up” approach, they argue that integrated learning would be an ideal approach and pedagogy. By integration is meant integration both as to curriculum and the use of a variety of pedagogical methods. McCowan and Knapper argue that learning in most fields and at all levels is most effective when the student is put in the role as an active participant in the learning process, and not in the role as a passive recipient of merely theoretical knowledge. In the passive role student learning has a much greater tendency to be both superficial and quickly forgotten. Moreover, the crucial point is that active involvement in learning helps the student to develop the skills of self-learning while at the same time contributing to a deeper, longer lasting knowledge of the theoretical material. To link philosophy of science to students’ project work in general and to the students’ final project in particular would most likely be both meaningful and motivating for the students. In this way lecturing can be reduced to short introductions of theoretical/philosophical frameworks when needed.

Conclusion

Our study has highlighted a number of barriers amongst engineering faculty in connection with the implementation of philosophy of science/liberal education in engineering curricula (cf. the above ideal type arguments regarding the rationale and scope of philosophy of science in engineering degree programs). These barriers have resulted in a lack of concrete actions of implementation amongst the very same faculty reinforced by a lack of official governmental or institutional specific guidelines as to content, place, duration and assessment of philosophy of science courses in engineering programs. However, in spite of the above barriers and in spite of the respondents’ hesitation and doubts as to the role and value of philosophy of science
in engineering, the general impression from our interviews is that the overall attitude among the interviewees is in fact welcoming (see also Christensen and Ernø-Kjølhede (2009)). Respondents thus generally expressed a belief that at the end of the day and given the “right” course design, philosophy of science would as a newcomer to the curriculum be more likely to strengthen the skills of engineering graduates rather than the opposite. In a broader perspective, liberal education curricular reforms such as the Danish initiative with the inclusion of philosophy of science also serves the useful purpose to establish a meta-disciplinary platform among faculty enabling them to currently reflect upon and improve the quality of engineering degree programs. However curricular reforms are difficult to implement as they are very complex on at least five counts (International Bureau of Education, 2006): 1. They are inextricably linked to perceptions of current thinking and actions on educational concerns and reforms around the world, 2. The vision behind curriculum reform is concurrently the expression of a political and a technological agenda which is open to criticism, 3. Curriculum reform is both a process and a product, which involves a wide range of institutions, stakeholders and actors, 4. The process of constructing a curriculum is unique to each national and institutional setting. It is the complex outcome of negotiations between stakeholders to meet the perceived needs and requirements of companies, students and society, 5. Quite often the strategic goals of stakeholders collide. Accordingly there are no international or national models that are readily applicable as our study also confirms. General guidelines for curricular reform may thus be helpful; however, successful implementation is dependent on its local context. As can be seen from our study, implementation has to go through a process of gradually gaining legitimacy among institutional constituencies. The duration and complexity of that process may vary considerably according to local context and degree program.

References

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Chapter 12

Socio-technical Integration in Engineering Education
A never-ending Story

Steen Hyldgaard Christensen and Erik Ernø-Kjølhede

Abstract: The introduction of theory of science in Danish engineering education may be seen as an exemplary attempt to integrate socio-technical and contextual competencies into bachelor engineering degree programs. In this chapter, we set out to investigate in what way boundary definition and demarcation between technical text and social context have influenced the process of introducing and implementing theory of science into professional engineering bachelor degree programs. To set the stage, we first discuss how contextual issues and socio-technical competencies have been incorporated in accreditation criteria for first-cycle engineering degree programs in the United States and Europe and some of the impediments for responding in engineering education. Second we give a brief account of the rationale for implementing theory of science into Danish professional engineering bachelor degree programs. Third we discuss our findings from an institutional example: a longitudinal case study carried out at Aarhus University, Institute of Business and Technology from Spring 2007 to Fall 2010.

Keywords: dialectics of boundary definition, socio-technical competence, contextual knowledge, theory of science, contested area, translation process, discursive strategies.

Introduction

The importance of incorporating contextual issues and developing socio-technical competencies in engineering education has been widely acknowledged in the engineering education community in Australia, Europe and the United States. High quality engineering design requires understanding of how the engineered artifact interacts with individuals, society, and the environment, both natural and manmade. In the US, the ABET EC 2000 criteria (www.abet.org) for accrediting engineering programs incorporate context in two out of eleven program outcomes (a-k) under criterion 3. The two context-related outcomes to be achieved by first-cycle engineering students are (c) “an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability”, and (h) “the broad education necessary to understand the impact of engineering solutions in a global, economic, and societal context”. In the European EUR-ACE accreditation framework (Document A1-en Final 17 November, 2005), context is incorporated as one outcome out of five under the heading “Transferable Skills”. First-cycle engineering students are expected to “demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice”. In Denmark, Executive Order
no. 527 of 21 June 2002 from the Danish Ministry of Education ordains inclusion of contextual concerns as one outcome out of five. Students graduating from professional engineering degree programs should thus be able to “plan, realize and control technical plants, and in doing so, include societal, economic, environmental and work environmental consequences in the solution of technical problems”. As it appears both in the EUR-ACE transferable skills criterion and the Danish executive order, there is a clear resonance with the American EC 2000 program outcomes mentioned above. A common feature in all three sets of outcome and goals is that emphasis should be put on increasing the breadth of problem-scoping (Kilgore et al. 2007) to embrace both local and global contexts when engaging in a design task.

However, contextual concerns defined in the US EC 2000 outcome (c) as an injunction to engineers to increase the breadth of problem-scoping is but one out of a broader range of socio-technical competencies to be acquired by first-cycle engineering graduates. In the EC 2000 criterion 3 (see below), no less than five (d, f, g, h, j) out of eleven outcomes are socio-technical competencies required of first-cycle engineering graduates. Outcome (i) and to some extent also outcome (j) cannot be said to be socio-technical competencies in a narrow sense. They should be interpreted as an injunction to engineers to currently update and develop their knowledge, skills and competencies. However all 6 outcomes below relate directly to liberal education (Ollis et al. 2004):

(d) Ability to function on multi-disciplinary teams  
(f) Understanding professional and ethical responsibilities  
(g) Ability to communicate effectively  
(h) Understanding impact of engineering solutions in a global and societal context  
(i) Ability to engage in lifelong learning  
(j) Knowledge of contemporary issues

Acquiring these socio-technical competencies is aimed at enabling students to focus on the general perspective and thus to contemplate their actions and their future profession in the larger context.

The broad education requirement as formulated in the EC 2000 criteria 3 under outcome (h) above is thus focused more broadly on the consequences of technology. The meaning of context here is different from outcome (c). The aim of outcome (h) is to incorporate contextual knowledge as background knowledge related to the relationship between science, technology and society. One way to interpret outcome (h) would be to see it as an STS requirement. Considerations of the impact of engineering solutions in a global, economic, environmental, and societal context therefore incorporate a broad variety of strategies and approaches. As context is a dialectical concept, perceptions of boundaries between technical text and social context differ both among engineers and among engineers and non-engineers. This observation is equally valid for the EC 2000’s outcomes (c) and (h). Boundaries between the technical and the social are not stable entities, neither in engineering education nor in engineering practice, but are amenable to reflection, negotiation and change over time (Bucciarelli, 1997, Faulkner, 2000, 2007). Contextualization thus unfolds its inherent dialectic in the realm between is and ought both in engineering practice and in education. In engineering education the dialectic of boundary definition may be
highlighted by the two fundamental questions: What is engineering for? And: What are engineering studies for? (Downey, 2009).

The introduction of ‘theory of science’ in Danish engineering education may be seen as an exemplary attempt to integrate contextual issues and socio-technical competencies into engineering bachelor degree programs in much the same way as defined in EC2000 outcome (h). However, since the 2001 decision to introduce theory of science this curricular novelty has given rise to a good deal of hesitation, resistance and controversy resulting in a considerable delay in its implementation (Christensen and Ernø-Kjølhede, 2008 and 2009). A possible explanation for the hesitation and in some respects resistance lies at an epistemological level. The dominant identity of engineers as “problem solvers” has been molded upon an epistemological distinction in engineering curricula between technical core and the non-technical periphery. The technical core/non-technical periphery distinction has had the consequence that knowledge hierarchies have emerged, which in many ways act as barrier mechanisms for development of socio-technical competencies. Usually attempts to develop such competencies are relegated to the non-technical periphery as add-on components to an already overcrowded curriculum (Downey et al. 2007).

Hybrid engineering degree programs, however, are interesting exceptions with different epistemologies which to some degree should make it easier to overcome epistemological barrier mechanisms. We therefore examine both a purely technical and two hybrid engineering degree programs in our longitudinal case study below.

In many ways theory of science has been a challenge to engineering identity. Hence, outcome and approaches have been very different among the Danish engineering education institutions (Christensen and Ernø-Kjølhede, 2008 and 2009). Before we embark on an account of the translation process theory of science went through to gain legitimacy at our institute, let us very briefly look into what initiated the discussion on introducing theory of science in engineering education in Denmark (for a more comprehensive account see Fink, 2001, Ravn Christensen, 2003, 2005, Christensen and Ernø-Kjølhede, 2008, 2009, and Hussman and May, 2009).

The Struggle for the Soul of Engineering – Four Discursive Strategies to tackle the Implementation of Theory of Science into Professional Bachelor Engineering Education

In 2001 theory of science became a compulsory curricular element in all bachelor degree programs in Denmark. This curricular novelty was intended to replace a previous Danish university tradition of offering what was called Philosophicum or Studium Generale courses intended to provide a general understanding of scientific work and specialization. Contrary to that, theory of science was meant to be a platform for specific reflections on professional identity related to: 1) the objects, theories and worldview of the professional field, 2) the relationship to other professional fields and disciplines, and 3) the relationship between professional fields and society (Ravn Christensen, 2005).

The new curricular ingredient was expected to be fully implemented by 2004. The aim of theory of science was laid down in a letter to higher education institutions from the Danish Government in 2001. The letter stipulated that for all degree programs both academic and professional:
Students should be offered an opportunity to qualify their professional specialty by seeing it in a broader and more general perspective", and that “The content of this curricular component must correspond to its purpose, namely to ensure correspondence between professional concerns and relevant concerns of a more general nature.

(Ministry of Education, 2001)

In 2006, The Danish Institute of Evaluation (EVA) formulated the following accreditation criterion (criterion 15 out of a total of 40 accreditation criteria) only for professional engineering degree programs: “Research methodology and theory of science must be part of the professional degree program in order to enable students to follow and apply R&D results in their field of specialization” (The Danish Institute of Evaluation, 2006, 2008). It is noteworthy here that both research methodology and theory of science are made a compulsory requirement in order to achieve accreditation of professional engineering bachelor degree programs. Three additional criteria (9, 12 and 16), which together with criterion 15 were defined as “central criteria”, stipulate requirements for R&D underpinning of professional engineering degree programs and their knowledge base:

Criterion 9: Easy access to and integration of knowledge about research and research results related to the specific field of the degree program should be provided through collaboration with universities and/or sector research institutions.
Criterion 12: The knowledge base of professional training must embrace results from both Danish and international R&D and experimental work.
Criterion 16: Professional training must integrate results from national and international R&D and experimental work relevant for the profession and well suited to serve as exemplars for the development and application of new professional knowledge.

Today theory of science has been fully implemented in all engineering bachelor degree programs, whether professional or academic, in Denmark. Approaches have been different but nevertheless theory of science has now found a place in engineering curricula. An overall assessment of the outcome has, however, not yet been carried out.

What concerns us here is the chain of reaction between the general governmental stipulations put forward in 2001, the specific accreditation criteria put forward by The Danish Institute of Evaluation (EVA) in 2006, and the process of institutional implementation taking place from 2001 onwards. An indication of doubt, hesitation and controversy regarding institutional response strategies on the part of engineering degree programs is that the implementation process in general has been characterized by a considerable delay compared with the original goal that theory of science should be implemented by 2004. As the initiative did not originate in the engineering community but was imposed, both internal and external constituencies became entangled in a struggle over the soul of engineering. Theory of science thus became a contested area and went through a translation process where discursive strategies were mobilized by relevant constituencies to safeguard or redefine boundaries between the technical and the social in engineering education (Christensen and Ernø-Kjølhed, 2008, 2009).

Based on previous research by the authors (2008, 2009) and based on a reading of a number of other sources (mentioned below), we argue that it is possible to construct a typology of responses or discursive strategies that stakeholders might adopt when faced with challenges that seek to alter the balance and the boundaries between the social and the technical. And clearly engineering education is a sort of
battleground where the contested area is fought out. We believe that four basic discursive strategies may be and have been mobilized by stakeholders in the Danish case:

1. *The discourse of Bildung* addressing the engineer as a human being (For the German origin of the notion of Bildung, see e.g. Ringer 1969, Gispen 1989. For US connotations see e.g. Florman 1987 and 1996. For the Danish discourse of Bildung in which theory of science in engineering became embedded, see e.g. Børsen Hansen et al. 2000, Johansen 2002, Sjöbjerg 2005, Ravn Christensen 2003, 2005, L.B. Christensen et al. 2006)


3. *The discourse of engineering science* addressing the engineer as an innovator and researcher (See e.g. The Danish Institute of Evaluation (EVA) in 2006, 2008, Millennium project 2008, The National Academies 2009)

4. *The discourse of engineering practice* addressing the engineer as a professional problem solver in different professional roles such as e.g. the environmental consultant, the designer, the system builder, the staging director, and the model developer (See e.g. Bucciarelli et al. 1997, Beder 1997, 1999, Jørgensen 2002, Sheppard et al. 2009)

In the influential formulation of Bourdieu (1994) what was at stake in the debate on how to implement theory of science in Danish engineering education was the formation of the *habitus* of engineers. In Bourdieu’s definition, habitus implies a set of habits and dispositions that have been inculcated through a social acculturation process: “The habitus as the word implies, is that which one has acquired, but which has become durably incorporated in the body in the form of permanent dispositions… the habitus is a capital, but one which, because it is embodied, appears innate” (Nash 1999). *Capital* as we use it here is thus related to the habitus of engineers and refers to the cultural and social capital broadly defined that engineers acquire through their education. Historically, especially the discourse of Bildung which relates to Bourdieu’s notion of cultural capital, has created a climate of controversy across the liberal arts-engineering divide, as this discourse was and still is alien to many engineers and largely seen as a misguided effort to reform engineering education. Moreover the discourse of Bildung was implicitly seen as a proxy for the cultural capital of an elitist mandarin culture (Ringer, 1969, Gispen, 1989) which was aptly described by C. P. Snow in 1959 in his influential essay “The two cultures and the scientific revolution”. (Snow, 2001). As will appear from the analysis below, at our institute particularly, discourses 2 and 4 appear to have had formative influence on the positions taken by engineering faculty members in the process of implementing theory of science in professional bachelor engineering degree programs.
Balancing the Social and the Technical: an Institutional Example of the Implementation of Theory of Science into Professional Engineering Degree Programs

The contention is that our institute provides a site that is well suited for a study of the process of implementation of theory of science as a proxy for the discussion of text and context in engineering education. The reason being that our Institute at the professional bachelor’s level offers both two hybrid engineering programs mixing technical and social science (Global Management and Manufacturing and Business Development) and one purely technical engineering degree program (Electronics).

We have investigated the translation process of the theory of science requirement into specific course programs as a longitudinal study. We have studied teaching plans, required readings, and lists of literature in the 3 professional engineering bachelor degree programs at our institute, and we have gathered empirical data from engineering faculty members. Our research design consists of both ex ante and ex post data collection. For the collection of the ex ante data we used two methods, an anonymous questionnaire survey carried out in 2007 and semi-structured focus group interviews carried out in 2008 in three focus groups with 3 faculty members of each degree program¹ (this ex ante research was partly published in Christensen and Ernø-Kjølhede, 2008 and 2009). By 2010 theory of science was fully implemented in the bachelor engineering degree programs making it possible to carry out an ex post study. The method applied for this ex-post study was semi-structured interviews with the two teachers responsible for theory of science in the bachelor engineering programs plus content analysis of course descriptions, teaching plans, required readings and lists of literature. In the following, we give a brief summary of our findings starting with the ex ante study drawing on data collected in 2007 and 2008 and published (in part) in 2008 and 2009.

Pre-implementation Expectations of and Attitudes towards Theory of Science among Teaching Staff

As theory of science is a new subject in the Danish engineering curriculum it was, at the beginning of its implementation, not yet well established in the minds of engineering faculty members at our institute. A comment written on the back of a questionnaire filled in by a respondent may serve as an illustration: “The issue (theory of science in engineering) and the way in which it is presented is some galaxies away from my world for which reason I haven’t answered a number of questions. A more extensive oral presentation might have been able to compensate for my engineer’s handicap”.

Below question 11 out of a total of 16 questions is meant to highlight issues of relevance for theory of science for engineers and to measure attitudes among engineering faculty members towards these issues. Question 12 is intended to measure

¹ The questionnaire was distributed to 35 potential respondents comprising the entire full-time teaching staff of our Institute’s three professional bachelor engineering degree programs in electronics, business development and global management and manufacturing (part-time teachers not included). 26 respondents filled in the questionnaire – one respondent however only partly. 16 respondents are engineers, 4 hold degrees in business studies, 5 in science, 1 in psychology.
perceptions among engineering faculty members regarding the relative importance of theory of science and research methodology.

**Question 11.** “Please indicate on a scale from 1 to 5 the relevance of the below mentioned issues for theory of science courses in engineering education”

<table>
<thead>
<tr>
<th>Dimension</th>
<th>A: Engineering roles and identity</th>
<th>B: Engineering culture and norms</th>
<th>C: The design process as a technical and social process</th>
<th>D: Knowledge generation and forms of knowledge in engineering work</th>
<th>E: The importance of technology and its impact on society</th>
<th>F: Ethical problems in engineering</th>
<th>G: Requirements of interdisciplinary and intercultural collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>1. Irrelevant</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2. Minor relevance</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal X 1+2 Opponents</strong></td>
<td><strong>6</strong></td>
<td><strong>9</strong></td>
<td><strong>2</strong></td>
<td><strong>0</strong></td>
<td><strong>3</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td></td>
<td>3. Some relevance</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4. Relevant</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal Y 3+4+5 Proponents</strong></td>
<td><strong>19</strong></td>
<td><strong>16</strong></td>
<td><strong>23</strong></td>
<td><strong>25</strong></td>
<td><strong>22</strong></td>
<td><strong>24</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

**Question 12.** “How would you evaluate the relative importance of research methodology and theory of science respectively?”

<table>
<thead>
<tr>
<th>Scale</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To learn research methodology is more important than theory of science.</td>
<td>17</td>
</tr>
<tr>
<td>2. To learn theory of science is more important than research methodology.</td>
<td>0</td>
</tr>
<tr>
<td>3. Research methodology and theory of science are equally important.</td>
<td>7</td>
</tr>
<tr>
<td>4. Neither research methodology nor theory of science is important.</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

As responses to question 11 are not binding in the sense that they would have formative influence on the implementation of theory of science, they are more likely to measure perceptions of what engineering faculty members would think would be “nice to know” for engineers (chiefly “The importance of technology and its impact
on society” and “Requirements of interdisciplinary and intercultural collaboration”). However responses cannot be said to measure perceptions of what engineers would think they would “need to know”. By contrast, responses to question 12 to a greater extent measure perceptions of what engineers think they would “need to know” (research methodology is clearly rated as more important than theory of science).

In our analysis of the data from the three focus group interviews carried out with teaching staff, we were furthermore able to identify a number of recurring arguments of an ideal typical nature. We have termed these arguments regarding the need, rationale and scope of theory of science as follows:

1. The “no need” argument. Illustrative quote: “The type of engineer that we educate is supposed to work in a company. He should be able to put things together and make them work. He is not supposed to question philosophically what he is doing and why he is doing it”.
2. The “instrumentalize it” argument. Illustrative quote: “Taking professional engineering degree programs which are not wildly academic as a point of reference, I think some of these abstract concepts, especially the methodological part of theory of science, simply may help the students to become better at solving problems”.
3. The “split it up” argument. Illustrative quote: “In my view it is not wise to make theory of science an independent module. Ideally it should be taught when needed in specific engineering disciplines or problem areas. In so doing, it would not have the negative side effect of increasing the pressure to remove vital engineering topics”.
4. The “trade-off” argument. Illustrative quote: “Which new topics should be incorporated and which ones should be removed? At the moment the curriculum is tightly packed… with courses which we have selected very carefully and which have proved their value in a company context. If additional courses are to be incorporated into the engineering curriculum they must relate to the engineering mode of thinking. They should not be constrained to merely philosophical reflections”.

These arguments taken together clearly serve to demarcate a boundary between “nice to know” and “need to know”. As shown above, our findings demonstrate a clear demarcation between the relevance of theory of science as “nice to know” and research methodology as “need to know”. However this boundary cannot simultaneously be interpreted as demarcating a boundary between “the technical” and “the social”. As an illustration a respondent argues: “A broader vision is needed. I firmly believe that to be able to cooperate with people with different educational backgrounds and participate in interdisciplinary and international collaboration we will have to learn to understand their norms and ways of framing and defining problems”. And another respondent comments that “we are not used to thinking along these lines. It has something to do with the engineering way of thinking. We do not seek knowledge merely for the sake of knowledge to be able to discuss it in the lunch room”. Moreover to demarcate the Bildung and engineering science discourses, the discourse of business and commerce and the discourse of engineering practice are in large measure mobilized by teacher respondents; some examples:
Example 1. They [the companies] say that the project managers they need must have business talent. They should be able to negotiate the right price, and be capable of establishing networks both internally and externally. Example 2. They [the students] simply live and breathe for the companies, in which they are hired and in which they work. I personally feel likewise. Example 3. Our students have a very good reputation indeed in the local companies: quite often we receive mail from companies that wish to hire our students or ask whether we have students who will complete their study within a short time in order to offer them employment. This quality stamp on our education therefore allows us to conclude that we currently teach our students the qualifications which are requested by companies.

The overall impression of our *ex ante* study was thus that respondents gave more weight to concrete research methodology as compared to the more general concept of theory of science. Further the respondents attached more importance to theory of science supporting the engineer as a businessman and problem solver rather than as a cultivated scientist. As also reported in our 2008 and 2009 articles, respondents on the whole held positive expectations and attitudes towards the inclusion of theory of science in the curricula. It was widely believed that theory of science had a potential to help improve the study programs. However, it should also be noted that the implementation phase had been remarkably long (six-seven years by the time of the survey) and that interviews reflected a good deal of hesitation and doubt as to how theory of science might be implemented in order to improve the studies and as to exactly which parts of the study programs it might be able to improve.

**Post-implementation Expectations of and Attitudes towards Theory of Science among the Teachers of the Subject**

In this section we examine how theory of science has been implemented in the three professional engineering bachelor degree programs at our institute. Before embarking on this, it is necessary to briefly describe the epistemologies of the three programs. Business Development Engineering (BDE) and Global Management and Manufacturing (GMM) can be characterized as hybrid engineering degree programs (combining social and technical science), and they differ from the third program, Electronic Engineering, as the epistemological core/periphery distinction cannot be said to uniformly follow the technical core/non-technical periphery distinction. In GMM, it may even be argued that the epistemological distinction is one between the business core and the technical periphery. A GMM respondent in the focus group interviews reported above thus observed that “GMM could equally well have been positioned as a business degree program… focused on management and supply chain management”. In BDE, marketing, business creation and business knowledge are defined as the epistemological core. However, here the epistemological core also embraces technical issues which are seen as the basis for business creation. Among teacher respondents from Electronic Engineering the epistemology is clearly molded upon the technical core/non-technical periphery distinction for which reason a technical orientation clearly prevails. When therefore speaking of theory of science in these three engineering programs, the crucial question is: Theory of science and methodology for what? Business or technology? How much business and how much technology? And can these concepts at all be separated?

We have carried out semi-structured interviews of one hour duration with each of the two teachers responsible for theory of science at our institute, and we have made
a content analysis of course descriptions, teaching plans, required readings and literature lists. In the Spring semester 2009, five years after the year of implementation stipulated by the Danish Government (2004), a new compulsory add-on course module was developed to be implemented in Spring 2010. The workload of the course is equivalent to 5 ECTS (European Credit Transfer System) credit points and in Spring 2010 it was delivered i) as a common course for students in electronic engineering and business development engineering at the 6th semester, and ii) as a separate course for students in global management and manufacturing at the 5th or 7th semester\(^2\). The objectives of the course are defined as follows:

The main purpose of the course is to give to the students a basic understanding of different approaches to problem-solving. Besides, the students are introduced to the relationship between scientific approaches and methods used to collect empirical information and data. The course also introduces students to professional cultures related to problem-solving and the conflicts and misunderstandings that may arise between the different perspectives. The students will also learn to assess alternative scientific approaches when defining solutions for specific issues.

(Course description 20 November 2009)

Problem solving in both engineering and business and inter-professional and inter-cultural collaboration are thus the central concerns in all three degree programs. This is very much in line with the \textit{ex ante} attitudes expressed by respondents above, and it would thus seem that faculty attitudes and discourses 2 and 4 above have been very influential in shaping the theory of science course module. The course content is focused on the following main areas (Course description 20 November 2009):

- Knowledge of various scientific approaches such as positivism, post-positivism, systems theory, hermeneutics, social constructivism.
- Understanding of the consequences of scientific positions at ontological, epistemological and methodological levels.
- Understanding of the consequences of scientific theory, for the concrete use of methods in connection with the resolution of a concrete problem.
- Understanding of the link between theory of science and the way a scientific article is organized and written.
- Understanding of the link between different professions and their methodological approaches to problem-solving.

For Electronic Engineering students and BDE students the subject is taught by a teacher with a PhD in sociology and with an assistant teacher trained as an engineer. In the course for GMM students the subject is taught by a teacher with a Master’s degree in business. The courses are based on lectures, student presentations and case study based exercises. The literature in the courses mainly draws on business and social research methodology\(^3\).

\(^2\) As formulations of objectives and main areas of content in the two course descriptions differ in length but not in substance, we have chosen to quote only from the course description for electronic engineering and business development engineering as this course description is more elaborate than the one for GMM.

In the interpretation of data from the semi-structured interviews with the two teachers of theory of science we follow a fourfold structure: 1. Attitudes among engineering faculty members and students at the beginning when theory of science was introduced. 2. The proportion of theory of science/research methodology related to technical science, social science, and the humanities or other fields in the course. 3. The competencies that theory of science courses are meant to create. 4. Attitudes among engineering faculty members and students today.

According to both teacher respondents, they were facing three challenges at the beginning when theory of science was first introduced: 1. To be able to interact constructively with engineering faculty members to get their support for the internal marketing to students of the course, 2. To be able to convince engineering faculty members that theory of science could help engineering students improve both their problem-solving skills and their ability to reflect critically, and 3. To position theory of science and research methodology as part of the epistemological core in engineering problem-solving in the three degree programs. Below, the teacher of the common course for students in Electronic Engineering and BDE gives the following characteristic of the initial situation:

When I started I didn’t see theory of science as the most fascinating subject to teach because of what I had heard... I really had to work hard to show that theory of science was not a threat to engineering students and faculty members... At the beginning faculty members were sceptical about me as I was seen as an academic (as opposed to a more practically oriented engineer. (inserted by the authors))... The engineering faculty members saw theory of science as something really academic... The students were told by engineering faculty members that theory of science is a boring subject... Engineering faculty members didn’t try to make sense of it and adapt to this new curricular requirement.

The GMM teacher respondent characterizes both the initial and the present situations this way:

As I see it theory of science is the glue that binds all the subjects in the engineering curriculum together... On the GMM program I have the feeling that the attitude of engineering faculty members towards theory of science is that they are not interested and that they really don’t care about it.

The Electronic Engineering and BDE teacher respondent also notices that there is a difference in the readiness to accept different worldviews and approaches between Electronic Engineering students and BDE students:

The readiness to accept that life can be different is higher in BDE than in electronic engineering... In electronic engineering the method is more rigid... In electronic engineering it is generally held that there is one right way and one right answer... Courses are not challenging students in the sense that they are confronted with different research paradigms and approaches... When they come to the course the BDE students are receptive to different approaches because they have seen the differences working in their courses.

Regarding the relative proportion between the more general theory of science component and the more specific research methodology component, the GMM teacher respondent comments:
As the course is oriented towards practical application the main focus of the course is on methods and techniques… I would say 80% lies here which also makes it easier to sell the course to students… I would however not go so far as to suggest that Bildung should have no place in the course. In my course Bildung would amount to 20%.

The other teacher respondent comments that emphasis should be put on what is readily applicable in the engineer’s toolbox and warns against too much emphasis on Bildung: “If you design the course as a merely theoretical course with a focus on critical reflection and discussion after a while there would only be very few students left in the class”. Moreover according to the Electronic Engineering and BDE teacher respondent, the proportion of research methodology related to technical science is 40%, social science 40%, and the humanities or other fields in the course 20%. In GMM, the proportion is that 10% research methodology is related to technical science, 70% to social science, and 20% to the humanities or other fields. Finally, regarding the various purposes that theory of science and research methodology are meant to support the two teacher respondents unanimously carried out the following ranking (ranked by relative importance in the course):

1. The student’s ability to solve concrete practical problems, be they commercial or technical in nature
2. The student’s ability to collaborate with people who demarcate and define problems differently in a corporate setting
3. The student’s ability to work in a scientific way both methodologically, theoretically, and critically
4. The student’s acquisition of a broad background of contextual knowledge – Bildung – related to the relationship between science, technology and society (STS).

As it appears, the ranking of the four purposes is in accordance with discourses 2 and 4 mentioned previously.

After completing the first common course for Electronic Engineering students and BDE students, the teacher comments that attitudes among engineering faculty members and students in BDE have changed positively whereas attitudes among engineering faculty members and students in Electronic Engineering have remained sceptical as they were initially. This is a clear indication that the boundary between the technical and the social is drawn differently in hybrid engineering degree programs and purely technical degree programs illuminating a difference between heterogeneous and more “mono-technical” engineering cultures. The teacher says it this way:

The BDE students value the course because they can see that it makes them stronger… Presently both engineering faculty members and students see theory of science as a natural part of their study program… Among electronic engineering students and faculty members there is a more sceptical attitude as it is not so obvious for them that theory of science is relevant for them… Electronic engineering students didn’t really take part in the course and they were not really able to see the use of it… because they so to speak work at the screwdriver level.

In GMM, attitudes among engineering faculty members have remained uninterested as they were at the beginning when the theory of science course was taught for the
first time, “they really don’t care about it” as the teacher puts it. Students however are not negative towards the course but compared with the openness that I have experienced in introductory methodology courses at the first semester [in other degree programs] students are gradually socialized into a professional engineering culture which makes them less open in the final part of their study [where the course is taught]...However I have not experienced that engineering students are dissatisfied with my theory of science course.

We might therefore conclude that students from hybrid engineering degree programs at our institute have attitudes towards theory of science and research methodology (as perceived by the teacher respondents) that are located along a continuum ranging from satisfied to not unsatisfied, whereas students from the technical degree program are more sceptical as they cannot see the use of it and therefore find it hard to believe that it can help them in any way.

Conclusion

To be able to respond to the grand challenges of our time (The National Academies, 2009) and to avoid engineering work declining into purely technical support vis-à-vis the threat from low wage countries (Millennium Project, 2008, Downey et al. 2007), it has been argued that there is a need for hybridization in engineering education (Williams, 2002, Jamison et al. 2011). “Hybridization reflects the need for different communities to speak in more than one language in order to communicate at the boundaries and in the spaces between systems and subsystems” (Gibbons et al. 1994, p. 37). Moreover, Jamison et al. (2011) have argued that theory of science could be interpreted as an exemplary attempt to help develop a hybrid imagination in Danish engineering students:

A hybrid imagination can be defined as the combination of a scientific-technical problem solving competence with an understanding of the problems that needs to be solved. It is a mixing of scientific knowledge and technical skills with what might be termed cultural empathy, that is, an interest in reflecting on the cultural implications of science and technology in general and one’s own contribution as a scientist or engineer, in particular. It can be thought of as an attitude of humility or modesty, as opposed to arrogance and hubris, in regard to scientific and technological development, and for that matter, to any kind of human activity. A hybrid imagination involves recognizing the limits to what we as species and individuals can do, both the physical limits and constraints imposed by “reality” as well as those stemming from our own individual limits of capabilities and knowledge. As such, a hybrid imagination is often manifested collectively, involving collaboration between two or more people when it is not explicitly a part of a social or cultural movement.

(Jamison et al. 2011, p. 4).

It would seem that such an endeavour is not an easy task. What has become evident from our longitudinal case study of the implementation of theory of science at our institute is that the degree of openness and readiness to acknowledge this new curricular component is varying in the three degree programs both among engineering faculty members and students. Attitudes range from positive acknowledgement and indifference in the two hybrid degree programs to scepticism and lack of acknowledg-
edgement in the more technical degree program. It has also become evident that what engineering faculty members may say in an *ex ante* survey may differ from how they act when it concerns core aspects of their professional identity (the *ex ante* survey showed positive attitudes among faculty towards the implementation of theory of science whereas the *ex post* interviews with the two theory of science teachers demonstrated that they experienced a good deal of scepticism or indifference among the very same faculty especially at the outset of the course).

The combined theory of science/research methodology approach that has been implemented at our institute is but one out of a broad variety of approaches that have been implemented in Danish engineering education. It seems that a viable approach has been found in the two hybrid degree programs whereas the approach in the electronics program might be characterized as only a temporary *modus vivendi*. There appears to be no optimal and final solutions in implementing theory of science in engineering education but only temporary solutions reached by negotiation and compromise. The integration of socio-technical competencies therefore seems to be a never-ending story.

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Appendix

PROFESSION

CULTURE

AND

COMMUNICATION

- an interdisciplinary challenge to business and engineering -

Editors

Seem Hylgaard Christensen
Bernard Delahousse

Institute of Business Administration and Technology Press
Herluf, Denmark
Two Cultures – Engineering and Business
Towards a Theory of Occupational Culture
By Steen Hvidgaard Christensen

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Two Cultures – Engineering and Business

Towards a Theory of Occupational Culture
By Steen Hylgaard Christensen

1.1 Introduction

"Each functional area thinks of themselves as being the company, or at least at the center of it. Engineering sees themselves as being central, with marketing taking their stuff and handing it to sales. Marketing sees themselves as coordinating all the other pieces. They're the ones that set the tone for the company in general. Sales people think if you don't get this problem solved by the end of the week, then we're going to lose every sale".

As it appears from the above quotation, organizations contain mechanisms that, in many ways, are similar to phenomena described within social anthropology. Unreflected acceptance of one's own functional area as representing the natural order of things and as the paradigm for understanding all other functional areas corresponds to the concept of ethnocentrism as used in social anthropology. Thus, in connection with the quotation and for want of a better expression, the expression occupational ethnocentrism seems justifiable. The distortion of communication, which the above mechanism may cause, will be addressed in the following and seen in a broader theoretical perspective.

In 1959, C. P. Snow wrote "The Two Cultures and The Scientific Revolution". With this essay he wanted to give a description of the gap between the attitude of natural science in theory and practice and the attitude of arts and literature. In C. P. Snow's view, failing to bridge this gap would have fatal consequences for humanity.

Snow describes the gap in the following way,

"Literary intellectuals at one pole – at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each

2. For analytical reasons, this essay will leave out of account any other than culturally determined causes of a distortion of communication. Accordingly not so much simple, linguistic misunderstandings as conflicting interests concerning strategy, economy, politics and organizations or psychologically determined conflict, etc. will be left out of account. This delimitation is necessary to be better able to draw a clear picture of or stylize the culturally determined distortion mechanisms.
other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground."

The reason for mentioning C. P. Snow in this context is first of all that he was among the first to use culture as conceptual foundation and theoretical perspective in an analysis of the differences between two domains of knowledge and intellectual disciplines - humanities and natural science, even if the concept of culture is used in a somewhat premature form. Secondly, Snow suggests the existence of problems of intercultural communication, which can only be solved through mutual understanding of and respect for the special attributes characterizing the two cultures. Thirdly, the problem as presented is as relevant today as it was then.

With C. P. Snow as a source of inspiration, the overall problem of the following study is indicated.

The theme addressed will be: Communication between occupational cultures in organizations. More specifically the main focus will be on:

1. Two essentially different occupational cultures in an organization.
2. Communication between occupational cultures.
3. The connection between national culture, organizational culture and occupational culture

Since C. P. Snow wrote his essay, the development within anthropology and the theory of organizational culture and within intercultural communication, a relatively new field of research, has called for an approach to the problem that is based on a more explicit theoretical foundation of culture and communication.

Two researchers of occupational culture, in particular, have made outstanding pioneer work within this field. One is Edgar Schein, whose book, “Organizational Culture and Leadership - a Dynamic View” published in 1985, has become a classic within this field. Edgar Schein is one of the few researchers who have tried to create a coherent theoretical frame of reference for the study of organizational culture. Among his other achievements are elaborate directions and methods applicable to empirical research. Schein’s cultural model sees the organization as a cultural entity, whose function is to ensure internal integration and external adaptation. The model has three levels of analysis, 1) Artefacts, 2) Values, and 3) Basic Assumptions. The value of this model as a tool of analysis if applied to occupational cultures will be discussed. Fundamentally, the problem is a question of level of analysis.

The other researcher is Geert Hofstede, one of the leading researchers within his field, a position he has enjoyed since he published his work, “Cultures and Organizations” in 1991. Based on his theory of the four cultural dimensions of value - power distance, individuality vs. collectivism, masculinity vs. femininity and finally uncertainty avoidance - Hofstede carried out an empirical survey in the subsidiaries of a multinational company in 50 countries, calculating - for each country - a numerical value as an expression of each of the four dimensions. Hofstede’s work stands out as an exemplary combination of quantitative and qualitative research strategies. Hofstede will serve as the theoretical basis for the fourth part of this book written by Jean-Louis Pelon.

In the following we will understand occupational culture in the sense of an occupational community as defined by Van Maanen and Barley:

“We define an occupational community as a group of people who consider themselves to be engaged in the same sort of work, whose identity is drawn from the work, who share with one another a set of values, norms and perspectives that apply to but extend beyond work-related matters; and whose social relationship meld work and leisure”

However, the notion of occupational culture is not without problems. Seeing an occupation as a culture involves choosing a certain perspective, and in doing so, excluding all other perspectives. In other words, it all depends on how you look at it - “beauty is in the eye of the beholder”. Seen in the perspective of the occu...
pational culture, the organization is not a cultural entity or a monoculture, but rather a conglomerate of subcultures. In other words, the occupational culture perspective is multicultural. At the same time this perspective implies that, to some extent, culture is resistant to attempts at changes.

The multicultural perspective also implies that occupational cultures or subcultures may function as an enhancing culture, as an integrating culture or as a counterculture in relation to the values of the organization. The choice of a monocultural perspective or a multicultural perspective will, to some extent, depend on the analytical unit.

However, the core of the concept of perspective is not whether certain occupations or functions are or have a specific culture, but methodologically to treat them and understand them "as if they were" cultures. In this way, the concept of culture will function as the filter through which we see the different functions or occupations in the organization. In this lies the theoretical perspective. Unlike all other potential theoretical perspectives, the cultural perspective will identify certain phenomena as being relevant and other phenomena as being irrelevant. They will differ from phenomena defined as relevant or irrelevant in the perspective of optional organizational psychology. What will be identified as relevant will also depend on how the concept of culture is defined. This suggests the importance of distinguishing between subject and perspective. The theoretical applicability of the cultural perspective must be assessed on its ability of collating, interpreting and explaining observations made in the organization - the subject - and on its ability of generating new ideas and reflections.

As mentioned above, the overall problem of this work is communication between occupational cultures, more specifically, between what will be described as engineering culture and business administration culture. However, these two groups are not very precisely defined, and it is a question whether, in themselves, they possess sufficient attributes of uniqueness to justify the designation as a culture. Nevertheless, there might be a certain rationale in talking about an engineering culture, inasmuch as engineering fulfills most of the criteria defining a profession and the notion of profession comes very close to Van Maanen's and Barley's definition of occupational culture. The same does not apply to business administration, as this group does not in the same way fulfill the criteria defining a profession. It would thus also be misleading to describe the group as an occupational culture. As there are substantial differences between different lines within business administration, the line would constitute a more appropriate unit to work with. It does not take a genius to spot the difference between an accountant and a marketing manager.

The choice of occupational cultures therefore only serves as an indication of the approach of this study, which requires further delimitation, and which should be seen in connection with the authors' employment in educational institutions which have in common that they offer degrees in both engineering and business administration. Furthermore, our interest in this field stems from an acknowledged importance of mastering interdisciplinary work as well as work across boundaries between professions. This applies to educational institutions as well as to public and private organizations and enterprises.

The subject matter will therefore be delimited to comprise the functions of development and marketing in the organization, here represented by the electronic engineer culture and the sales and marketing culture. The choice of those two cultures meets three criteria. First, each of the two groups has sufficient attributes of unity to justify a definition as an occupational culture. Secondly, they seem to be conspicuously different. Thirdly, it is possible to study the two groups in an educational context as well as in an occupational context. A more implicitly empirical delimitation is to be found in the assumption that electronics enterprises of a certain size would offer an exemplary subject of research, which could lend the results great assertive power. The enterprises in question would have to be so big as to have a relatively big R&D department and a relatively big marketing department. A concrete delimitation to specific enterprises cannot be made here and now. The reason for this is to be found in the nature of this assignment as an explorative literary study.

However, the number of empirical analyses of organizational and occupational cultures is surprisingly small compared to the number of theoretical and meta-theoretical contributions to the debate on culture in general. The reason for this may be that making an empirical study of the culture of an organization is far from simple. In this connection, however, mention should be made of a work that this study refer to quite often, viz.'Engineering Culture. Control and Commitment in a High-Tech Corporation' by Gideon Kunda, published in 1992. Under all circumstances, some of the problems encountered first in connection with cultural studies are: How to study the notion of culture? Which phenomena and data to look for? How to approach the problem in practice?

The epistemological interest attached to this work is primarily of an analytical nature. The intention is, as far as possible, through a well-founded selection of objects, theoretical perspective, analytical units and methodical approaches, to describe and understand the culture of the level chosen as it sees itself, and not as it should see itself. The thesis is that a multicultural perspective offers a better understanding of the complexity and dynamism of an organization than does a monocultural perspective.

This also indicates the position of this work in the discussion whether the cultural approach implies that the organizational culture is automatically seen through the filter of the top management, and thus serves as a basis for top-down organizational changes. In this context, Mats Alveson and Per Olaf Berg warn against too optimistic expectations as to the extent to which "a culture can be controlled". This skepticism can also be seen from the following quotation by Joanne Martin and Caren Siehl.
"It is likely that cultural development, like other aspects of organizational functioning, is not as responsive to direct managerial attempt at control as many would like to believe. It may be that cultures cannot be straightforward created or managed by individuals. Instead, cultures may simply exist and managers may capitalize on the cultural effect they perceive as positive or minimize those perceived as negative. Perhaps the most that can be expected is that a manager can slightly modify the trajectory of a culture, rather than exert major control over the direction of its development."

At the same time, the perspective chosen implies that the subject and analytical unit must be seen from within as well as from without, through a native view as well as through an external view. This means that an occupational culture's self-perception and categorization of values can only be determined from within, whereas an external view can be applied when it comes to determining what characterizes the occupational culture on the artefact level, and a profession-sociological analysis can determine what distinguishes the occupational culture from other occupational cultures.

Through this we hope to open the eyes to ethnocentrism, which is open or latent in any occupational culture, and which is conceptualized through the native-view approach. In this respect the introductory quotation suggests what is at stake. A deeper understanding of the relativism in one's own culture should make it easier to understand and accept that other occupational cultures have different sets of values. In other words, what we apply here is cultural relativism. At the same time this would constitute a good starting point for expedient communication with other occupational cultures in the organization. Adopting a quotation by the German philosopher Jürgen Habermas, we can also say that this work is inspired by a practical, epistemological interest:

"...hermeneutical research unfolds reality under the guiding interest to preserve and to broaden the intersubjectivity of possible action-oriented communication. Understanding of sense is structurally oriented towards a possible consensus of acting persons in the context of a communicated self-image. This we term, in order to differentiate it from the technical, the practical epistemological interest." (My translation)

An analysis of the communication between occupational cultures in organizations, in this case between two functional areas in the organization, viz. the sales and marketing function and the development function, is - in terms of application of methods and theory - so complex that it would not be feasible within the frames of one single discipline of science. Understanding the problem, no matter how concrete it might appear, demands an interdisciplinary approach. The analysis would thus involve eight central theoretical areas, as shown in the figure below.

Figure 1. Overall theoretical frame for the following study and for the book as a whole.

The most distinctive feature of this method is that, on the one hand it must take into account the specific characteristics of the two functional areas chosen, which makes specific demands in terms of theory and method. On the other hand, the method must ensure that the results can be generalized at a more abstract level.

The following account thus has two main goals. Firstly to clarify a social-anthropologically as well as sociologically oriented concept of occupational culture. Secondly to establish a theoretical model which can be applied in an empirical survey. However, this survey is not to be carried out here. The model will then be used to place the other articles of this book in relation to an overall theoretical structure. At the same time it will serve as a concrete proposal for a more expedient approach to C.P. Snow's original two-culture-problematic.

The structure of the account is as follows: In subsection 1.2 we shall discuss the concept of culture as applied in social anthropology. The aim is to determine an objectivistic concept of culture, which takes into account that culture has 1) an external and an internal dimension and 2) a micro- and a macro-level. Implicitly as well as explicitly, the discussions in the following subsections will be based on this concept of culture.

In subsection 1.3 we shall discuss the problems of applying a social-anthropological concept of culture in the study of organizations. We shall develop a critique of the methodological and practical instrumentalism as well as of the cognitive

5. This discussion takes place both in an instructive and inspiring research study of the field of theories of organizational culture by Mats Alvesson and Per Oluf Berg, entitled "Fertigarkultur och organisationssymbo- lism. Utveckling, tereniseringsprosoplog och sjukvall deca", Studier/Interv, Lund, 1988 and in an artic- le by Joanne Mearns and Cavan Selig, entitled "Organisational Culture and Counterculture: An Uneasy Syntesis." In Organizational Dynamics, pp. 52-64, Autumn 1983. The above quotation is from this arti- cle, p. 53.

narrowing and diluting of the concept of culture characterizing substantial areas of the theory of organizational culture. At the same time we shall argue in favor of the view that occupational culture is best understood in its organizational context if seen in a multicultural perspective.

Subsection 1.4 is devoted to considering occupational culture through the lens of profession sociology. Our primary interest here will be the occupational-cultural socialization process. To begin with, we shall establish a profession-sociological ideal type. Afterwards we shall study this ideal type thoroughly and in that connection consider to which extent the engineering profession fulfills the conceptual characteristics. Furthermore, we shall apply the concept of profession as a criterion of demarcation against the sales and marketing culture, which does not possess the characteristics of a profession.

In subsection 1.5, we shall study more closely the definition by van Maanen and Barley of an occupational community. Even if van Maanen and Barley's theory can be seen as an indication of an expansion of the perspective of the profession sociology, we shall show that not all occupations qualify for the designation "occupational community". At the same time we shall demonstrate that occupational cultures form around these occupational communities. Finally we shall point out two problem complexes in the theory. First, that van Maanen and Barley do not provide concrete directions on how to operationalize the theory. Secondly, that the theory holds an unclarified problem of level.

Subsection 1.6 is a study of Edgar Schein's theory on organizational culture. Schein's theory is interesting in a number of ways. First of all, it includes a definition of culture, whose basic mechanism can be applied in this context, viz. the three previously mentioned levels of culture. Furthermore, it includes a fruitful and relatively simple model of analysis plus methodological considerations and directions on concrete collection of data. This subsection will start out with a presentation of Schein's theory with a view to evaluating its applicability. Following that, it will be demonstrated that in an occupational-cultural context it is necessary to make a number of reservations to Schein's theory.

In the last subsection before the presentation of the final model of analysis — subsection 1.7 — the discussion becomes more abstract. We shall here discuss if it is possible to place the engineering culture and sales and marketing culture in relation to a sociological concept of action. To begin with, the two cultures will be placed in relation to an abstract concept of rationality. At times the presentation will be an exegetic discussion of Max Weber and Habermas' rationality theories. The aim of this discussion is to determine the different cognitive outline conditions of the two occupational cultures. After that, the concept of rationality is connected to central concepts from Habermas' philosophy of science in a quasi-transcendental perspective.

In the last subsection — subsection 1.8 — we shall integrate and synthesize the previously discussed attempts at theories in a theoretical model of occupational culture. This model will appear in two versions — one for the engineering culture and one for the sales and marketing culture.

1.2 The concept of culture in social anthropology

As indicated in the name itself, social anthropology is closely related to sociology, another central discipline of social science. Common to the two disciplines is the study of society as a social creation. Both disciplines seek to answer the same fundamental questions: How are societies at all possible? What has combined into and what is combined in a society? And why and how does a society cohere? To be more specific, it could be claimed that the subject of the two disciplines is what has been called "the social tie", i. e. the integration mechanism or mechanisms that make a society more than a numerical group of atomized individuals.

Often a distinction is made between the different types of integration. System integration is integration effected through the state (power) and the market (money), whereas social integration is effected through internalization of norms and values. Finding a conceptual tool to describe the latter as an aspect in line with the political and economic aspects has been especially important to social anthropology. The reason for this can be found in the focus of social anthropology on those types of society where the state and the market have had much less or no importance at all as social integration mechanisms.

Traditionally, social anthropology and sociology have specialized in different lines, with social anthropology being concerned with the traditional, pre-industrial society or the so-called primitive society, to use a rather loaded expression, whereas the main subject of study of sociology has been the modern industrial societies. Today, this distinction is difficult to maintain, however, inasmuch as the approaches and working methods used by social anthropology are becoming more and more popular in connection with the description of modern ways of living within the urban as well as within the industrial field.

In the following we shall take a little more closely at some of the problems connected to the attempt at defining a concept of culture within social science. One of the first attempts at giving a precise definition of the concept of culture was made by Edward B. Tylor in his study, "Primitive Culture" from 1871. This study marked the beginning of modern social anthropology's preoccupation with culture. Therefore, a discussion of the concept of culture may well take its starting point in Tylor's definition, which determines culture as

8. A more complete presentation of anthropology, its history, disciplines and different schools can be found in The New Encyclopaedia Britannica, 15th edition, under the entry of anthropology.
"...that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society".

The core of this definition is first that cultural knowledge, capabilities etc. constitute knowledge and capabilities which are not acquired or experienced by the individual, but are learned from others. Secondly, this cultural property is described as something passed on from one generation to the next through the process of upbringing and education. Thirdly and finally, this definition implies that culture also includes elements outside human consciousness such as custom and art.

Tylor's definition is both too broad and too narrow. Too broad in the sense that it implies that all knowledge and capabilities are to be seen as cultural and, as such, as obligatory for all members of a given society. Without this knowledge and these capabilities an individual would not be considered a full member of society. However, it is possible to be a full member of the Danish society without knowing anything about quantum mechanics and without knowing how to drive a car.

The definition is too narrow in the sense that it requires cultural knowledge to be passed on from one generation to the next. This excludes that knowledge experienced by the individual can be considered part of the cultural property. Knowledge about how to shop, what to buy from which shops, how to cash money in a bank, how to read a map constitutes some examples of cultural knowledge which is obligatory and which can be acquired by the individual himself. Furthermore, the definition is too narrow in its definition of the material or objective side of culture.

Whereas Tylor sees the core of the concept of culture in the notion of passing on cultural property from one generation to the next, Ward H. Goodenough sees it in the obligatory nature of cultural knowledge and capabilities. Goodenough's definition runs as follows:

"A society's culture consists of whatever it is one has to know or believe in order to operate in a manner acceptable to its members, and do so in any role that they accept for any one of themselves. Culture, being what people have to learn as distinct from their biological heritage, must consist of the end product of learning: knowledge, in a most general, if relative, sense of the term." 14

By this we have made a qualification of the notion of cultural knowledge as it is to be understood in this study, i.e. as a part of the knowledge created by society. At the same time Goodenough's definition of culture is more relevant, seen from the point of view of social science, as it is essential to be able to ascertain what knowledge is required for an individual to operate in society and be accepted as a member.

In this, Goodenough distinguishes between two types of cultural knowledge, viz. knowledge about norms and knowledge about facts. The former category comprises knowledge of moral principles, etiquette, certain central rules of law, etc. This, in other words, constitutes knowledge about what behavior will be considered desirable or prescribed and what behavior will be considered unacceptable and will be met with disapproval or prohibition.

The cultural knowledge of facts can be subdivided into two groups. First a practical, instrumental knowledge of how to manage the practical problems of social life. How to shop, to stop at the red light, etc. Secondly, knowledge of little practical value, but nevertheless, knowledge that belongs to "what any decent human being must know", i.e. knowledge about politics, history, characteristics, collective qualities, national character, etc.

The critical point in Goodenough's definition is first of all that it fails to go into details about the role played by cultural knowledge. Here it would be more expedient to distinguish between two functions, which are closely connected. First, cultural knowledge comprises principles of interpretation enabling the individual to understand his environment, including the social one. It also provides the background for and the purpose of various social institutions. And secondly, by warning about norms, which need to be kept, and by giving practical advice and prescriptions for acceptable and desirable behavior, cultural knowledge helps a person to act adequately and correctly.

However, at one single point, Goodenough's definition represents a step backward by exclusively comprising elements with a purely mental existence. In this respect, Tylor represents an objective concept of culture while Goodenough represents a subjective concept of culture. The subjective standpoint implies that culture is seen as a purely mental phenomenon, i.e. as the knowledge underlying the social behavior. In a sense, one may claim that "cultures do not exist", but are merely a framework for understanding, which we apply in order to organize certain data. We may therefore also talk about a cognitive notion of culture.

Furthermore, the objective notion of culture, which this study of the social anthropological concept of culture feels committed to, claims that cultures have a mental as well as an extra-mental existence. According to this understanding, culture has an external as well as an internal dimension. Therefore, a more visible definition of the concept of culture must take into account the criticism voiced above. Thus a definition may run as follows,
Culture consists a) in the (non-hereditary) information about the world view and the values and norms, with which compliance is obligatory in society, plus in the knowledge of factual questions, including the symbolic code of society, which is obligatory, i.e. which an individual must possess in order to be accepted as a full member of society; b) of the sum of acts performed applying this knowledge; and finally c) of the tools, works of art, symbolic objects and other material products which this behavior makes use of and which it produces, inasmuch as knowledge of their use belongs under a), and which d) separate individuals belonging to this society from individuals belonging to other societies.12

From the above definition of the concept of culture as found in social anthropology, it appears that culture is a feature found in all types of society. To qualify for the designation of society, and thus a culture in the above sense, requires a unit that comprises a certain number of families and generations. In this respect a tribe may be a suitable illustration of what is meant. One single family cannot constitute a society as little as any one group can.

Furthermore, the definition implies the following:

1. Culture is learned; it is not a biological heritage, and it is handed down from one generation to the next.
2. All human beings are embedded in a culture.
3. Culture generates a common identity for the members of a society.
4. Culture consists of whatever one has to know and believe in order to operate in a manner acceptable to the members of a particular society.
5. Culture influences the members of a society, so that they will behave in a uniform and predictable manner.

6. Culture is whatever distinguishes the members of one society from the members of another.
7. Culture represents a form of order, which presents itself in a symbolic form, and which enables the members of a society to understand themselves as well as the world they are living in.
8. Culture has an internal as well as an external dimension or a mental as well as an extra-mental dimension.

In the following, this point of view will be elaborated in more detail in connection with a reflection on the cultural theory developed by Hans Gulstrep.14 The advantage of Gulstrep's theoretical model is that it gives a clear impression of the complexity of the concept of culture, and at the same time gives us an indication of the difficulties of transferring a concept of culture belonging to social anthropology to organizational theory.

For Gulstrep, culture contains a horizontal as well as a vertical dimension. In the vertical dimension we find the manifest or visible part of culture as well as the core culture, which cannot be observed. Thus culture is to be seen as a truncated cone, turned upside down. This cone is cut through by five parallel, horizontal lines, resulting in six smaller truncated cones. These cones represent the six vertical dimensions of culture, which Gulstrep divides in the following way, with the upper level of the cone representing the first vertical dimension:

1. The symptom level, immediately observable
2. The structural level which is difficult to observe
3. The normative level of morals and rules
4. The partially legitimized values
5. The generally accepted highest values
6. The fundamental conception of the world

The upper three levels represent the visible part of culture – the manifest culture – whereas the bottom three levels constitute the more hidden, but more fundamental core culture. Each level is subdivided into a number of dimensions as shown in the following:

Cultural level

1. The symptom level, immediately observable

Cultural Elements

Behavior:
Everyday actions like eating practices and working practices
Performance of music, singing and dancing

12. In her Ph.D. dissertation from 1999, Winif Johansen distinguishes between three fundamental concepts of culture on the basis of a classification principle, which differs from the principle applied in this study. This is also the distinction between: 1) The Behavior Approach; 2) The Symbol Approach; 3) The Value Approach. The notion of culture as behavior implies that culture is considered as some kind of text, to be read and described by the ethnographer. This concept of culture is a descriptive concept focusing on behavior and action. Consequently, the ethnographer will concentrate on describing similarities in behavior and action in order to be able to ascertain whether what he is dealing with is a cultural unity. He will describe and map out the concrete and observable "cultural properties" like institutions and languages, including aspects like gender roles, upbringing, work relations, etc. The notion implies understanding culture as "a system of variables". The Value Approach perceives culture as a normative system of values. The concept of culture is to be understood as an explanatory concept rather than a purely descriptive concept. The ethnomethodological interest is to explain why behavior varies from culture to culture. Such an explanation will only become possible when the shared values, norms and attitudes underlying the external behavior have been uncovered. Thus culture is to be understood as some kind of mental programme. The Symbol Approach perceives culture as a network of symbols and signs generated in the communication between human beings. Culture as signs refers to a certain perception, interpretation of and way of relating phenomena which are shared by a group of human beings. This concept of culture is a semiotic concept, whose primary, epistemological interest is interpreting shared cultural signs. Cf. Winif Johansen, Kulturtegniser i tekst og billede - Kultur og kommunikation i skole og friskole, Copenhagen: Handelsbogakademien, 1995, p. 35-45.

13. This definition is adopted from Peter Collins' definition. See Collins, op. cit. p. 30.

Practice of religious and political rituals
Language usage
Etc.

**Material products**
Tools
Habitations and clothing
Produce of agriculture, fishing, and hunting
Products of trade and industry
Infrastructure
Material works of art
Etc.

**Intangible products**
Formal laws and rules
Knowledge and skills
Prose and lyrics
Music, singing and dancing
Myths, legends and rituals

**Social structure**
Kinship relations
Family relations
Gender relations
Tribal and caste relations
Relations between different age groups
Business relations

**Economic structure**
Ownership of land
Pay and working conditions
The principle of decision-making rights
Production conditions in general

**Political and administrative structure**
Social decision basis
Channels of influence
Election/appointment system
Foundation of status
Administrative processes
Role of political parties

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**Structure of language and communication**
Language structure
Vocabulary
Forms of communication
Linguistic differentiation

3. The normative level of morals and rules
Tradition and custom
Informal rules and norms, including morals governing business and work relations and relations between the genders
Principles of punishment and rewards, formal, legal rules as well as ideological and religious
Informal social control
Justified own control
Social perception of space, distance, touch, etc

4. The partially legitimized values
Judgment criteria for a number of values, such as
beautiful/ugly
healthy/unhealthy
honor/shame
innocence/guilt

Limits to solidarity
Competition rules and norms
Forms of cooperation
Foundation of trust vs. mistrust

5. The generally accepted highest values
Responsibility towards nature and future generations
Social responsibility to other people
Perspective in space and time
Overall quality criteria
Taboos
Codes of honor
Humor and irony
Conflict solving
Need of consensus
Content of the notion of work
6. The fundamental conception of the world

The human being in nature
The human being in time and space
The human being in relation to other nations
The human being in relation to the ego
The human being in relation to the periods before birth and after death
The human being's perception of the true nature of the human being
The human being's roots in past, present and future
The human being's perception of the two genders
The human being's fundamental structure of thinking

The horizontal cultural dimension contains eight cultural segments. Here the starting point for Gullestrup is that people who enter into social relations will always seek to have a number of basic needs fulfilled in some form of social relationship. Not necessarily through cooperation, it may well be in the form of suppression or exploitation, but in some form of relationship. The concrete mode of fulfilling these basic needs and the concrete mode of organizing the social relationship will vary in time and space, depending on a number of culturally determined factors.

Gullestrup's cultural theory may therefore be said to be functionalistic, inasmuch as a functionalistic concept of culture implies determining culture through its dual function, i.e. on the one hand securing the internal integration in society and on the other securing the external adaptation to the surrounding nature or to the surroundings in general. More specifically, Gullestrup's point of view implies a functionalist-evolutionist concept of culture.

This point of view is inspired by the theory of evolution expressed by Charles Darwin in his work, "The Origin of Species by Means of Natural Selection", which was a clash with creationism (the belief that God created all species in their final and complete forms, and that the different species are unchanging). Here Darwin states the fundamental mechanism of evolution: the individuals' fight for existence and the selection of those individuals most suited to their conditions constitute the core of Nature's way of creating development.

A functionalistic-evolutionistic concept of culture thus implies viewing human culture as a functional equivalent of the instincts, with which the animal species are endowed. The development of culture takes place through the adaptation of society to the surroundings and not through the execution of a principle inherent in the human species or society. An illustration of this could be the Eskimo culture, an example of a culture that has adapted to nature under very difficult living conditions. However, the adaptive capacity of human culture is much more sophisticated than the instincts of animals. The focal point of this way of thinking is expressed in the following quotation from Collin:

"Culture, like instincts, is collective knowledge typically passed on from one generation to the next. This releases the individual from having to collect this knowledge himself. The advantages of culturally determined behavior rather than instinctive behavior lie in the much greater flexibility and the cumulativity of the former. Flexibility is primarily expressed in a culturally determined behavior being capable of adaptation to a much more differentiated set of living conditions than instinctive behavior, which is always adapted to a fairly narrow ecological niche. Secondly, the flexibility is expressed in the much greater speed in the adaptation to the living conditions. It is possible for a technical innovation to disseminate in the course of a single generation through a complete society by virtue of simple copying. Genetically coded changes, on the other hand, take from twenty to fifty generations to pervade a population."

In the following model you will find a number of culturally determined factors or cultural segments, which are to be seen as extensions of the functionalist-evolutionist concept of culture expressed by Hans Gullestrup. These factors or segments are all equally important and therefore at the same level. The model consists of a number of fundamental questions.

1. How is nature worked?
2. How are the results of this process allotted?
3. How do members of the society socialize?
4. Who is to decide over what and whom?
5. How are knowledge, ideas and attitudes communicated?
6. How are the individual and the whole integrated, maintained and developed?
7. How is a common identity created and maintained?
8. How is the perception of the relationship between life and death manifested?

15. Collin, op. cit., p. 73.
These eight horizontal dimensions are found at all six levels of the cone. Using the economic institutions as an illustration, they can be analyzed at six vertical levels. However, as Gullesnup's theory gives no instructions as to the empirical treatment of such a segment, this lets the reader of the model down. The model contains no methodological rules and gives no further instructions or examples of how to operationalize the model when it comes to specific, cultural segments. The strength of the model lies in the theoretical level, i.e., its convincing documentation of the complexity of the social anthropological concept of culture.

As it appears clearly from an observation of the horizontal, cultural dimension by Gullesnup, the social anthropological concept of culture is essentially a macro concept, introduced with a view to describing central features found in all human societies. The importance of this in relation to the field of organizational culture is to be discussed in the following, where the relative quality of the concept of culture will be considered more closely. In this connection it is important to be aware that every treatment of the concept of culture will always contain a macro level as well as a micro level, which as such is not contradictory to what was said above. The two levels are logically connected as two sides to the same question. As a complete integration between all individuals in a given culture is impossible, a culture will always produce subcultures, which are its own positive or negative mirror images. In this sense, we will find subcultures in minority groups, majority groups, classes, castes or other groups within a larger sociocultural system.

In their theory of organizational culture, Joanne Martin and Caren Siehl operate with three different types of subculture, viz., enhancing subcultures, orthogonal subcultures and countercultures. The enhancing subculture represents the positive mirror image of the macro culture. It is in accordance with the latent core culture of the macro level but has an enhancing effect on the more manifest cultural levels. The marketing culture of an organization will often be an example of such a subculture, just as the yuppy-culture of the 1980s was a subculture in relation to the macro level of society in that same period.

The orthogonal subculture is characterized by the members accepting the core culture of the macro level at the same time as being loyal to their own subculture. Provided this subculture does not clash with the macro culture in any essential respects. The staff in a development department, electronic engineers or more functionally based communities, are examples of this type of subculture. On the societal level, subcultures like youth cultures, senior cultures, and village cultures can be described as orthogonal.

The counterculture, on the other hand, represents the negative mirror image of the macro level. In the counterculture the overall culture is challenged. There is a direct conflict between the value system of the subculture and the value system expressed in the overall culture. On the societal level the "autonomous communi-

nities" in the big cities, the "Hell's Angels" clubs and the so-called "Green-Jacket" culture (a Danish group of right-wing extremist young people), together with political, religious, and other ideology-based subcultures, can be said to constitute countercultures in relation to Danish culture. It is assumed that this division into types of subculture is applicable to the micro level as well as to the macro level.

The following quotation by Edgar Schein serves as a good illustration of the relativity in the concept of culture.

"The word "culture" can be applied to any size of social unit that has had the opportunity to learn and stabilize its view of itself and the environment around it - its basic assumptions. At the broadest level, we have civilizations and refer to Western or Eastern cultures; at the next level down, we have countries with sufficient ethnic commonality that we speak of American culture or Mexican culture. But we recognize immediately that within a country we also have various ethnic groups to which we attribute different cultures. Even more specific is the level of occupation, profession, or occupational community. If such groups can be defined as stable units with a shared history of experience, they will have developed their own cultures. Finally, we get to the level of analysis that is the focus of this book - organizations. Within organizations we will find subunits that can be referred to as groups, and such groups may develop group cultures."

At the same time the quotation illustrates a shift in the concept of culture from being a concept founded in social anthropology with society as the central unit, to a concept founded in social psychology with the group as the central unit.

### 1.3 Problems with the transfer of a concept from social anthropology to the study of organizations

In this section we will deal with some of the problems of transferring a concept from social anthropology to the study of organizations. In order to bring out a number of central points we find it expedient to start in the management-oriented corporate-culture literature, as this literature emphatically exposes a number of the weaknesses that are characteristic of organizational culture. The fundamental way of thinking is indicated already in the titles of some of the central studies, e.g., "In Search of Excellence. Lessons from America's Best Run Companies" by Thomas J. Peters and Robert H. Waterman Jr. from 1982 and "Corporate Cultures", also from 1982 by Terrence E. Deal and Allan A. Kennedy, and finally "Gaining Control of The Corporate Culture", a collection of articles from 1985, edited by Kilman, Saxton and Serpa.

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The fundamental point of view is that corporate culture perceived as shared values, attitudes, rituals, myths, heroes, etc. has an integrating effect on the members of the organization at the same time as creating an increase in efficiency, productivity, and earnings.

Wilkins and Patterson express this point of view as follows:

"Culture is interesting, not only because it provides unobtrusive control and motivation, but also because it can provide a virtually unassailable competitive advantage."18

Seeing that culture is an extremely effective instrument of motivation and control it is important for the management "to gain control of the corporate culture". The idea is that culture can be managed by "measuring" the existing culture in relation to the culture desired. Indeed, Wilkins and Patterson actually describe the desired culture as an "ideal culture". Any gap causes intervention by the management. The following fundamental questions are to be answered:

1. Where do we need to be going strategically as an organization?
2. Where are we now as a culture?
3. What are the gaps between where we are as a culture and where we should be?
4. What is our plan of action to close those gaps?19

The organizational culture's integrating role consists in its ability to appeal to those dimensions in people that are not rational and volitional. As expressed by Peters and Waterman: "good managers make meaning for people as well as money". By appealing to what is irrational and emotional in people, the management creates a higher meaning in and to the job performed by the individual. With everybody's attention being directed at the same goal in evangelical enthusiasm, a feeling of belonging is created. The concepts of "sacredness" and "profanity" as known within the sociology of religion give a good illustration of the forces at stake:

"This force in shared cultural meanings stem from what Durkheim calls the sacred. Unlike the profane, which is concrete, rational, and material, the sacred refers to the emotional dimension of the human being (Ray, 1986, p. 290). Therefore, the sacred is a strong source of social integration. In fact, the sacred is precisely a function that enhances and maintains the cohesive forces between the members of a society (Ray, 1986, p. 290). A collectivity cultivating what it holds to be sacred in fact cultivates itself: and it does so through those dimensions in the human being that are non-rational and non-volitional."20

We shall now first raise a number of fundamental objections to this concept of culture and after that raise a number of fundamental objections to the entire field of organizational culture.

The first objection to the corporate-culture literature is that it is based on a prescriptive/normative view of culture and does not comply with generally accepted rules for scientific impartiality and objective, and transparent selection of empirical material, etc. Thus it takes more pride in giving good advice and directions for managers than in working on a scientifically acceptable basis.

The second objection is an extension of the first and is aimed at the use of an a priori concept of culture, i.e. the concept of "the ideal culture", in which the "shared" meanings (values, attitudes, rituals, myths, etc.) constitute the fundamental building blocks. Inasmuch as culture here is defined as a monolithic, unitary culture, the conceptual definition of culture as an integration instrument becomes more important than the empirical sensitivity of the concept of culture.

The a priori assumption is that the "sharing" meanings have a controlling effect on behavior without any consideration for whether the "shared" meanings indeed "mean" the same to all groups of employees, as meaning is not an immanent quality of the perceived. Culture is expressed through signs and symbols, which need interpretation. What is "real" is a social construction depending on the systems of interpretation through which the perceived is understood. Signs and symbols may therefore "mean" something different whether seen from the point of view of the management or from the point of view of the employees.

The third objection applies to the perception of culture as a management tool. The assumption is that members of an organization have a common understanding of "existing culture" and "desired culture", which is far from certain, and neither is it certain that their actions can be controlled through cultural intervention. Both can only be determined through an empirical study. Alvesson and Sandkull have developed a matrix, which shows the connection between management methods of compliance and modes of participation displayed by the employees.21

19. Ibid., p. 364.
Figure 2. Modes of participation and methods of compliance

<table>
<thead>
<tr>
<th>Methods of Compliance</th>
<th>Modes of Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Submissive</td>
</tr>
<tr>
<td>Coercion</td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td></td>
</tr>
<tr>
<td>Norms</td>
<td></td>
</tr>
</tbody>
</table>

The corporate-culture literature implies that it is possible to win emotional approval of the values set by the management. Therefore, according to the corporate-culture literature, the members of an organization belong in the bottom right of the model. However, the model shows that the relationship is more complex. About this Alvesson and Sandell say,

"We have also witnessed a greater degree of managerial sophistication in employing a blend of several methods for achieving compliance. Nor are the modes of participation to be found in pure form, but rather as opportunism (as blend of submission and calculation), loyalty (submission and morale) or self-righteousness (calculation and morale). The mixed forms outside the diagonal are not likely to be the unstable ones; it would be more difficult to maintain the pure cases."

What on the surface looks like a one-dimensional and homogeneous connection between methods of compliance and modes of participation, on closer examination proves to be a multidimensional and heterogenous connection.

The statement rather seems to imply that agreement can be reached by employing a combination of conviction, force, threats, manipulation, reward and conscious selection of staff, which justifies the use of the term "social engineering" rather than creation of culture. The reason for this is that the concept of culture used by the corporate-culture literature is instrumental, engineering and technocratic and in this sense far away from the concept of culture as used by social anthropology, which puts heavy emphasis on the spontaneous character of culture. The term "esprit de corps" is thus a more appropriate term to use to describe the existing or desired community spirit, traditionally referred to as corporate culture.

Secondly, it is assumed that once the desired culture has been established, it will also cause an increase in the productivity, efficiency and profits of the organization. So far, there is no empirical proof of the latter.

A fourth objection to the corporate-culture literature is that the staff is reduced to passive receivers of culture. "Control by corporate culture views people as emotional, symbol-loving, and needing to belong to a superior entity or collectivity (Bay, 1986, p. 259)." The staff are waiting for motivation and are not meant to have an independent ability, much less a right, to produce "meaning" from their own perspective and basis of experience, for which reason the organization makes itself immune to "cultural phenomena" that do not fit into the perspective of integration. However, if the corporate culture only reflects the visions for the organization held by the management group, the concept of corporate culture will look more like a concept of ideology than an empirically sensitive and extensive analytical concept of corporate culture.

In the sociological understanding of the concept of ideology, ideology is defined as those ideas by which a power relationship is legitimized. Whether these ideas are true or false is not essential. The central point is the legitimizing role of ideology. Back in 1979, before the emergence of the concept of corporate culture, Henry Mintzberg predicted the ideological consequences of what he called the "missionary organization".

This organization "would have its own primary coordinating mechanism - socialization, or standardization of norms - and a corresponding main design parameter - indoctrination. The members would coordinate their behavior via the norms they share, partly as a result of their indoctrination in the organization. The organization would even have a sixth dimension, at any rate visible to those people with a sixth sense. It would be ideology. The attentive visitor would feel it immediately. In fact, ideology represents a sixth important force in the organization, something which pulls in the direction of a feeling of having a mission."

After focusing on some of the weaknesses of a management-oriented integration perspective in connection with the concept of organizational culture as used in the corporate-culture literature, we shall now turn to some general problems in connection with the use of a social-anthropological concept of culture in organizational theory.

First of all, comparing the concept of culture as used in this discipline with the complex concept of culture as used in social anthropology as discussed in section 1.2 of this study, it is obvious that the concept has been watered down and narrowed down to an extent which justifies the claim that in this sense the concept is used metaphorically. It is important to bear in mind that the concept of culture in social anthropology, as we have seen, is essentially an analytical macro concept, which says something about central features of the social totality. Among these central features are kinship structures, the character and organization of the social production, the relationship between the genders, religion, artistic activities, etc.

21b. Ibid. p. 141-162.
Rather, the organization and management literature applies the concept of culture within a social-psychology framework, where the urgent problem is to explain a number of fundamental questions: Under what circumstances can an actor be made to change fundamental attitudes and behavioral patterns? Or more generally: What mechanisms determine a compliance with the cultural norms by a member of the society?

Consequently, the concept of culture of social anthropology cannot, just like that, be used as a micro concept as there is no guarantee that the two concepts, society and organization, are homogeneous and congruent phenomena. Considering that the phenomena with which social anthropology is concerned are essentially different from the phenomena with which the theories of organizational culture are concerned, they are more likely to be heterogeneous and divergent phenomena. What is interesting is therefore not so much whether an enterprise has or is a culture and in which ways one company differs from other companies, but rather the fact that in the 1980s everybody - managers, politicians, administrators and scientists - suddenly oriented themselves according to a concept that seems to be part of the spirit of the time.

Peter Dahler-Larsen claims that here the concept of organizational culture emerges as a solution to three problems: (1) an efficiency crisis that initially generates an interest in the conditions for the Japanese "Wirtschaftswunder", (2) a social value crisis resulting from what postmodernist philosophy has called the "death of the great story" and (3) a crisis in organizational theory. The theories of organizational culture here seek to establish an alternative to hitherto dominant rational/functionalist perceptions of organization and a methodical alternative to positivistic-based quantitative studies.

This point of view is implicitly supported by the following quotation from Deal and Kennedy.

"Today, everyone seems to complain about the decline in American productivity. The examples of industries in trouble are numerous and depressing. Books proclaim that Japanese management practices are the solution to America's industrial malaise. But we disagree. We don't think the answer is to mimic the Japanese. Nor do we think the solution lies with the tools of 'scientific' management: MBAs' analyses, portfolio theories, cost curves, or econometric models ... We need to relearn old lessons about how culture ties people together and gives meaning and purpose to their day-to-day lives."

The next problem is the heterogeneity of the field of organizational culture. The area is characterized by not having reached the paradigmatic certainty that characterizes an established science. That, at any rate, is the conclusion of a comparison with natural science. In that sense the field is in what Thomas Kuhn, a physicist and philosopher of science, calls a pre-paradigmatic or pre-scientific phase.

Joanne Martin speaks about three competing perspectives within the theory of organizational culture: (1) a monocultural perspective of integration, (2) a multicultural perspective of differentiation and finally (3) a perspective of fragmentation, where the focal points are ambiguities and inconsistencies in the corporate culture; but not even this division is generally accepted as Alvesson and Berg speak about conventions of organizational culture, which are much more numerous than the three just mentioned.

It takes more to solve this problem than cutting the Gordian Knot by setting a common standard for the study of organizational cultures, thus eliminating all doubt about what the concept of organizational culture stands for. Such a procedure would, as emphasized by Collin, be a misunderstanding of the function and status of scientific concepts.

"Such concepts are often introduced by being connected to a loose and partly implicit description isolating a certain class of phenomena or objects as the field of application of the concept (its 'extension', to use a technical term). After that empirical studies of these objects will be initiated, and in favorable situations they will lead to a theory about them. In the light of this theory a real definition is constructed, giving us the empirical 'essence' of the objects, i.e. the qualities of the objects which, in the light of the theory, enable us to explain their most essential data."

The last problem to be discussed here is that often, within the field of organizational culture, there is an unclarified problem of levels. Here the central question is: on which level are we when analyzing the culture of an organization? Alvesson and Berg mention seven different analytical levels in connection with the concept of culture.

1. Culture in societies and nations.
2. Regional and local cultures.
4. Organizational and corporate cultures.
5. Functional subcultures at organizational level.
6. Social groups in the organization.
7. Professional and functional cultures.


Here, the crux of the matter is how the relationship between the actual analytical level and the superior levels and the relationship between the actual analytical level and the subordinate levels are to be perceived and conceptualized. Are these relationships in fact a relationship of complementarity, where focusing on one level excludes simultaneous focusing on another level? In other words, does the relationship between the cultural levels resemble the relationships in quantum physics? It is well-known that an electron may be perceived either as a wave or as a particle, but it may not be perceived as both a wave and a particle at the same time. This is what constitutes the epistemological complementarity. Is it possible that something similar can be said about the relationship between the different cultural levels? The question seems to be unclarified. Alvesson and Berg illustrate the problem of levels in the following figure.

Fig. 3. Levels of culture

Geert Hofstede was the one who first showed how the cultural value dimensions at the two top levels - in Hofstede's theory the dimensions of power distance (equality vs. inequality), individualism vs. collectivism, masculinity vs. femininity and finally uncertainty avoidance - are manifested in the family, at school, at work and in the state. Consequently, these dimensions manifest themselves at the organizational level. We shall come back to Hofstede's theory in a later section.

Here it only serves as an illustration of the fact that what at the organizational level (level four) appears to be cultural differences in fundamental values of the organization, when seen from a higher level (level one), turns out to be homogeneous manifestations of the value dimensions of the national culture, so that what characterizes organizations within a given national culture, in terms of value, makes them uniform and predictable. It is in this sense that culture may be seen as something deep-rooted which is not immediately accessible for conscious attempt at changes. The relationship between superior and subordinate will typically manifest the value dimensions of the national culture.

At level five we find functional subcultures at the organizational level, more specifically a management culture. However, it is important to note that this management culture goes far beyond the individual organization and can be seen as an expression of a general tendency among managers in a given society at a given point in time. Instead of focusing on shared values etc. (what previously was referred to as shared meanings) it would be more relevant to focus on the organizational forms of domination, methods of achieving compliance and methods of controlling and monitoring. It is at this level there is a shortcut in the corporate-culture literature. Without making any empirical study, it is assumed that the ideas, doctrines and valuations of this functional group are shared by everybody in the organization.

As it appears from the figure, the problem is a highly complex one and will not be exhausted here, but the following fictitious example from an educational institute may serve as illustration. The institute offers bachelor degrees in electronic engineering, production engineering, business administration and economics, and foreign languages (LSP). In the institute there is a management function, an administrative function, a teaching or pedagogical function, etc.

We shall here focus on the pedagogical function. Within this area, the teaching function is undertaken by electronic engineers, production engineers, economists, linguists, humanists etc., and, at the receiving end, there are of course students within the above study programs. Depending on the section observed, it would be fair to speak about a pedagogical culture, which expresses the values and attitudes common to the teachers. At the same time this culture can also be seen as a professional culture. Here autonomy will be a central value.

Within the pedagogical function there will be different occupational cultures with specific characteristics. At the same time, some of these cultures, such as the engineers, will also be professional cultures, even if the engineers, in their function as teachers, operate in a context not connected with engineering proper. Also at this level, autonomy will be a central value. At the horizontal level, pedagogical culture as well as occupational and professional culture go far beyond the in-

individual institute, at the same time as the relationship between students and teachers, and among teachers, at a vertical level will manifest the value dimensions of the national culture. Some of the occupational cultures will function as integrating subcultures, others as orthogonal subcultures, etc. ...

As it is seen, the argument may easily develop into an absurdity. To avoid this, it is necessary to bear in mind the problem of levels and the ensuing limitations. Also seen is the importance of determining when the concept of culture is used metaphorically and when it is used in a social anthropological sense. Alvesson and Sandvik give the essence of the above considerations in the following:

"When we pass from one department of business administration to another, we will not meet a new culture with characteristics that we do not understand or that we are unable to operate in. It does not seem appropriate to use an anthropological conception of culture to explain what are simply minor variations within the same overall society or subgroup (e.g. a professional group). It would be more reasonable to talk of the organizational amalgamation of the impact of overall cultural determinants, which trigger and stress various values, beliefs, symbolic operations, etc. In a specific organization certain peculiar cultural features may be found, but in most cases we would expect these to deviate only marginally from what is to be found elsewhere."31

Finally, the conclusion of this section may be presented in the following statement. Instead of speaking about a special organizational culture, for analytical purposes it will be more appropriate to perceive the organization as the point of convergence or the meeting place for the social macro culture and broader social subcultures in the form of occupational and professional cultures. Thus, seen in this perspective, management culture should also be perceived as a social subculture.32 That this cocktail of occupational and professional cultures differs from one organization to another is evident inasmuch as the number and type of occupations and professions will vary from one organization to another. Through this, the visible variations between the different organizations are given a different explanation. What is gained is, however, that the concept of organizational culture is deconstructed and relieved of its metaphorical status in favor of the less heavily loaded notion of *esprit de corps*. Such a notion will be more accessible for consciously planned alteration strategies, but will leave the culture proper unchanged.

With a paradoxical and somewhat provocative formulation we may perceive the organization as 'a community of those who have nothing in common'.33 Those who have nothing in common are the occupational and organizational cultures. Hereby, the concept of profession is given a central role. Therefore the focus of our next section will be the contribution from the sociology of professions concerning this concept.

1.4 The contribution from the sociology of professions

The reasons for allotting a full section to the concept of profession are first of all that a profession is characterized by a number of features that separate it from other types of occupations or functional areas. Secondly, it lies near at hand to see the profession, its educational foundation and practices and the attached ideology and basis of legitimacy as a characteristic of the social division of labor. This makes it possible to see the profession as a social subculture. Thirdly, "professionalization" in the sense of giving an occupation the status of a profession may be perceived as a special strategy for looking after the interests and desires of an occupation to achieve social prestige and fourthly, the concept of profession may be employed for an analytical and conceptual distinction between what was initially described as business administration culture and engineering culture.

In everyday language, the notions of profession and professional are used in a number of different senses. It is thus possible to say about a person that he is a carpenter or a bricklayer by profession. In the same way we may speak about professional racing cyclists and other sports people, who earn their living by practicing their sport. We may also say about a person that he has a professional attitude to his work, which no doubt is a positive characteristic. However, the notion may also be used in a negative sense, inasmuch as a professional attitude is used as a synonym for a cold and distancing behavior.

In everyday Danish, the term 'stand' (English: order) seems to point to the sociological use of the concept of profession. In Danish, we may thus speak about 'lægestanden', the medical profession (=order), 'ingeniørstanden', the engineering profession (=order) and 'tæknistanden', the teaching profession (=order), but not about the bricklayer profession or the business administration profession. The use of the concept of order in connection with an occupation or trade indicates on the one hand a corporation type of organization of the trade. A corporation is characterized by holding a market monopoly, such as the medieval guilds. On the other hand, the concept refers to the origin of the profession as an official order.

Even if there is some disagreement about the definition44, the concept is employed in a much narrower sense within sociology, where - in spite of all the differences - there seems to be a general consensus that only relatively few occupational groups can be characterized as professions. The sociology of professions is particularly concerned with discussions of (1) which characteristics the profes-

33. The formulation (Danish: Fælleskabet af dem, som udfører fællesskab) is the title of Peter Dbelum-Larsen's Ph.D. dissertation, as quoted before.
sions possess, (2) which occupational groups are professional, and (3) to what extent an occupational group must possess the professional characteristics to qualify for the term profession.

To a high degree, the problem concerning the concept of profession within sociology is one of methods as, in principle, there are two paths open. We may interpret the concept as a specific notion and, in a "Max Weber sense", develop a characteristic concept of profession, by which is understood that, in order to give the cognition unique means of expression, we formalize and comprise certain features of the phenomenon into an ideal type which empirically is not found in its pure form. In this connection, studies of the specific professions may then ascertain to what extent they fill the conceptual characteristics.

The other path leads to the development of an empirically based sociology of professions in which the focal point is the genetic aspect. This implies a historical approach according to which the concept is seen as a historical design. Here the processes of professionalization within a given field in different countries will be compared. The main focus will be on differences in the process of professionalization and the consequences of this professionalization. Here, far-reaching generalizations are less frequent.

In this connection it would make sense to follow both paths. The establishment of an ideal type is a pedagogically expedient presentation, offering an immediate survey. Furthermore, it is possible to use the ideal type as a demarcation criterion for what can and what cannot claim the designation of profession. On the other hand, it would be natural to make a historical comparison of the professionalization process of the engineers in England, Germany and France. Here there are obvious differences in the background for and the course of the process. Such a historical approach will be introduced by Wilhelm Bonke in the second main section of this book.

Herskin and Jespersen employ an ideal type of the pure profession, comprising seven characteristics. As mentioned before, this ideal-type design does not fully correspond to any existing occupational group, but denotes a prototype. The model is quoted in its entirety without using quotation marks.

1. **Long, formal education.** The professional has a long, standardized education from a university or an institute of higher education. The foundation of the education is a well-defined theoretical area, such as law or medicine.

2. **Strong professional identification.** The professional identifies more with his profession than with his workplace, and the professional norms constitute a guide to the professional in doing his job.

3. **Specialist status.** The professional works within a well-defined field with certain functions and is acknowledged as the best educated, the specialist, within this field.

4. **Autonomy.** Whether the professional is employed in an organization or is self-employed, he works autonomously, which means that, to a high degree, the professional determines not only the means, but also the objectives of his work.

5. **Monopoly status.** The professional group includes everybody with a given education, holding a monopoly within a number of occupations and functions, which may not be performed by anybody else.

6. **Service orientation.** Without consideration for his personal interests the professional chooses the solution best suited for his client or society.

7. **Self-control.** Rather than the official bodies, it is the strong professional organization which, in internal courts or tribunals, exerts control of the practice of the members.

Traditionally, the medical profession has been considered as the profession closest to the ideal type. As it appears from the model, it is not a conceptual characteristic for the professional to be an independent businessman or a free artisan. Also employees in public and private organizations, who are subordinate to an employer, are included in the ideal type. This is of vital importance to this study, as the majority of engineers are employees and thus subordinate to an employer.

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54. A discussion of this problem can be found in Eila Fredheim: The Theory of Professions: State of the Art. In: The Sociology of the Professions. Edited by Robert Dingwall and Philip Lewis. The Macmillan Press Ltd. London 1993. Ulf Torgersten gives the following definition of the concept of profession: "We say that we have a profession where (1) one specific, long, formal education is acquired by (2) people who, in general, are oriented towards certain (3) professions which according to social norms cannot be held by anybody else but holders of this particular degree or education" (my translation). In simpler terms: a certain higher education, a one-sided professional motivation and professional monopoly are three distinct conceptual characteristics. Ulf Torgersten: Professionsevnen. Universitetsforlaget. Oslo 1972. p. 10. Maggi Sarfati Larson provides the following determination, if not definition, of the concept of profession: "The visible characteristics of the professional phenomenon - professional association, cognitive base, institutionalized training, licensing, work autonomy, colleagues 'control', code of ethics". Maggi Sarfati Larson: The Rise of Professionalism. A Sociological Analysis. University of California Press, Berkeley 1977. p. 206.


57. However, this statement is not unchallenged, as Robert L. Whitehall makes a clear distinction between engineers who are subordinate to an employer and engineers who are independent. He sees only the latter as exercising a profession: "So long as the individual is locked upon as an employee rather than as a free artisan, to that extent there is no professional status". Whitehall in: Mike W. Martin & Roland Schützinger, Ethics in Engineering. McGraw-Hill Publishing Company, New York 1989, p. 168.
One problem concerning the ideal type is, however, that to a great extent it reproduces the professional self-perception, and therefore can be seen as an integrating part of the professional ideology. The ideal type, so to speak, looks upon the profession through the profession's own eyes. In a sociological context this would constitute a bias or a distortion of the perspective. Compared with the main field of interest of this study this is of minor importance, indeed it may even be considered an advantage as we wish to consider the profession as a societal subculture, for which reason the self-perception and value basis of the profession is of vital importance.

Therefore, we shall now make some fundamental statements concerning the individual person's entry into the profession or the socialization of the profession. By socialization is to be understood the process through which the skills, role patterns, values and norms are acquired and internalized. This takes place through education at a university or another institute of higher education. Ulf Torgersen expresses it as follows:

"The university and the institute of higher education normally require a minimum of presence by the coming member of a given profession, and this physical presence forms the basis of environments which influence each individual person. These environments, which have a professional as well as a personal side, are both strong and distinct, and thereby are of substantial importance to the individual's incorporation in the profession. In these environments attitudes and values, behaviors and ways of handling interpersonal relations are learned." 38

In an article entitled "The Reproduction of the Professional Community" by Paul Atkinson, the sociologist Robert K. Merton is quoted for the following statement concerning the medical faculties' socializing function: the point is that "medical students can be substituted by students in engineering and business administration without challenging the validity of the statement.

"(Medical students) are engaged in learning the professional role of the physician by so combining its component knowledge and skills, attitudes and values, as to be motivated and able to perform their role in a professionally and socially acceptable fashion." 39

A little later in the article it says,

"It is their function to transmit the culture of medicine and to advance that culture. It is their task to shape the novice into the effective practitioner of medicine, to give him the best available knowledge and skills, and to provide him with

a professional identity so that he comes to think, act, and feel like a physician. It is their problem to enable the medical man to live up to the expectations of the professional role long after he has left the sustaining value-environment provided by the medical school." 40

According to Ulf Torgersen the variations in the norms, attitudes and values of the different professions will depend on differences between five parameters. 41

1. The preconditions, in general, of the students, including social and psychological preconditions, interests and motives, etc.
2. The use of the educational institute and the contact with the teacher, especially concerning number of lessons, teaching methods etc.
4. Occupational structure and careers.
5. Political function and political ideology.

As a concrete example of how these differences manifest themselves, Torgersen analyzes differences between the studies of law and philology in Norway around 1972. Here there are obvious differences in the recruitment for the two studies. The study of law mainly recruits students from the upper social classes, whereas the study of philology mainly recruits students from the middle classes. There is also a trend that students enrolling in philology have achieved higher marks in their entrance exams than students enrolling in law studies.

Furthermore, the study of law is shorter than the study of philology, for which reason the law student will be less closely connected to the university than the philology student. This may indicate a general trend towards students aiming at a professional career spending less time at the university than students who are more oriented towards the academic subject areas of their studies. Also the formal requirements differ. Where the philology graduates have to write a thesis, there are no such requirements for the law graduates. On the other hand, examinations play fundamentally different roles in the two studies.

First of all, in spite of a rather slender instruction - at least in the first half of the 20th century - law examinations are very complex. It is therefore quite normal for students to pay a lawyer to "coach" them before the final examination.

Secondly, the importance of the law examination is signaled through the members of the legal profession who are drawn from outside the university world to participate in the examination, either as examiners or external examiners. As far as Norway is concerned, at the time in question, the best among lawyers, including Supreme Court judges, permanent secretaries etc., participate in the examination of the law graduates.

38. Ulf Torgersen, op. cit., p. 45.
40. Ibid., p. 226.
41. Ulf Torgersen, op. cit., p. 43.
Thirdly, the mark achieved at the final examination plays a crucial role. It is imperative for the future career of a law graduate to have achieved high marks in the final examinations. Failing that, a law graduate has no possibilities of a career in a ministerial department. At the same time the examination marks are generally known among the law graduates and are of importance to the self-image and status of the law graduate and to his respect for other law graduates.

The philosophy graduates have a different attitude to exams. Here the focal point is the subject in itself rather than the exam. The attitude to examinations is more vague and ambivalent. The tendency to draw on people from outside the university in connection with exams will be less clear than in the law studies. The examination marks do not play the same role as they do to the law graduates although, of course, they are of importance for a future career as a researcher. Nor are the marks generally known and thus do not in themselves contribute to establishing a certain status hierarchy.

Concerning the occupational structure and career opportunities there are differences between the different professions. Within each profession there are different occupational possibilities, which together constitute a hierarchy. These hierarchies will be very different from one profession to the other. Within the medical profession there will be a type of hierarchy, which will be very different from what can be found within the military profession, which again will be very different from what we find within a development department consisting of engineers or within a consulting engineering firm. The latter is characterized by having much fewer status levels. Within the different professions the incitement for advancing in the hierarchy might also vary depending on whether need for status marking was psychological or professional. Incidentally, it should be noted that in this context we are not discussing careers that go beyond the profession, such as an electronics engineer turning CEO.

A comparison between law graduates and philosophy graduates shows a marked difference. Whereas the hierarchy among philosophers is not particularly differentiated, the law graduates enter a multibranch and a multilevel hierarchy, as expressed in the following quotation:

"A feature of the two hierarchies worth noting is the position of university posts. In the 19th century this was particularly clear. The so-called Hof- og Embedsmand were printed at the back of the official yearbook ranking the occupations in 18 classes, later in only 12. For law graduates the top five levels were occupied by a number of practical posts, with university posts ranking sixth and down. For philosophers there were no posts above university posts. This may explain the interest in "practical occupations" among law graduates and in university careers among philosophers. For both groups the posts in question constitute the top of the career ladder."

As it appears from the quotation, the different professional hierarchies increase the fundamental differences in values expressed at this level as a difference and social priority when distinguishing between "practitioners" and "theorists". Let us now consider the list of the five above-mentioned factors, i.e. political function and political ideology. The political function of a profession will be a reflection of the way in which it offers premises for social decisions. It is obvious that the engineer plays a more central role in connection with the establishment of...
that the existing disparities in influence potential are likely to be overdimensioned by the philologists, who exaggerate their own weakness and insignificance. This disparity has as a derived consequence or condition - it may be difficult to decide which came first: the hen or the egg - that the smaller the political and organizational influence potential, the more the dominant political ideology in the respective professions will tend towards the left.

The above reflections have been made with the purpose of illustrating the complexity of the professional socialization process on the basis of five fundamental parameters. The idea of the somewhat sketchy presentation has been to indicate the direction of an in-depth analysis and to make clear why a too careless treatment of the concept of organizational culture might easily lead to absurdities.

In addition to the socialization process happening in the course of the studies, other important socialization factors are the college control and discipline, all of which are vital elements in the professional ideology and self-image. Here it is important to be aware that, in principle, the assessment of the conduct of the professional as a result of the professional autonomy can only be judged by co-professionals: "Judgment by one's peers". This appears from the following quotation from Blau & Scott:

"The larger society has obtained an indirect social control to the professional community, which thus can make judgments according to its own norms. Professional control appears to have two sources. First, as a result of the long period of training undergone by the practitioner, he is expected to have acquired a body of expert knowledge and to have internalized a code of ethics that governs his professional conduct. Second, this self-control is supported by the external surveillance of his conduct by peers, who are in a position to see his work, who have the skills to judge his performance, and who, since they have a personal stake in the reputation of their profession, are motivated to exercise the necessary sanctions."

In relation to the ideal type, the profession, or more precisely the professional organization, will develop norms for three fundamental relations.

1. The relation between society and members of a given profession.
2. The relation between a client and a member of a given profession.
3. The relation between a member of a given profession and another member of a given profession.

In connection with the relation between society and members of a given profes-

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44. Further on the concepts of public and private and the attachment of literature to the private sphere, see Jürgen Habermas: Strukturwandel der Öffentlichkeit. Untersuchungen zu einer Kategorie der Bürgerlichen Gesellschaft. Luchterhand Verlag GmbH. 1962.
45. Ulf Torgron: op. cit., p. 51. A similar difference may be observed when comparing Bachelor graduates within engineering and business administration with Bachelor graduates within business language. The organizational influence potential of the two former groups is remarkably higher than that of the business language Bachelor graduates. One of the reasons for this is that business administration graduates and engineering graduates modern and post-modern society have adopted the roles of some kind of "high priests" in the new secular "religion" of growth ideology. The social influence potential of engineers will also appear from a historical view of the influence of engineers on the forming of the modern industrial society.
47. As far as the engineering profession is concerned, this problem receives a very sober and thorough treatment in Michael Martin & Roland Schnitzler, Ethics in Engineering. McGraw Hill. New York 1989.
sion, which is the most vague of the relations, and which is the one most diffi-
cult one to subject to sanctions, the discussion focuses on which moral obliga-
tions to society are connected to the professional expert role in general, and
which moral obligations, in connection with a loyalty conflict between employer
interests and social interests, would be connected to the professional expert role
in particular.

The question is here when and how the professional must warn the public or
undertake a so-called "whistle-blowing." What obligations to society does an engi-
neer have, who has knowledge of a fault in the design of an airplane, which may
have fatal consequences? We shall not go deeper into a discussion of the problem
but only state that the central norms concerning the relation between a member of
a given profession and society will often be formulated in a code of ethics for
the profession, as illustrated in the American "Code Of Ethics For Engineers,"
covering the "National Society Of Professional Engineers. Founded 1934." 48

"Engineers shall at all times recognize that their primary obligation is to protect
the safety, health, property and welfare of the public. If their professional judg-
ment is overruled under circumstances where the safety, health, property or wel-
fare of the public are endangered, they shall notify their employer or client and
such other authority as may be appropriate." 49

The second relation, the relation between client and a member of a given profes-
sion is based on what Blau and Scott call affective neutrality. Time and again,
this affective neutrality is to safeguard the client against emotional exploitation and
the professional against breaking down under the pressure of his own feelings of sym-
pathy and compassion with the client. Neither the surgeon, nor the cancerous pati-
ent will benefit from a nervous breakdown suffered by the surgeon while operating.

In connection with the endeavors towards the professionalization of areas within the
social and health sector, which has not had the status of a profession before, within

48. For a more detailed treatment of the concept of "whistle-blowing," see Martin & Schinzinger, op. cit.,
p. 219-222.
49. Ibid., p. 352.
50. Holland and Belgium are examples of countries in which instruction in "professional ethics" is compulsory
in those undergraduate studies within the health care areas which aspire to the status of profession. By defi-
nining these areas as academic undergraduate studies, so that of the fundamental requirements to a profes-
sion is fulfilled, i.e. that the recruitment to the profession is secured through scientific education. Thus nus-
ting has developed from vocation to profession. Today's nurse is no Florence Nightingale any longer. Social
 counselling is another example of an area seeking the status of a profession. In many cases social advisors
 have developed relatively well-defined fields of activity, but their education and theories are composed of
 psychology, law, economics, sociology, etc., and each of these groups would claim a deeper understanding
 of the individual areas than the one mastered by the social advisors. In an attempt to win professional sta-
tus, such a group must now try to develop a specialty, which stands as a well-defined field, and which
 nobody else can claim. - In the case of the social advisor it seems that there are attempts at specializing in
 family therapy and community work. At the same time the group will have to emphasize its present advan-
tages, and this implies that the social advisors emphasize precisely their capability of exercising several
 areas, which they may integrate in their work." Herlin & Jeppesen, op. cit., pp. 428-429.

nursing and social counseling, a necessary step in this process quite obviously is the
drafting of a code of "professional ethics." The objective of this instruction in ethics
is to increase the awareness of the professional of the ethically relevant factors in the
relation between the client and the professional and to teach the professional style.

Both the affective neutrality and the relation between the client and the profes-
sional are essential elements in the self-image of the professional. This relation
between the client and the professional must not be based on self-interest or per-
sonal profit. The relation is based on a professional estimate of what serves the
interests of the client best, which means that, in principle, the relation is of an
altruistic nature. Should the opposite occur, it would be disqualifying for the pro-
fessional and it would be met with sanctions from the professional community.
This is where the professional distinguishes himself from the businessman whose
conduct is egoistic and governed by a legitimate self-interest. This difference is
expressed in the following quotation from Blau & Scott,

"Professional decisions must not be based on the practitioner's self-interest, where-
as in business life self-interests are expected to govern decisions. This differ-
ence does not mean that professionals are less selfish than businessmen are or
less interested in economic advancement. It means that while each party to a
business transaction is assumed, by the other and by the community, to act strict-
ly in terms of his own interests, it is not legitimate for a professional to let his
decisions as to what services to render be influenced by self-interest. If he does,
the condemnation and the sanctions of his colleagues and of the community will
hurt his interests in the long run." 51

In the last of the three relations mentioned, the relation between a member of a
given profession and another member of the same profession, the main strategy
is to look after the status of members as specialists, their autonomy in performing
their duties, and their monopoly status in certain fields of activities and functions.

It is in this relation the strongest means of sanctions are found. If the profes-
nonal code of conduct is violated, the most severe sanction would be exclusion
from the status group. The consequence of such exclusion is temporary or per-
manent forfeiture of the right to practice the profession in question. A lawyer may
thus be disbarred in the same way as a medical practitioner may lose the right to
practice his profession.

For the engineers the professional code of ethics will typically include formul-
ations like the following:

"Engineers shall avoid all conduct or practice which is likely to discredit the pro-
fession or deceive the public." 52

Except for these general observations we shall not go deeper into a discussion of this problem.\footnote{53}

The objective of the above analysis has been to see the profession in a double perspective, i.e. on the one hand to get closer to an understanding of the concept of profession and the professional socialization process in order to be able to make a linkage to the concept of occupational culture, and on the other, to perceive professionalization as a special strategy to maintain the interests of a trade in winning professional status, autonomy in work situations and monopoly in fields of activities and functions.\footnote{54}

Closing the above discussion we shall now apply the concept of profession as a criterion of demarcation on the business administration studies, where, as mentioned in the introduction, the main focus will be on marketing. After that we will discuss the engineering profession's deviations, if any, from the ideal type presented.

Applying Ulf Torgerson's definition of profession, we may ask if, with regard to marketing, there is an unambiguous connection between one particular higher education, a unilateral occupational motivation and an occupational monopoly. In other words, is the connection as unambiguous as it is for members of the medical profession? The first assumption is met inasmuch as the Danish Business Schools offer specialty study programmes both at undergraduate and at postgraduate levels within marketing. The second assumption has not been met as the occupational motivation takes many different directions. Some are motivated by the possibility of a management position, some by the desire for starting their own business, others are motivated by the prospect of a job in the advertising industry, and others yet by the prospect of a job as a researcher or a job as a lecturer. Neither has the third assumption been met, as there is no occupational monopoly for graduates with the degree in question. In principle, anybody may apply for a job within marketing and get it too.

\footnote{53} The Danish profession of engineers distinguishes itself from the ideal in not having a code of ethics. What is important for the status of the profession is the delineation downward. Membership of the Association of Engineers in Denmark requires "a minimum of three years of university studies with a considerable content of mathematics or natural science subjects, providing a basis for solving engineering assignments or project assignments requiring technical and/or natural science skills." Cf. Articles for the Association of Engineers in Denmark (November 1998).

\footnote{54} However, the process may also take the opposite direction, towards de-professionalization of a trade. Ulf Torgerson mentions four factors which may cause de-professionalization: 1. Populism. This implies doubt and discrediting the role of the professional as a specialist. 2. Innovationism. By this is understood that the cognitive basis of the profession undergoes frequent changes. 3. Specialism. In this it is implied that the cognitive basis of the profession does not form a unity, but rather is split into a number of different specialties which can no longer be combined. 4. Personalism. This implies that personal preconditions get to play a more important role than the professional preconditions. Ulf Torgerson, op. cit., pp 72 ff. A combination of 1 and 4 can be observed in connection with the appointment of lay vicars in the Danish church, where the qualifications previously required were those of a degree in theology. Presently and historically we have also seen how the vicars, in carrying out their profession, have been challenged by lay preachers within religious revival movements. This also involves a combination of 1 and 4.

The same type of argumentation can be applied in connection with business management, as it appears from the following quotation in which a comparison is made with the ideal type of a profession:

"Business people, by whom I mean managers, that is people who have a responsibility for the operation of a firm or part of a firm, with the authority to make decisions of some moment on their own, are not licensed, nor subject to any course of study. They are professional insofar as they are employed managers and make a living thereby. But are they members of a profession? Is there a peer pressure or accepted behavior constrained from within a peer group, apart from legal market requirements? Is there a unique code of ethics formally promulgated or informally imposed by peers on the person in question? In general the answer is in the negative, but in specific circumstances the answer is in the affirmative but often with a question mark. Peer pressure on a free wheeling manager may be interpreted as a conspiracy as in a price fixing paper.\footnote{55}"

If we then turn towards the engineering profession as a whole and compare it to the ideal type, there will, as stated by Magali Sartift Larsson\footnote{56} - be a number of deviations. First, engineering does not constitute a functionally homogeneous field in the social division of labor, such as treatment of diseases, nursing, care of the elderly and administration of justice. Indeed, engineers may be perceived under the abstract category of "coordinators or devisors of physical objects", but, in terms of definition, this will not distinguish them from technicians, mechanics, architects, etc. There is a historical explanation of this:

"There was not, therefore, one earlier type out of which the modern engineer developed, nor one single functional area, as in the case of healing, but different specializations which separately gave rise to present day engineering specialties - as well as to architecture, its derivations, and numerous "instrument-making" crafts which never reached or even aspired to the status of professions.\footnote{57}"
Secondly, the cognitive foundation of the profession does not constitute a unity, as is the case of the medical profession. If it did, it would be at a very abstract level. The engineering study programmes cover a very heterogeneous range, from electronic engineering, mechanical engineering, chemical engineering, civil engineering, production engineering, to export engineering, "business development engineering", etc.

Thirdly, in engineering, the relation between the professional and his client is of a fundamentally different nature from the relation between a lawyer and his client, and the relation between a medical practitioner and his client. The latter two relations are characterized by the receiver of the service being the client, who is thus the end consumer of the service. Within the engineering profession the client will often be an employer who buys labor and not services. This means that the market for engineering services is subordinated to an organized clientele, so that the relation to the end consumer becomes less prominent or is mediated. Although we have admitted that the ideal type also comprises members of a profession employed in public or private organizations, the relation between an engineer and his client is fundamentally different from the relation between a doctor employed at a public or a private hospital and his client/patient. Here the contact between the two remains direct.

Fourthly, the above factors are of importance to the form and degree of autonomy within the engineering profession. Magali Sarfati expresses it as follows:

58. Unlike diploma engineering studies, the cognitive basis of business administration studies in Denmark, including especially undergraduate studies (MA-study programmes), are characterized by a high degree of unity with a curriculum common to practically all MA-study programmes. Nevertheless, it is noteworthy that the curriculum was initially determined in relation to a concrete business environment, and only relatively late, i.e. after 1955, attached to a more research-based knowledge. This dual governing of the practical aspect and the research aspect – has resulted in a fragmented and conglomerate theoretical structure. The MA-study programme is characterized by a large number of disciplines often not related across discipline boundaries and in the worst case contradictory. An example of disciplines, which are not related, is management accounting and theory of consumer behavior. Heine Andersen emphasizes theoretical inconsistencies within two areas, management theory and consumer behavior. He expresses it like this: "According to the usual, neo-classically based management theory (known from macro economics) the enterprise is perceived as governed by a central subject, which, on the basis of a clear objective (profit maximization) and on the basis of perfect information, rationally calculates the optimum. This perception is founded on macro economic theory. Against this there is an organizational management theory, in which are included internal corporate processes, conflicts of objectives, conflicts of interests, group patterns, norms and attitudes, hierarchies of power, etc. (known from the subject organization), all of which are factors breaking with the neo-classical management image. To a high degree, the fundamental concepts of organizational theory originate in such disciplines as sociology, social psychology and psychology. In the same way there are inherent and contradictory theories of consumer behavior. Here, as above, one extreme is the rational, fully informed utility-maximizing actor, an image once again originating in neo-classical macro economics. The other extreme is the "irrational" consumer who may be governed either by internal psychological factors beyond his/her control (instincts, unconscious motives, habits, etc.) or by external influences (socialization, norms, advertisements, stimuli, authorities, etc.). This image originates in psychology and social psychology". Cf. Heine Andersen (Ed.): Introduction. Videokabsten & metodebog. Samfundslitteratur, Gyldendal 1994, 4. udg. bd. 1, p. 20.

"Autonomy in defining the content of work - or the control over new cognitive areas - does not by itself compensate for the structural subordination of the professional market. The subordination of the engineer's role submits the selection of technical problems and the criteria that are brought to bear in its solution, at least partially, to heterogeneous consideration. Autonomy is chiefly gained outside the professional role, by acceding to positions of command or responsibility in the dominant market."

As it has appeared from the above observations, the engineering profession differs from the ideal type of a profession in some important respects. As already indicated, the reasons for this are to be perceived in a historical perspective. The professionalization of the field of engineering is thus to be seen in the context of:

- engineers being in charge of, developing and running the industrial production,
- engineers projecting, developing and running the infra structure, public transport and communications plus the public service system and energy supplies,
- engineers creating the basis for further forming and modernizing society through the development of a new technology in the form of technical instruction, research and development.

Such a historical perspective will be applied in main section 2 of this book, outlining the development of the process of professionalization in Germany, Great Britain and France.

1.5 Occupation as culture. The theory of John Van Maanen and Stephen R. Barley on "occupational communities"

John Van Maanen and Stephen R. Barley's theory of organizational culture, as formulated in their comprehensive article from 1984 "Occupational Communities: Culture and Control in Organizations", constitutes an expansion of the perspective in relation to the sociology of professions. Van Maanen and Barley do not perceive profession in isolation as a particularly privileged type of trade or occupation, which by definition differs from all other trades in the social division of labor, but as a phenomenon that, in a potentiated form, institutionalizes elements inherent in any kind of functional and occupational community. At the same time, this occupational community forms the basis of the creation of "work cultures", which can be seen as "cultures of achievement", i.e. cultures which are centered around occupation and oriented towards achievements, cultures which are not career-oriented in a traditional sense as is the case with those cultures designa-

60. This formulation adapted from Michael P. Wagner, op. cit., p. 241.
Organizations in trade unions and professionalization can be seen as counter strategies to "external" attempts at restricting the autonomy and self-control in an "occupational community". These counter strategies may be different concerning the choice of means but the ends are fundamentally identical, i.e. to secure the control of who can perform the work, how it is to be done and how it is to be rewarded.

"The distinction between the two strategies hinges, first, upon the degree to which an occupation attempts to trade on its special knowledge and second, the degree to which an occupation faces organized opposition when attempting to assert its independence and establish the legitimacy of occupational self-control. The values and ideologies supporting each process reflect choices about how occupational self-control can best be gained and guarded rather than any deep discontinuities of purpose." 60

We will now rephrase the four conditions of the definition by saying that the definition includes four dimensions:

1. Demarcation
2. Social identity
3. Reference group
4. Social relations

Concerning the first dimension - demarcation - Van Maanen and Barley claim that it is based on the idea of "consciousness of kind" - a consciousness of being of the same kind. It means that the relevant demarcation line for an occupational community is the line drawn by the members themselves. The demarcation line is thus determined in accordance with internal criteria or "native concepts". It is therefore difficult for an outsider applying purely external criteria, in advance, to know where the line is drawn.

This has theoretical as well as methodological importance. Theoretical importance in breaking with the principles of traditional occupational theory, which operates with external categories concerning categories of employees, such as academically educated staff, skilled and unskilled workers. Methodological importance insofar as the qualitative methods, as known from anthropology and ethnography, are the only possible methods if the occupational community is to be perceived from the inside, through a native point of view. Understanding a native point of view therefore requires an ability to distinguish between the conceptual categories or taxonomies applied by the "natives".

Let us illustrate the reasoning with an example. From an ethnographic study of high-technological occupational cultures within the electronics industry in Silicon Valley in California, Kathleen L. Gregory summarizes a number of interviews with...
employees in Pacific Microcomputer Corporation (PMC). The following quotation from an interview with a software engineer shows what the relevant internal classifications look like:

"The main distinctions are what you'd call software types and hardware types. And then, well I was going to say you're not interested in marketing, but in fact a lot of people in marketing, it seems to me, are converted engineers. (People in) manufacturing, production, sales, communication, personnel, those are all totally separate careers."  

Three categories are employed: Software types, hardware types and converted engineers. Later on, the article quotes the same software engineer:

"The difference is really, computer scientists are more interested in the academic side of it, and they will want to write a paper about what they did, and don't really care deep down in their hearts whether customers have any use for anything that they're doing. Software engineers may have exactly the same training. They could take the same courses, but they see themselves as builders, and want to get something built."  

The mentioned classifications thus form the basis for distinct occupational communities, which would not be directly identifiable for an outsider.

Another interesting example of a classification concerns a phenomenon mentioned by Joseph Weizenbaum, professor of informatics. In describing the hacker, the computer bum or the extreme technologist, he uses the phrase "compulsive programmer" drawing the picture of a distinctly occupational culture with an almost autistic or ludomaniac relationship to data technology. No doubt, the hacker is a marginal phenomenon in the engineering culture, but surely, as a type, very interesting. Weizenbaum describes him for the hacker is male — in the following way:

"Wherever computer centers have become established, that is to say, in countless places in the United States, as well as in virtually all other industrial regions of the world, bright young men of disheveled appearance, often with sunken glowing eyes, can be seen sitting at computer consoles, their arms tensed and waiting to fire their fingers, already poised to strike, at the buttons and keys on which their attention seems to be as riveted as a gambler’s on the rolling dice. When not so transfixed, they often sit at tables strewn with computer printouts over which they pore like possessed students of a cabalistic text. They work until they nearly drop, twenty, thirty hours at a time. Their food, if they arrange it, is brought to them: coffee, Coles, sandwiches. If possible, they sleep on camp beds near the computer. But only for a few hours — then back to the console or the printouts. Their rumpled clothes, their unwashed and unshaven faces, and their uncombed hair all testify that they are oblivious to their bodies and to the world in which they move. They exist, at least when so engaged, only through and for the computers. These are computer bums, compulsive programmers. They are an international phenomenon."  

These classifications thus form the basis of distinct occupational communities not immediately identifiable by outsiders.

According to Van Maanen and Barley, the second dimension in the definition of an occupational community - social identity - is closely linked to the first, as a "consciousness of kind" logically requires the coexistence of a "consciousness of difference". An occupational community in the sense used by Van Maanen and Barley also assumes a strong occupational identification. The degree of occupational identification will depend on two factors, the strength of the occupational commitment and a number of codes surrounding the occupation and serving as the visible manifestation of the identification. Van Maanen and Barley express it as follows:

"Becoming a member of an occupation always entails learning a set of codes that can be used to construct meaningful interpretations of persons, events, and objects commonly encountered in the occupational world."  

We shall now take a closer look at the occupational codes mentioned, the most conspicuous of which are codes of language, equipment and dress. A comparison between the medical profession and carpenters or pipe fitters would show marked differences.

In his book, Engineering Culture: Control and Commitment in a High-Tech Corporation, Gideon Kunda, who belongs to the circle of ethnographers around Van Maanen and Barley, and who does research work in extension of the research programme presented in the above article, makes some interesting observations in connection with an analysis of the dress codes in the high-technology development enterprise Tech in Silicon Valley. He compares the development function with the marketing function. The informal dress code prevailing among engineers in the development function expresses that their attention is oriented towards more abstract values, at the same time as the code shows a distance to the outer world, and in particular to the world represented by the sales and marketing function.

"The dress code (among development engineers) is loose, if rather drab. Business attire seems almost theatrically out of place and suggests association with the outside world, usually with "business types". The general demeanor combines a studied informality, a seemingly self-assured sense of importance, and a clearly con-

64. Kathleen L. Gregory, op. cit, p. 370.
represented by one single person, who, in that case, would be the exponent of the values, attitudes, norms and perspectives shared by the reference group.

Secondly, the reference group will serve as the legitimizing instance of the values, attitudes, norms and perspectives of the occupational community. The reference group thus represents a particular system of interpretation, through which phenomena in the organization are interpreted and understood. This provides a degree of autonomy as organizational "truths" may be redefined and reinterpreted.

Concerning the last dimension - social relations - the definition of occupational community says that work and leisure will tend to meld. The crucial point here is not that members of an occupational community out of interest for their occupation are engaged in work-related activities both at work and in their leisure time. The importance of social relations is rather:

"The tight network of social relations created when members of an occupation seek, for whatever reasons (e.g. pleasure, anxiety reduction, opportunistic advantage, etc.,) close relationships with one another outside the workplace.

As indicated in the opening of this chapter, Van Maanen and Barley distinguish between the concepts of "occupational community" and "work culture". Therefore, it may be relevant to make a few observations on the concept of culture employed by Van Maanen and Barley. The following observations are based on the chapter "Occupational Communities as Work Cultures."

It appears here that the concept of "work culture" is to be interpreted subjective-ly as the authors adopt Ward H. Goodenough's definition of culture as "the things a person must know to be a member of a given group." Culture is thus to be perceived as a shared compulsory knowledge, which must be mastered by members of the occupational community. In other words a cognitive notion of culture, with culture being perceived as a mental scheme for understanding and interpreting, primarily with a view to decoding occupational and organizational "meanings and signs". Van Maanen and Barley express it in the following way:

"In occupational communities these "things" include decoding schemes for assigning meaning to the various practical routines which members engage in during a workday, as well as the typical objects, persons, places, times, and relations members encounter at work (and, often, beyond). At a deeper, interpretative level, these surface manifestations of culture reflect integrative themes or orde-

71. In their book Women in Engineering, Gender, Power and Workplace Culture, Judith S. McIlvree and J. Gregg Robinson make a list of work values in engineering. The list is developed in connection with an empirical analysis of differences between male and female engineers in the USA and comprises a number of numerical values, which may be disregarded in this context. The list comprises ten values, which are as follows: (1) Being treated as a professional by one's superior; (2) Having a possibility of researching new ideas concerning technology and systems; (3) Having stability in one's private life as well as in one's working life; (4) Cooperating with others who are the best within their field; (5) Working with projects which have direct importance for the corporation's success potentials; (6) Helping the corporation build a reputation as a first-class organization; (7) Working with projects of one's own making; (8) Learning how to establish and run a business; (9) Becoming a leader within one's own field of activity; (10) Parenting technical ideas. See Judith S. McIlvree & J. Gregg Robinson: Women in Engineering, Gender, Power, and Workplace Culture. State University of New York Press. Albany 1992, p. 87.
ring assumptions held by the membership which provide for some commonality and connection across specific domains of thought and action.\textsuperscript{75}

The advantage of applying a cognitive concept of culture in the understanding of occupational cultures is that it becomes clear just how deeply rooted such cultures are. Comparing cultures therefore corresponds to comparing codes and fundamental assumptions, which form the basis of behavioral and cognitive diversity. However, the disadvantage of such a concept of culture is that culture is reduced to being a purely mental phenomenon, i.e. the underlying value system that governs the behavior. This has already been criticized above.

Having looked at some of the central elements of the occupational community, we shall now take a closer look at the importance of the occupational culture perspective in relation to the career aspect. The problem encountered is that the traditional career model solely focuses on vertical mobility and hierarchical promotion. In this sense, career is thus mainly a matter of concern for a relatively small group of leaders and administrators. From the perspective of the occupational community, such a career model will be irrelevant, first of all because the external categories of the model are not adequate, secondly because for most employees the possibilities of organizational promotion are very limited, and thirdly because everything that a traditional career implies, in terms of pursuit of money and power, is looked upon with some skepticism through the lens of the occupational community. Van Maanen and Barley therefore suggest an alternative model:

"An alternative model would be to consider the 'controlling social structure' of a career to be the social context which the worker considers most proximal. Hence, a career's backdrop is the standard by which the career holder measures the career, not the standard of the observer."\textsuperscript{76}

However, Van Maanen and Barley's model is not to be understood as a rejection of the traditional career model, but rather as a supplement, which gives the possibility, in terms of career, of taking into consideration added competence and experience gained within an occupational field. Van Maanen and Barley therefore distinguish between internal and external careers. The phrases are defined in the following way:

"The phrase 'external career' refers to the path and sequence of positions and roles that constitute a career in an organization or occupation. 'Internal career' connotes the meaning career-related roles have for an individual."\textsuperscript{77}

Important to the understanding of an internal career sequence is the existential meaningfulness in the concept of career-related roles. The principal idea is that within an occupational community it is possible to be promoted from a peripheral role to a central role or from low status to high status through professional skills and experience. In Van Maanen and Barley's terminology it is possible to "move towards greater inclusion" and to "gain centrality".

"People who move towards greater inclusion "gain centrality" within the network of community members. They may attain special privileges, increased rewards, become privy to secrets about "how things really work," and gain heightened respect from community members. Individuals who have achieved visible centrality in the community are often identified by the labels or folk types used by members to note occupational wisdom. The "sage", "pro", "guru", "old hand", and legendary "old timer" are stereotypes in this regard. As these social types suggest, centrality can carry prestige, honor, knowledge, and power."\textsuperscript{78}

Van Maanen and Barley mention three areas that function as the basis for this informal promotion. (1) The work in itself (experience, knowledge, skills, techniques, finesse, etc.). (2) The surroundings in which the work is carried out (attractive corporations, functional areas, etc.). (3) The network of social relations connected to the work (contact with people possessing high professional status, etc.)

Regarding the engineering culture we may clarify the difference between external and internal careers by means of four criteria taken from Håkan With Andersen and Knut Holten Sørensen's book "Frankenstein's Dilemma:" 1. Aim. 2. Control. 3. Rewards and 4. Influence.

1. Aim. Companies' requirements to engineers are that they must develop new products the engineers insist on maintaining a high technical standard.

2. Control. The organizational control is hierarchical while the professional control lies in the group of colleagues.

3. Rewards. Companies reward by status in the organization while professional reward derives from status in the profession.

4. Influence. Organizational status and authority derive from position while professional status and authority are founded on special competence.

As engineers generally are a homogeneous group, the outline of three typical careers emerges, representing an internal career, an external career and a mixture, viz.,

1. A career with a strong technological-professional orientation
2. A career with a strong management orientation

\textsuperscript{75} Ibid., p. 308.
\textsuperscript{76} Ibid., p. 323.
\textsuperscript{77} Ibid., p. 355, note 23.
\textsuperscript{78} Ibid., p. 324.
3. A career with a strong orientation towards practical business-oriented challenges.

The last part of Van Maanen and Barley's article is entitled "Occupational communities and organization". In this part they deal with three topics, viz. "Organizational Complexity and Managerial Control", "Organizational Loyalty and Work Careers" and "Innovation, Technology, and Managerial Control". We shall not make any in-depth analysis of this part of the article as the objective of this chapter has been to analyze and offer a more varied understanding of the notion of an occupational community. However, it is important to be aware of the programmatic objective of Van Maanen and Barley's article as they do not give any concrete instructions as to how the notions are to be operationalized. In the next chapter we shall therefore consider a theory that includes this dimension, viz. Edgar H. Schein's theory of organizational culture.

1.6 A model of analysis – a critical presentation of Edgar Schein's theory of organizational culture

Without doubt, Edgar Schein is one of the key figures within the theory of organizational culture. Not only has he written many books on areas within social psychology, organizational psychology, career development and theory of organizational culture, his importance also appears from the number of quotations, theses and literature references in books and articles all over the world, just as his models and methods of analysis are applied in consultative matters.

In this chapter, we shall discuss the possibility of applying Edgar Schein's cultural model in connection with an analysis of occupational cultures, knowing that such a venture will conflict with Schein's intentions and up to a point will constitute an amputation of the theory. Nor can it be denied that such a venture will also involve some degree of eclecticism. The reason for making the experiment anyway is that, in addition to a definition of the concept of organizational culture, Schein's theory also contains a fruitful and relatively simple, empirical analytical model plus methodical considerations and instructions for concrete collection of data. Consequently, to a great extent the model may serve as a heuristic guide.

Applying Schein's model to an analysis of occupational cultures initially calls for an alteration of the analytical unit and perspective. Whereas Schein's interest lies in the analysis of the value elements in the organizational community or the common organizational culture seen from an integration perspective, the main interest of this study is the analysis of organizational subcultures seen from a differentiation perspective. The reason for this is, as argued above - both implicitly and explicitly - that occupational cultures must be presumed to be organizational subcultures, which, in the context of organization, will manifest themselves at departmental and functional levels. Consequently, the alteration in question is a shift in the analytical level from the whole to the part and a shift in perspective from integration to differentiation. In Joanne Martin's terminology we must expect the engineering culture, represented by the development function, to constitute an integrating or orthogonal subculture, and the business administration culture, represented by the sales and marketing function, to constitute an enhancing subculture.

Second and in extension of the above, the perspective chosen here necessitates questioning Schein's use of the notion "basic assumptions". In Schein's theory these assumptions constitute a cognitive structure with a normative effect on conduct and understanding of the environment. The problem is not that "the basic assumptions" constitute a cognitive structure. The problem is where the basic assumptions come from. The claim that being employed in an arbitrary enterprise immediately should affect a person's cognitive structure seems a downright postulate from Schein. Under all circumstances this question can only be answered through an empirical study.

Schein postulates that the question can be answered by analytically keeping within the frames of the organization. However, as Van Maanen and Barley demonstrate, it is necessary to dig one layer further down. The relation between what you can do and who you are, or between occupation and identity, is of much greater importance than the relation between where you work and who you are or between place of work and identity. Therefore, the socialization taking place through the course of education must also be included as an extremely relevant factor. We shall revert to this point of critique later in this chapter.

The chapter will be divided into the following three sections: first a brief presentation of the basic concepts of Schein's theory. After that, an example of how Schein's cultural model may be operationalized and what it can be used for. Finally we shall make some critical observations of the theory seen in the light of the concept of occupational culture.

Schein's concept of culture is defined as follows:

Culture is "A pattern of basic assumptions - invented, discovered or developed by a given group as it learns to cope with its problems of external adaptation and internal integration - that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems."

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Even if Schein's starting point in two aspects is the same as that of the corporate-culture line, viz. first, the assumptions that the organization is a community with a homogenous culture and second, a management-oriented approach, his definition of culture demonstrates that he is much more subtle and theoretically reflective. Schein's definition intends to say something general about culture and has not in advance restricted the options of choice of analytical unit.

The focal point of the definition is the definition of culture as basic assumptions. The basic assumptions are the deep-rooted and fundamental characteristics of the organizational culture. In the model these characteristics have the status of the invisible core of the culture and constitute a cognitive and affective system that governs the behavior of the group members and tells them how to perceive, feel and react to the external environment. The basic assumptions form around five dimensions, constituting what Schein describes as the cultural paradigm, as illustrated in the table below. Around these paradigms it is possible to build cultural typologies, as did Hofstede.

**Figure 4. Basic Underlying Assumptions Around Which Cultural Paradigms Form**

1. **Humanity's Relationship to Nature.** At the organizational level, do the key members view the relationship of the organization to its environment as one of dominance, subjugation, harmonizing, finding an appropriate niche, or what?

2. **The Nature of Reality and Truth.** The linguistic and behavioral rules that define what is real and what is not, what is a "fact", how truth is ultimately to be determined, and whether truth is "revealed" or "discovered"; basic concepts of time and space.

3. **The Nature of Human Nature.** What does it mean to be "human" and what attributes are considered intrinsic or ultimate? Is human nature good, evil, or neutral? Are human beings perfected or not?

4. **The Nature of Human Activity.** What is the "right" thing for human beings to do, on the basis of the above assumptions about reality, the environment, and human nature: to be active, passive, self-developmental, fatalistic, or what? What is work and what is play?

5. **The Nature of Human Relationships.** What is considered to be the "right" way for people to relate to each other, to distribute power and love? Is life cooperative or competitive; individualistic, group collaborative, or communal; based on traditional lineal authority, law, charisma, or what?

As it appears from the table the five dimensions constitute abstract anthropological categories. Schein's analysis of these dimensions is very comprehensive and demonstrates the scope of his theoretical foundation. However, Majken Schulz calls attention to two problems in connection with the application of the table in concrete analyses.

First, the risk of drowning in complexity, as there are three, four or five sub-approaches attached to each dimension. Besides, determining whether the table can be or is to be applied in its social-anthropological sense or is to be applied metaphorically is difficult. Secondly, distinguishing between the dimensions is difficult. Thus it will be possible to place the same statement in several dimensions.

Indeed, in his concrete analyses Schein does not even observe his own instructions. He may almost seem to be cracking nuts with a sledgehammer in making extensive theoretical preparations only to reach relatively simple and uncomplicated basic assumptions as illustrated in his analysis of the two companies, Multi and Action.

In addition to this deep level of culture, Schein operates with two more levels, viz. artefacts and values, the visible manifestation of the core culture or the surface level of the culture. Artefacts, which are man-made objects, are visible but often not decipherable as their meaning only becomes clear in the light of the basic assumptions. The same object may therefore mean different things in different cultures.

Values are located at a higher level of awareness than the basic assumptions. This level may be seen as the normative level of culture telling something about the group's sense of what "ought to be". It is at this level we find the strategic values of the organization. Schein talks about espoused values, but implicitly operates with a distinction between espoused values and values-in-use. Espoused values are normative values painting a picture of the organization as it sees itself and would like to be perceived by others. This corresponds to the organization's self-perception. Values-in-use, on the other hand, serve as a guide for behavior. Values which at some time serve as espoused values may later - if met with general acceptance in the organization - become so natural and indisputable that they are transformed into values-in-use and eventually into basic assumptions. This process is described by Schein as a cognitive process of transformation.

Schein's three cultural levels are expressed in the following figure.
As it appears from the model, the three cultural levels constitute a vertical hierarchy. The three levels are characterized by different degrees of visibility and analytical accessibility, but both the artefact level and the value level reflect the basic assumptions of the culture.

Analytically it will therefore be natural to start from the top, because here it is possible to collect empirical data about the organizational culture. Thus the artefact level is accessible through observation and the value level through interviews and research in archives. However, it is not possible - by means of empirical research techniques - to collect data concerning the basic assumptions. This level can only be accessed through deduction from and interpretation of empirical data.

In a sense, the analysis may suggest a hermeneutic circle in which there is interaction between preconceived ideas and experience, between part and whole. The whole - the basic assumptions - is only accessible through the part - the visible manifestations of the culture. However, our encounter with the part is not unbiased. We observe the part in the light of our preconceived ideas. Torsten Thuern expresses it in the following way:

"It shows not only that experience and preconceived ideas presuppose each other in a continuous circular motion. The spiral may suggest that greater experience creates better preconceived ideas, which in turn means that subtler details may be perceived. Preconceived ideas are developed from prejudice to real understanding."

Having studied the vertical levels of the culture we shall now turn to its horizontal or functional dimensions. As it appears from Schein's definition of culture, a group or an organization must - in order to survive - solve two different but fundamental, universal problems, namely external adaptation and internal integration.

To survive the group must thus learn to survive in, and adapt to, the external environment. In this context, the primary contribution of the horizontal cultural dimension is to give the members of the group a common understanding of the environment of the group or the organization and teach the group to survive in these surroundings. The internal problems of integration concern the group's ability to function as a group and to integrate its internal processes to secure the maintenance of its ability to survive and adapt. In this context, the contribution of the horizontal cultural dimension is to give a solution to the organization of the relationship between the members of the group. Seen in this perspective, the culture is the "glue" that holds the organization together by creating a frame of reference and interpretation of the day-to-day phenomena common to the members of the group.

As it appears, Schein's perception of culture is a functionalist perception inasmuch as he sees culture by analogy with a biological mechanism whose role is to perform a number of vital functions in order to survive while being subordinate to a certain life cycle - birth, growth and death. Such a perception implies three aspects, a genetic aspect - how the culture has emerged - a functional aspect - how the culture survives - and a dynamic aspect - how the culture changes. Concerning the genetic aspect, Schein claims that culture mutatis mutandis is created by management. However, he acknowledges that the relation between management and culture is more intricate than presented in the corporate-culture theories. By operating with three stages in the creation of culture related to the development of the organization, Schein indicates that the relation between culture and management is connected with the dynamic aspect. We shall not elaborate on the aspect of change, but refer to Schein's thoughts in chapter 12, "Organizational Growth Stages and Culture Change Mechanisms."

The cultural functions, which Schein considers vital to the survival of the organization may be summarized in the following table.

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83. ibid., p. 14
85. ibid., p. 57.
86. Schein op. cit., pp. 270-295.
A somewhat simplified interpretation of the cultural model may indicate that the "raw material" of the culture is received through the horizontal dimension, and through processing of this "raw material" a process of learning is initiated, leading to the creation of the vertical levels of the culture.

Schein expresses the thought in the following way:

"Culture should be viewed as a property of an independently defined stable social unit. That is, if one can demonstrate that a given set of people have shared a significant number of important experiences in the process of solving external and internal problems, one can assume that such common experiences have led them, over time, to a shared view, and this shared view has to have worked for long enough to have come to be taken for granted and to have dropped out of awareness. Culture, in this sense, is a learned product of group experience and is, therefore, to be found only where there is a definable group with a significant history."88

As it appears from the quotation Schein makes certain demands on a group for a culture to crystallize.

1. The group must be a stable social unit.
2. The group must have existed long enough for the members to share the experience of serious problems.
3. The group must have had the possibility of finding solutions to these problems and a chance to see the effects of the proposed solutions.
4. The group must have had the opportunity of including new members and of passing on the acquired experiences to these new members.

After this short outline of the relations between the different levels and functions of the cultural model, the next step is operationalization of the model; but first a few remarks as to the application of the model in the context of this study.

To some extent occupational culture is an abstraction since such a culture does not exist in a vacuum but will always be embedded in a concrete organizational context. The occupational culture exists in a symbiotic relation with the organization. It will therefore also be influenced by the organization. In this there is nothing strange. The influence is likely to be the greatest at the artefact and value levels. Influence on the basic assumptions cannot be excluded either, but as indicated above, the occupational culture is characterized by a degree of inertia partly due to the close connection between occupation and identity within occupational communities. Consequently, the occupational culture has settled in a distinct cognitive structure resisting change.

The basic assumptions of the occupational culture are therefore to be viewed in the broader context of education and society. In this context the thesis is that the basic assumptions are a result of a professional socializing process taking place outside the concrete organization. One should therefore be careful not to draw too hasty conclusions on occupational cultures on the basis of observations in one single organization, but constantly keep an eye on other organizations with similar occupational cultures. In this context, Schein's model may therefore be applied for an analysis of the form of symbiosis between a concrete occupational culture and organization.

After these general remarks, we shall now focus on how the vertical levels and the horizontal functions of the model may be operationalized. We shall begin with the artefact level. As Schein has not performed any operationalization of this level but only indicated the principles in his concrete analyses, there is room for interpretation. Therefore, the following table is to be seen as such an interpretation and at the same time as a guide for observing the artefact level, leaving room for further specification.

In connection with the analysis of the artefact level the observation guide may be applied to the point, but as it is not a given fact that all artefacts are equally significant, the observer may make a discretionary choice in the light of his preconceived ideas. As the artefacts are indicators which all point in the direction of the cultural paradigm, too mechanical an analyzing procedure will be unduly elaborate in terms of method applied. This procedure seems to be in accordance with Schein's own instructions both for a consulting and a clinical practice as described in chapters eight and nine.

Another aspect that calls for attention is that cultural stereotypes are often formed around the artefact level. Thus electronic engineers are often stereotyped as "computer nerds" with clear reference to item 4 in the observation guide.
1. Physical expressions
   - architecture and design
   - the office
   - decorations in lobbies and conference rooms
   - dress code
   - presence

2. Language
   - sounds and noise
   - manner of speaking
   - special expressions
   - slogans

3. History
   - small stories from everyday life
   - accounts from critical events
   - stories about "the good old days"

4. Technology
   - material
   - operations
   - knowledge

5. Visible traditions
   - social traditions
   - management traditions
   - working traditions

We shall therefore suggest the following interpretation of value:

Values are an ideal or factual standard for measuring what serves the interests of the organization best, concerning external adaptation and internal integration in the short and in the long run.

Values are thus defined as the basis on which the members of the organization form their judgment of situations, conditions or acts as desirable or undesirable for the organization. Following a division proposed by Sørensen and Strandgaard Pedersen, these values may then be divided into internal and external values depending on the audience they are addressed to and the purpose they serve. External values may thus possibly have external legitimizing as well as image building purposes. The above reflections may be summarized in the following table offering a more complex picture of value than Schein's own model of culture.

<table>
<thead>
<tr>
<th>Expoused values</th>
<th>Internal use</th>
<th>External use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value-in-use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In an occupational cultural context, the relevance of such a fine-meshed net must be determined, but in all circumstances the table may serve as a useful guide for interviewing and recording.

We shall now turn to how the eleven functions concerning external adaptation and internal integration appearing from fig.6 can be operationalized in relation to the concept of occupational culture. This will require the inclusion of views and conclusions from the chapter on Van Maanen and Barley's theory on "occupational communities". The starting point is Schein's description of the external adaptation functions of culture.

From figure 9 it can be seen that the function "mission and strategy" in relation to the occupational community is divided into three independent functions. The first of these is developing consensus on who constitutes the environment, both inside and outside the organization. In terms of external adaptation and chances of survival, the occupational community has to reach consensus on who the

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89. The grouping is from Majken Schütz, op. cit., p. 32. A similar operationalization is made by Sørensen and Strandgaard Pedersen, op. cit., p. 32.

90. Martine Cardel Gersten defines a stereotype in the following way: "A stereotype can be characterized as an exaggerated but not necessarily erroneous assumption concerning a group of people. This assumption masks differences between individual members of the group. The greater the difference between cultures in a given area, the higher the probability that this area will be included in a stereotype image of the other culture. Like prejudices, stereotypes influence the treatment of information. They create expectations and people will automatically seek to confirm these expectations by paying more attention and attaching greater importance to the information which is congruent with these stereotypes. In this way stereotypes may create a self-fulfilling prophecy. (My translation). Cf. Martine Cardel Gersten: Pjerus fra Danmark, Handelshøjskoleforlag, København 1990, p. 44.

91. Sørensen & Strandgaard Pedersen op. cit. p. 27.

92. Ibid., p. 27.
**Figure 9. The external adaptation functions of the occupational culture**

<table>
<thead>
<tr>
<th>Schein's functional areas</th>
<th>Operationalization in relation to the occupational community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission and strategy</td>
<td>Internal and external environment</td>
</tr>
<tr>
<td>Obtaining a shared understanding of core mission, primary task, mandates and intent functions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The occupational community's understanding of the environment inside and outside the organization.</td>
</tr>
<tr>
<td></td>
<td>Strategies for achievement of professional autonomy</td>
</tr>
<tr>
<td></td>
<td>Free-market demand for qualifications held by the occupational community.</td>
</tr>
<tr>
<td></td>
<td>Occupational organization, trade union or professionalization strategy.</td>
</tr>
<tr>
<td></td>
<td>Power potential.</td>
</tr>
<tr>
<td>Goals</td>
<td>Job areas and functions</td>
</tr>
<tr>
<td>Developing consensus on goals derived from the core mission.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Core and periphery areas, primary and secondary tasks.</td>
</tr>
<tr>
<td>Means</td>
<td>Goals</td>
</tr>
<tr>
<td>Developing consensus on the means to be used to attain the goals, such as the organization structure, division of labor, reward system, and authority system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing measures and standards for performance of professional competence.</td>
</tr>
<tr>
<td></td>
<td>Making professional competence visible.</td>
</tr>
<tr>
<td>Measurement</td>
<td>Means</td>
</tr>
<tr>
<td>Developing consensus on the criteria to be used in measuring how well the group is doing in fulfilling its goals, such as the information and control system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The occupational community's &quot;exoteric&quot; knowledge and knowhow; job interfaces (ethnocentrism and stereotypes).</td>
</tr>
<tr>
<td></td>
<td>Measurement</td>
</tr>
<tr>
<td>Developing consensus on the criteria to be used in measuring how well the group is doing in fulfilling its goals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing consensus on the appropriate remedial or repair strategies to be used if goals are not being met.</td>
</tr>
</tbody>
</table>

"friends" are and who the "enemies" are. The next new function is 'strategies for achievement of occupational autonomy'. This function has been introduced in extension of its central status in Van Maanen and Barley's theory. Finally "job areas and functions" has been introduced as a function indicating the raison d'être of the occupational community, i.e. the justification for the sheer presence of this field in the organization. It is important to be aware that the functions are viewed through a native view, through the lenses of the occupational community.

93. Schein, op. cit., p. 52. The operationalization in the right side of the figure is mine.

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**Figure 10. The internal integration functions of the occupational culture**

<table>
<thead>
<tr>
<th>Schein's functional areas</th>
<th>Operationalization in relation to the occupational community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common language and conceptual categories</td>
<td>Ditto</td>
</tr>
<tr>
<td>If members cannot communicate with and understand each other, a group is impossible by definition.</td>
<td></td>
</tr>
<tr>
<td>Group boundaries and criteria for inclusion and exclusion</td>
<td>Ditto</td>
</tr>
<tr>
<td>One of the most important areas of culture is the shared consensus on who is in and who is out by what criteria one determines membership.</td>
<td></td>
</tr>
<tr>
<td>Power and status</td>
<td>Ditto</td>
</tr>
<tr>
<td>Every organization must work out its pecking order; its criteria and rules for how one gets, maintains, and loses power; consensus in this area is crucial to help members manage feelings of aggression.</td>
<td></td>
</tr>
<tr>
<td>Intimacy, friendship, and love</td>
<td>Ditto</td>
</tr>
<tr>
<td>Every organization must work out its rules of the game for peer relationship, for relationships between the sexes, and for the manner in which openness and intimacy are to be handled in the context of managing the organization's tasks.</td>
<td></td>
</tr>
<tr>
<td>Rewards and punishments</td>
<td>Ditto</td>
</tr>
<tr>
<td>Every group must know what its heroic and sinful behaviors are; what gets rewarded with property, status, and power; and what gets punished in the form of withdrawal of the rewards and, ultimately, communication.</td>
<td></td>
</tr>
<tr>
<td>Ideology and &quot;religious&quot;</td>
<td>Ditto</td>
</tr>
<tr>
<td>Every organization, like every society, faces unexplainable and inexplicable events, which must be given meaning so that members can respond to them and avoid the anxiety of dealing with the unexplainable and uncontrollable.</td>
<td></td>
</tr>
</tbody>
</table>
The table of figure 10 showing on the internal integration functions of the occupational culture shows that there is good correspondence between Van Maanen and Barley's categories and Schein's. However, the last function might be excluded. It has, however, been maintained as a function reserved for "the irrational" aspects.

The aggregate cultural model is now to be understood in such a way that, in principle, each of the 13 functions of the occupational culture contains the three vertical levels of culture - the artefact level, the value level and the level of basic assumptions - for which reason a complete functionalist cultural analysis will be very comprehensive. However, as the objective is reaching a cultural paradigm, and with all functions as potential roads to take in order to reach the basic assumptions, a discretionary selection of functions for analysis must be made in the light of our preconceived ideas.

Before taking our leave with Schein, there is reason to mention a few critical reservations to Schein's theory and methodological starting point.94

In its basic ambition Schein's cultural theory may have a certain superficial resemblance to Gullesen's theory; however, with the significant difference that basically, Schein's concept of culture is rooted in social psychology, whereas Gullesen's theory originates in social anthropology. Thus, in Gullesen's theory, the horizontal dimension indicates the elements in the social division of labor on a macro level whereby the concept of institutions come to play a central role. As Gullesen sees it, the cultural socialization takes place via institutions - family, school, education, job, etc. Therefore, the difference between the two cultural theories can be described by claiming that where - to Gullesen - the central elements in the understanding of culture are society and the social institutions, and the socialization taking place via these institutions, in Schein's theory the social psychological learning mechanisms are granted a privileged status.

That this involves a theoretical incongruence has been stated before. The difference is further accentuated when comparing the genetic aspect. Where Schein claims that culture is formed by management, Gullesen does not commit himself, as culture is to be understood as something innate, whose origin is lost in a mythical past, which nobody has any chance of saying anything precise about. Methodologically, there is reason to make certain reservations to Schein's clinic aproach. Schein himself describes the difference between this and the ethnographic approach in the following way:

"The clinical model involves one other fundamental assumption - one can understand a system best by trying to change it. In this regard the clinical and the ethnographic models differ sharply that the aim of the ethnographer is generally to leave the system as intact as possible. The ethnographic model thus implies that the culture can be deciphered if one spends sufficient time observing and interacting with it minimally. The clinical model assumes that culture will not reveal itself that easily and that one must actively intervene to determine where stable rituals, espoused values, and basic shared assumptions are located."95

It is possible that Schein is right but in the context of occupational culture it is important to insist on an "interest-free" ethnographic approach. The intention is not to manipulate the culture but to understand it.

Seen in an occupational cultural perspective, it is necessary to make five reservations to Schein's cultural model. The reservations concern:

1. The clinical approach
2. The analytical level
3. The functionalistic basis
4. The fundamental assumptions
5. The analytical reductionism

Having discussed the possibility of applying Schein's model to an analysis of occupational cultures and having found it suitable in several points, we nevertheless end up with five reservations to the model.

The fundamental requirements to a revised model, maintaining Schein's basic mechanism, i.e. the three levels of culture - artefacts, values and basic assumptions - must be for it to be able to account for these five reservations and in this connection, primarily to be able to connect between the macro level and the micro level of the occupational culture in question.

94. ibid., p. 66. Concerning common language and conceptual categories. An example of the non-existence of a common language in an organization could be the Hersey Institute of Business Administration and Technology. One of the school's central strategic values is interdisciplinarity. A closer analysis of what is understood by the concept, however, shows that interdisciplinarity means something fundamentally different seen from a practical and from a theoretical perspective. The engineering department, which traditionally has a practical approach, thus understands the concept in relation to people. In this sense, interdisciplinarity means cooperation between people across occupational and professional boundaries. The more theoretical understanding of the concept sees the concept in relation to subjects or disciplines. In this sense interdisciplinarity implies the application of theories, methods, models and perspectives from different disciplines within the same area, or more extensively, from different areas. Thus, in this sense, interdisciplinarity is a methodological concept, which no ipso is not related to cooperation at all. Such an understanding tends to be more prominent at the department of business administration, even if this department may also be influenced by elements of a more practical approach. The problem is that it has not been possible to determine, ex cathedra, whether one or the other is the right one. What can be observed here is, when not surfaced, a cognitive difference, which in this case is manifested as a difference in the immediate way of categorizing.

The reason for not presenting this model from the very outset is that the fundamental idea of the preceding chapters was to unfold the concept of occupational culture by approaching it from several angles and perspectives. The method chosen has been both to give a critical presentation of relevant theoretical approaches and by means of these approaches to analyze facets of the occupational culture. In the next passage we will attempt to place the engineering and marketing cultures in an action theoretical and cognitive macro perspective.

The two occupational cultures will be seen as exponents of different forms of rationality and will be placed in relation to a tentative abstract and general concept of rationality.

The method applied will be as follows:

First, we will introduce the concepts of rationality as used by Max Weber and Jürgen Habermas. Here the argumentation will be that the two occupational cultures seen in a sociological perspective can be considered as what in Habermas’ terminology is called “subsystems of purposive action.” This purposive action will then be differentiated into two types of action, viz. instrumental action and strategic action. These two types of action will serve the purpose of determining the different cognitive outline conditions of the two occupational cultures. After that the concept of rationality will be connected to central concepts from Habermas’ philosophy of science in a quasitranscendental perspective. Finally we will consider the reflectivity of the two occupational cultures. This will be illustrated by means of the duplicity of the concepts of engineering ethics and business ethics.

The opinion will be that the current interest in ethics among engineers and business people finds itself in an inconclusive situation between the two poles of a normative rationality and an instrumental rationality - between an understanding of ethics as an objective in itself and an understanding of ethics as a means to an end. In the following, we will not pay too much attention to this discussion, as it lies outside the scope of this study.

1.7 Forms of rationality and epistemological interests within technology and marketing. A quasitranscendental perspective

More than any other researcher of society, Max Weber (1864 - 1920) has succeeded in leaving his mark on the concept of rationality, not only in his own time around the turn of the century, but also in later social research within sociology, political science, history and philosophy. Many sociologists consider him as the grand old master of his discipline. Others consider him less respectfully as a conservative, indeed almost militaristic nationalist who, with his doctrines of power and authority, contributed to paving the way for Nazism. Everybody agreed that he was a controversial person. With his encyclopedic knowledge, Max Weber was intellectually the most all-embracing scholar among the leading figures of sociology.

Among recent Weber researchers there is, as pointed out by Troels Nætager, general agreement that the systematic center in Max Weber’s sociology is the rationalization problem and the resulting modernization process. Rationalization is perceived principally as a universal historical phenomenon. However, through...

97. The concept of quasitranscendental, which holds connections pointing towards the transcendental philosophical epistemology of Immanuel Kant and Habermas’ philosophy of science, is to be understood in the following way: The transcendental aspect indicates that experience and cognition seen in a macro perspective is assumed to be subordinated functional outline conditions which constitute the cognitive direction of the occupational culture. The project quasi-indicates that the concept is being used sensitive-ly and that the outline conditions are historically variable. The concept which is used here in relation to the sales and marketing culture may be illustrated with the following quotation from Weber: “The capitalist economic order of today is a very conscious one into which a person is born. It simply exists, so each person, as a factually unalterable casing in which he or she must live. To the extent that people are interwoven into the context of capitalistic market forces, the norms of its economic action are forced onto them. Every factory owner who operates in the long term against these norms will inevitably be dis-entangled from the economy. With the same degree of inevitability, every worker who cannot or will not adapt to the norms of the marketplace will become unemployed.” Max Weber: The Protestant Ethics and the Spirit of Capitalism. Sociological Publications, Chicago 2001, p. 18.

In the same way the engineer meets the technological world as an objective, given reality, whose technical imperatives he must submit to.

98. The way in which environmental issues are treated in engineering studies is an interesting example of this duality concerning ethical questions of engineering. Study programmes for this new area of “environmental management” is not primarily an institutionalized ethical reflection of the relationship between ethics. The study programme is conceived as a technical study area with a number of disciplines attached to the focus is environmental certification of private and public organizations and institutions. Environmental issues thus turn into questions concerning methods, procedures and regulations. The instrumental rationality imposed on the environmental ethical discussion that entails a closing of the discussion as a consequence of changes in the economic conditions for public and private organizations and not as a consequence of ethical self-reflections in the engineering profession.

99. The view of the German and Habermas in no way pretends to be an adequate treatment of the different theoretical approaches concerning either text based on this theory or other theoretical shifts of emphasis. Like the treatment of Edgar Schein this treatment is essentially eclectic. The cybernetic approach, i.e. an abstract formulation intended to determine under which conditions knowledge and experience are constituted in the two above-mentioned occupational cultures.

out his scientific work, Weber's primary focus is to shed light upon the specific nature of western rationality and the underlying causes. He is particularly concerned with determining the character of the rationality of modern society and the corresponding ethical conduct of life.

His very comprehensive concept of western 'rationality' comprises three important elements of meaning, viz.:

a) the ability to master the environments by means of calculation; this result of empirical knowledge can be termed technical-scientific rationality
b) the systematization of related meanings following the inherent urge of the 'cultural being' to see the world as a meaningful cosmos; this aspect constitutes the metaphysical-ethical rationality
c) the determination of a "methodical mode of living" on the basis of the institutionalization of related meanings and interests constitutes practical rationality. 101

Weber's overall theory of rationalization comprises two steps: cultural and social rationalization—plus a theory on the transition from one to the other. The first step is the demythologization that implies rationalization of the religious worldview and thus forms the basis of the universal, historical development of "modern" structures of consciousness. The second is the question of how these rationalization structures are applied in social institutions thus turning into a lever for a specific modernization process.

The rationalization theory concludes in a pessimistic diagnosis of contemporary society, whose point of departure is two theses: the modernization process is accompanied by both loss of meaning and loss of freedom. The causes for this are to be found partly in the breakdown of religious worldview, resulting in a crisis of meaning and an attitudinal vacuum with a subsequent loss of meaning, partly in the institutionalization of the purposive rational (zieckrational) type of action in subsystems within the fields of economics and (state) administration. The institutionalization is accompanied by increasing bureaucratization resulting in a loss of freedom.

After this brief outline of the contents of the rationalization problematic, we shall now move on to Weber's conceptualization of the rationalization problematic.

A good point of departure for this will be Weber's definition of sociology, which expresses his theoretical and methodological approach and which at the same time can be seen as a draft programme for an empirical sociology.

'Sociology (in the sense in which this highly ambiguous word is used here) is a science which attempts the interpretive understanding of social action in order thereby to arrive at a causal explanation of its course and effects. In 'action' is included all human behavior when and in so far as the acting individual attaches a subjective meaning to it. Action in this sense may be either overt or purely inward or subjective; it may consist of positive intervention in a situation, or of deliberately refraining from such intervention or passively acquiescing in the situation. Action is social in so far as, by virtue of the subjective meaning attached to it by the acting individual (or individuals), it takes account of the behavior of others and is thereby oriented in its course. 102

As it appears from the quotation, Weber's sociology is founded on two central principles. The first principle is that the point of departure of sociology is action and interaction and not supra-individual conceptions like organ, structure, function, system etc. The second principle is that the path of sociology towards causal explanations passes through an interpretive understanding of the action. Thus he is one of the first sociologists to introduce "meaning" as a theoretical foundation of action. The methodological foundation is a teleological and monological model of action in which an isolated and "lonely" subject pursues specific goals in relation to the environment.

With this point of departure Weber strives to establish a typology of forms of action through which the rationalization takes place. Individual forms of action must be seen as ideal types, by which Weber in the following concise formulation understands:

"The ideal type... is no "hypothesis" but it offers guidance to the construction of hypotheses. It is not a description of reality but it aims to give unambiguous means of expression to such a description... An ideal type is formed by the one-sided accentuation, of one or more points of view and by the synthesis of a great many diffuse, discrete more or less present and occasionally absent concrete individual phenomena, which are arranged according to those one-sidedly emphasized viewpoints into a unified analytical construct (Gedankenbild). In its conceptual purity, this mental construct cannot be found empirically anywhere in reality. It is a utopia. Historical research faces the task of determining in each individual case the extent to which this ideal-construct approximates to or diverges from reality. 103"

Overall, Weber distinguishes between theoretical and practical rationalization. By theoretical rationalization he understands "a growing theoretical control of reality by means of more and more precise, abstract concepts." Practical rationality is understood as "methodological achievement of given practical ends by means of

more and more precise calculation of adequate means. Our principal interest here is the practical rationality. In its entity Weber's theory of action can be summarized in the following table:

**Figure 11. Max Weber's typology of practical rationality**

<table>
<thead>
<tr>
<th>Practical rationality</th>
<th>Formal</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment of means</td>
<td>Choice of ends</td>
<td>Value orientation</td>
</tr>
<tr>
<td>Instrumental rationality</td>
<td>Rationality of choice</td>
<td>Normative rationality</td>
</tr>
<tr>
<td>Purposive rational actions ( Zweckrational)</td>
<td>Value rational actions (Wertrational)</td>
<td></td>
</tr>
</tbody>
</table>

As it appears from the table, Max Weber divides the concept of practical rationality into three aspects.

1. employment of means
2. ends
3. value orientation

Weber uses the term instrumental rationality about employment of means. The degree of instrumental rationality may be determined on the basis of the degree of efficiency of the planning of the means application in realizing pre-defined ends.

The second aspect - ends - is termed rationality of choice. The degree of purposive rationality of any given action can be determined ‘by the degree of correct end calculation seen in relation to precisely perceived values, available means and peripheral conditions.”

About the third aspect - value orientation - Weber uses the term normative rationality. The degree of normative rationality of a certain action is determined by 'the strength with which the underlying standards of value and principles constitute a unifying systematizing force and effect of the action.'

Practical rationality thus ideally preconditions an optimal connection of instrumental choice and normative rationality in any given action. This might indicate the establishment of a critical, reflexive, action theoretical standard not only capable of reflecting on the efficiency of ends - means relations, but also on the rationality of the ends and the propriety of the application of means. That this, however, is not the case appears from the following quotation:

'To judge the validity of such values is a matter of faith, and it may also be a task for the speculative contemplation and interpretation of the meaning of life and of

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106. The definitions seen from Lauge Bangsland Rasmussen: Ingeniøren - det legitime banc af gillokommet malmen vedræk og de myldre klister. Institut for Samfundsog Danmarks Tekniske Højskole. København 1987, p 23. The development of the idea of this chapter has been inspired by chapter 3 of the above book: Rationality. However, the intention here differs from the intention of Bangsland's. His intention is to find out if the engineer's self-perception can be defined in terms of an overall rationality concept. The idea in this chapter is to look behind this self-perception by looking into its constitutive conditions.

108. Lauge Bangsland Rasmussen op. cit. p 23.
the world as such. However, it is obviously not a matter for the empirical science as cultivated in this magazine." (My translation).

Weber's sociology is an understanding, hermeneutically oriented sociology - not a critical social theory. But the very possibility of substantiating the validity of such values, which Weber refers to as faith and contemplation, is decisive to even speak about normative rationality. Normative rationality is not just a question of the strength of norms but to a greater extent of their rationality, and thus of the possibility of substantiating these norms rationally. Only then do we reach normative rationality. That the validity of values - as Weber correctly states - is not a topic for empirical science does not exclude the substantiation of values in terms of meta ethics, i.e. philosophically and thus rationally. This, as we shall see later, is one of the aspects challenged by Habermas in his critique of Weber.

Placing the engineering culture in relation to Weber's typology intuitively does not pose particular problems. It will be placed under instrumental rationality. However, the question is if Weber himself has a concept of technique or technology, which can be applied. This is problematic, firstly because Weber's concept of technique is used synonymously with the concept of technology and secondly because it is very diffuse:

"In this sense there are techniques of every conceivable type of action, techniques of praying, of asceticism, of thought and research, of memorizing, of education, of exercising political or religious control, of administration, of making love, of making war, of musical performances, of sculpture and painting, of arriving at legal decisions. All these are capable of the widest variation in degree of rationality. The presence of a "technical question" always means that there is some doubt over the choice of the most efficient means to an end."  

Weber also uses the concept of technique in a narrower sense, even if it remains too diffuse:

"The rationality of employing means is measured by the objectively testable efficacy of an intervention (or of a purposeful omission). This permits us to distinguish between "subjectively purposive-rational" and "objectively correct" actions. We can also speak of a "progressive rationality of means" in an objective sense. If human behavior (of whatever kind) becomes in any respect "more correctly" oriented from a technical point of view, then we have a "technical advance". This concept of technique is also a broad one; it extends not only to instrumental rules for mastering nature, but also to rules for artistically mastering materials, or, for example to techniques for "dealing with human beings politically, socially, educationally, propagandistically."  

Here we encounter the same problem when placing the sales and marketing culture in relation to Weber's typology. There is no intuitive problem of placement. The sales and marketing culture will be placed under choice rationality. The question is if Weber's own concepts allow this placement.


The closest we get - and still far from a precise definition - is Weber's comments in chapter 13, where he says:

"Where complete market freedom is given, the highest degree of formal rationality in capital accounting is absolutely indifferent to all the substantive considerations involved. But it is precisely the existence of these substantive factors underlying monetary calculations that determine a fundamental limitation on its rationality. The rationality is of purely formal character. No matter what the standards of value by which they are measured, the requirements of formal and of substantive rationality are always in principle in conflict, no matter how numerous the individual cases in which they may coincide empirically. It is true that they may be made to coincide theoretically in all cases, but only under assumptions that are wholly unrealistic. The formal rationality of money accounting has as such no implications for the actual distribution of goods."  

As it appears from the quotation, Weber claims that there will always be a conflict in principle between the formal and the material rationalities, and that the former - the highest degree of formal rationality - is limited by the latter. To be more concrete, this means that the purposive rational (zwecreation) market economic action in principle always conflicts with the normative and actual distribution of goods. Only under the condition of total free market economy do we have "the highest degree of formal rationality".

Theoretically, this has two essential implications. Firstly, social actions within Weber's framework of action theory can only be assessed under the aspect of purposive rationality. Secondly, if social rationalization processes are to be studied in their totality it must be on a different action theoretical foundation.

The conclusion of the above considerations concerning forms of action within the engineering culture and the sales and marketing culture is therefore that, even if

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112 Max Weber: The Theory of... op.cit. p. 212.
the two occupational cultures with an intuitive approach can be placed in relation to Weber's typology of action, Weber's own concepts do not allow the desired differentiation. The reason for this is that both occupational cultures can be perceived as expressions of a formal rationality, i.e. as subsystems of purposive actions. This, as we have seen, is due to the vagueness of Weber's concept of technique/technology and to the inapplicability of his concept of economy on sales and marketing for good historical reasons.

We shall now turn to those parts of Jürgen Habermas' theory of rationalization that are relevant in this context. The principal point of departure will be his monumental 1200-page-long work entitled "Theorie des kommunikativen Handelns", whose part one is subtitled "Handlungsrationalität und gesellschaftliche Rationalisierung".

Jürgen Habermas, today a professor of philosophy and sociology at the university of Frankfurt, was born in 1929 and grew up in wartime and post-war Germany. Together with the inheritance from the so-called "Frankfurt School", his personal experiences from that period have made him one of today's most prominent advocates of a radical democratic construction within philosophy, social theory and cultural debate.

Habermas has a long, wide-ranging production behind him. With his wide reading and almost encyclopedic knowledge about the philosophical as well as the sociological tradition he has carried on this tradition and at the same time taken a critical stance to it. In social sciences, his theoretical position is described as "Critical Theory" and in recent years he has succeeded in placing himself as one of the most important figures in international philosophy and social theory.

The theory on the communicative action takes the form of a historical reconstruction of theories, in which Habermas step by step, through a survey of theoretically fruitful approaches, theoretical inconsistencies and deficiencies, reconstructs action theoretical positions in the classics of sociology such as Max Weber, George Herbert Mead, Emile Durkheim and Talcott Parsons, with the aim of including them as factors in a wider theory of rationalization.

As indicated by the title of the work, the basic concept of this rationalization theory, which like Weber's theory has a universal historical aim, is the concept of the communicative action. Habermas develops his rationalization theory in relation to three recurrent complexes of themes, viz.:

1. A concept of the communicative rationality,
2. A dual concept of society connecting the paradigms of system and life world,
3. A theory of modernity which explains the ever more visibly prominent types of social pathologies by the assumption that the communicatively structured areas of life are subjected to the imperatives from independent, formally organized action systems." 113

Habermas says about his project that, as its point of departure, it has the thesis "that the rationality problematic is not brought to sociology from the outside. Every sociology that claims to be a theory of society encounters the problem of employing a concept of rationality - which always has a normative content - in three levels: it can avoid neither the metatheoretical question concerning the rationality implications of its guiding concepts of action, nor the methodological question concerning the rationality implications of gaining access to the object domain through an understanding of meaning, nor finally can it avoid the empirical-theoretical question concerning the sense, if any, in which the modernization of societies can be described as rationalization." 114

In this context, we shall primarily look at Habermas' transgression of Max Weber's action theory. As mentioned before, Weber's methodological point of departure is a teleological and monologically conceived model of action. 115 Habermas criticizes Weber that, in spite of being one of the first sociologists to introduce "meaning" as a fundamental concept of action theory, he is not able to reach the concept of "social action" or "interaction". The reason for this is precisely Weber's methodological point of departure which has the consequence that "mutual understanding" and interaction only become derived phenomena.

Habermas points out 116 that the above theoretical inconsistency with Weber is connected to another and more important problem of, firstly, the question of which aspects of action are eligible for rationalization, and secondly which model of action should be applied as a foundation of the evaluation.

According to Habermas, there are two versions of the action theory - an official and an unofficial version. About the first version, which is to be found in "The Theory of Social and Economic Organization" in the article "The Types of Social Action", pp. 115-118, it can be said that with the goal direction as the starting point Weber distinguishes between three different goals of action - utilitarian, value-oriented and affectual - corresponding to 1) a purposive, 2) a value rational and 3) an affectual type of action. Furthermore, Weber operates with a type of action that he calls traditional action. This type of action serves, however, important it may be in terms of adding to the historical understanding - as a rather vague and imprecise miscellaneous category. 117

The characteristic of this almost hierarchical classification is that the degree of rationalization diminishes, the closer we get to the traditional action. Most rational and rationalizational is - in accordance with Weber's methodological pre-judgment - the purposive action.
We shall now turn to the unofficial version that is to be found in the same work by Weber, but which is more interesting because it is the direct inspiration for Habermas' own typology of action.

**Figure 12. An alternative typology of action**

<table>
<thead>
<tr>
<th>Coordination</th>
<th>Degree of Rationality of Action</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through interest positions</td>
<td>De facto customary action (&quot;Sitlu&quot;)</td>
<td>Strategic action (&quot;Interessenhandeln&quot;)</td>
<td></td>
</tr>
<tr>
<td>Through normative agreement</td>
<td>Conventional action based on agreement (&quot;Gemeinschaftshandeln&quot;)</td>
<td>Post-conventional action based on agreement (&quot;Gesellschaftshandeln&quot;)</td>
<td></td>
</tr>
</tbody>
</table>

The central aspect in this model is the concept of "social action", being action-coordinating mechanism either determined by interests or by normative understanding. This opens up for other rationalization aspects than goal direction, which is important for Habermas' own project.

However, Weber is not consistent in carrying through this distinction between social relations, imparted via interests, and social relations, imparted via normative understanding. Consequently, according to Habermas, Weber has not been able to make the unofficial typology of action fruitful for the problem of social rationalization. The official version has been conceived so narrowly that social actions in this typology can only be evaluated from the purposive aspect.

Habermas' reconstruction of Weber's action theory is therefore first of all a reconstruction of the unofficial version and ends up in the following action typology.

**Figure 13. Jürgen Habermas' typology of action**

<table>
<thead>
<tr>
<th>Action orientation</th>
<th>Result oriented</th>
<th>Orientated towards reciprocal understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-social</td>
<td>Instrumental action</td>
<td>—</td>
</tr>
<tr>
<td>Social</td>
<td>Strategic action</td>
<td>Communicative action</td>
</tr>
</tbody>
</table>

As it appears from the table, in accordance with the unofficial version of Weber's action theory, Habermas distinguishes between result-oriented action and action oriented towards reciprocal understanding. After that he divides Weber's purposive-rational action into instrumental and strategic action.

What is common to the two types of action is that they choose ends and means on the basis of egocentric result calculations. The difference between them is that strategic action always takes place in a social context whereas the instrumental action does not necessarily do so. In this context it is important to be aware that the instrumental action per se does not rule out social interaction as contributor to the achievement of the end. The social interaction just is not the ultimate goal of the action. Habermas expresses it as follows:

"We call an action oriented to success instrumental when we consider it under the aspect of following technical rules of action and assess the efficiency of an intervention into a complex of circumstances and events. We call an action oriented to success strategic when we consider it under the aspect of following rules of rational choice and assess the efficacy of influencing the decisions of a rational opponent. Instrumental actions can be connected with and subordinated to social interactions of a different type -- for example, as the "task elements" of social roles, strategic actions are social actions by themselves."

When action is oriented towards reciprocal understanding -- in the unofficial Weber version, post conventional action based on agreement (social action) -- Habermas speaks of communicative action. In the communicative action we find the normative implications of Habermas' own concept of action and rationality -- his radical democratic project. The decisive criterion for communicative action is that all participants without reservation strive to achieve consensus through unrestricted argumentation and that they allow this consensus to be the action-coordinating foundation.

About the communicative action Habermas says,

"By contrast, I shall speak of communicative action whenever the actions of the agents involved are coordinated not through egocentric calculations of success but through acts of reaching understanding. In communicative action participants are not primarily oriented to their own individual success; they pursue their individual goals under the condition that they can harmonize their plans of action on the basis of common situation definitions. In this respect the negotiation of definitions of the situation is an essential element of the interpretative accomplishment required for communicative action."

120. ibid. p. 285.
121. ibid. p. 285.
This is not the place to elaborate on the very comprehensive substantiation of Habermas’ theory on the communicative action that is founded on the philosophy of language. Such substantiation would lead us far beyond the intention of this section. Instead we shall focus on the strategic action, which Habermas divides into three subtypes.

**Figure 14. The strategic type of action**

<table>
<thead>
<tr>
<th>Social actions</th>
<th>Strategic actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicative actions</td>
<td>Concealed strategic action</td>
</tr>
<tr>
<td>Strategic actions</td>
<td>Open strategic action</td>
</tr>
<tr>
<td>Unconscious deception (Systematically distorted communication)</td>
<td>Conscious deception (Manipulation)</td>
</tr>
</tbody>
</table>

By hidden strategic action Habermas understands a situation in which at least one of the participants hides at least some of his motives for the action. In that case it may be either a question of conscious misrepresentation or deception (manipulation) or unconscious misrepresentation or deception as a result of mental repression.

As a tentative conclusion to this section, we are now able to make the desired differentiation concerning forms of rationality in the engineering culture and the sales and marketing culture respectively. Firstly it is important to bear in mind that Habermas’ concept of instrumental rationality also does not preclude social interaction as instrumental in the achievement of the end. Social interaction only is not the ultimate purpose of the action. The action is primarily result-oriented.

This forms the basis of seeing the engineering culture as a subsystem of instrumental actions and thus as an expression of an instrumental rationality. This is quite in accordance with the interpretation of technology and natural science presented by Habermas in "Theorie des kommunikativen Handelns" and previously expressed in his works from 1968 "Technik und Wissenschaft als ‘Ideologie’ and ‘Erkenntnis und Interesse’.

Likewise, it should be possible to argue plausibly that the sales and marketing culture can be seen as a subsystem of strategic actions and thus as an expression of a strategic rationality. What primarily characterizes the sales and marketing culture is that the action situation is social and that the action is controlled by egocentric result calculations no matter whether the ego is to be seen as a person, a department, a company or an organization. Habermas himself has argued in favor of perceiving the economic system as a subsystem of purposive-rational actions. However, he has not said anything specific about sales and marketing.

It is important to show what is implied by the differentiation between the forms of rationality and what is not implied. The differentiation does not imply that other types of action than those impuited to the engineering and the sales and marketing cultures respectively cannot be found. Neither does it say – even if the intention is to establish the cognitive framework of the occupational culture – anything about intelligence. What it does imply, however, is that norms of thinking and behavior, so clearly different within the two fields, express a difference best conceptualized as a difference between the ideal types of instrumental and strategic rationality.

Having determined the framework of the two occupational cultures with these ideal types, we shall now connect the ideal types to the concept of epistemological interest in a quasi-transcendental perspective. The first question to pose might be if the knowledge required to become a competent salesman, a competent AD, a competent manager, a competent researcher within marketing research or a competent engineer, be it a theorist or a practitioner, has common denominators. This may seem to be a meaningless question. Science and practical business seem to be essentially different, the former being related to cognition and the latter being related to actions.

Even so, one of the points in Habermas’ philosophy of science is that the meaningfulness in such a question is only seemingly so. In his critique of the objectified self-perception of Positivism, i.e. the interpretation of science as being free of values, Habermas claims:

"In reality, however, knowledge about the apparently objective world of facts is founded transcendentally in the pre-scientific world. The possible objects of the scientific analysis in advance constitute themselves in those conditions of our primary world which can be understood intuitively." 102 (My translation).

What Habermas says here is that everyday practice must be granted epistemological status. In continuation of this Habermas distinguishes between the two forms of practice: work and interaction. These forms of practice, manifested through the previously mentioned three types of action – instrumental, strategic.

102. Ibid. p. 355.

123. Jørgen Habermas: Vitskap som ideologi. The quotation is from the article: Erkendelse og interesse, p. 106.
and communicative action – are connected to different transcendently given interests. Work is an expression of man's wresting with nature. Consequently, human cognition has been influenced by an interest in emancipating from the force of nature by controlling nature.

Unlike work, interaction is not influenced by a technical interest, but rather by what he calls a practical interest, i.e. a practical interest in acting rationally and in reciprocal understanding in social life. These transcendently given interests are both the motive for scientific research and the condition of its objectivity. Habermas expresses it as follows:

"The approach consisting of technical control, of practical understanding and of liberation from the forces of nature determines the specific points of view necessary to be able to see reality. As we discover the impassability of those transcendental limits to a possible conception of the world, a piece of nature through us wins autonomy in nature." (My translation)

Habermas now connects these transcendental interests to different fields of knowledge. He distinguishes between 1) the empirical-analytical sciences, 2) the historical-hermeneutic sciences, 3) the systematic action sciences, and finally 4) a critical social science. The classification corresponds to the classification of sciences into natural science, humanities and social science. What is interesting in this context is that technical-natural scientific research belongs under 1) and the market-economic research belongs under 3). We shall therefore now look into which epistemological interests influence these.

About the empirical-analytical sciences Habermas says that potential theories could be based on hypothetical-deductive connections between statements that allow deduction of empirical regularity hypotheses or laws of nature. These enable propositions under given initial conditions. Such knowledge Habermas calls nomologic (from Greek nomos = law). The application of empirical-scientific theories on reality takes place through the informative securing and expansion of result-controlled behavior. The epistemological interest in these sciences is therefore an interest in technical command over objectified processes. 125

Also the systematic action sciences – economics, sociology, and political science - aim at the production of nomologic knowledge and they, too, are governed by an interest in technical command. The knowledge produced by these sciences is command knowledge. 126

After this verbal firework display, we can now synthesize the above account into the following table, which will serve as a basis of inspiration for the final theoretical model of occupational cultures.

Fig. 15. The relationship between the concepts of work and interaction 127

<table>
<thead>
<tr>
<th>Action-oriented rules</th>
<th>Institutional framework</th>
<th>Reciprocal expectations about behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social norms</td>
<td>Symbolic interaction</td>
<td>Role internalization</td>
</tr>
<tr>
<td>Technical rules</td>
<td>Systems of purposeful-rational action</td>
<td></td>
</tr>
<tr>
<td>Level of definition</td>
<td>Intersubjectively shared ordinary language</td>
<td></td>
</tr>
<tr>
<td>Content-free language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of definition</td>
<td>Reciprocal expectations about behavior</td>
<td></td>
</tr>
<tr>
<td>Conditional predictions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanisms of acquisition</td>
<td>Role internalization</td>
<td></td>
</tr>
<tr>
<td>Learning of skills and qualifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function of action type</td>
<td>Maintenance of institutions (conformity to norms on the basis of reciprocal enforcement)</td>
<td></td>
</tr>
<tr>
<td>Problem-solving (goal attainment, defined in means-ends relations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanctions against violation of rules</td>
<td>Punishment on the basis of conventional sanctions: failure against authority</td>
<td></td>
</tr>
<tr>
<td>Inefficacy: failure in reality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Rationalization&quot;</td>
<td>Emanation, individuation, extension of communication free of domination</td>
<td></td>
</tr>
<tr>
<td>Growth of productive forces, extension of power of technical control</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

124 Ibid. p. 32
126 As far as marketing research and consumer behavior research is concerned, it may seem that Habermas' model is too simplified in claiming that the knowledge produced within the systematic action sciences is purely nomologic. Studies of consumer behavior are characterized by the employment of different paradigmatic foundations – behaviorism, cognitive psychology and hermeneutics. Only behaviorism and cognitive psychology, being positivist, aim to produce nomologic knowledge, i.e. knowledge which is oriented towards control of consumer behavior. The postpositivism and hermeneutically oriented consumer behavior research aims "to create interpretations which may change preconditions and thus create new realities and potentials for action." However, the question is whether this research is really "unbiased" ethnographic research in "consumer folklore" which stops at the recognition and acknowledgement of differences or whether transcendental interests are at stake as well. It is a question what such research is to be used for. The application of qualitative methods at the methodological level of the consumer behavior research is not an iso or an argument against Habermas' point of view that interests are involved at a transcendental level. More on this discussion on the basic paradigm of consumer behavior research in the article: Forbrugsbrøder i videnskabelig smerte. In: Claus Buhl, H. H. Andersen (Eds.): Viden og forbrug. Bind 2. Samfundstidsskrift. Gyldendal 1990. pp. 113-145.
127 The table is drawn from the article: Tolkning og viden om "ideologi". P. 18. In: Jürgen Habermas: "Viden om ideologi" (Technology and science as "Ideology") in: Jürgen Habermas, Toward a Rational Society, p. 93.
The above table is a summary of Habermas' Weber reconstruction as it appeared in 1968. In connection with the table we shall discuss the last problem raised towards the end of the last subsection: the question of reflectivity in the two occupational cultures. The reflective capacity of a given occupational culture will—metaphorically speaking—be determined partly by its competency, as a player in playing the game, partly by its ability, on the basis of a normative rationality, to reflect beyond the game, i.e. reflect on the rules and the boundaries of the game, on the relationship between fellow players and adversaries, on what the game is about and on the fundamental rationale and function of the game.

That such self-reflection is possible can be seen from a book by two engineers, "Frankenstein's dilemma — En bog om teknologi, miljø og værdier" ("Frankenstein's dilemma — A book about technology, environment and values" (my translation)). It is a fact that there is an infinitude of examples within both occupational cultures discussed here, which we do not need to go further into. However, the question is the extent to which such critical self-reflection is institutionalized.

It is true to say that Executive Order No 681 of 15 May 1996 from the Danish Ministry of Education states that the objective of Danish study programmes for civil engineers, as well as for diploma engineers, is to provide a complete and well-balanced program which qualifies Danish engineers to undertake occupational functions in which they:

1. are able to put technical research results, natural-scientific and technical knowledge into practical use in development projects and in solving technical problems.
2. are able critically to acquire new knowledge within relevant engineering areas and independently to solve engineering tasks.
3. are able to plan, realize and control technical plans, and in so doing, are able to include societal, economic, environmental and working environmental consequences in the solution of technical problems.
4. are able to fulfill a role in management and cooperation relations with people with different educational and cultural backgrounds.

The reflective elements are boldfaced. The critical question is how and to what extent they are reflected in the curricula taught. At first glance there is reason to be skeptical. In this connection it is natural, and worthwhile, to consider Jürgen Habermas' double concept of rationality. Referring to this double concept of rationality we will leave the final word to Håkon With Andersen and Knut Holm Sørensen, both engineers:

"How can we measure human lives against comfort, efficiency and costs as it is practiced when it comes to road construction? It is obvious that these measurements can only be based on cultural values, and not on expert knowledge—whether it belongs to the child psychologist or the transport economist. The technocrat will postulate the existence of a "common best" identifiable by the experts."

Here he seems to be in line with a number of politicians. In his point of departure he who claims to work for "the common best", uses a rhetorical concept with a broad appeal. In politics an agreed compromise achieves the status of a "common best" (we rarely get to know if any other solution would have been better). Among experts a "common best" becomes the point of departure for a technical dispute. Which expert decides which is the best solution for a crossroad? Is it the road engineer who stresses effect on traffic flow? Is it the economist who stresses minimizing risk of accidents? Is it the architect who stresses the ethics of the road construction in harmony with the surrounding environment? We must accept that a rational expert rule builds on at least two fallacious assumptions: the belief that society is rational and predictable and the belief that expert knowledge can be summarized as the different loads on a bridge. Expert rule or parliamentary democracy, we need politics to make balanced decisions on matters which in fact do not lend themselves to balanced decisions."

In the next subsection, the above theories will be integrated and synthesized in a theoretical model of occupational culture (figure 16). After that the model will be operationalized on the engineering culture (figures 17 and 18) and on the sales and marketing culture (figures 19 and 20). Figure 21 shows a model of the problem issues discussed in the last part of the book, covering the connection between national culture, national organizational culture and occupational culture.

1.8 The theoretical model of analysis – Edgar Schein turned upside down

**Figure 16. Interrelation between macro and micro levels of occupational culture**

<table>
<thead>
<tr>
<th>Macro level</th>
<th>Micro level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macro level</strong></td>
<td><strong>Occupational culture at institutional level</strong></td>
</tr>
<tr>
<td><strong>Micro level</strong></td>
<td><strong>Occupational culture at org./dept./individual level</strong></td>
</tr>
</tbody>
</table>

**Artifacts (Visible)**
- Physical and institutional manifestations of occupational culture

**Values**
- Underlying institutional values
- Obligatory knowledge (cf. Collin)
- Norms, values and perspectives

**Basic assumptions** (The quasi-transcendental cognitive frame)
- Cognitive framework
- Type of knowledge
- Relationship to environment
- Transcendental interest
- Action orientation
- Function of action type
- Sources against violation of rules
- *Rationalization* Institutionalized reflectivity
  - Cf. Weber and Habermas

**Artifacts (Visible)**
- In connection with job

**Values (Conscious)**
- Work values
- Demarcation
- Social identity
- Reference group
- Social relations
- Norms, values and perspectives
- Career patterns
  - (cf. van Maanen and Barley)

**Basic assumptions (Unconscious)**
- The occupational-cultural paradigm in its organizational context
  - It is assumed that the occupational culture enters into a symbiotic relationship with the organization and thus functions as enhancing, orthogonal or as a counter culture
  - Cf. Martin and Seidt

**Hypothesis**
- Causal relation. The cognitive framework serves as principle of interpretation when changing levels

---

**Figure 17. Interrelation between the macro and micro levels of the engineering culture with indication of methodological applicability of different levels**

<table>
<thead>
<tr>
<th>Macro level</th>
<th>Micro level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macro level</strong></td>
<td><strong>Occupational culture at institutional level</strong></td>
</tr>
<tr>
<td><strong>Micro level</strong></td>
<td><strong>Occupational culture at org./dept./individual level</strong></td>
</tr>
</tbody>
</table>

**Artifacts (Visible)**
- Arrangement of work place
- Physical placement of work place
- Technical equipment
- Type of work
- Form of work
- Form of meeting
- Codes of conduct
- Dress codes
- Language codes/discourse
- Status symbols
- *Work relations to sales and marketing
- *Sales and marketing stereotypes

**Values (Conscious)**
- Work values
- Internal occupational classifications
- Social/occupational identity
- Local/corporate orientation
- Status/metas criteria
- Career patterns
- Reflectivity on technology – human beings – nature – society

**Artifacts (Visible)**
- Technologies
- Technological systems
- Infrastructure
- Private and public enterprises
- Educational and research institutions (engineering)
- Engineering / Professional associations
- *Communication / Discourse

**Values**
- Technological paradigms
- *Technological systems as outline life form
- *Role of engineering and research in society
- *Educational objectives
- *Attitude to human beings
- *Attitude to nature
- *Attitude to society
- *Professional ideology
- *Engineering ethics
- *Engineering roles
- *Influence potential

**Basic assumptions (Unconscious)**
- The occupational paradigm in its organizational context
  - It is assumed that the occupational culture enters into a symbiotic relationship with the organization and thus functions as either an enhancing or an orthogonal culture

**Hypothesis**
- Causal relation. The cognitive framework serves as principle of interpretation when changing levels

The dimensions marked by * will be discussed in the following sections of this book.
Figure 18. Ideal type concerning "Basic assumptions" of the engineering culture or quasitranscendental cognitive framework at macro level

<table>
<thead>
<tr>
<th>Basic assumptions (The quasitranscendental cognitive framework)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive direction</td>
</tr>
<tr>
<td>Instrument rationality</td>
</tr>
<tr>
<td>Type of knowledge</td>
</tr>
<tr>
<td>Neomological, technically applicable knowledge, technical rules</td>
</tr>
<tr>
<td>Relation to environment</td>
</tr>
<tr>
<td>Objectifying / The non-social and social environment is viewed as object</td>
</tr>
<tr>
<td>Transcendental interest</td>
</tr>
<tr>
<td>Technical control</td>
</tr>
<tr>
<td>Action orientation</td>
</tr>
<tr>
<td>Result-oriented (product development, rationalization, economic growth)/ System rationality</td>
</tr>
<tr>
<td>Action situation</td>
</tr>
<tr>
<td>Non-social (nature)/social (society)</td>
</tr>
<tr>
<td>Function of action type</td>
</tr>
<tr>
<td>Problem-solving (goal attainment, defined in means - ends relations)</td>
</tr>
<tr>
<td>Sanctions against violation of rules</td>
</tr>
<tr>
<td>Inefficacy (failure in reality)</td>
</tr>
<tr>
<td>&quot;Rationalization&quot;</td>
</tr>
<tr>
<td>Growth of productive capacity, extension of power of technical control, rationalization</td>
</tr>
<tr>
<td>Institutionalized reflectivity on technology – nature – society</td>
</tr>
</tbody>
</table>

Figure 19. Interrelation between the macro and micro levels of the sales and marketing culture with indication of methodological applicability of different levels

<table>
<thead>
<tr>
<th>Macro level</th>
<th>Micro level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational culture at institutional level</td>
<td>Occupational culture at day-to-day/ individual level</td>
</tr>
</tbody>
</table>

- **Observation**
  - Literature studies

- **Artifacts (Visible)**
  - Markets
  - Economy – Local/Global
  - Market forms (competition)
  - Market type (B2C, B2B)
  - Market product
  - Market place (space)
  - Practices
  - Private and public enterprises
  - Professional marketing agencies
  - Educational and research institutions
  - Professional associations
  - Communication / Discourse

- **Observation of participants on the basis of the hypothesis**

- **Values**
  - Marketing paradigm
  - Market as ideology
  - Market as ideal (the perfect market)
  - Role of educational and research institutions in society
  - Occupational objectives
  - Self-perception of private and public enterprises
  - Attitude to human beings (the marketing vision of man)
  - Attitude to society
  - Market/Business ethics
  - Marketing rules
  - Influence potential

- **Observation of participants on the basis of the hypothesis**

- **Interviews on the basis of the hypothesis**

- **Deduction from the macro level**

- **Revision of hypothesis if necessary**

<table>
<thead>
<tr>
<th>Basic assumptions (Unconscious)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The occupational paradigm in its organizational context</td>
</tr>
</tbody>
</table>

- It is assumed that the occupational culture functions as an enhancing culture

- **Hypothesis**
  - Causal relation
  - The quasitranscendental cognitive framework serves as principle of interpretations when changing levels

The dimensions marked by * will be discussed in the following sections of this book.
Figure 20. Ideal type concerning "Basic assumptions" of the sales and marketing culture or quasi-transcendental cognitive framework at macro level

<table>
<thead>
<tr>
<th>Basic assumptions</th>
<th>(The quasi-transcendental cognitive framework)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive direction</td>
<td>Strategic rationality</td>
</tr>
<tr>
<td>Type of knowledge</td>
<td>Nomological, and strategically applicable knowledge, strategies</td>
</tr>
<tr>
<td>Relation to environment</td>
<td>Objectifying / The social environment is viewed as object</td>
</tr>
<tr>
<td>Transcendental interest</td>
<td>Successful self-assertion (enterprise/organization/individual)</td>
</tr>
<tr>
<td>Action orientation</td>
<td>Result-oriented influence on adversary</td>
</tr>
<tr>
<td>Action situation</td>
<td>Social</td>
</tr>
<tr>
<td>Function of action type</td>
<td>Creation of, and commercial and strategic exploitation of, need</td>
</tr>
<tr>
<td>Sanctions against violation of rules</td>
<td>Inefficacy (margination, decline or non-survival)</td>
</tr>
<tr>
<td>&quot;Rationalization&quot;</td>
<td>Survival, progress, economic growth</td>
</tr>
<tr>
<td>Institutionalized reflectivity on the rules of the game - aims - action - customization - consumerism</td>
<td>Low</td>
</tr>
</tbody>
</table>

Figure 21. Interrelation between national culture, national organizational culture and occupational culture

Macro level Value dimensions/Workplace (Joost Hofmann)
- Power distance
- Individualism vs. collectivism
- Masculinity vs. femininity
- Uncertainty avoidance

Macro level
National culture
National values manifested in organizations

Micro level
Épith de corps

Micro level
Organization
Manifestation of the occupational culture in the organization or departmental or functional level

Manifestation of national organizational culture in organization

125 The connection between the macro level and the organization is elaborated further in the article by Jean-Louis Polon: Culture and the work place. See p. 334.
1.9 References


