

Chapter 7

Studying Engineering Practice

Anders Buch

Abstract The study of engineering practices has been the focus of Engineering Studies over the last three decades. These studies have used ethnographic and grounded methods in order to investigate engineering practices as they unfold in natural settings – in workplaces and engineering education. However, engineering studies have not given much attention to conceptually clarifying what should be understood by ‘engineering practices’ and more precisely account for the composition and organization of the entities and phenomena that make up the practices. This chapter investigates and discusses how a ‘practice perspective’ can make a contribution to Engineering Studies by clarifying the theoretical and methodological presumptions behind this widely used – but only vaguely conceptualized – study of practices. The chapter highlights the inspirations of practice theory and delimits practice theory from other accounts of human activity in order to clarify what a practice perspective suggests. Further, it clarifies the concept of practice and highlights how practices are fundamental in understanding the fabric of social orderings. Having accounted for these theoretical perspectives of practice theory the chapter will draw out some methodological consequences and discuss the ramifications of a practice theoretical approach for Engineering Studies.

Keywords Engineering studies • Practice theory • Methodology • Context

Introduction

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 1950s and 1960s the predominant perspective was that of the engineering profession studied by sociological methods including studies of engineers serving authoritarian regimes. In the 1970s the perspective shifted to

A. Buch (✉)

Department of Philosophy and Learning, Aalborg University Copenhagen,

A.C. Meyers Vænge 15, Copenhagen SV 2450, Denmark

e-mail: buch@learning.aau.dk

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 extent – used ethnographic and grounded methods in order to investigate the specifics of engineering work practices in situated perspectives. 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 provide new material for a richer understanding of engineering culture (e.g. Bucciarelli 1994; Vinck 2003; Henderson 1999; Kunda 2006; Downey 1998; Barley and Kunda 2004; Johri 2010). The situated studies of engineering work practices have reflected on the organizational and corporate embedding of engineering work and described the minute negotiations that take place on a day-to-day basis in the reproduction of engineering culture.

A smaller body of engineering studies has supplemented the situated diachronic perspectives on engineering work practices by introducing synchronic perspectives that illuminate the broader life-worlds of engineers – thus reflecting on the subjective dimensions of engineering practices as narrated through the life-stories of practicing engineers (e.g. Buch and Christensen 1998; Buch 2002; Mellström 1995). Likewise, a small number of other studies have given accounts of the process of *becoming* an engineer and the process of neophytes entering engineering culture at engineering schools and universities (e.g. Downey and Lucena 1997; Tonso 2007).

What unites all these ethnographies is the awareness of context in studying engineering – an awareness that the phenomenon of engineering should be studied as and through situated practices; i.e., that engineering should be seen as a bundle of activities immersed in, influenced or determined by, and composed of various entities and phenomena. Although not all of the mentioned ethnographies explicitly talk about engineering in terms of situated practices, it is clear that all of them view engineering as social and material activities that are situated in time and space, part of a 'wider scene' and characterized by relatively durable ways of doings and sayings, rules, conventions, specific tools, equipment, procedures, analytical preferences, etc., that we recognize as part of engineering culture. This approach comes close to a practice perspective by recognizing the heterogeneity and complexity of the sites where engineering culture is enacted, reproduced, or even transformed. But it is also clear that engineering studies have not given much attention to conceptually clarifying what should be understood by 'engineering practices' or more precisely accounting for the composition and organization of the entities and phenomena that make up the practices.

In what follows I will investigate and discuss this 'practice perspective' – or the 'practice lens' as it is often referred to (Feldman and Orlikowski 2011; Corradi et al. 2010) – and thus make the theoretical and methodological presumptions behind this widely used – but only vaguely conceptualized – approach to the study of engineering culture more explicit. However, it is not the ambition of this chapter to review the body of literature of engineering studies or to analyze the theoretical and methodological approaches of existing contributions to the field. Instead I will suggest and outline a proposal for a research agenda for engineering studies by drawing

on insights from the emerged interdisciplinary research tradition of practice theory. In doing so, caution must be made not to reify or hypostasize practice theory – in fact it is more precise to talk about practice theories in the plural. Practice theory is not a unified theory and methodology. Practice theory is better described as a set of theoretical and methodological insights that are historically affiliated and bear conceptual similarities. I will start by highlighting the inspirations of practice theory and delimit practice theory from other accounts of human activity in order to clarify what a practice perspective suggests. I will then continue to clarify the concept of practice and highlight how practices are fundamental in understanding the fabric of social orderings. Having accounted for these theoretical perspectives of practice theory I will draw out some methodological consequences and discuss the ramifications of a practice theoretical approach for engineering studies.

Practices

Practice theoretical approaches have made their entry in the social sciences and humanities over the last 30 years. Still more scholars in different disciplines and with different research interests and backgrounds have focused on the day-to-day practices of actors in their studies. Philosophers like Theodore Schatzki (1996, 2002), Joseph Rouse (2007) and Andreas Reckwitz (2002a, b) have sketched out the fundamental ontological and epistemological presumptions of practice theories in relation to agency, the social, and society, and described how practice theories draw on philosophical insights from mainly the late Wittgenstein and the younger Heidegger, but also significantly the early Giddens, Bourdieu, Butler, and the late Foucault. In organizational studies, social scientists like Wanda Orlikowski (2000, 2002), Silvia Gherardi (2006), Davide Nicolini (2013) and others have theorized and analyzed the role of technology within organizational development and change, and learning theorist like Paul Hager et al. (2012), Jean Lave (1988, 2011), Jean Lave and Etienne Wenger (1991) and Etienne Wenger (1998) have demonstrated how learning processes are best understood as transformations of and within practices. In another intellectual tradition, namely activity-theory, Yrge Engeström (1999) and others have studied work practices and stressed the interplay with the material environment and the role of tools as essential features of human practices. The practice theoretical approaches have spread to other areas of research like consumption (Shove et al. 2012; Warde 2005) and sustainability studies (Shove and Spurling 2013; Cohen et al. 2013). In Science and Technology Studies (STS), practice theoretical approaches have appeared most notably in the works of Karin Knorr-Cetina (1985, 1999) and Joseph Rouse (1996, 2002), but practice theoretical approaches are held in common with many STS approaches, e.g. in the traditions of ethnomethodology, actor-network theory, and other posthumanist perspectives (e.g. Pickering 1995). Several announced scientific journals have devoted special issues to the discussion of the new practice approaches within the social sciences (e.g. *Organization* 2000, *The British Journal of Sociology* 2002 and *Human Affairs* 2007) – thus practice theoretical

approaches have come to the fore and significantly influenced contemporary social science. Many scholars have observed this impact and describe the increasing attention to social practices as a ‘practice turn’ in social science (Schatzki et al. 2001) or a ‘bandwagon’ of practice based studies (Corradi et al. 2010).

But what have made the practice perspective so attractive to these social scientists? What are the general assumptions that draw researchers of different intellectual origin and tradition together in studying such diverse phenomena as ‘consumption’ and ‘scientific knowledge production’ by using the ‘practice lens’? In a newly published introduction to practice theory Nicolini (2013) characterize the general assumptions within practice theoretical studies. He points to five assumptions (2013, 1ff.): Firstly, it is a characteristic of practice theories that they focus on the lived social life of actors. Thus the social activities and work processes of actors are studied and the routinized rule governed and institutionalized characters of performances are given special attention – not as explanatory devices, though, but as accomplishments of human activities. Thus the practice theoretical approach stresses the productive and reproductive aspects of human activities in understanding stability and transformation within social formations. Learned skills, rituals, procedures, etc., are central foci for investigations. Secondly, practice theoretical approaches try to do away with dichotomies and refuse to understand human activities in binary terms of agency/structure, subjective/objective, and body/mind. Practice theories stress that human action is embodied, and temporally and spatially situated in material environments. In order to understand human action it is thus mandatory to reflect on the specific physical and material settings within which the actions take place. Thirdly, practice theories do not conceptualize human agency in line with the classical conceptions of either the *homo economicus*, i.e. the autonomous rational individual with purposes, intentions, etc., or the *homo sociologicus*, i.e. the norm-abiding or rule-following ‘cultural dope’. Instead practice theories conceptualize human agency in terms of the *homo practicus* – the human agent that ‘carries’, but also ‘carries out’ social practices (Reckwitz 2002a, p. 256). Practice theory is a branch of culturalist theories, but it deviates from structuralist and subjectivist (phenomenological and interpretative) cultural accounts by focusing on the enactment of practices. Fourthly, practice theories resolutely reject representational theories of knowledge, meaning, and language. ‘Knowledge’ is not a property of the mental states of individuals, but is better understood as ‘knowing’ that is produced and shared within concrete activities and practices. Likewise, discourse does not belong to a separate non-material structural realm, but is an integral part of unfolding human material practices. Finally, practice theories foreground that the dynamics of practices should be understood in terms of power relations, interests, negotiations, conflicts, etc. Thus the perspective recognizes the highly contingent features of human affairs and stresses the interruptions, contestations and unevenly distribution of resources and privileges in social life.

These characteristics of practice theoretical perspectives are, of course, highly interwoven in theoretical accounts, as they are in concrete studies informed by the practice theoretical approach, and it is also the case that practice theorists have different concrete interpretations of the tenets outlined above. It would be

presumptuous – and in fact misleading – to stipulate that *a* practice theoretical position can be identified. Instead, more authors (e.g. Nicolini 2013) – borrowing Wittgenstein’s concept – have pointed to the fact the theories bear a ‘family resemblance’ to one another: No strict communalities can be found in all of the theories, but many similar features can be traced in many of them. It would thus be more precise to speak of practice theories – in the plural. But the aforementioned approaches do share a common awareness of the fundamental relational character of being-in-the-world. Individuals are not isolated observers or agents that occasionally interact with other individuals or the material environment, nor are relations construed as abstract structures that bind actors together. Actors construe relations as links between particular and specific entities – both human and non-human. Likewise, humans do not interpret each and any occurrence in order to experience the world they live in. Practice theory recognizes that things are mostly always-already-interpreted; we have become familiar with the world through the training, routines, socialization, ways of life, etc., that makes us human. What preoccupies researchers within the tradition is thus, according to Martha Feldman and Wanda Orlikowski (2011, p. 1240), to investigate the ‘why’, ‘how’ and ‘what’ of practices. The ‘why’ question is primarily dealt with by philosophical reflections over the ontological and epistemological status of social life. Here practice theoretical approaches argue for the ontological primacy of practices. The ‘how’ question of practice theories is answered by the specific practice theories of, say, Pierre Bourdieu (1990), Lave and Wenger (1991), or Engeström (1999). They specify the dynamical mechanisms that explain how relations within and between practices are enacted, reproduced, and transformed. Finally, the ‘what’ question deals with the empirical findings of practice theories. It will take us too far to elaborate on the ‘how’ and ‘why’ questions. Practice theories comprise a broad range of theoretical approaches and span numerous fields of research. To illustrate what practice theories can offer Engineering Studies I will instead focus on the ‘why’ question and account for the ontological thesis of practice theory. Here I will primarily refer to the work of Theodore Schatzki.

The Primacy of Practices

As this book testifies, the role of context is central to the study of engineering (work) practices. Firstly, engineering studies recognizes that engineering is part of a ‘wider scene’ and that engineering is not just about technical specificities. There is seemingly a broad consensus in engineering studies that engineering and technology must be studied as complex phenomena through ethnographic methods that are sensitive to the complexities of the endeavor. But the consensus stops when scholars try to answer questions about the complexities. What exactly is this ‘wider scene’ and how do the complexities impact, shape, or determine engineering (work) practices? Context is often invoked to indicate that engineering is not a self-sufficient, self-determined, and self-explanatory phenomena, but, on the contrary, part of something

more that 'surrounds' it. The use of context thus indicates that something – the text: engineering – is part of and entangled in something more that surrounds it. Secondly, context indicates that forces of determination are at play within this entanglement that somehow give structure and establish orderings. And thirdly, that the entanglement is made up of various entities that are interconnected (Schatzki, 60ff.). These characteristics vaguely and only formally make the use of context intelligible. We need to learn more about in what sense engineering is surrounded by 'something', how that 'something' is affecting engineering, and the character of the various entities that make up the context. Engineering studies are thus challenged to be more precise and explicit about specifying the ontological and epistemological presuppositions of contextual investigations.

I suggest that engineering studies can benefit from the development of practice theoretical accounts. Practice theory sees practices as fundamental units of analysis and investigates the specific activities and the organizing of the activities in detail. I suggest that this focus can help engineering studies to be more specific about invoking contextual analysis and thus be more explicit about outlining what elements and mechanisms are at play in engineering contexts. It is true that the concept of practice has been used in a variety of ways (cf. Turner 1994) and it thus might seem a poor qualifier for being more precise about the use of context. But through the work of Theodore Schatzki (1996, 2002, 2003) the concept has been specified to give more precision. I will follow Schatzki's account of practices and illustrate how the notions he introduces are relevant for understanding engineering (work). Schatzki broadly characterizes practices as sets of doings and sayings (2002, p. 73). Practices thus comprise bodily actions as well as linguistic utterances, gestures, etc., and thus subsume what in other theoretical traditions are labeled as behavior and discourse. What unites these actions and linguistic utterances into sets of doings and sayings are the specific tasks and projects that impose orderings of the actions. What makes us characterize a reading of a thermometer or the reporting of temperature increase as part of engineering practices are by reference to the tasks (e.g. doing experiments) and the project (e.g. developing enzymes) of which they are a part. Practices are thus composed as hierarchically ordered wholes that have certain duration in time. The regularity of the doings, sayings, tasks, and projects does not have to be constant over time in order to qualify as practice. Practices can change and innovate over time and it is a matter of empirical investigation to trace these changes as they unfold. But for doings and sayings to qualify as part of a practice it is essential that regularities can be detected and disruptions are outbalanced by continuities.

Practices thus indicate that human activities are linked through certain *normative orderings*. One essential ordering element is the *practical understandings* of the actors. Actions are considered competent and qualified according to standards and procedures – mostly implicit and tacit by nature. The bio-chemical engineer who is engaged with the development of a new enzyme must know how to deal with experimental settings and among a lot of other things know how to read a thermometer. Furthermore she must be able to identify why and when it is appropriate to read the thermometer and how to respond to an increase in temperature in the experimental situation. She must be able to see things like an engineer (cf. Goodwin 1994) and frame problems and (research) questions accordingly. Practice theory emphasizes

that these activities are founded in the practical skills and know-how that actors acquire through participation in practices and through drill. Practical understanding displays an ability of knowing ‘how to go on’ and having ‘a feeling for the game’, thus acting according to the prevailing standards of the practice. Bourdieu stresses (1990, Chap. 4) that the acquisition of the skills is very much a matter of bodily incorporation and Wittgenstein highlights the importance of drill and training in learning how to follow rules and partake in ‘a form of life’ (1958, §218ff.). From a practice theoretical perspective it is important to understand the *processes of becoming* an engineer and understand how the practice of engineering is reproduced through learning and training activities. That might be in engineering schools and universities but also very significantly in work practices. Practices thus only exist as continual (re)productions or accomplishments.

Another ordering element is of course the *explicit rules*, regulations, instructions, standards, and procedures that are pertinent for specific practices. Engineering is a profession that is regulated by professional bodies, legislation, corporate rules, standardization of equipment, safety procedures, etc. The institutional role of engineering as a profession in society is regulated through myriads of restrictions and allowances that shape and order the labor processes through e.g. the division of labor among professionals, and the incentive structures in wage or contract labor. These explicit regulations are very much based on conventions and bear huge national differences. But they are essential in shaping the practices of engineering education and work. Gary Downey and Juan Lucena (2005) for example demonstrate how the ongoing internationalization of engineering work has ramifications for engineering education and thus the formative training of engineers into the profession.

According to Schatzki a third ordering element that links doings, sayings, tasks, and projects is the *teleoaffective structures* of practices. “A ‘teleoaffective structure’ is a range of normativized and hierarchically ordered ends, projects, and tasks, to varying degrees allied with normativized emotions and even moods (Schatzki 2002, p. 80).” These structures need not be explicitly conscious goals to, or ends in view for the actors, but should rather be seen as structural signifiers that give an overall sense to actions. Schatzki emphasize that these structures are recurring effects of actions and should not be conflated with structuralist accounts. The teleoaffective structures emerge when there is general agreement about what is acceptable or unacceptable to do in situations. The presence of teleoaffective structures does not exclude controversy or disagreement about specificities but provides an overall sense of purpose and direction for the activities. The structures both produce the practice and are produced by the practice. Louis Bucciarelli and Sarah Kuhn (1997, p. 212) describe the ‘object worlds’ that engineers live within in the following words:

....the goal of storytelling and scenario making is to achieve closure: arrive at a design that is fixed, repeatable, stable, unambiguous, and internally consistent. Object world thinking is thinking about the rigidly deterministic. [...] The engineer’s ability to abstract from a concrete situation, to see an object as a collection of forces, or as a network of ideal current generators connected in series and in parallel, is key to problem solving and to managing complexity within object worlds. One of the crucial skills conveyed as part of disciplinary training is the ability to look at a design, or at a collection of objects, and to see them as an abstraction to which scientific principles can be applied.

These observations of the overall goals that inform engineering work both describe the overall teleology installed in engineering practices and clearly demonstrate the normativities, values, and virtues that actors subscribe to in engineering practices.¹

A final ordering element relates to the *general understandings* that are available to and shared by actors within a practice, though these general understandings, as the word indicates, are not proprietary of specific practices, but are generally shared norms and values. However, they are also active in structuring specific practices. Engineers like all other members of a community endorse certain religious, ethical, ideological, or political norms. Many of these are codified in codes of conduct within companies or professional societies and associations (cf. Van de Poel and Royakkers 2011, Chap. 2), but they need not be explicitly stated to be conductive. These general understandings thus often span different practices and can make them overlap at specific junctures in history.

These ordering elements of practices are not meant to be jointly exclusive or exhaustive characteristics. On the contrary the elements are combined in the doings, sayings, tasks, and projects of the practice in complex and interwoven ways. Thus the specific constellation of these – and maybe other – elements compose the uniqueness of the practice. Furthermore, practices are always situated in specific orders or arrangements that comprise both practices and non-human/material objects. The arrangements and the social practices thus jointly constitute the overall site where things exist and events happen (Schatzki 2002, p. 63). Sites are a special kind of contexts – namely the kind where practices unfold in activities and events. To put this point another way, sites are the kind of contexts where actors' ends and human intentions matters. Sites are thus not only locations in objective time and space or even activity-place space, but they are also significantly teleological located. Sites are part of 'wider scenes' of events and activities. The bio-chemical engineers reading of the thermometer is an activity that is part of the event of the experiment. Likewise, the experiment is part of a project about the development of new enzymes, and this project, in turn, a part of a company's ambition to develop new products that can increase profits, etc. Sites are thus nested. Finally, for an event or activity to occur within a site is tantamount to that event or activity being a constituent part of that context. Activities and events are thus both contained in the site, but also an integral part of the sites makeup.

This site ontology forefronts and gives special attention to human activities and social practices by highlighting the teleological and intentional dimensions of activities. While recognizing that practices are intrinsically interwoven with material objects, and that objects in significant ways order, prefigure, and causally impact practices, the ontology is reminiscently humanist. It gives special attention and priority to human endeavors.

¹I am quoting Bucciarelli's and Kuhn's description of the 'object worlds' of engineers not to make a general point about concept of 'object worlds' in relation to teleoaffective structures, but to illustrate the overall teleology and normativity that is installed within engineering practices.

Methodological Pluralism

What are the consequences of a practice perspective for engineering studies? It is obvious that the practice perspective introduces a new ontology of sites, orderings and practices and thereby envisions the research object – engineering – in new ways. Engineering is not to be studied as either encompassing structures or individual achievements, through the lens of technological determinism or subjective voluntarism, or as an act of intellectual or manual work. Instead the practice perspective suggests that engineering should be studied as an ongoing practice of day-by-day skillful and goal oriented social and material reenactments of procedures and (codified or tacit) rules. Thus the practice theoretical perspective not only suggests a new ontology, but – by implication – methodological approaches:

In the end, I believe, one should adopt a neo-Quinian picture of social investigation in which (1) ontologies are part of the conceptual armature of social investigation and (2) arguments about ontological issues are part of the overall enterprise of social research, another part of which is the methodic gathering of data. (Schatzki 2003, p. 189)

Schatzki thus, by alluding to Quine’s doctrine of confirmation holism (Quine 1961), suggest that the conceptualization of practice ontologies should be informed by methodological considerations and vice versa. Although Schatzki (2002) throughout the development of his ontological suggestions gives empirical illustrations, he does not develop a methodology. Others within the practice tradition have, however, elaborated detailed accounts (e.g. Gherardi 2012; Nicolini 2009, 2013). Nicolini seems to agree with Schatzki that methodologies and ontologies are closely interwoven and that the researcher in his/her investigations must develop a sensitivity and flexibility to adopt the right tools for the right job. In recognizing the complexity, heterogeneity, and uniqueness of practices and the varying research interests of researchers, different methods and approaches must be adopted. In the broad spectrum of practice theoretical approaches different research agendas have appeared. In the traditions of discourse analysis and conversation analysis special focus has been given to the role of language and communication in practices (e.g. Fairclough 1995; Richards 2001), theorist like Orlikowski (2000) and Activity-Theorist (e.g. Engeström 1999) have, respectively, paid much attention to the role of technological artefacts and the role of tools within practices, Lave and Wenger (1991) have stressed the role of identity and belonging to communities of practice, and ethno-methodological research (e.g. Garfinkel 1967) has given special attention to the minuteness of day-to-day activities as accomplishments of practices. Practice theorists have thus adopted different methods and approaches according to the specific research interests and the specific character of the practices investigated. Nicolini (2013, p. 213) suggests that the practice theorist adheres to a methodological pluralism in research:

[...] I will embrace a [...] strategy that can be described as a form of programmatic eclecticism or, more simply, a toolkit approach. My main tenet is that to study practice empirically we are better served by a strategy based on deliberate switching between theoretical sensitivities.

Just as the study objects of practice theorists – the constituents of practices – are situated in and reenacting complex practices, so are the researchers themselves. Researchers select their study objects according to specific purposes, goals, interests, perspectives, and motives and their research practices are prefigured by material, technological, institutional, and economical restraints and affordances. The character of the theoretical perspective, the chosen nature of interaction and intervention in relation to the objects of study, and the chosen methods of data interpretation all underlines the performative, partial, and perspectival nature of research. The deliberate and reflexive consideration of the choice and use of methods and theories can be seen as strengthening validity and transparency in the research process. But the practice theorist must insist that there is no one privileged perspective or method that can represent the totality or complexities of practices. In understanding the character and dynamics of practices, research will always be on its way to find more apt and more sensitizing questions and concepts for investigation as well as reconsidering the overall usefulness of methods.

It must be realized that practices always exist and develop in relation to other and wider practices. Practices are nested and bear relational ties of causal, spatial, intentional, restrictive, and affording characters to the arrangements they are part of (Schatzki 2002, 38ff.). To understand these entanglements and relations adequately Schatzki proposes (2002, p. 41) that the accounts

....of social relations must satisfy at least two desiderata. First, it must construe relations as links among particular entities, as opposed to types of hypostasized abstractions. Second, it must cover the full range of connections among components of arrangements through which human lives hang together, not just links that join humans directly.

These desiderata point to the fact that practices are impacted by and have ramifications on events and happenings beyond the practice considered. Schatzki thus calls for methods of study that are able to understand the situated and contextual character of the practices. Nicolini suggests a research method that honors Schatzki's requirements. He suggests that the repertoire of practice theories is mobilized according to the specific character of the research field and the specific interests of the researcher. This calls for a reflexive, flexible, and innovative use and combination of tools available. He does, however recommend that the research follow a pattern of zooming in and zooming out on the practices under investigation. Starting by zooming in on the located practice – i.e. the doings and sayings of the participants in the practice, describing the temporal flow of the practice, accounting for the practitioners' general understandings and horizons – Nicolini argues (2009, p. 123) that the researcher can start organizing the ethnographic research process. The zooming in should then be followed by a process of zooming out in time and space in order to 'follow the practice' wherever it has ramifications. This process of zooming out is motivated by the same reasons George Marcus (1998) laid down for doing multi-sited ethnographies, namely the increasingly dispersed and network character of human lives. The zooming out is thus laying out the rhizomatic nature of practices and describing the texture of connections between practices. The process of zooming in and zooming out should be iterated until the researcher feels comfortable explaining why the practices are the way they are.

Studying Engineering Practices Through the Practice Lens

Feldman and Orlikowski (2011) point to two advantages in adopting the practice lens. Firstly, practice theory does not pretend to produce theoretical generalizations and give universal explanations. Instead practice theoretical studies are preoccupied with the situated dynamics of practices. “[But a]lthough each context of study is different, the dynamics and relations that have been identified and theorized can be useful in understanding other contexts. In this way, theoretical generalizations are powerful because they travel” (Feldman and Orlikowski 2011, p. 1249). Secondly, Feldman and Orlikowski stress that practice theoretical generalizations can be of practical use in identifying organizational levels of change and supporting or restricting specific microdynamics, e.g. by highlighting the reproductive effects of identified practices.

Let me try to exemplify the potentiality of the practice perspective vindicated by Feldman and Orlikowski by introducing two very different research projects of relevance to engineering studies. Neither of these projects is conducted under the aegis of ‘practice theory’ in any strict sense, but they serve to illustrate problematics that are both central to engineering studies and that can be framed in terms of practices. The first project is the ongoing PROCEED project (Program of Research on Opportunities and Challenges in Engineering Education in Denmark)² that strives to elicit the challenges facing engineering (education) today and analyze the response strategies taken towards these challenges. The other one is an experiment with the human practices in synthetic biology undertaken by Paul Rabinow and Gaymon Bennett (Rabinow and Bennett 2012). This project aimed to develop ethical practices among groups of bio-engineers that did research in synthetic biology.

Challenges Facing Engineering Education

The literature on the challenges facing engineering is vast.³ Although most observers agree that the challenges are many there is no consensus about the nature of the challenges. Some observers stress that labor market demands call for engineers to be more business oriented and flexible in order to guarantee employability and competitive advantages on a personal, organizational and national level. Other observers call for engineers to recognize their professional responsibility and to conduct their engineering professionalism in ways that serves humanity and the environment. Still other observers stress that the disintegration and proliferation of technological knowledge in modern society calls for a new brand of hybrid engineers that can synthesize technical and social elements. Thus, according to the observers, engineering education has to change its curriculum and didactical principles to

²For more information visit: <http://www.proceed.dk/?languageId=1>

³The points made in this sections are further developed in Buch (2012).

accommodate the challenges as perceived by the respective observers. The challenges are thus construed in an ontology that stipulates them as objective and irredeemable. This construal installs a one-way causality that demands certain changes within engineering education in order to accommodate the objective challenges facing engineering. Reformers thus contemplate how curriculum and didactics should be changed in order to educate either more flexible, more responsible, or more hybrid engineers.

Now, reframing this problem in the light of the practice lens construes the problem in a different way. First of all, the ontological status of the challenges should be reconfigured and situated in relation to specificities of the observers' normativities and positions in society. The challenge perceptions should be understood on the basis of the interests, privileges, and power relations associated with the observers' positions. Furthermore, the manifestations of the challenge perceptions should be studied as material-discursive practices – and so should engineering education. Thus, secondly, the one-way causality between presumed societal, normative, and epistemic challenges to engineering on the one hand and engineering reform on the other must be questioned. Challenge perceptions (i.e., the initial framing of what engineering is and what is wrong with contemporary engineering education) and response strategies (i.e., indications of how engineering education should be reformed) are intimately linked and co-constitutive. It is not possible to establish a 'view from nowhere' to identify challenges and suggest reform initiatives. The challenges to engineering are always perceived from somewhere, e.g. the perspective of commercial enterprises, the engineering profession, or academia. Furthermore, these vistas are formations of enacted material-discursive practices that privilege certain virtues – such as e.g. profit, professional autonomy, or intellectual reflection.

The PROCEED project studies practices in engineering work by ethnographic methods that elicit the practical understandings, the rules, the teleoaffective structures, and the general understandings of the engineering practices. This is *not* done in order to establish a 'more realistic corrective' to engineering reform initiatives, although it does qualify imageries about what engineering work 'really' is nowadays. Instead, the intention of doing engineering ethnographies – seen from the practice theoretical perspective – is to identify dynamics and relations at play in engineering practices that can be theoretically generalized. One significant thesis of my research is that in order to understand engineering practices adequately the specific relations between the constitutive relationships of engineering educational practices and engineering work practices must be illuminated. My studies in engineering work practices indicate that the professional preferences, perspectives, and aspirations of engineers significantly points to formative processes, identity formations, and socialization processes initiated during engineering education. Accordingly, the practice theoretical methodology recommends to 'follow the practice' around – significantly, I would argue, from engineering educational practices to engineering work practices. Adopting a practice theoretical perspective in engineering studies thus calls for undertaking more longitudinal studies of transitions between engineering education and engineering work. It is vital to understand the ramifications and dialectical interplay between educational practices and work

practices in engineering when educational reform initiatives are discussed. The discussion gets off on the wrong foot when challenges to engineering work practices are reified and engineering education is perceived as an independent variable in construing a ‘match’ between demands for engineering competencies and the production of engineering capabilities in education. Adopting the practice lens can rectify this deficient perspective and provide a richer and more dynamic way of framing the discussions on reforming engineering education.

Designing Engineering Practices

Feldman and Orlikowski’s second point has to do with change and how practice theoretical studies can contribute to stimulate changes in practices by highlighting the micro-dynamics of the practices. It is obvious that the analytic identification of dysfunctionalities within practices can provide a good starting point for interventions. The question is whether the practice theoretical approach has potentiality beyond the mere analytic identification of micro-dynamic dysfunctionalities. It is not possible to settle this question here, but I will point to an interesting research project conducted by Rabinow and Bennett (2012, 2013) in synthetic biology. I leave it as an open question whether Rabinow and Bennett’s approach describes a way forward for practice theoretical interventions.

Rabinow and Bennett (2012) report on an intervention ‘experiment’ they conducted at the Synthetic Biology Engineering Research Center (SynBERC) from 2006 to 2010. They were invited to participate in a NSF project and develop bioethical procedures and reflections for the new research traditions of synthetic biology. Instead of framing the task as a question of providing ethical criteria and codas for scientific conduct, their ambition was to make a design for human practices in research processes that could lead to human flourishing in the sense of the ancient Greek concept of eudaimonia. For reasons we do not have to go into here the project failed and the initiative at SynBERC was abandoned, but it is worth considering the general idea of an interventionist practice theoretical approach. Rabinow and Bennett suggests that this approach should be outlined as an ‘anthropology of the contemporary’. Unlike Foucault’s method of ‘a history of the present’ that problematizes present constellations and practices and demonstrates their inherent contingencies by using archeological and genealogical methods, an ‘anthropology of the contemporary’ proceeds through different rationales:

[...] techniques for demonstrating contingency and for opening up possibilities, such as the history of the present allows, are not the principal aim and necessity. Rather, analytic modes are needed for giving form to under-determined and emergent relations, and for specifying the significance of these relations (Rabinow and Bennett 2013, p. 2).

Rabinow and Bennett suggest that research engineers and anthropologists join up in collaborative practices in order to reflect on possible blockages and opportunities in research. The common task at hand is thus to reframe the blockages and opportunities in new ways that opens for new solution spaces. When the anthropologist enters a

practice and engages in collaborative reflections with the practitioner, new avenues of actions are made available for enactment. Thus Rabinow and Bennett suggest a new research agenda where anthropologists and other social scientists concerned with the study of human practices join up with researchers in the natural and technical sciences as co-researchers in order to incorporate ethical reflections in the unfolding research process. This practice theoretical proposal indicates a shift from downstream to upstream or midstream research where the role of social scientists are changed and the performativity of the research enhanced. I will refrain from discussing the viability of Rabinow and Bennett's proposal. But the example helps to illustrate the performative potentialities of practice theoretical approaches.

Conclusion

Engineering studies is a relatively new research field. Although there is a rich literature on engineering work and engineering education, it is only recently that efforts have been made to establish engineering studies as a research field in its own right with scientific journals, conferences, etc. In this chapter I have suggested that the practice theoretical research approach could serve as an impetus for engineering studies. Although it must be recognized that practice theory is not a monolithic theory or a unified methodology I have argued that it has potentials that can support and propel engineering studies. By stressing that the phenomenon of 'engineering' should be conceived as enactments of practices of skillful work, routines, rules, rituals, and procedures, and by paying attention to the normativities of these practices, the complexities and dynamics of engineering can be studied without resorting to reified conceptions. Likewise, practice theoretical efforts to avoid dichotomies can help understand engineering practice as an embodied activity that unfolds in materially situated contexts. I have proposed that Schatzki's outline of a site-ontology could serve as a useful conceptualization of 'context' in engineering studies and thus guide investigations in paying attention to how practices are normatively ordered according to the general and practical understandings, rules, and teleoaffective structures. Further, I have argued that engineering studies could benefit from the methodological resources of practice theories. Here I suggest that engineering studies employ the plurality of methods made available by practice theories in accordance with the specificities of the particular site of study and the perspective of the researcher. Finally, I have exemplified how the adoption of a practice perspective in research could suggest new avenues for structuring engineering studies that have 'practical' implications. All in all, I have made an argument for engineering studies to consider adopting the practice theoretical lens in developing the research field and for developing an adequate conception of context to understand engineering practice.

In closing this chapter I would like to point to the critical potentials of practice theory. Charles Taylor has discussed the development of the practice theoretical perspective through the work of Heidegger and Wittgenstein (Taylor 1995). His discus-

sion shows that Heidegger's account of the 'finitude' of human existence (Dasein) and Wittgenstein's account of 'meaning' as an unfolding 'form of life' (Lebensform) both aim to contextualize human understanding in relational and situated ways. Taylor sees Heidegger's and Wittgenstein's accounts as significantly counter-cultural and critical in the sense that they oppose the western cultural ideals of human intelligibility as disengaged and atomistic. Heidegger and Wittgenstein thus confronted the western intellectual legacy by criticizing the mentalist, rationalistic, individualistic, and disengaged ideals and conceptions that have informed science and technology in our culture. In drawing upon the insights of Heidegger and Wittgenstein, practice theory thereby installs a fundamental critique of the ontological and epistemological foundation of prevailing western scientific and technological enterprise. I think the critical perspective of practice theory would be an appropriate stance in the study of engineering practice and expert cultures – although, judged by the standards of the field under study, properly a rather awkward one.

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Anders Buch M.A. in Philosophy, University of Copenhagen, and Ph.D. in Educational Studies, Roskilde University. He holds an associate professorship in Techno-Anthropology at Aalborg University Copenhagen at the Department for Learning and Philosophy and he is affiliated to the Centre for Design, Innovation and Sustainable Transitions (DIST). He has published articles and books on knowledge, learning, education, and the professional development of engineers. He is presently involved in the strategic research alliance PROCEED: “Program of Research on Opportunities and challenges in engineering education in Denmark.”