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Multi-sited ethnographies and studies of engineering practice

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Abstract

The reproduction, development and transformation of engineering work and culture have been the focus of a number of theoretical and empirical studies over the last 60 years or so (Barley 2005). In the 1950'ties and 1960'ties the predominant perspective was that of the engineering profession studied by sociological methods including studies of engineers serving authoritarian regimes. In the 1970'ies the perspective shifted to Marxist inspired discussions of the engineering profession in relation to class structure in parallel to studies of engineering education and skills from a perspective coming from Industrial Sociology. Over the last 30 years the studies have – to a large extend – used ethnographic and grounded methods in order to investigate the specifics of engineering practices in situated perspectives. Thus the overall trend has been from a macro to a micro perspective.

We argue that this trend has – in many respects – led to a richer and empirically sensitive perspective on engineering work and culture. Thus, detailed studies of engineering work practices or engineering education provide new material for a richer understanding of engineering culture. On the other hand, however, the specific and strictly situated focus of these studies threatens to limit discussions of engineering practices to departmental and discrete institutional settings. We propose a research agenda that – inspired by George Marcus' multi-sited ethnographic methodology (Marcus 1998) – sees (and contrasts) engineering practices in diverse settings (e.g. engineering education and engineering work) in order to uncover the material-discursive transformations in these practices.

In our oral presentation we will outline the research perspective we intend to use in our study of engineering practices in the research program PROCEED. Our study will rely on the fundamental presumption that engineering practices are produced and reproduced in two – different, but mutually constitutive – institutional contexts: one located in institutional settings that are concerned with the reproduction of engineering knowledge and skills, i.e. engineering education and research, and the second based in engineering work, institutionally situated in organizations and companies.

Thus our study will address these two institutional contexts by investigating their fields of material-discursive practices. Engineering work and education are not viewed as distinct spheres performing independent versions of engineering theory and practice but as one of interplay and mutual constituency.

Introduction

Technology is an integral part of the modern world – both in regard to solutions and problems. Engineering – understood as the profession that deals with bringing about and implementing technological change – has thus become an endeavor of the utmost significance to modern society. Correctly or not, technological solutions are seen as the answer to most of the problems we face today and ingenious engineers are struggling to solve the problems. But what are the problems and how does the engineering 'mind set' frame these problems? Is engineering education – as practiced within engineering schools and universities – capable of providing the right kind of knowledge and the relevant skills for engineers to deal effectively with the problems? Thus, does engineering education face the challenges of our times? These questions are fundamental to the research project PROCEED (Program of Research on Opportunities and Challenges in Engineering Education in Denmark). In engaging with the project it is therefore worth dwelling on the specific character of the challenges, how they are perceived, and from which perspectives.

In our research project we take three fundamental challenges facing engineering as the starting point for our research. We can identify these challenges within the general discourse and specifically within the engineering community:

1. one challenge is related to the widely recognized need for *societal responses* to resource depletion and environmental deterioration, that has been brought to light in the debate over global warming and climate change,
2. another is related to the increasing complexity of technology and its permeation of all aspects of contemporary life, society and global collaboration, giving rise to a need for design skills for socio-technical integration and a sense of *social responsibility on the part of engineers*, and
3. a third challenge is coming from advances in technology and science themselves, in such fields as information technology, biotechnology, media technology and nanotechnology, in which *the traditional boundary between scientific and technical knowledge is increasingly blurred*, creating new needs for engineers both in terms of design capabilities and modeling, or simulation skills.

The responses to these challenges have been contradictory. On the one hand, engineers are expected to add commercial and entrepreneurial skills to their scientific and technological competence, and, on the other hand, they are expected to contribute to the development of more sustainable and socially useful technologies, which calls for an environmental consciousness and sense of social responsibility as part of their engineering identity. It is therefore often proposed that engineering education needs to be reformed both in regard to its didactical methods, but also in regard to the curriculum. But nothing much seems to have happened. There are many explanations to the lack of reforms in engineering education, but one important explanation has to do with the contradictory and unclear picture of challenge perception within the field.

This paper is a 'work in progress paper' where we make some preliminary reflections on the research design and methodological approaches of our study. Thus the paper does not intend to produce empirical material of engineering practice. Instead it discusses and reflects on the methods and approaches of our coming research. The paper will focus on challenge perception in engineering through three different perspectives. To begin with we discuss challenge perception in engineering on a conceptual basis, trying to clarify the epistemological and ontological presuppositions made when talking about challenges to engineering practice and engineering education.

Hereafter we turn to methodological issues. We will give a brief survey of how engineering practice has been studied through the last 60 years or so. It will become clear that the methodological approaches taken to the study of engineering practice is informed by underlying epistemological and ontological presuppositions.

In our oral presentation we will turn to our own research project PROCEED in order outline the research design and the methodological approach we intend to apply in our study. PROCEED is about engineering education and how engineering education should be transformed in order to meet new challenges to engineering practice. Here we will argue that engineering education and engineering practice are in fact two – interrelated – practices that need to be studied in their interplay. We will further argue for the methodological position that 'challenges' in engineering practice should not be taken as the starting point for the investigation. Rather 'challenge perception' in engineering is in need of explanation – and engineering practice and education are in fact relevant sites for the study of 'challenge' discourses.

Challenges to engineering practice

Engineers face a lot of problems and challenges today. Many studies have been made to identify them using scenario methods and other techniques (e.g. Millennium project 2007; The Engineer of 2020; Douglas et al., 2009). To begin with it is useful to group the types of challenges to engineering that are formulated in the various reports.

One set of challenges can be grouped into the category *Societal Challenges*. Here the challenges are basically seen as challenges deriving from society: society continually changes and engineering must adapt to remain relevant. This line of reasoning has different variants. One line of the argument will state that the labor market for engineers is determined by the societal need for engineering services and products – thus the engineering profession must adapt to changing needs of customers. The engineers must be aware of the dynamics of the market and have commercial insight in order to be employable. Another variant of the argument will state that contemporary societies face a lot of new problems. Environmental deterioration, global warming and climate change has become a threat to our very existence. Society must face these problems and try to regulate production and consumption in order to prevent the destruction of our environment. Technology and engineering must be pursued by society in order deal effectively with these challenges. Thus, engineers must, among other things, improve their administrative skills and their leadership in order to become society's new environmental vanguards. The challenge perceptions grouped in this category are mostly functionalist in the sense that they strongly emphasize the pre-eminence of the social world / society as the driver for change in engineering. Challenges are posed by society and should be met by the engineers. The engineers are the servants of society, delivering neutral technical solutions that can be put to use in accordance with the priorities and needs of society.

Another set of challenges relates to the category of *Social Responsibility* of the part of the engineers. Here engineering is viewed as a pervasive and powerful enterprise that affects the lives of all living creatures on our planet. According to this perspective on challenges to engineering engineers must take the responsibility upon them and work to improve living conditions for all men and the environment in general. The important challenge facing engineers nowadays does not so much stem from engineers meeting society's expectations. Instead the real challenge for engineers is to change society to become a better place. Political and ethical motives are at the root of this perspective. Challenges are not primarily seen as something that should be reacted to. Instead the proactive and transformative element in engineering is stressed. The real challenge for engineering is to employ their skills and knowledge in ways that serves humankind and sustains the environment. In this perspective engineers must strive not to let technology deteriorate to one-dimensional technical fixes. Instead technological solutions must always take social aspects into consideration. Via socio-technical solutions the engineers can help to create a better world. Being a social responsible engineer implies working with the social and technical elements as a heterogeneous assemblage. Engineers must improve their social skills and learn to frame and solve problems in ways that has the *real* problems in mind.

A third category of challenge perception sees the challenges of engineering in relation to the internal evolution of the techno-scientific complex. Science and technology has change dramatically over the last decades. New disciplines and areas of research like information technology, biotechnology, media technology and nanotechnology have proliferated and transformed engineering practice in radical ways. In this light Rosalind Williams (2002) have challenged the engineering profession by asking what it exactly is about. The traditional engineering disciplines come short in grasping the new areas of research and industrial production. The techno-scientific complex with its many new disciplines is extremely diversified and hard to comprise within the engineering curriculum. Thus the main challenge from this internal perspective on engineering practice relates to defining the core elements of engineering. This challenge has very profound and practical consequences for engineering education. What should engineers know and what should be at the core of engineering curricula? Is it mathematics, physics, chemistry or are these traditional scientific disciplines not the essential ones? If not, what should be put in their place? This third category of challenge perceptions evolves around epistemic questions.

Philosophical interlude

So, what are the challenges to engineering and engineering education? And how should they be studied? Should they be taken for granted as they are stated above? What is the status of the challenges? Are they inevitable in the sense that the categories reflect essential – or even objective – features about engineering's position within society? It is certainly clear that the challenges described have a reified status. It is not up to the individual to define the challenges otherwise. The categories of challenges represent socially established facts that are widely taken for grated in the sense that people adhere to their existence and act according to their reality. To adopt a terminology of John Searle's (1995) it could be said that the 'challenges to engineering' are *objects* in the sense that they are in the world. They are ontological subjective but epistemological objective items. Thus 'challenges to engineering' is a socially constructed category that is established through peoples actions and beliefs about the role that engineering is playing – or ought to be playing – in society. It is clear that the challenges would not be there if people did not subscribe to their relevance. Likewise, it is also clear that the challenges are real in the sense that people abides to their existence.

Where does this leave us as researchers? One way of approaching the study of engineering challenges would be to accept the objective status of the challenges at face value and without further ado. The task would be to investigate how the challenges could or should be met in engineering education through e.g. pedagogic and didactical measures, redefinitions of core curricula, specification of learning outcomes, dealing with congestion problems within engineering curricula, optimizing teaching, etc. This approach is surely tenable and a substantial part of PROCEED's activities will indeed deal with these matters. But this approach risk contradiction if it is not accompanied by further reflections on the status of the challenges. The challenges point to different problems and vindicate different approaches to engineering education. Thus approaching the categories by this functionalist avenue would be vain.

The fact that the challenges are produced and sustained through social processes calls for a more critical and reflective approach. We suggest that it would be fruitful to investigate how and why the challenges are construed and perceived in the way they are. Thus we inscribe our research in broad research tradition of 'social constructionism'. The label of this research tradition is indeed vaguely defined and often driven to extreme positions. Therefore it is worth pausing to define our position in more detail. Using Ian Hackings (1999) conceptual clarification of types of 'social contructionism' we want to unfold and clarify our position. Constructionism in relation to challenge perception can be stated in three successive steps.

(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 contingency of the shaping of challenge perception in engineering practice should be recognized.

(2) Further, it should be recognized that the responses in engineering education to the stated challenges are contradictory and incompatible. It is unproductive to reform engineering education on the basis of an unreflected acceptance of the stated challenges.

(3) 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

Hacking (1999, 19 ff.) identifies six stances in constructionism that identifies gradations of commitment.

1. A historical stance – A historical constructionist does not go beyond our thesis (1), and as such does not have the normative stance required to commit to our thesis (2) and (3).
2. An ironic stance – The ironic constructionist goes one step further than the historical, but does not necessarily embrace our thesis (2). The ironic constructionist understands that the stated challenges to engineering should not be taken at face value and that they are a result of multiple social factors. But the ironist also sees that the way we perceive challenges to engineering is so entrenched in today's society that it has become impossible to alter. Though contingent the challenges – as stated – have obtained a de facto inevitability that would make it futile to deconstruct them.
3. The reformist stance – The reformist constructionist fully embraces our thesis (2), but, like the ironist, acknowledges the fact that we, as researchers, cannot completely transform practices in order to eliminate or alter existing challenge perceptions. However, the reformist believes that some aspects of challenge perception may be slowly reformed, so as to ameliorate the contradictory and incompatible elements in today's challenge perception.
4. The unmasking stance – This fourth grade of constructionist commitment is parallel to the reformist stance but it has a different strategy of action. This method "does not seek to refute ideas but to undermine them by exposing the function they serve" (Hacking 1999, 20). This stance stems from the tradition of Marx and Mannheim and would e.g. in the case of challenge perception to engineering show how the perceptions are linked to capitalist modes of production. The stance will fully embrace thesis (1), (2) and (3)
5. The rebellious stance – The rebellious constructionist fully embraces thesis (1), (2) and develop the argument further into thesis (3)
6. The revolutionary stance – The revolutionary constructionist is a rebellious one who moves beyond the realm of thoughts, ideas, analysis and criticism and actively attempts to change the world.

It is, thus, important to clarify which of these grades of commitment our research is informed by. In our view the historical stance is evident and well documented.

The overall aim of PROCEED is to "improve the education of engineers, so that they might better be able to turn the challenges into new opportunities, in commercial, societal and professional terms." Thus the commitment of our project exceeds grade 1 and 2 in the sense that we have an ambition to transform engineering education in certain respects. The project does not in particular have ambitions to "unmask" challenge perception in engineering. Our general theoretical stance does not presuppose that removing a veil of misconceptions will in effect bring enlightenment and eventually change. While project may not be characterized as 'activist', but we expect to engage in experiments in engineering education and thereby contribute to interventions in how engineering training is organized and performed. On the other hand we do not – in any direct sense – expect to be involved in establishing new educational initiatives. Thus, we are most willing to characterize our commitment as either reformist or rebellious. We certainly hope to produce are more cogent and nuanced picture of the challenges facing engineering and engineering education.

It is our conviction that a thorough study of engineering practices will in fact shed some new light on the challenges that face engineering and engineering education today. In the next section we will give a short review of engineering studies in order to highlight some strengths and weaknesses' in the approaches. This historical review and discussion will establish a background for our proposal of a research design and methodological framework for our research. This design and framework will be presented in our oral presentation.

A survey of studies of engineering practice

Our focus in the following survey of literature has been on studies of engineering not taking the outset in stylised and normative assumptions about how engineers should acquire their skills and handle their professional tasks. This approach has often been dominant in publications from engineering educations and other engineering institutions in their attempt to position themselves and outline 'heroic' futures for engineering (as e.g. in NAE 2004). Instead we have been looking for studies based on observations and rich descriptions of the performed practices of engineers and how they approach, delimit, and solve problems in practice. These practices will most often be informed and framed by the knowledge and heuristics learned during engineering education and following experiences from working within specific domains of engineering. Engineers are expected to become problem solvers through their training and this may entail the development of specific mind-sets related to being and working as an engineer. The question raised in our project is how these forms of knowledge, skills, and mind-sets are the result of the combination of educational training and the performed practices in the field of engineering work including the involved selection, delimitation, and solving of what is considered engineering problems.

Engineering has been the topic of many different forms of description and analysis of which we will focus upon those based on empirical material reflecting engineering practices and the mind-set of engineers. As the body of literature on engineering is quite immense it is important to notice that our focus will exclude some parts of this literature, that sometimes also may have contributions to the understanding of the practices and the professional framing of these practices – at least in specific parts. There is e.g. a huge literature on engineering education in the form of reports written under auspices of government or engineering institutions which most often refer to rather stylised views on engineering though their list of authors may include practicing engineers (see e.g. NAE 2004; Manning 1991; etc.). There are also a large number of publications introducing philosophies of engineering often based on personal experiences (see e.g. the writings of Samuel Florman 1976, 1987; Goldberg 2006) as well as individual stories of heroic engineers based on biographical materials of their achievements and lives (see e.g. articles and books written about Edison as a heterogeneous engineer and inventor and in historical outlines as e.g. Arnold Pacey (1974)) including also memoirs written by engineers based on their lived experiences. A special perspective often including detailed accounts of specific events and cases are the studies of engineering ethics in relation to failure and accidents (Whitbeck 1998). A vastly growing strand of publications concerned with the future of engineering education including normative advice for teaching, learning, didactics and curriculum planning is surfacing in recent years often following up on outlines of reforms and initiatives by government or engineering institutions. These include also more formalised, research based and cross-country organised initiatives as e.g. the CDIO approach and the Pathways Studies project (Crawley et al 2007; Shepard et al 2009; Mårdsjö 1998). These publications may include case-studies and also implicitly give indications of the direction of the main reform discourse on engineering education. Also in novels written for a broader audience engineers several times appear as main characters whose heroic intentions or achievements are contrasted with disasters and personal doubts (Johansen & Jakobsen 1992). The approaches in this literature are for most parts not included in our survey.

Progress, nation states and manpower

After the Second World War enormous attention was given to the role of technology as the central driver of societal development, not least based on the achievements in military applications of technology during the war. This lead to increased efforts, also by governments, in the attempt to improve research funding and expand the capacity of engineering educations (see e.g. Teknkerkommissionen 1959; Finniston 1980).

During the 1960's engineering as many other educations were seen as crucial to the economic growth in society leading also to new perspectives in the study of engineering competencies and the role of engineers in society. With growing emphasis on mass consumption and also increased internationalisation of industry and the markets for technology based products the training of engineers and technicians was a potential bottleneck for further development. New emphasis was given to the role of the engineering profession and its social status (Krähenbühl 1975; Berner 1981). The dominant perspective was taken from the sociology of professions where the ability to construct and sustain a professional identity was core including the legal and institutional arrangement this entailed. While the first studies did see the engineering profession as a rather homogeneous group, later studies included differentiation in the different types of work included in engineering and a focus on how engineering work was organised (Neef&Pelz 1997; Neef 1982; Lutz &Kammerer 1975). The new focus on the organisation of engineering labour included an organisational perspective on engineering work and sometimes also a critical perspective on the potentials for a degradation of engineering work by companies' application of new managerial routines (Braverman 1974).

A critical revision of the role of engineering in societal development not least pointing to the role of engineers as supporters of the Nazi regime in Germany followed renewed critical discussions in society on the impact of technology on industrial workers and on the environment questioning the 'neutrality' of technology. Not that this discussion about the role of engineers in military and societal development was completely new, but the idea of a neutral technology and engineers as the mere providers of technological knowledge was questioned. In Germany this discussion lead to several studies of the role of engineers leading to the conclusion that only little moral resistance against the utilisation of technology for inhumane purposes could be observed (Hortleder 1970). This followed a series of studies of engineering taking as the outset that engineering is a somewhat homogeneous profession finding national differences in engineering practice leading to the conclusion that the rise of the engineering profession has had close linkages to the nation state building during the 19th century (Crawford 1989; Whalley 1986; Gispen 1990; Meiksins& Smith 1996). Whether this was a consequence of differences in how national institutions performed their identity or how engineers were practising their skills has been less evident, though later studies have pointed to differences also in engineering practice coming out of the different positions and institutional framings at the national level (Hård 1999).

The role of engineers in the early nation state formation also resulted to a quite strong public image of engineers being a progressive force in society. This image was substantiated by the role engineering played in the establishment of the core infrastructures of modern society like transportation, telecommunication, oil supplies, electricity networks and water systems including also the creation of large national corporations and their role in the technical progress. This perspective has strongly been supported also in recent historic studies of technological systems and the engineers as system builders (Hughes 1983, 2000; Akera 2007). Also broader accounts of the role of engineering in society and in relation to culture and modernisation has been published giving new perspective of e.g. the relationship between the role of engineering knowledge and practice within controversies at the engineering institutions and in relation to technical knowledge as a core part of the building of modern society (Runeby 1976; Wagner 1999; Buhl & Nielsen 1994; Harnow 1995). Though coming from different disciplinary background the overall perspective of these studies is to demonstrate how technological development is intertwined with societal change and how the engineering profession is crucial in this process.

Engineering work, practice and gender

What engineers do when they do engineering was at first approached in a series of studies taking up specific, but still stylised aspects of engineering in an attempt to identify the core methodologies and characteristics of engineering problem solving (Jakobsen 1994). Some of the core issues in these studies have been the identification of core characteristics within engineering like the role of drawings as an intrinsic tool in engineering communication and design (Ferguson 1992; Henderson 1999) others have pointed to the special characteristics of the use of scale models, tests, and guiding designs in engineering problem solving (Vincenti 1993; Hård 1999; Beder 1998; Baillie & Catalano 2009; Heymann 2005; Jørgensen et al 2009). Some of these studies have been accused of having the purpose of creating engineering as a special form of knowledge and practice separating it from the natural sciences that has been seen as the dominant form of science setting the standards for what real science should be and also from other forms of practice (Juhlin& Elam 1997; Elam 1983). This has for many philosophers of technology positioned engineering in the mists of application of sciences positioning engineering educations is the realm of professional training. Following in this line of argument studies have been conducted to identify, often from a science studies outset, what might be the differences between engineering science and knowledge production and the natural sciences (Pedersen & Hendrix 198x; Auyan 2004; Sørensen 1998; Christensen et al 2009). These studies most often have an empirical basis for their observations and claims, but find their material in historic cases taken from written material in archives and accounts of engineering practice, some though also using case material based on observations interpreted within perspectives from sociology and innovation studies.

These studies were followed by some more specific studies of engineering work and use of knowledge often looking for the relationship between educational training and the competences required to master typical job functions. Inspired by studies in the medical professional in which questions were raised to whether the training of doctors was adequate in relation to the job functions there were supposed to carry out, similar studies were conducted within the field of engineering. These studies were in the 1970-80's mostly carried out as questionnaire based surveys or interview studies from a sociological point of view where practising engineers were asked about the job functions and their use of theoretical knowledge as taught in engineering schools. This was then complemented by historic studies of engineering institutions and their role in building engineering competence including eventual missing perspectives in the curricula (Jakobsen& Jørgensen 1984).

The last strand of literature that we have found most inspiring for our project is contemporary ethnographies of engineers at work or broader studies of engineering lives. Within this field of research the details of engineering work is reflected in the account of how problems are identified and approached including the need for partly creating new vocabularies to handle wicked and often new problems as well as the use of material objects, drawings, sketches, and other intermediaries in the process of communicating about design ideas and solutions (Bucciarelli 1994; Henderson 1999; Vinck 2003; Downey 1998). Following up on the critical perspective of engineering as a profession, studies have also been tracing engineering cultures as forms of professional independence within organisations attempting to control the outcomes and performance of engineering (Kunda 2006; Barley & Kunda 2004; Henriksen 2004). Research projects have also been conducted on engineers not focusing on their professional performance and knowledge but giving a broader perspective on their lives of which several have included reflections on becoming an engineer and the mind-set of engineers in a broader social context (Mellström 1995; Buch& Christensen 1998). Complementing the studies of engineering also studies of laboratories have contributed to the understanding on how communication and sense making is performed in scientific work (Traweek 1988; Latour&Woolgar

1979). Some publications include contributions to understanding engineering identity and lives by including descriptions of experiences from meeting and working with engineers (Williams 2003; Star 1995; Downey &Dummit 1997). Student biographies of becoming an engineer at engineering schools are rare, but a few have been written by students in the form of (re)collected diaries of specific teaching and learning situations giving an insight into the creation of what could be considered an engineering mind-set of heuristics, rationales, and disciplinary knowledge (White 1958).

The gender issue is a recurrent theme also in ethnographic work on engineering culture most often characterised as a typical male culture – at least at the outset – where female engineers either have to take on male values and attitudes or act with deliberate emphasis of their personal performance (Wajcman 1991; Faulkner 2000, 2007; Mellström 1995). In this perspective the linear and outcome dominated perspectives build into modern societies use and praise of science and technology is also reflected in the modern dichotomies lying behind the divisions between production and reproduction as well as technological knowledge versus the knowledge related to social sciences and the humanities. Divisions reproduced in the gendered aspects of the division of labour and identities.

Diversity of perspectives in ethnographic studies

Ethnographic studies of engineering though more and more important as contributors to understanding engineering practice and professional knowledge show a great variety in the perspective or view (‘erkentnissinteresse’) that guides what is observed and what is put to the front stage of the narratives and reflections coming out of the studies. Ethnographic approachesare to a certain extend united in ideals of studying the field on its own premises by collecting rich materials from every day practices and situations and using open interview methods. However, a dramatic difference in the focus on the ethnographies can be observed. Some are searching for how engineers associate meaning to their daily practices and carriers, others are observing how companies organise and motivate professional engineers to be disciplined and creative at the same time and how this is reflected in the engineers identity, last but not least some have studied how professional engineers use knowledge and perform tasks using different media to handle new and wicked problems in their communication and design practice where existing knowledge is not satisfactory and solutions not applicable in simple ways leading to a need for developing new notions and experiences. These three (characteristic) ethnographic approaches will be discussed in the following.

In Kunda’s (2006) ‘Engineering culture’ a very distinct perspective is presented at the outset in the form of motivated research questions concerned with corporate management of culture in the organisation as a form of normative control in a setting where conventional management measures are not well suited. The book starts with a discussion on the limits to control based management initiated by observations of the site and arrival of workforce at the start of a working day. The observations and interviews made with managers and employees is centred around the search for measures and processes that can substantiate the character and impact of a management culture that deliberately is addressing the need of having the large group of specialised and professional engineers to be highly motivated and partly self organising to reach the often vague goals of development tasks. Throughout the book ‘Tech culture’ is the code for these measures more or less deliberately taken by managers by building an ideology and rituals that can support sustaining the relations between the engineers self and the organisation. Goffmans symbolic interactionism (1961) is core to this study as an approach to looking for those elements that seem to be crucial in the construction and maintenance of company culture.

The study concludes in the tensions between the freedom in the work situation and the internalisation of control among the employees: ‘The evidence suggests that though many members maintain a sense of freedom, they also experience a pull that is not easy to combat, an escalating commitment to the corporation and its definition of reality, coupled with a systematic and persistent attack on the boundaries of their privacy.'

In this cited second edition the author include a epilogue raising questions to the seemingly timeless account made in the original study performed before the first publication in 1992. The company soon after went out of business after a period of turbulence and claims could be made that the managerial culture was more fitted for a company operating as an 'eternal start-up' with emphasis more on continued innovation than on flexibility and efficiency. Attempts to change a company culture met severe resistance and the company did not succeed. Instead of focusing on loyalty, long term relations as was the case new values have entered as elements of company culture taking up strategies of outsoucing and reengineering producing distinctions between core employees and those at the margins. In this perspective the specific study turns out to picture a specific period in managerial strategy though also emphasising a challenge that is rooted in the characteristics of innovation, design-oriented engineering work.

In his study of 'Engineering lives' Mellström (1995) engages with a number of engineers in two different companies with two different aims. The first is to show how 'meaning is produced, reproduced, and socially organised' by focussing on situated activities and social practices in time and space. The second is to 'show how the build-up of individual perspectives and horizons in engineering are constructed in a continued process of socialisation'. Mellström uses a number of classical elements to construct his material from the field studies building on Goffman and the perspective of socially constructed and symbolically communicated meanings emphasising the role of micro cultures. These elements include meetings, shop talk and small talk, stories and jokes, metaphors, etc.

The first part of the study is based on the observer's reflections on the site, the workplace and detailed observations of the conversations, meetings and small talk among the engineers in formal and informal settings. The approach to studying engineering turns out to be very important also for the outcomes of the study as the author ends up generalising the observations around the role of stories, jokes and laughter as measures used to create symbolic boundaries and handle controversial situation and the tensions between managers and engineering teams. The involved narratives also function as mediators between different categories of engineers and persons with different status. The engineering 'tribe' is encoded by generalising its performance in interaction rather than for the professional association of meaning in the flow and development of arguments. In the second part the focus in the study is 'going beyond the individual workplace and look to individual experiences of life in engineering'. A core conclusion from this part of the study is that 'for most of the engineers lives are centred around occupational careers' and that 'occupation is a central life interest and other non-work activities in one way or another are meant to complement the content and route of the occupational career'. This leads to the conclusion that the 'deep-rooted career mentality is a constitutive and fundamental part of engineering and the middle-class form of life that goes with it'. Still engineers carry with them at work their personal social life and substantive elements of communication is – as among other employees – not focussed on formal work assignments and problem solving but related to their private lives. The implicit rationality of technical work are emphasised in the final conclusions of this study as 'elements of a linear conception of time are enacted and manifested in practice as well as during life courses' arguing that the 'individualism, compartmentalisation, and periodisation are crucial components, is then to be seen as a reproductive cultural form at the productive heart of Western culture, i.e. science and technology'.

A much more detailed interest in how engineers perform work tasks and cooperation around not well structured and known problems – argued to be a large part of engineering – is found in one of the classic ethnographies 'Designing Engineers' written by Bucciarelli (1994). This study is based on participant observations where the author in several of the cases was involved as an engineer in the design teams. The authors double role and inside engineering 'view' does affect both text and observations as he is not acting in the same way as the two first authors we have discussed who were acting as observers not as participants in the processes. Bucciarelli in his study claims to be one of the observed at the same time as he is researching engineering practice. Though this may lead to a long discussion of 'going native' as it has been common in anthropology the question for us is specific and more related to how the analysis is performed than how the data were collected. In this perspective the authors' ability to decode and partake in the sense-making processes seem to be crucial for the outcome as it brings the reader much closer to the process of engaging with liminal knowledge (Knorr Cetina 1999).

Bucciarelli elaborate two different processes crucial to engineering design, one called the object world and the other comprising of communication within design processes carried by narratives. The object worlds constitute the established knowledge and meanings associated to specific artefacts (objects) and also highlighting the potential differences in how different disciplines, professions, and different users understand and model these object – so to say 'see' the objects not just in an object with a assigned script or purpose, but as a representation of specific ways of analysing and modelling this object within their practice by applying their professional repertoire of methods and heuristics. In the process of developing new artefacts (object) such a pre-existing object world will most often not exist, or at least exist in potentially useless forms related to other, different designs. Therefore the design dialogues and exchanges through different means of communication become crucial for the creation of new meanings, notions, and models representing the new designed objects in the making. The ability to maintain such dialogues and the uncertainties of being involved in fields not well described challenges engineering conception of working with objective and consistent knowledge. It also demonstrates how rather close engineering specialisations can have huge problems as e.g. similar notions carry different meaning within their respective object worlds. Bucciearellys study does provide important insights in the design process and highlights the challenges of working with liminal knowledge in a field dominated by existing models and designs.

We will finalise our discussion with two recent ethnographic studies of engineering work practices written by Vinck (2003) and Henderson (1999) respectively. They share the field study practices of anthropologist of being observers of engineering teams in performing their practice. They also share an interest in demonstrating how artefacts and other means of communication like drawings play a very important role in engineering practice compared to e.g. texts. Vinck's cases are taken from different areas including technical support work at CERN with emphasis on the very complex and different types of tasks and influences that shape engineering work, the creation of design aid tools, and household waste containers. The study focus on the different means and mediations involved where the stabilisation of meaning may be less important than the performance of the objects constructed. The focus is on the social world of the involved designers and their use of tools to mediate communication. Henderson has studied two engineering design settings with emphasis on the use of drawings and computer tools in the design process. Her outset is the basic observation that the conventional means of codification in science cannot account for the means of communicating crucial knowledge and insights in engineering where less formalised and codified means of communication like sketches, technical drawings are used to model and communicate a diverse combination of knowledge and experience. The study has a focus on the attempts to standardise such representations within computer graphics in design engineering and the limitations to these tendencies.

Reflections leading to our research approach

It is interesting to observe that several of the early studies of engineering seemingly have taken up rather uncritical the conception of engineering being a homogeneous profession. Difference was found in the ways engineering was (institutionally) related to the formation of nation states and later to the role of engineers as white collar workers contributing to the growing middle class of skilled workers separated from and seeing themselves as constituting a socially independent group compared to the blue collar workers. These motives have been followed up also in more recent studies but now with more focus on how professional engineers perform and use knowledge and experience as well as different means of communication in the their practice.

It is quite obvious that engineering cannot be reduced to the use of language, mathematics, and science based methodologies as these do not cater for the huge amount of experience and heuristics that goes into engineering practice. The means of communication and the logics of reasoning within engineering employ a broader set of elements than the idealised version of natural science build upon. In the light of criticism of idealising science through contemporary analysis of techno-science this does also apply though in different laboratory settings for what is considered scientific work.

In our perspective it is important to go beyond a distinction between an internal perspective on engineering work focusing on the reasoning and specifics giving meaning to engineering practice and the external perspective focusing on the social formation of engineering practice within teams, corporations, and lived careers as it is stated in e.g. Mellströms analysis. While the internal perspective most often is left to the engineers, anthropologists focus on the latter. The tension can even be found within the three studies of engineering work practices where Bucciarelli is taking up internal aspects of how meaning and sense-making processes are crucial in their specific form to engineering practice while Vinck and Henderson tend to generalise their findings by emphasising specific means and processes of communication. They highlight very crucial elements related to e.g. the priority of performance over aligned meanings and the extended use of e.g. sketches and models to illustrate a very large variety of elements and supporting communication in design situations. By addressing the problem of standardisation and codification of these forms of communication the specific heuristics and forms of knowledge involved in engineering is highlighted bringing also useful knowledge to educational planning that otherwise tends to focus on the codified, disciplinary structured knowledge.

The question for us in defining the ‘ethnographic optic (view)’ that we want to employ is not to avoid any framing, rather to choose a framing that emphasise how engineering identity and professional consciousness – how homogeneous it may turn out to be – frames how challenges, problems, and work tasks are interpreted, reproduced, and eventually translated into workable problems to be solved. Adding to this how routines and heuristics as well as disciplinary framings influence both problem identification and the search for solutions and design synthesis in engineering practice.

In PROCEED we will be studying how the three challenges – mentioned in the introduction – have been conceived and responded to within engineering educations and in the constitution of engineering competences, identities and consciousness. Our special attention is on how these educational responses and the responses within the engineering profession can be traced in the practices of engineers. The two main factors also defining the sites for our study are:

1. the educations and their presentation of engineering knowledge and heuristics as well as shaping of the identities and consciousness of engineering students e.g. in relation to how problems are conceived, delimited, and responded to, and
2. the work practices that can be identified in engineering departments, consultancy work and engineering design projects and how the challenges in these contexts are represented in the ways problems are confined and solved.

One experience still to be considered and handled in the layout of our study is the observation that some – maybe many – engineering students already very early in their education seem to take on some very basic norms representing what could be considered an engineering ethos. The research challenge is whether this can be understood through the in depth interviews and observation of students' daily lives, or if we need to add another site or eventually look for broader societal framings of modernist nature of technology and engineering as the 'rational' and 'constructive' elements of society's constitution.

In the selection of companies and educations to study the three challenges will be guiding as we expect to look for practices and competences that reflects core responses to the challenges as well as their eventually more marginal influence on 'other' fields of engineering practice.

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