Practicing & Changing Engineering Design

a practice perspective on challenges in engineering design education

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PhD Thesis

Rikke Premer Petersen

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Practicing and Changing Engineering Design
PhD thesis
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to my dad.
wish you had been here to discuss and contribute.
now I understand us both that much better.

RESUMÉ

Med ph.d. afhandlingen *Ingeniør-design i Praksis og Forandring* har målet været at bidrage til en mere situeret og socialt informeret forståelse af den kløft der tilsyneladende er imellem ingeniøruddannelse og ingeniørbeskæftigelse i lyset af nutidige og fremtidige udfordringer for ingeniør-design professionen.

Områderne uddannelse og beskæftigelse repræsenterer konceptuelle forståelser af læring og arbejde i vores vestlige samfund, men har også historisk rodfæstede infrastrukturer der holder de relaterede institutioner fast. Baseret på et etnografisk informeret studie af ingeniør-design inden for begge områder anlægger projektet et praksis-teoretisk perspektiv for at åbne op for disse forståelser og infrastrukturer og finde ud af hvordan vi kan forstå den tilsyneladende vedholdende udfordring med at spejle professionel ingeniør-design praksis i vores akademisk baserede uddannelsessystem.

Projektet bruger thick descriptions af det empiriske materiale til først at give en forståelse af hvordan ingeniør-design-arbejde foregår i praksis. Ved at frame ingeniør-design praksisser som i bund og grund epistemiske praksisser (fyldt med flertydighed) bliver analysen sensitiv overfor heterogeniteten og den socialitet der ligger ud over de emner der typisk diskuteres af undervisere og arbejdsgivere i ingeniørfaget (såsom specialiseret og kodificeret viden og kernekompetencer).

Dernæst, ved at skifte fokus til ideer om forandring og udvikling af ingeniør-design praksisser, giver projektet en analyse af de infrastrukturer der opretholder og stabiliserer uddannelse og beskæftigelse. Det empiriske materiale illustrerer hvordan forandring af eksisterende praksisser kræver mere end initiativ og lokal ageren fordi de underliggende infrastrukturer er seje og rækker ud over mange forbundne praksis-bundter.

Ph.d. projektet bidrager således med en ny praksis-teoretisk forståelse af ingeniør-design i praksis og forandring i Danmark.

SUMMARY

With the thesis *Practicing and Changing Engineering Design* the aim has been to contribute to a situated and socially informed understanding of the perceived gap between engineering education and engineering occupation in light of contemporary and future challenges for the engineering design profession.

The spheres of education and occupation represent conceptual understandings of learning and working in our western societies, but also historically rooted infrastructures that hold our institutions in place. Based on an ethnographically informed study of engineering design within both spheres, the project pursues a practice theoretical perspective to open up these understandings and infrastructures in order to find out how we might understand the seemingly persistent difficulties of resonating professional engineering design practices in our academically informed educational system.

The project uses thick descriptions of the empirical material to first of all provide an understanding of how engineering design work is practiced. By framing engineering design practices as essentially epistemic practices (wrought with ambiguities) the analysis is sensitive to the heterogeneity and sociality that lies beyond topics usually discussed by engineering educators and employers (such as specialised and codified knowledge and core competences).

Then, shifting attention to the ideas of changing and developing engineering design practice, the project offers an analysis of the infrastructures that uphold and stabilise education and occupation alike. The empirical material illustrates how changing existing practices requires more than initiative and local doings because the underlying infrastructures are tough and reaches across many interconnected bundles of practices.

The PhD project thus contributes with novel practice theoretical understanding of practicing and changing engineering design in Denmark.

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PREFACE

Paraphrasing Bucciarelli's introduction in "Designing Engineers" (1994): This is a storybook. But a storybook in more than one way. As any PhD thesis, this is the story of traveling through and engaging in a research topic. The words written on these coming pages are the material result of many hours, many thoughts, many frustrations, quite a few tears, and finally a growing understanding of a to me new world of researching.

But apart from the story of the lone PhD student who set out to 'know' something new about her world, it is also the story about becoming an engineering designer, working like an engineering designer, and attempting to change what it means to be an engineering designer.

I therefore invite my reader to come with me on a journey through a diverse but interlinked landscape of engineering design practices in Denmark – a landscape I have engaged in as an engineering designer myself, but now turned around to look at as a young scholar.

April 2015

Thanks

This PhD project has been financed by Aalborg University, Department of Development and Planning and the Danish Strategic Research Council as part of the PROCEED research alliance (www.proceed.dk). Thank you for offering the opportunity to conduct the research that presented here.

I am also most grateful to the individuals that have allowed me to peek into their professional lives for a period, looking over their shoulders and asking them questions. My project would be nothing without the insights that you have given me.

No doubt this thesis has greatly benefitted from discussions and suggestions proposed by my two advisors. Ulrik, you will remain a great inspiration with your (seemingly) boundless insights and opinions of the world in general and engineering in particular. Anders, you took me under your wing and opened a completely new way of reflecting and thinking about myself and the world that surrounds me. It has been a struggling exercise for me – but despite all of my tears of frustration I would not have been without it. Thank you for continuing to see some potential in my work even when I saw nothing at all. I truly would not have made it through this rubric's cube of a project without you.

I have also been fortunate to spend my time as a PhD candidate in a multifaceted research environment surrounded by dedicated scholars at the DIST centre in Copenhagen. Though life as a PhD candidate can at times be solitary – or perhaps especially because of this – the everyday environment is crucial when trying to hold on to your sanity. Therefore I owe my follow PhD 'roomies' many thanks for both inspiration and distraction, for laughter and shared frustrations, for making it all an experience worth cherishing. Signe, Anne Katrine, Charlotte and Louise you especially have made the world of difference.

Last but not least a big thanks to my mom for loving me through it all. You may not understand my work but you understand me.

1

I begin with an idea
and then it becomes
something else.
Picasso

INTRODUCING

What is engineering design today? What role does engineering education play in the development of this profession? How is engineering design changing in light of contemporary and future challenges? And why is it not changing very much?

This first short part will provide an overall introduction to the thesis, its origin, ambition and direction. Engineering design is a field close to my heart and moving into it as a scholar rather than a practitioner has been an interesting though also challenging journey. My interest has been to explore the relation between engineering education and engineering occupation, giving my problem area a dual character that permeates the entire thesis. All of this is tied together in the problem statement, which forms the common thread through the following parts.

1 INTRODUCTION

engineering on the move

I grew up as the daughter of an engineer. My dad was what we in Denmark called a *teknikum* engineer – a type of education which is now long gone. He originally trained as a bricklayer with a local master builder and then built a 3-year engineering degree in building construction on top of this. In his work at a consulting engineering company he actively used that he literally knew how buildings are constructed for he had done so with his own hands. A recurring anecdote in my childhood home was how the local constructors he supervised as a project leader respected him when he arrived on site in coveralls, rubber boots and hard hat ready to go through even the dirty details and make notes in his little notebook (not like his colleagues in hard-hat and tie). They respected him for his practical know-how and understanding of their work. Today, when looking at the meticulous drawings he produced as part of his final project at the Teknikum or the brick house he designed and build for our family I find myself marvelling at these traces of what today appears to be a lost craft.

Engineering design in some of its forms has thus always been present in my life and working with my hands continues to be something I treasure today. However, when I myself started studying engineering I experienced a different way of developing the required engineering competences. Had I chosen to follow in my dad's footsteps and become a contemporary civil engineer I would have been subjected to a curriculum where theory precedes practice, where the general precedes the particular and where basic science forms the grounds for understanding and later applying engineering sciences. I instead chose what today appears as a kind of middle ground to these two strategies of educating engineers: I applied to a design-oriented engineering program where hands-on project work was integrated alongside the theoretical introductions right from the first semester. The engineering design program that I attended was a new

addition to an otherwise largely traditional selection of educational programs. It embodied an ambition by the faculty to try to change the way engineering education is thought and engineering design is done.

Engineering design in its many forms is essential in our contemporary societies and an abundance of complex economic, social, and sustainable challenges means that we need engineering designers capable of engaging with such intricate, multi-facetted, and essentially open-ended tasks. But the question is whether our current ways of educating engineering designers sufficiently prepares them for such work? Having received an engineering degree today means that you have been able to 'survive' large amounts of mathematics and science courses that other people grow faint just thinking about – and it thus automatically grants you considerable respect. But is the continued scientification of the engineering profession really in our best interest? Does mathematics and natural sciences continue to form the most important foundation for offering engineering solutions to our intricate contemporary challenges?

The purpose of this thesis is to understand the intricate relation between engineering education and occupation and how the past and present holds consequences for the future of engineering design practices. My hope with this is not to come up with the answers to how we should educate engineers in the future, but rather to help build an understand of what it is that feeds into such education and the actual work-situations that graduates will later engage in, especially focusing on the design work.

MOTIVATION

My own background in one of the new, more socially informed, engineering design programs necessary influences my motivation for venturing into this particular project.

I recognise that we are all individuals. Demarcated by our physical bodies and dedicated brains, each of us is a unit; an individual recognisable from others; each of us unique in our own way. But we are also equipped with amazing senses that enable us to perceive and respond (more or less consciously) to the world that surrounds us – especially enabling us to relate to other individuals. And so we are all essentially *social*. We do not live our lives in isolation but in constant confrontation and interaction with others. We form relations and our relations form us. We are not who we

are simply as a consequence of ourselves, but also as a consequence of the sociomaterial contexts we live in.

Sometimes, however, we do everything we can to neglect or minimize this aspect of our being. Especially the scientific traditions build on a strong individualistic and positivist understanding where social elements such as ethics, politics, and empathy are given no legitimate room. In search of natural laws human relations and local situations should ideally play no part. Science must remain neutral and raised above all the chaos and unpredictability of human interaction. The engineering professions have spent many years working towards these scientific ideals. Today, engineers have a reputation for being rational problem solvers to whom numbers and things speak louder – and more truthfully – than human voices. Everything can be measured and translated into an equation, a diagram or a chart.

While this image is often unjust it does hold some truth. For decades our engineers have been trained to value science and objectivism, to provide factual evidence, and to validate solutions with increasing accuracy and accountability. This has played a major part in securing the technological development that underpins our contemporary societies. But – as an engineer myself – I must also admit that numbers cannot be the answer to everything!

What do we do when humans and empathy are put into the equation? How do we design solutions that actually *work* in the sociomaterial context that is our everyday life?

The dichotomy between the technical and the social proves to be more and more problematic as technologies become more and more intrinsic parts of the majority of our lives. Technologies influence what we are able to do, how we are able to do it, even where we are able to do it. Technologies fuel our mobility infrastructures, enable our food production, facilitate our communication, support our health systems, and much more. Today, most of us cannot imagine life without a refrigerator in our kitchen, a smart phone in our pocket, a GPS in our car, a computer at our work. But technologies do not emerge by themselves – they are products of interactions, which more often than not involve engineers. Engineers have in this way become intrinsic to the way we have built our societies. This is also why politicians and industrial leaders are so worried when the young generations seem to have lost all interest in that which is (apparently) truly at the heart of engineering: Natural science and mathematics. So

great efforts are now put into growing an interest in numbers and physics experiments in children right from an early age.

Meanwhile, studies of engineering work have shown that engineering is much more than crunching numbers in front of a computer. Engineering work is complex, ambiguous and full of contradictions. It is not only technical but also very much social – and the two are intimately linked together. Designing the future technological solutions that we simply cannot live without relies not only on a sound pool of knowledge within natural science, but just as much (or even more so) on being able to navigate insecurity, negotiate, and form temporal alliances in a social context.

When we know so much about engineering work and all that it implies (due to research within for example science and technology studies (STS) and engineering studies) I wonder why it is still so hard for us to build engineering educations that 'make' great engineers? Why is it so hard to attract a broad selection of students to the engineering professions? Why are employers consistently complaining about the capabilities of new graduates? And why is it so hard to renew the engineering professions, for example as a reaction to the vast social and sustainability challenges we are facing?

My motivation for going into this project is a bubbling hope on the one hand to better understand the challenges that my own profession is facing, and on the other hand to start finding some alternative openings for moving it forward in light of the global, social and environmental challenges that humanity is facing. Focusing on how engineering design is being practiced today I hope to improve the understanding of the intricate elements involved in such work, and focusing on some of the current efforts to change engineering design I hope to identify some of the challenges that such efforts meet. Challenges that any potential openings will have to tackle.

PRESENTATION

I am myself a relatively visually oriented person. As such, I often draw simple visual representations of the ideas or connections that I am trying to figure out. This helps me place elements in relation to each other, form an overall understanding, and look beyond specific phrasings. In this thesis I have chosen to include a selection of such visual representations

– making it perhaps more visually oriented than the average thesis. As is the case with any representation these should not be seen as an attempt to capture *everything* – and might just as well draw attention to what is *not* represented as to what is. When I include them after all it is because I believe that textual and visual representations in collaboration come closer to mediate a whole than for example a text on its own is able to. Different representations spur different kinds of thoughts and 'speak' to different kinds of readers.

Throughout the text I will also introduce concepts from my theoretical framework and use them in my descriptions and discussions. To give the reader a quick way to re-acquaint with these along the way, the most central terms are briefly outlined in the back of the thesis under *Concepts*. In the main text these will typically be in italics to make it clearer when the terms are used with their theoretical reference.

1 PROBLEMATISATION 2

education and occupation

With this thesis I am moving into contested waters. Politicians, corporations, students, unions, and of course scholars from various fields all have plenty of opinions of what 'real engineering' is or should be and how the engineering community may best serve our societies. This chapter is meant to lay out my path into these waters through the overall problematisation and ends up with the problem statement that shall navigate us through the rest of this thesis. First, however, it is necessary to briefly outline the problem area that I will be working within.

PROBLEM AREA

In a welfare society, such as the Danish, education is considered an investment in order to achieve a high employment rate but also to achieve a highly *qualified* level of occupation capable of driving the economy of the country. Both the degree and the type of occupation are thus dependent on a well-functioning educational system. Through education (preferably of an increasing level) competent individuals are shaped that are capable of managing all the different types of tasks that our society holds – but also capable of developing and pushing society continuously forward.

You could thus claim that education and occupation are two reflections of each other: Education must prepare for occupation and occupation thus necessarily becomes a product of education. At the same time occupation sets up requirements for education, meaning that education is also a product of occupation. This is quite simplistically put here, but it seems clear that there is some sort of reciprocal relationship between the two spheres – but also that there is some area of tension between *education* and *occupation*.

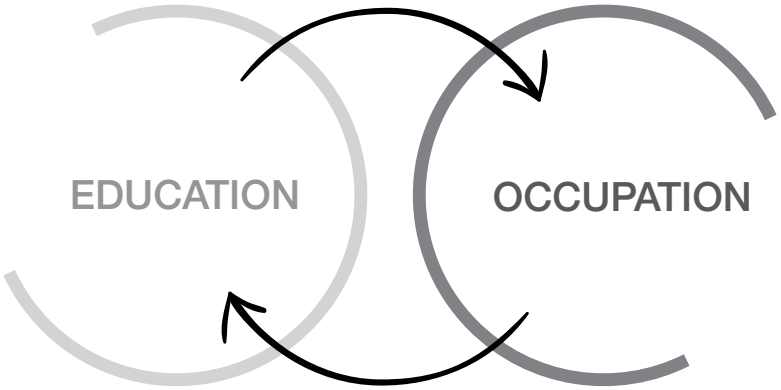


FIGURE 1 | Reciprocal relationship between the spheres of education and occupation.

Even though the history of education and a professional occupation domain goes way back in time, and despite of countless efforts to reform and develop both, it remains a contested field raising more questions than answers. This is the problem area that I am venturing into through this project. Not to come up with the answers, but rather to make my small contribution to improve the understanding of what it is that goes on in-between and across education and occupation.

Let me therefore give a short introduction to these two spheres in order to make my view of these clearer.

EDUCATIONAL SPHERE

In Denmark and the rest of Europe we have well-established institutions and long traditions for education. We see a good education as a prerequisite for the 'good' lives we live, for our wealth and our societies' progress and through education we are brought up to contribute to this. From their study on teaching and learning in the primary school system Kemmis *et al.* offer the following definition of education:

> *"In our view, education, properly speaking, is the process by which children, young people and adults are initiated into forms of understanding, modes of action, and ways of relating to one another and the world, that foster (respectively) individual and collective self-expression, individual and collective self-development and*

individual and collective self-determination, and that are, in these senses, oriented towards the good for each person and the good for humankind." (Kemmis et al. 2014, p26)

While I agree with the general perspective of this definition I do not look at education in quite such broad terms in this thesis. First of all, I shall only deal with the final steps of formal education – that is, the part that builds on previous steps of primary and secondary education before specialising within what we might call professional fields. When we talk about these so-called 'higher' parts of the educational system education is no longer primarily a means to empower and lift the population. Higher education is in stead linked to the development, continuation, and production of professions and professional identity. This is not where you acquire basic skills such as reading or writing or calculating (you should already know how to do that), but instead it is where you develop very specialised skill-sets aimed at the execution of specific types of tasks linked to your prospective profession.

The orientation towards the good of the person and the good of humankind that Kemmis *et al.* point out above also covers another element of education that lies beyond the acquisition of knowledge and skills, however. This is often referred to by the German term *Bildung* (in Danish we call it *dannelse*), which loosely refers to the cultivation of students into persons both in themselves and in the world. While this is a very important part of education (though at times regrettably marginalised) it lies beyond the scope of this project. However, the perspective I am assuming does leave room for a certain kind of professionally oriented Bildung, linked to the professional identity and codes of conduct – more on that later.

My particular interests in this thesis lie within the engineering professions, and so I focus on *engineering education* at a bachelor/master level. Looking at the trajectory of an individual in the educational systems, this is the last 'step' in the educational sphere before entering the job market as a professional engineer within the occupational sphere. This final step is managed by some of our grandest institutions in society: The universities. Engineering has not always been a university education, though, but I shall return to that historic development later.

Universities are typically viewed as knowledge institutions or even 'knowledge banks' devoted to developing and disseminating knowledge at the same time. They thus house a unique mix of research, teaching,

and learning. And we expect that the 'things' students are taught in these institutions are based on the newest research. In other words, students are expected to be stuffed with the newest knowledge and methods within a specific field when they emerge as graduates from their university studies. Not that the only goal of the research conducted at universities is to 'pass it on' to students, but this is the part of the universities' activities that I am interested in here.

Using an industrial metaphor, the universities can thus crudely be regarded as complex machines processing the 'raw material' of young pupils produced by the primary/secondary schooling system, adding elements of knowledge and skill-sets, and then delivering the 'product' of finished graduates equipped with diplomas guaranteeing their qualifications to potential buyers/employers. Much research is aimed at what goes on within this 'machine' and how we might produce the best result. There are large fields within pedagogics, learning, and cognition, which deal with how educators can/should convey their knowledge, how students can/should take up this knowledge, which cognitive processes this draws on in our minds etc. No doubt that the way we educate has improved as a consequence of these efforts. Contemporary education is not about rote learning and physical punishment. Instead, concepts such as problem/project-based learning have grown popular, building on ideas of learning by doing, the value of reflection etc.

This brings me to the second delimitation of my focus. The educational sphere can also be viewed as a professional occupation in itself. Teachers, instructors, and educators all work here to guide and facilitate the learning and development of the students. No doubt that the professional and pedagogical approaches they bring with them hold a great influence on the level and quality of learning that the students take with them. I, however, have neither basis for nor interest in discussing the pedagogics or teaching styles found in the educational sphere. Instead my interest lies with *learning* as a practical and reflected process.

OCCUPATIONAL SPHERE

The occupational sphere is more heterogeneous and difficult to characterise. Put bluntly, it is where most of us spend the majority of our adult lives; it iswhere we generate the income necessary to sustain our living

costs. Put less pragmatically, it is also where many of us find satisfaction in doing a professional job that we are good at and passionate about.

We may find occupation in many different institutional and organisational settings: In private companies from large global corporations to small entrepreneurial endeavours, in public institutions, in organisations, in research institutions, consultancies etc. In all of these people, who we might call *professionals*, work in an abundance of job profiles spanning a multitude of disciplines.

In a knowledge society a significant part of the jobs available will be knowledge-intensive rather than manual and thus be dependent on the intellectual skills of the employees. In so-called *knowledge-intensive firms* (Alvesson 2004) you therefore find a large concentration of people with an academic background from higher education. This kind of formal education seems to promise both the availability of a certain kind of theoretical and analytical knowledge, but also the presence of a certain level of competence and expert knowledge.

Looking at engineers specifically they can find occupation within many different types of workplaces. The engineering specialisations span widely – from chemical engineering to mechanical engineering to building construction – and even within these specialisations the occupational sphere holds many different possibilities. In broad strokes, however, the kinds of positions that engineers hold are typically linked to some form of development work – though it is not rare to find engineers in management-oriented positions either. In large corporations we thus often find engineers in research and development (R&D) organisations charged with the development, documentation and testing of new technical solutions. In this way the occupational sphere spans a majority of occupational areas for engineers. My focus here is on R&D work within the private sector, though much may apply for the public work places as well.

Over the years the occupational sphere has become a place of much circulation for the individual engineer. Where previous generations of engineers made their carriers within a single company, it is now more usual to do so across positions in different companies. In fact, rotation among jobs has become an indicator of the growth we want to create in our societies and changing governments all cater for a flexible labour market where qualifications are easily transferrable and upgradable. This is considered a way for knowledge to travel within or across sectors, supporting the idea of a dynamic knowledge society. Bringing 'something new' is thus often

considered a greater asset today than knowing the company 'bottom up'. In recent years, however, the financial crisis had the negative effect of reducing this job rotation. People were afraid to give up the job they already had in search of a new one (further up the carrier ladder) and risk unemployment. The increased unemployment rates also meant that each job opening had an excess of applicants. A good thing for the companies, you could say, because they were able to pick and choose the most experienced and skilled candidates; not so good for especially the new graduates who had to compete with very experienced people even for 'junior' positions.

Today, we still see unemployment rates for newly graduated engineers that are significantly higher than for engineers overall. The latest statement from the engineers' central organisation in Denmark thus makes up the general unemployment rates for Danish engineers to be a modest 2,5% while it is almost one third of the newly graduated engineers (Akademikerne 2014). Companies seem to prioritise bringing in new employees that are able to participate fully in the work from day one without any additional training – which they do not believe the new graduates are capable of (Bernth 2014).

While my focus here is not particularly on new graduates these numbers do illustrate that there is some sort of 'gap' between the educational and occupational spheres. Somehow the transition across does not occur as smoothly as we like to tell ourselves. For some reason an engineering diploma alone does not ensure that you are a desirable future employee. That is why I find this space across education and occupation an interesting problem area to venture into.

PROFESSIONAL ENGINEERING

The engineering profession that we know today is a highly heterogeneous construction, seemingly always on the verge of slipping apart and yet – so far – held together by a strong institutional tradition. There are in fact embedded tensions in the way we continue to think and do modern engineering education and occupation today, which have strong historical roots. However, providing a clear and linear account of the evolution of engineering is a next to impossible task. Looking back you may be able to draw some overall lines of development, but what is of interest here is

not so much a description of the steps of such a development process but rather the elements that have fed into and influenced the development.

So, you might ask, what is the engineering profession build from? It is actually a profession with multiple roots, which have been greatly influenced by historical developments (and in turn greatly influenced history), technological and industrial developments, and changing social priorities. It is also a profession that has found different manifestations in the different regions of the world. I will not be going into all of this here but instead attempt to outline the overall area of tension in which the engineering profession has evolved (Auyang 2004, see instead Jamison, Heymann 2012, Jørgensen 2014, Kirby *et al.* 1990 [1956]).

How the profession unfolds at different times and at different places appears to be the result of shifting tensions between three 'poles' focussing on: 1) the *practical* utilisation and construction of technology, 2) the *systematic* management and planning of technology, and 3) the *academic* understanding and development of technology (Jørgensen 2014).

The *practical* focus has strong roots in what we might call the craft tradition – that is, the community of skilled craftsmen, artisans, and master builders, which headed the early industries and technological developments. Auyang points out that: "Historically, engineers and their predecessors came mostly from working families, toiled with their hands, relied more on their own thinking and experience than on schooling, and were obliged to deliver products on demand" (Auyang 2004, p114). Well into the 19th century these craftsmen used their significant personal experience and practical skills to either reproduce or modestly evolve known technical constructions to specific needs. You might say they had an embodied 'feel' for or intuition about technologies and their configuration. Up through time this practical association with technologies has been an important element in the engineering profession, though with varying influence.

The *systematic* focus instead has its roots within the military tradition. Historically the military has had great influence on the infrastructural developments of for example transport and communication. The success of such large-scale projects has relied on a strict hierarchical organisation and standardisation ensuring a manageable system of supply chains and technical solutions. Developing down-to-earth doctrines for applying mathematics, geometry, and logic on specific types of problems was an important cornerstone in this work (not to be confused with the more philosophical approach to these subjects found within the university tra-

dition). These doctrines also formed the basis for some of the first textbooks on mechanics and construction. As the engineering profession extended into a civilian profession[1] this focus on a systematic approach to technology has persisted, though it often fades into the background as something taken for granted.

The *academic* focus brings something different to the melting pot of engineering. A long scholarly tradition extends back to medieval cathedral and monastic schools but was more formally established with the first European universities from the 11th and 12th century. However, these existed quite separate from the technological developments. Efforts of constructing abstract and universal theoretical ideas were thus the domain of philosophers and theologians and were strongly linked to the church and (royal) elite until the Age of Enlightenment. Around the same time the Scientific Revolution (starting in the 17th century) also strengthened the emerging research tradition at new national academies. Unlike the traditional university disciplines these new natural sciences developed a research tradition using *empirical* experiments as structured ways of examining nature and using mathematical models as powerful explanatory tools to develop new 'laws of nature' rather than the abstract conceptual thinking embodied by the old universities. This academic focus has had strong influence on the development of the new engineering sciences as well as the science base of engineering educations.

Overall, especially two steps have influenced what we know as the engineering profession from the beginning of the 20th century. The first was the establishment of an accompanying formal education – and thus an official professional title. From the middle of the 18th century the 'polytechnique' schools[2] offered engineering degrees based on practical understanding as well as scientific development with inspiration from the French *Grand école* (these also later inspired the technical universities and their theoretical foundation). Before this, people doing engineering-like work would be referred to by a diversity of titles (mostly influenced by the craft tradition). The new polytechnique graduates were, however, not intended to take over the work of the skilled technicians and constructors or to join the social elite with the university scholars. Instead they entered into the state administration and management of the emerging new industries. As the engineering educations evolved, however, so did the position of engineers in society.

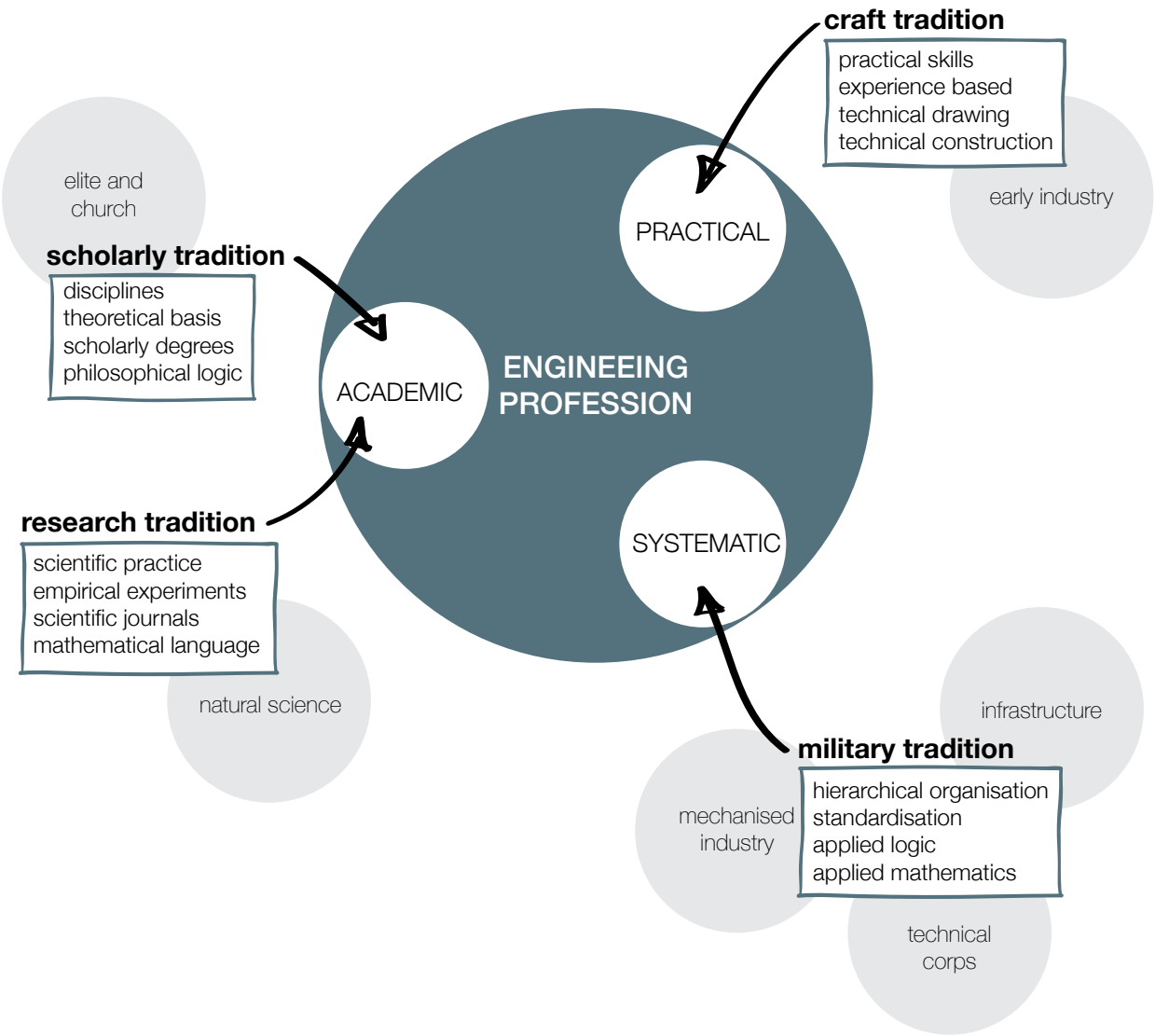


FIGURE 2 | The area of tension in which the engineering profession has evolved.

Because the new engineering educations came to hold such great influence on the practical formation of the profession the *institutionalisation* of the educations also put significant marks on the way we understand and reproduce engineering today.

The new natural sciences were from the beginning strongly linked to the development of the engineering profession – and vice versa. The academies of natural science were entirely devoted to scientific research and not education. Hence it became the new polytechnique schools that to a large extend provided the basic science educations until these disciplines were eventually accepted into the universities and granted their own faculties.

The second step towards engineering as the academic profession we know today was closely related to this development. The meeting between the new natural sciences and the practical engineering understandings thus led to the development of the *engineering sciences* as distinct disciplines in themselves and not just 'applied' versions of the natural sciences. Specialised engineering disciplines such as materials science, control theory, and nanotechnology have since emerged. These scientific developments have in turn also resulted in an increasing number of engineering specialisations and a growing scientification of the engineering educations.

This, however, is not a process without consequences. A report from the American National Academy of Engineering thus points out that:

> *"As time has progressed, however, a disconnect between engineers in practice and engineers in academe has developed and grown. The great majority of engineering faculty, for example, have no industry experience. Industry representatives point to this disconnect as the reason that engineering students are not adequately prepared, in their view, to enter today's workforce." (National Academy of Engineering 2005, p20)*

Again an indication of the contemporary gap experienced between education and occupation.

Now, engineering is still a very broad field to focus on, and a field that continues to grow with technological and scientific advances. The focus here will thus be delimited to *engineering design* in some of its concrete manifestations within education and occupation respectively.

The rest of this thesis will be diving into this particular field of engineering in-between and across the overall spheres of education and occupation – but why is this so interesting?

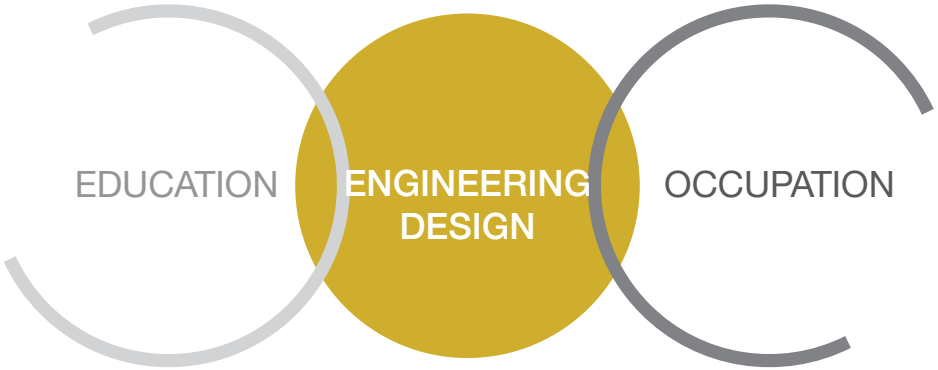


FIGURE 3 | The problem area in-between and across education and occupation.

ENGINEERING DESIGN

The field of engineering design is just one example of an engineering science that has emerged from the process of engineering scientification. While design is essential to all branches of engineering work I will with the term *engineering design* be referring to the field focussed on the creation of new technical artefacts (in some respects the direct predecessor of the craft tradition). Dym *et al.*'s definition can help describe this even better (though understood more widely across the engineering fields):

> *"Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints." (Dym et al. 2005, p104)*

But why is engineering design an interesting field to zoom in on? Engineering design is actually in itself a loosely defined field of expertise with quite different annotations in different contexts. Apart from the overall tensions in the field of engineering there are also some more specific tensions related to the design field.

The notion of 'design' is actually a relatively recent descriptor of engineering work and the way we understand engineering design work is also influenced by several design traditions. During the 1960ies the design perspective first started emerging in the engineering curriculum as part of the construction subjects, most notably in the mechanical tradition (Dym *et al.*

2005, Heymann 2009). The design part has subsequently been strengthened through inspiration from the traditionally more creative and synthesis-oriented industrial design tradition and most recently what you might call the social design tradition (referring to different strands of user-focussed design approaches).

Each of these traditions contributes to the heterogeneous area of tension between analysis, technology, synthesis, creativity and sociality that make up the field of engineering design. They each bring different types of representations (in a wide sense), which are valuable in different situations. An important part of engineering design is thus also to translate between these (Dym *et al.* 2005).

Different strands of engineering design and different design programs emphasise different elements in this area of tension, though most are at

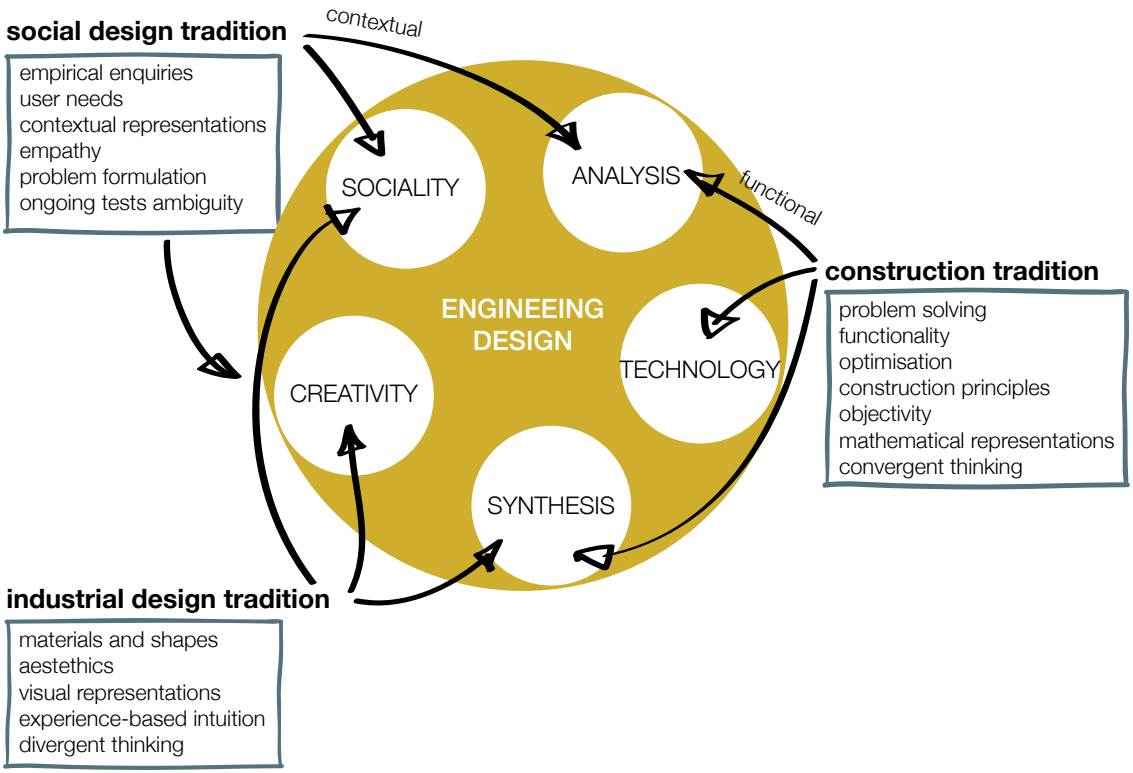


FIGURE 4 | The area of tension in engineering design.

least touched upon peripherally. The strands I will focus on here especially emphasise the social, analytic, and creative elements. In the Danish context the notion of 'engineering design' remains relatively new and not widely applied, though so-called *design engineers* have been educated for a little more than a decade – we shall return to these in Part 3.

AMBITIONS TO PROCEED

When I started this project I became a part of the PROCEED[3] research alliance. You can read from the project description that the overall aim of this alliance was to inform reformation of engineering educations in Denmark to ensure that they live up to the opportunities and challenges facing the engineering professions. In other words, by studying what engineering occupation is in need of, how engineering education works, how engineering institutions have responded to previous challenges, and how engineering students learn, we wanted to point out how engineering education might be improved. An ambition welcomed by the Strategic Research Council, which provided the funds to run this 4-year project.

My project was formulated within this framework. I wanted to focus on the societal challenges requiring engineers to develop *design competences*[4]. By looking at different engineering workplaces and discerning which kinds of design competences they were using and looking at engineering educations attempting to provide such design competences, I originally thought I would be able to come up with suggestions for how we might better equip engineering students with the type of design competences that companies need.

But how do you look for 'competences'? What are they made of? And how are they transferred between education and occupation?

Competences play a central role in how we perceive and talk about both education and occupation: You need to be competent in order to do a professional job, and competence requires explicit knowledge and rule-based skills relevant to your profession. Typically you will acquire this knowledge and such skills through relevant education aimed at the individual learner. Becoming competent is thus in the everyday often seen as an individual accomplishment, though it also includes an idea of being able to *function* in a specific job context.

This has grand implications for the way we have designed our educational system. It seems like we perceive the 'commodity' flowing between education and occupation to be these competences, which are packed in specific combinations within the individual graduate transcending from one sphere to the next. Explicit, academic (and theoretical) knowledge is the currency of education; books provide prestige. 'Higher educations' are termed as such precisely because we value the academic knowledge that these convey *higher* than the more practical knowledge that for example vocational training provides. Competences acquired through academic studies are thought to be worth more (to the society and the economy) than other types of competences.

So why is it that knowledge and competences do not simply flow from the new graduate and into the work at hand when the auditorium and library are replaced with a desk in an open office space or a project room? Why is it, despite of all the efforts that are going into matching competences produced by education with competences needed by industry, that a gap between education and occupation remains? Could it be that we are looking at education from a perspective that locks us into an inappropriate way of doing education? Could it be that we need to look at the connection between these two spheres in a different way? Perhaps competences alone are too narrow a way to describe the relationship between these great spheres.

PROBLEM STATEMENT

In this thesis I would like to question the paradigm of academic education around which engineering is now moulded. With my focus on engineering design it seems particularly problematic that we continue to reproduce a certain understanding of education, competence, and professional engineering. Engineering design is a field that evolves rapidly and transcends the realm of the technical. In a recent report on the competence requirements for Danish engineers in 2020 commissioned by the Danish Society of Engineers (IDA) we read that:

> *"In 2020, research and development engineers must be able to understand and exploit technological convergence at the interface between known and new technologies and increasingly with services embedded as part of the value proposition. In-*

novations are increasingly expected to be a result of team efforts bringing together different fields of expertise. Communication skills, including mastery of foreign languages, are necessary to be able to cooperate effectively with professionals with another area of expertise, who may also be located in another country and in another company. Communication skills therefore also include expectations regarding a global mind-set and cultural sensitivity." (Teknologisk Institut 2013, p8)

The configuration of engineering design, cf. Figure 4, is thus changing and the way we understand the role of engineering education needs to be adapted accordingly. We need to find better ways of understanding the mutually tense and dynamic relationship between engineering education and occupation. The overall question that runs through and ties this thesis together is thus:

How can we understand our academic educational system when it comes to resonating professional engineering design practices?

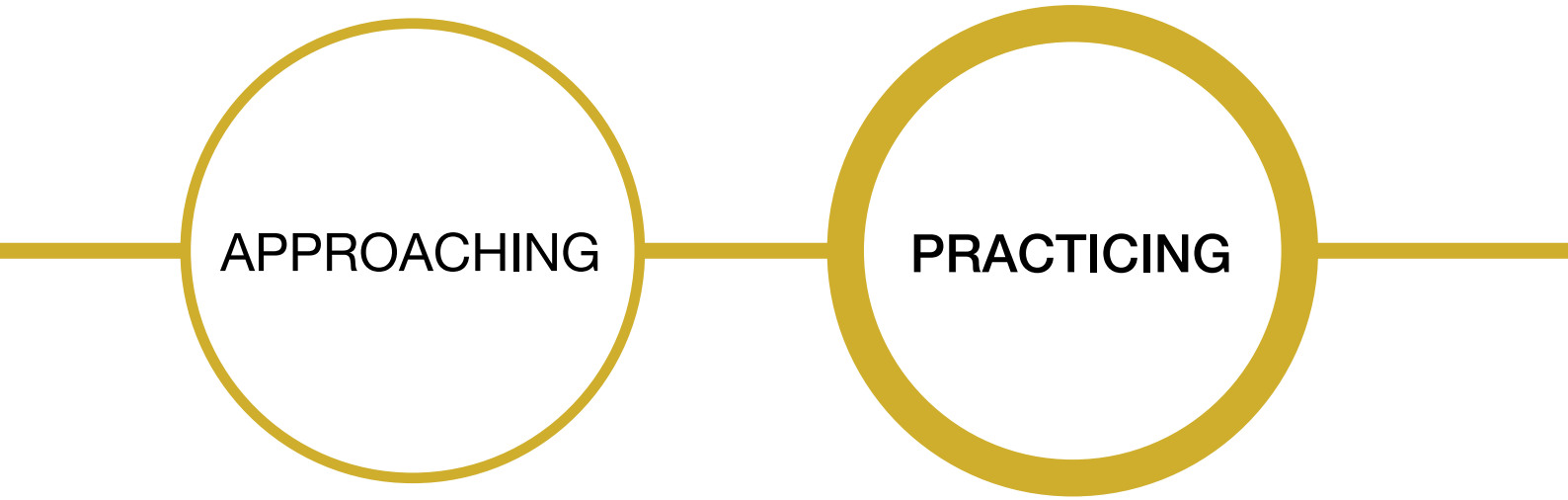
While this question is necessarily broad I will close in on an answer through two successive moves.

First of all, I will take a closer look at how engineering design is *practiced* in order to find out how we might understand design competence: How is competence build and used? How does knowledge figure into this? And what does it take to do engineering design work from a 'practical' perspective? Looking at two specific cases of design practice in the Danish context from occupation and education respectively I will present my attempt at an answer to these questions in Part 3.

Second, I will shift my focus to the efforts of *changing* how you do engineering design in order to become more aware of the kinds of challenges that such efforts face: What does it take to do engineering design work from an institutional perspective? How do ideas of change find their way? And why is the result typically so modest? Looking at two cases where such a change is initiated, also in Danish occupation and education respectively, I will point to some of the challenges that appear to retain us in the traditional ways of doing in Part 4.

By juxtaposing my observations in education and occupation my hope is to end up in a position that allows me to unfold a deeper understanding of engineering design as practice and a profession on the move.

Structure

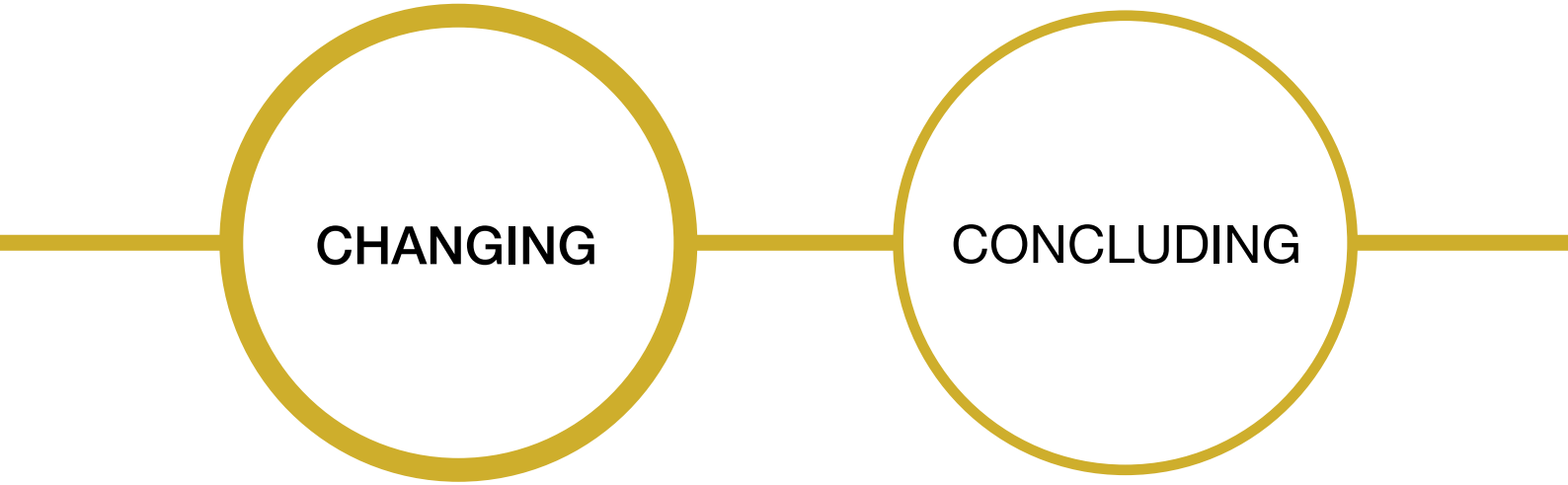


PART 2 | Outlines the basic practice theoretical perspective and multi-sited methodological approach that I have taken to study everyday engineering design practices immersed in organisational structures in this project.

PART 3 | Guided by my first move through the problem area this part focuses on the local practices of doing engineering design in occupation and education respectively.

After an elaboration of the problematic perceptions in the part introduction the main chapters will present the empirical material from two of the empirical sites. The first site is from the occupational sphere and will lead to a subsequent discussion of epistemic practices. The second site is from the educational sphere and will lead towards a discussion of situated learning.

The concluding chapter sums up what the two sites show us about education and occupation in relation to practicing engineering design.

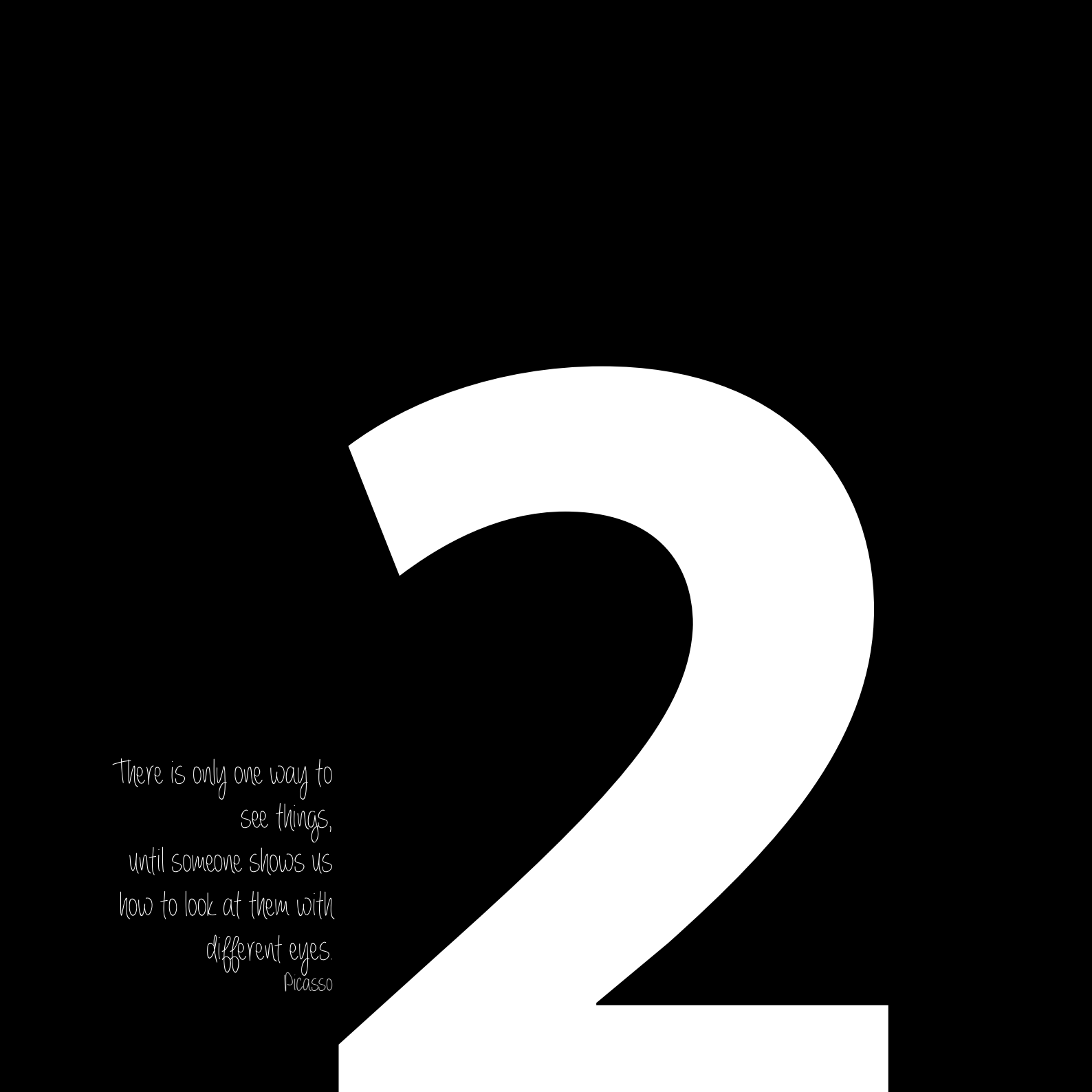


PART 4 | My second move zooms out to focus on the larger constellations of practices that engineering design is entangled with through organisational infrastructures in occupation as well as education.

The part introduction introduces a selection of practice theoretical concepts to help expand the analysis in this direction. The third site, again from the occupational sphere, is presented and discussed in relation to organisational infrastructures. The fourth site returns us to the educational sphere and a discussion of the challenges of initiating new educational initiatives aimed at renewing engineering design practices.

The concluding chapter sums up the infrastructural implications for changing engineering design practices.

PART 5 | The concluding part aims to pick up on how the present exploration of practicing and changing engineering design can help us expand on the understanding demanded in the overall problem statement.


There is only one way to
see things,
until someone shows us
how to look at them with
different eyes.
Picasso

APPROACHING

Before diving into the problem area head on this part shortly outlines the ontological, epistemological, methodological, and conceptual considerations that form the basis for my approach.

Ontology refers to assumptions about the form and nature of reality and what, as a consequence, can be known about this reality, while *epistemology* (in close relation) refers to assumptions about ways of enquiring into that form and nature of reality. *Methodology* then refers to the combination of methods that can be used to actually go out and find what this perspective implies can be known (Guba, Lincoln 1994). Finally, the conceptual considerations provide a fundamental analytical framework to make sense of and represent what is found out.

PERSPECTIVE 2 | 1

relations give meaning

Where you start from and what you look for holds a great influence on what you might see. In this chapter I will therefore lay out the fundamental ontological and epistemological perspectives that form the foundation for this thesis.

Beginning my work on this PhD project I was not a blank slate. I came to this project with a degree in engineering design, funding from a research alliance interested in engineering education, and connections to Danish scholars within STS. With this thesis it is thus not a surprise that I am moving into the realms of engineering studies, looking at what it is engineers actually do and how they do it.

Amongst engineering institutions there is a strong understanding that what engineers do contribute to the general and societal human advancement. This understanding tends to equate technical engineering work with benefits for humanity as a whole – what Downey (2014) refers to as a *normative holism* – implying a linear correlation of scientific knowledge leading to technological abilities. Much work within engineering studies aims to challenge this normative holism in engineering education as well as engineering work, pointing out how this perspective overlooks the complexities of relations and mutual influence between the social and the technical in the activity of doing engineering (Downey 2014).

By now it is no secret that I myself am 'a product' of an engineering education. I have been through all of the subjects of mathematics and natural/engineering science that traditionally qualifies an engineering degree. As such, I come from a world where 2+2 = 4 and where logic is the fundamental driver of realisation. That being said, I am not formed by what you might call a *traditional* engineering education. The educational developers behind my study program were not mathematicians and scientists from the natural sciences but instead STS scholars. Therefore I also

come from a world where technical objects are nothing without their context and user and where social empathy is a central driver in development of new technological solutions. My way of viewing the world thus has a strong *sociotechnical* flavour.

As I started working on this PhD project, however, I soon realised that in order to open up my problem area and thus treat the engineering domain empirically I was in need of something more. In my research the starting point is not a technology as it has been in my engineering capacity but rather a *profession*. Here I am not interested in the resulting products of engineering actions but in the *processes* of getting there. Therefore I eventually chose to abandon the individual nodes of actor-networks and instead focus on the *relations* and *performances* that produce these networks (and keeps them alive) (see e.g. Schatzki 2002). With Bucciarelli I thus recognise that "Designing is a *social* process" (Bucciarelli 1994, p20 (emphasis added)) and therefore I have chosen to pursue a fundamental *practice perspective*.

A PRACTICE PERSPECTIVE

How we live, how we interact with each other, how we make sense of our activities can be seen as practices unfolding and giving meaning to our doings. I approach this thesis from the idea that reality is formed by interweaving practices including both social and material entities that are fundamental to the production, re-production and transformation of social organisation. My practice-based ontology thus has roots in the philosophical and sociological traditions, basically trying to understand how people (in this case engineers) understand each other and the world through their actions. The focus on practices in this sense actually comes to play in several academic disciplines, such as philosophy (e.g. Schatzki 2001, 2002, 2012, Reckwitz 2002), organisational studies (e.g. Gherardi 2001, 2012, Orlikowski 2002, Nicolini 2013), and learning theory (e.g. Lave, Wenger 1991, Wenger 1998, Hager, Lee *et al.* 2012), focussing on agency and the social, organisational development and technology, and learning processes respectively. Despite their differences in focus and interests they are joined in a fundamental emphasises of processes, actions and their ordering relations.

SITUATEDNESS

First of all the practice perspective builds on the idea of *situatedness* and thus extends from the paradigm of 'situated action' (Mead, Dewey, Goffman and later Suchman), which criticises the de-contextualised rationalism (Gherardi 2006). Perhaps most noteworthy here is how this paradigm teaches us that context is not just a container or scene for our actions but rather a *resource* for these actions. Instead of isolating objects or people from their context, it thus acknowledges *situations* as physically located occasions where actors (and their interests) and environment (with its objects and opportunities) meet and are reciprocally defined (Gherardi 2012). As Suchman (2007) emphasises: We understand the world and each other through our actions. All actions thus hold material as well as social elements from which they cannot be separated, which the descriptive adjective of *situated* actions reminds us.

Looking for professional and educational practices I am thus also interested in how the physical environment and the objects in it interact with the construction of situations and facilitates the performance of the practitioners' tasks and, as Gherardi puts it, "especially the idea that these elements are 'held together' and express a contingent logic embedded in the situation" (Gherardi 2012, p19).

In this respect what engineers do and how they do it is not simply a question of which types of tasks they perform or what kinds of logics they apply. Instead their work "is a knowing-how in situation, a knowing-how 'to work together' which weaves relations among people, objects, languages, technologies, institutions and rules" (Gherardi 2012, p206). Looking for situated actions in this respect also moves the focus from the individual actor – not to the wholeness of society – but somewhere in-between where individuals are carriers of collectively sustained practices.

Being in the world is thus not just a matter of being *situated* but also about *relating* to each other and our environment.

RELATIONAL EPISTEMOLOGY

Viewing the world as situated practices the next question is how I might 'see' this kind of reality. From a substantialist position I would focus on static entities and facts, but the situated perception of action fundamentally challenges the stability of these. Applying a *relational epistemology* instead

lets me focus on the continual and processual dynamics of being and doing in the world without giving prominence to either humans or objects, but rather considering them as inextricably related (Gherardi 2012).

Relations and processes are at the heart of practices. Through our sayings and doings we create these relations, not only between people but also between artefacts, groups and networks. It is through these relations that each entity develops its properties (Østerlund, Carlile 2005, 92). In other words, I do not see people or even things having inherent qualities, but only achieving these in relation to others; only in relation to others can something come to have meaning. This relational position thus again emphasises the need to avoid seeing social phenomena as aggregates of individual's actions, which disregards relations to the 'context' but also to other practices.

Looking for practices I am thus interested in finding these relations that tie people and objects together and co-constructs them. From a practice perspective these relations are not static links like you would find in a grid structure but rather dynamic connections re-produced through on-going (inter)actions. They are also not necessarily unequivocal but quite possibly conflict-ridden. Tensions in these relations can then cause displacements within the practices throughout the re-productions.

Viewed from this perspective engineering design becomes a result of different practices and constellations of objects carried by engineering designers as well as other people involved in their work. This allows me to approach ideas of competence and learning from a non-individualistic perspective and open up for queries about why certain ways of doing engineering persist within education and where challenges for engineering endeavours arise within occupation. In this thesis I will thus not speculate on the motives behind individual's actions but instead focus on the collective relations that produce a sense of meaning and purpose for these situated actions.

My perspective thus forms a kind of analytical compass guiding my journey into the field of engineering studies and through my empirical material. It gives me a way of approaching and understanding not only my problem area, but also my own relations to this.

2 METHODOLOGY

framing my view

Moving on from how I see the world to how I have been interacting with the world, this chapter focuses on the methodological framework that links to my problem statement and the more concrete research design that has guided my journey into this thesis.

Seeing the (social) world as constituted by interweaving practices and constellations of objects means that *practices* and *materiality* are also what my methodology needs to be sensitive towards. In order to gain insight into engineering design practices I thus need an empirical approach that enables me to capture, unfold, and understand the situations in which engineering design work takes place through local social action, heterogeneous relations, and resources for actions (objects and environments). My practice focus thus seems to privilege a close up, in-depth, case study-based research design of the ethnographic sort (Trowler 2014).

ETHNOGRAPHIC FRAMEWORK

While 'ethnographic' is a heterogeneous term, which is today used in connection with quite different types of research, you might overall say that ethnographies attempt to uncover local 'ways of life' and grasp what local people experience as meaningful, how they do so and the complexities of their relations. Alvesson puts it this way:

> *"I think that the term serves us best if reserved for studies involving a longer period of fieldwork in which the researcher tries to get close to the community (organization, group) being studied, relies on their accounts as well as on observations of a rich variety of naturally occurring events (as well as on other material, e.g.*

documents or material artifacts) and has an interest in cultural issues (meanings, symbols, ideas, assumptions)." (Alvesson 2003, p171)

It is a very established tradition of enquiry with strong ties to anthropology and the study of foreign cultures, however today ethnography is practiced within many research fields. Ethnographic inspiration can thus also be found within engineering studies with seminal examples such as (Bucciarelli 1994, Downey 1998, Faulkner 2007, Henderson 1999, Vinck 2003).

My intent with an ethnographically inspired framework is to be able to offer situated and rich descriptions of local engineering design practices as they take place in the Danish context today. Rather than providing answers or 'the truth' I hope to provide a basis for a nuanced understanding of the elements that play a part in how engineers design and how they are able to design – as Emerson *et al.* call it: "the multiple truths apparent in other's lives" (Emerson *et al.* 2011, p4). Staying open to such emerging findings is essential for exploring the dynamics of practices.

Given that the practice perspective stresses the *social* nature of practices, it is also important to use methods that go beyond the individual. The social nature of engineering design work implies that it is achieved through interplay between several individuals, often with different backgrounds and different takes on design. An ethnographic approach is sensitive to this collective dimension of doing while being able to access the multiple dimensions of social practice: Social action, relatings and resources for actions.

My ontological understanding of practices also implies that the practices I am interested in are always located at particular sites and performed at particular times. They are *real* in the sense that they do not make up an ideal form in themselves or are performed on the basis of predetermined scripts. Instead they unfold *at* a site shaped by the particular historical and material conditions that exist there (Kemmis *et al.* 2014, p33). So what, then, is a *site*?

THE SITES OF PRACTICES

A site is where practices unfold into actual social activities, where things exist and where events happen. It is, however, not only a physical space (or even a demarcated physical space) but more importantly a place in objective time (placed in history) and teleological location (pointing to-

wards certain ends) (Buch 2014a). A site is thus not just a container of happenings (as the idea of 'context' is often used) but plays an integrated role in what can and does take place there, or as Schatzki puts it: "A site is inseparable from that of which it is the site" (Schatzki 2005, p468).

Now, the idea of *sites* is also an analytical construct – but a useful one in relation to scoping and delimiting fieldwork. Ethnographic enquiries can thus with advantage be scoped within such sites. However, each site is also always part of a wider scene – you could say they are nested in other (greater) sites.

Bringing this back to my problem area, then the spheres of education and occupation makes up two such great, however quite diffuse, sites. A more typical ethnographic study would find a local site within one of these and explore the practices unfolding there. However, with my interest in understanding what goes in between and across the spheres of education and occupation my research also extends beyond the individual site.

MULTIPLE SITES

In the mid 1980'ies George Marcus started formulating an alternative to the traditional, single-site, intensive ethnographies (Marcus 1986). This other mode "moves out from the single sites and local situations of conventional ethnographic research designs to examine the circulation of cultural meanings, objects, and identities in diffuse time-space" (Marcus 1995). We now call this *multi-sited ethnography*.

Multi-sited ethnography provides a way to move *across* sites of fieldwork (Marcus 1999). It is thus possible to pursue relations and associations across quite diverse, but nevertheless interlinked, sites. Marcus puts it this way:

> *"I am interested here in multi-sited strategies that raise the nature of relationships between sites of activity and social locations that are disjunctive, in space or time, and perhaps in terms of social category as well." (Marcus 1999)*

With my socially informed practice perspective it makes sense to look at how a phenomenon such as 'engineering design' is manifested and practiced across different sites. In this way juxtaposing studies of practice in companies (resembling the original engineering studies) with studies of engineering education (resembling research done in engineering education

research) I hope to establish a more nuanced picture of the dynamic engineering design practices that are produced and re-produced at different sites in education and occupation.

RESEARCH DESIGN

My situated practice perspective thus urges me to get up from behind my desk, follow in the footsteps of other scholars of engineering studies, and actually go out and see how engineering is done 'in practice'. But where and how do you find these practices? Right from the beginning the project has been designed as a qualitative multi-sited ethnographic study, though the individual sites have fallen into place over time. As it turned out I did not have to move very far from my own desk to find a taste of what I was looking for, in fact my own 'home base' at the university offered quite productive empirical material. My research design thus also reflects the opportunities I have had to gain access to relevant empirical sites of engineering design.

SITES OF ENGINEERING DESIGN

Over the course of the project I have had the opportunity to sit in on four different design-related projects in the engineering context. I have framed these as four different sites – two placed within the educational sphere and two from the occupational sphere. These sites have been selected in order to represent some of the new and emerging forms of more socially oriented engineering design that we are seeing today. That is, sites where the 'balance' of engineering design is considering the social and creative poles in the area of tension to a greater extent (see Figure 4 in the Problematisation). Each of the four sites will be introduced at length in Part 3 and 4, so I will only provide a brief overview here.

Through the educational sites (Site 2 and 4) two Danish engineering design programs are represented. The first is the program in *Design & Innovation* initiated at the Technical University of Denmark (DTU) in 2002 – from which I myself have received my engineering degree. The second is the more recent engineering program in *Sustainable Design* initiated by my colleagues at Aalborg University (AAU) in 2013. At the first of these

sites my enquiry is oriented towards student's project work in the on-going education of new engineering designers, whereas at the second site my enquiry is oriented towards the educators developing a new design-oriented program.

The two occupational sites (Site 1 and 3) are actually physically located at the same place: At Volvo's *User Experience Competence Centre* in Copenhagen. This is a recent addition to Volvo's R&D organisation, starting from 2012. At the first of the sites found here my enquiry is oriented towards the doing of design work in a professional project, whereas my enquiry at the second site is oriented towards a strategic initiative to influence the organisational structures in which such design work takes place.

Originally the project had an additional educational and occupational site respectively, both focussed on *architectural* engineering design in order to also represent the wide array of design ambitions within the engineering field. After an initial round of field visits and interviews these sites were, however, left out of the final research design. Partly due to practical issues of gaining sufficient access to the practices taking place at the sites and partly in relation to creating a more cohesive account of engineering design practices. Clarke argues that: "abandoning a selected site should not be viewed as failure. Rather, this trying out of sites should be viewed as theoretical sampling where you seek out particular kinds of data in order to analytically explore some idea" (Clarke 2005, p170). Given that these were my first field visits they have contributed to adapting my subsequent visits at the final four sites.

Taken together in pairs, these four remaining sites thus enable us to explore elements of both *practicing* (Site 1 and 2) and *changing* (Site 3 and 4) engineering design in Denmark and in that way explore the overall problem statement.

METHODS OF ENQUIRY

In a multi-sited study the empirical methods need to be flexible enough to adapt to the local conditions at each site. In order to find traces of the unfolding design practices at the different sites I have, however, generally used qualitative methods traditionally linked to ethnographic studies (interviews and observations).

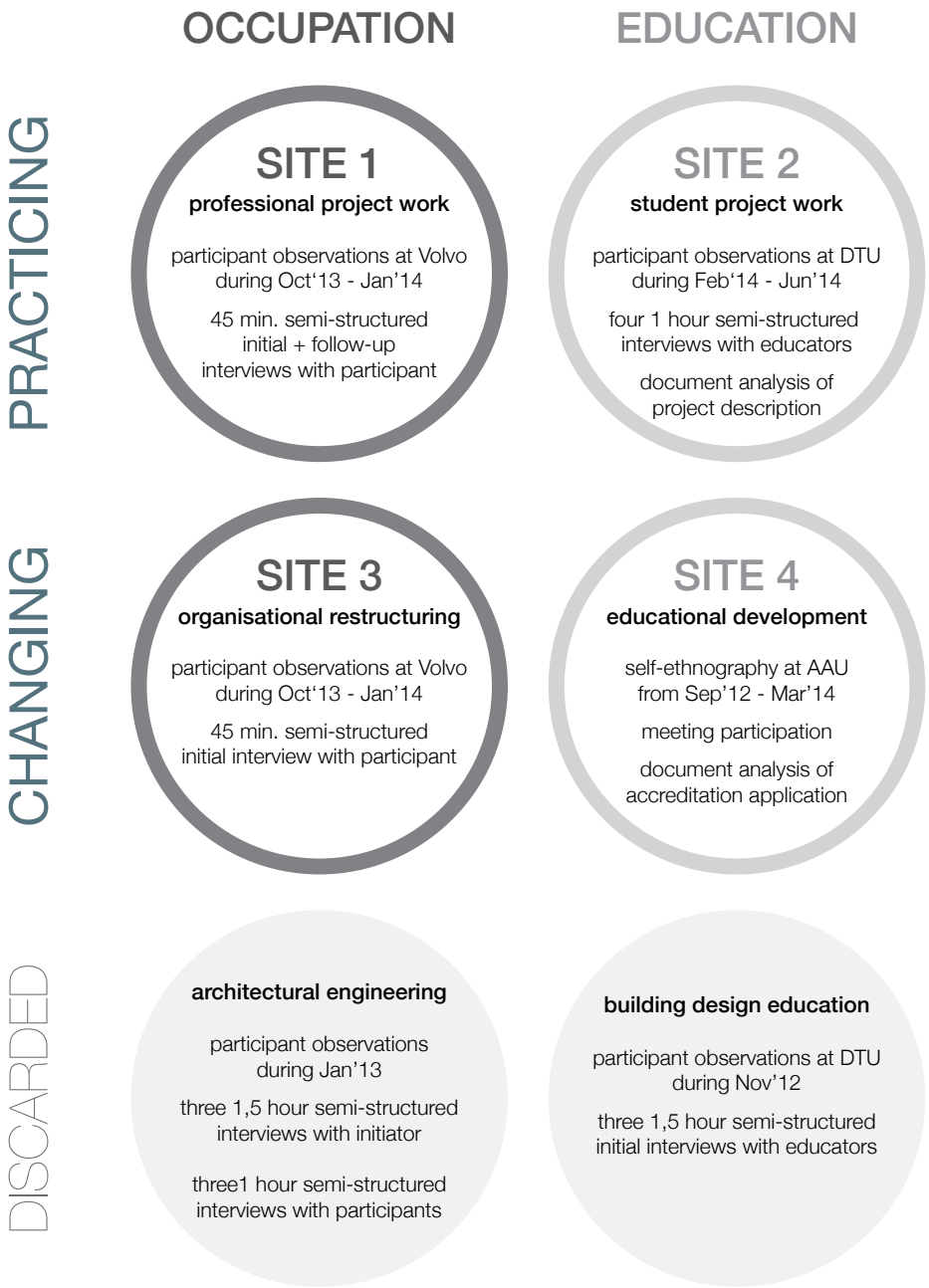


FIGURE 5 | Overall research design and empirical methods.

INTERVIEWING

When I started my empirical enquiries at the two sites that were subsequently discarded I focussed mainly on interviewing individuals with central significance at the sites. I used semi-structured interviews to explore the dilemmas and complexities linked to the doing of (architectural) design. But while these interviews with individuals gave me access to personal reflections and accounts I lacked a more nuanced understanding of the complexities and tensions at play in the everyday design work. From an initial interview-based approach I thus changed to a dominantly observational approach at my visits at the subsequent sites. This has given me access to thicker, though also temporally and situated more narrow, 'slices' of empirical material.

Interviews have, nonetheless, remained a part of the research approach, though from a more secondary position. Interviews (all semi-structured) have thus been used to establish a more historically situated understanding of the current doings at the sites and enabled me to clarify the circumstances surrounding certain situations that I have observed. An overview of the interviews conducted are included in Figure 5.

OBSERVING

As indicated above I have had different relations to the sites that I have visited, which also means that I have had different opportunities for carrying out my observations.

Within ethnography *participant observations* are the most common way to learn about the activities of the people under study in their natural setting. Characteristic of this method is that you need to be open, interested in learning more about others, and first of all patient. By being a good listener and actively looking, engaging in natural conversations, and writing detailed field notes you slowly build an understanding of the interaction between various participants and start capturing the mundane of the everyday (Kawulich 2005). This is necessarily a labour-intensive effort that could easily span several years to get the 'full picture'. However, doing a multi-sited ethnography naturally posses some restraints on how much time you are able to spend at the individual sites. My participant observations at sites 1-3 have thus been of a limited duration compared to more conventional ethnographies. In order to get a sense of the progress being made in the respective projects while maintaining a certain closeness

to the involved people I have chosen to distribute my visits a couple of weeks apart over the duration of the on-going projects.

While I have been a stranger to the people I have observed at Sites 1-3 (though not a stranger to being at Site 2) things have been different at the last site. Site 4 is actually grounded with the group of people that I am institutionally linked to as a PhD fellow. It is thus a familiar – or at least everyday – setting for me as well as the people that I have observed, which changes the ethnographic approach somewhat. Alvesson (2003) suggests the term *self-ethnography* for this kind of research where you move from being a participant observer to an observing participant: "A self-ethnography is a study and a text in which the researcher-author describes a cultural setting to which s/he has a "natural access", is an active participant, more or less on equal terms with other participants" (Alvesson 2003, p174). The idea of a self-ethnography is thus to utilise the position one is in for the secondary purpose of making observations. It should not be understood as an ethnography of oneself (auto-ethnography) but of what goes on *around* oneself in one's own cultural setting (Alvesson 2003). Instead of dedicated and planned field visits the empirical material from this site has thus emerged while I have been tending to my normal business at the university. By keeping an eye (and ear) open to when interesting situations may occur I have been able to join and keep up with process of developing and starting the new education. Most distinctly I have been able to join meetings from a very early stage of the process and observe the interactions and emerging discussions at these (while also joining the conversation to a certain extent).

In addition to the interviews and observations certain documents have also been analysed along the way within the educational sites where I have had access to such. This has mainly been the official module or program descriptions, but also documents produced by the students as part of their work at Site 2.

The details of the individual enquires will be elaborated in Part 3 and 4 under the site introductions, however this outline has hopefully provided an overview of the elements involved in the empirical field work. The study is designed in this way to provide rich and situated empirical material of the local practices unfolding at these different kinds of sites of engineering design practices.

WORKING WITH THE EMPIRICAL MATERIAL

Making ethnographic enquiries across different sites and using different methods necessarily result in a heterogeneous collection of empirical material. Making all of this 'come together' is a challenging analytical task. At the same time the duration implied by ethnographic approaches results in another challenge: How to keep the data 'alive' and available and when to stop looking and start processing?

Three stages of analysis dominate the way I have worked with the emerging empirical material. To begin with an overall *Situational Analysis*, then development of *thick descriptions* from Site 1 and 2 focussed on the elements of engineering design practices, and finally condensed thick descriptions from Site 3 and 4 focussed on the infrastructures keeping practices in place.

SITUATIONAL ANALYSIS

With roots in the social worlds framework and Grounded theory (drawing on symbolic interactionist sociology and pragmatist philosophy) Clarke has developed a theory/methods package that she calls *Situational Analysis* (Clarke 2005). In accordance with my situated practice perspective this qualitative analyses uses the idea of the 'situation' as the starting point for working with different kinds of 'maps'. I have used the *situational maps* (Clarke 2005) to start opening up the accumulating empirical material while my field visits were still ongoing. This has enabled me to start grasping the messy collection of people, objects, and discourses that are drawn together and collectively produce the situations that I have observed.

The act of mapping out your data – iterating the process and adding, removing, revising – is a way to dive into your empirical knowledge and piece together a picture that may otherwise stay hidden or obscured in the piles of transcripts, field notes and documents inhabiting your desk. These maps have thus acted as a kind of sophisticated 'mind map' able to hold on to my thoughts along the way, help compile an overview, and start identifying interesting relations across.

When entering a new site in my study I have used what Clarke (2005) calls *messy maps* to empty my head of all the elements I believe to play a part at this site. Later, when new materials see the light of day, I have then revisited these messy maps and added, rearranged, removed, scaled etc.

From the messy maps I have also created so-called *relational maps* linking the different elements together in order to sustain and develop ideas of interesting stories worth exploring.

Working with these situational maps was a way for me to start getting acquainted with my empirical material and identify some of the analytical possibilities it contained. Beyond this initial analytical work, however, I have not continued to work with the maps due to their quickly exponential rise in complexity (and thus blurring of perspective). Instead what will dominate this thesis are rich descriptions extracted and constructed from my field notes.

RICH DESCRIPTIONS

Geertz (1973) claims that what defines the enterprise of ethnography is the elaborate endeavour of creating *thick descriptions*, that is, making careful accounts of social phenomena in which layers of meaning are expressed. Such rich descriptions started emerging more or less on their own from my observational field notes after each visit. Each visit provided new details of the everyday life of engineering design professionals, students, and educators. Emerson *et al.* put it this way:

> *"Fieldnotes grow through gradual accretion, adding one day's writing to the next. The ethnographer writes particular fieldnotes in ways that are not predetermined or prespecified; hence, fieldnotes are not collections or samples decided in advance according to set criteria. Choosing what to write down is not a process of sampling according to some fixed-in-advance principle. Rather, it is both intuitive, reflecting the ethnographer's changing sense of what might possibly be made interesting or important to future readers, and empathetic, reflecting the ethnographer's sense of what is interesting or important to the people he is observing." (Emerson et al. 2011, p14)*

My work with the situational maps discussed above thus inevitably has had some influence on the kinds of notes that I have jotted down in my notebook at my different visits. In that way the understandings that I have build through my mapping process also indirectly lives on in the thick descriptions you will later encounter.

I have chosen to structure my empirical data into *sketches* and *episodes* inspired by Emerson *et al.* (Emerson *et al.* 2011). *Sketches* are meant as a kind

of snapshot of the context and mood, thus providing a sort of backdrop for imagining the following descriptions of interaction. *Episodes*, on the other hand, focus on extracts of such interaction over a delimited duration of time, such as individual or interlinked events (Emerson *et al.* 2011).

The episodes included in this thesis represent, however, only slices of the practices that unfold at each site over time. Through my visits I have necessarily only had access to a fraction of what goes on – and there will also always be more going on than the observer can notice or record. The resulting thick descriptions should thus not be perceived as simple reporting of data and descriptions of objective reality as Alvesson points out: "The text […] tells a story, it adapts a particular style, the author make all kinds of moves in order to create certain effects, e.g. trustworthiness, legitimacy, brilliance" (Alvesson 2003, p173). My own subjectivism will thus inevitably be part of my data production and shine through in the text, which is recognised in the feminist tradition as *partial perspective* (Haraway 1988). It is thus deliberate that I also place myself in the episodes to underline that this is my (partial) perspective of what unfolded.

In the concluding Part 5 I shall offer my reflections of how the research design has provided opportunities and challenges when being so close to the sites visited.

2 CONCEPTUAL FRAMEWORK

3 looking for practice

During the past maybe 30 years engineering studies have established a tradition for a line of studies using ethnographic and grounded methods to make detailed studies of everyday engineering work practices in a situated perspective (e.g. Bucciarelli 1994, Downey 1998, Henderson 1999, Vinck 2003). But even though this tradition perceives engineering work as socio-material activities situated in time and place then it remains unclear what exactly makes these activities into 'practices' (Buch 2014b) – though a few scholars have started to engage more explicitly in how to conceptualise *engineering practices* (see e.g. Buch 2014b, Johri 2014, Stevens, Johri *et al.* 2014).

In this chapter I will lay out the basis of the conceptual framework that I approach my empirical material with. Drawing primarily on Schatzki's interpretations of practices I am proposing an explicit practice theoretical framework, which rests on my ontological and epistemological perspectives. This gives me an overall vocabulary or an 'analytical compass' to embark on the empirical work. Later, in the introductions to Part 3 and 4, I will extend on this framework with some more particular practice theoretical concepts from learning theories and organisational studies among others in order to move deeper into the analysis.

PRACTICE THEORY

The field of practice theory is no homogeneous field united around *a* theory of practice. Instead it is an interesting landscape of theoretical approaches focussing on different aspects and implications of the situated practice perspective. While they are not necessarily conflictual, it would also be problematic to try and collect them all under one. Most strands of practice theories share similar historical roots and ambitions of dissolving

the traditional dualities of theory/action, body/mind, actor/system and so forth, but they also have different strengths and different views to bring to the analysis. Nicolini (2013) therefore also suggests consciously making use of these differences in the practice theoretical frameworks and explore the different theoretical sensitivities and strengths in order to bring forth a *thicker* understanding of the empirical material.

What the different strands of practice theory typically do have in common is a sensitivity oriented towards *activity*, or the processual of human doings, *relations*, or how nexuses of practices link together, and the *material* dimensions of the social (including the human body).

SOCIAL ORDERINGS

Not surprisingly the central concept of practice theory is that of *practices*. So what is a practice? Looking trough the practice literature there are many attempts to answer this questions. Most practice theoreticians would agree that to understand practices we have to look for the situated actions that take place through our (bodily) doings and sayings (e.g. Gherardi 2012, Nicolini 2013, Schatzki, Knorr Cetina *et al.* 2001, Shove, Pantzar *et al.* 2012). In general, practice theoreticians will thus agree that practices are social phenomena that organise different people's activities (including nonpropositional bodily abilities) in constellations of some sort and that important features of human life must be understood as rooted in these practices (such as science, power, and organisations - but also reason, identity, learning, and communication) (Schatzki 2012).

So, as Nicolini points out: "Practice theories do more than just describe what people do. Practices are, in fact, meaning-making, identity-forming, and order-producing activities" (Nicolini 2013, p7). How this meaning is organised or constructed different authors offer different suggestions of. I will here take my point of departure in Schatzki's suggestion that "a practice is a set of doings and sayings organized by a *pool of understandings*, a *set of rules*, and a *teleoaffective structure*" (Schatzki 2001, p53, emphasis added)[5]. Since these three orderings will provide the basis for my initial analysis, let me just expand a bit more on what they imply (see also Schatzki 2002).

POOL OF UNDERSTANDINGS

The *pool of understandings* collects senses of how to go on in a situation; knowing how to *perform* basic actions (doings and sayings) that relates to the practice (for example knowing how to ask questions, how to draw a person, or how to operate a program). In other words these are *practical* understandings. The *pool of understandings* also includes knowing how to *recognise* actions that are (or are not) part of the practice, and how to *respond* to such action. It thus includes what we might call know-how and skills in everyday speech. These practical understandings thus links to the history and tradition embedded in a practice, evolving what is perceived to be the sensible ways to go on doing.

SET OF RULES

The *set of rules* compiles explicit linguistic formulations concerning how things *should* count (for example definitions) or how they *should* (or should not) proceed (for example through actual instructions or maxims). These rules can be self-imposed as well as official regulations, however they do not *determine* action. Instead the practitioner has to actively relate to them (either following them or challenging them).

TELEOAFFECTIVE STRUCTURES

Finally, the *teleoaffective structures* combine teleology (orientation towards ends) and affectivity (how things matter emotionally). These structures thus provide a sense of *purpose* to the practice and shapes commitments to achieve this purpose, linking overall ends, means, and moods. These structures thus relate strongly to the future or direction of the practice; what you should be working towards. In this sense *teleoaffective structures* govern what it *makes sense* to do or is *acceptable* to do beyond what is specified by understandings and rules.

These ordering elements are analytical constructs and necessarily overlap to some extend. They should not be understood to necessarily lay out all that goes on within a practice, but they do provide some analytical distinctions that can help structure and describe what is found in the empirical material.

Manifestations of an unfolding practice can thus be seen when people's sayings and doings perform some of these *understandings*, *rules*, and *teleoaffective structures*, in this way ordering and giving a sense of continuous meaning to their activities. The practical understandings are what must be mastered to participate actively in the practice, the rules offer an explic-

it reflection of how to go on, while the *teleoaffective structures* makes it all meaningful and gives it a direction.

These orderings naturally influence each other and also change over time as the practice is re-produced. They reside in the practice and not in the individual, who may through his/her doings and sayings adapt to these in varying degrees. The individual practitioners are therefore usefully understood as the *carriers* of the practices (and thus not the direct object of study).

Keeping the carriers and the practices analytically separate helps underline the fact that practices do not *determine* what a person does or why, in the sense that past performances determine present ones. Instead there is an immanent indeterminacy connected to human activity. Not saying that the present always differs from the past – far from, but that "every present is potentially the site of something new" (Schatzki 2011, p6). I shall expand on these ideas of change in Part 4.

BUNDLES OF PRACTICES

Looking at the social as such a field of practices we also find a tangle of sameness and similarity among activities, which suggests another kind of order. We can perceive activities of, for example, sitting on rows in a room and listening to someone speak, of reading certain chapters in a text book, and of working together with peers on an assignment as being part of some order of *formal educational activities* even though they are very different activities.[6]

Carried by people, practices always exist *in relation* to each other, and the individual becomes the place where they meet. Different kinds of relations thus exist between individual practices, linking them together in so-called *bundles*.

Where you make the distinction between a practice and a bundle of practices depends on which scale you are looking from. For example you might see designing as a practice in itself, but you could also 'open it up' by viewing it instead as a bundle of closely interrelated practices such as drawing practices, analytical practices, interview practices, communication practices, etc. In this way practices are effectively *nested* within each other, forming what Gherardi (2006) calls a *texture* or a field of practices.

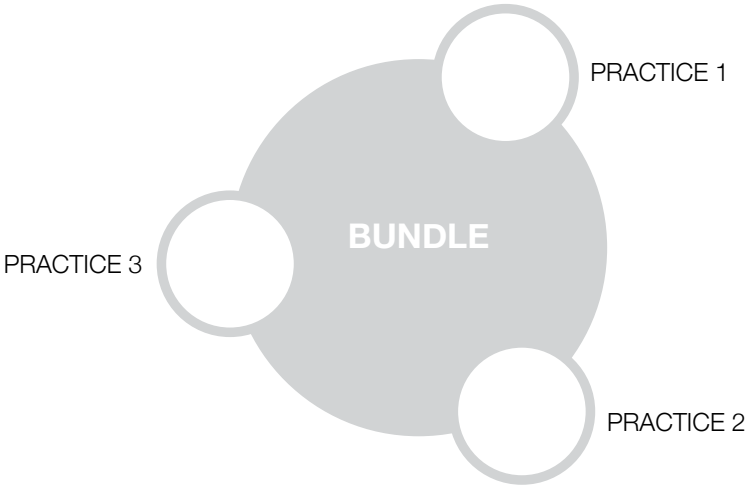


FIGURE 6 | Different practices can form relations linking them together in a bundle.

But the situated perspective also urges me to look beyond the doings of humans in the bundles of practices. From a philosophical perspective Schatzki keeps human actions and the performance of material entities analytically distinct (unlike for example actor-network theory where material entities are also attributed with agency). I will here hold on to Schatzki's perspective that only human actions attribute intentionality and affectivity. This, however, does not mean that the material world is without influence – far from.

MATERIAL ARRANGEMENTS

From the situated and relational perspectives adopted in this thesis it is not enough to look at the people engaging in these nexuses of activities. There will always be material components of the doings and sayings. Most basically the physical human body, but also material entities like tools, buildings, furniture etc.

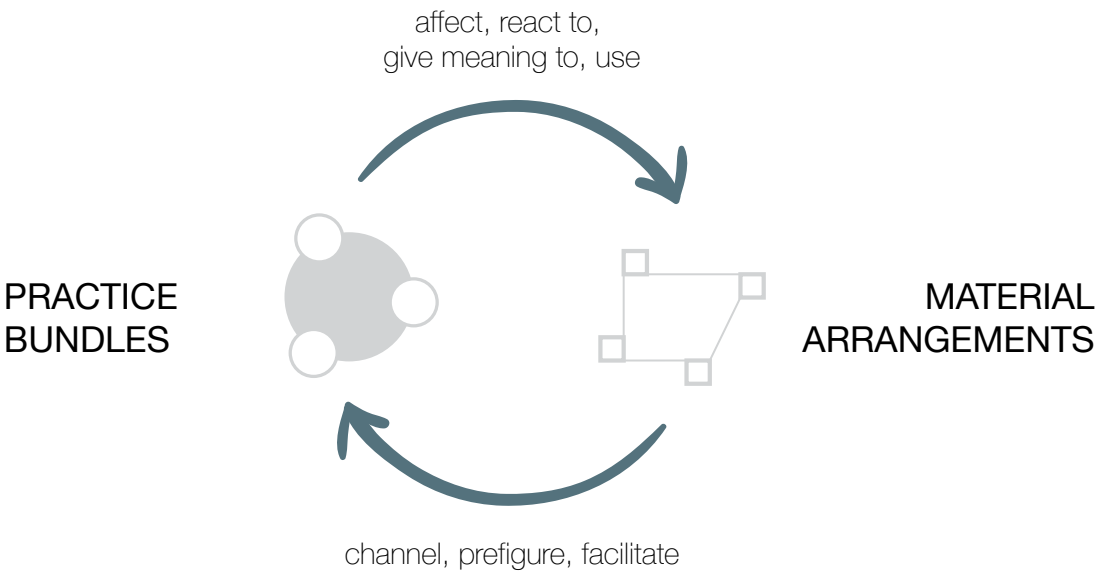
Apart from above ideas of organised human activities in practices Schatzki also operates with the notion of *material arrangements*. These are interconnected material entities such as human bodies, organisms, artefacts and things (Schatzki 2011).

The performances of practices inevitably occur in a material world providing not only a setting but also opportunities and restraints anchored in

the physical objects that populate it. The presence of a blackboard or a projector in a classroom for example necessarily influences the teaching activities that may take place there just as the presence or absence of walls between work stations in an office environment influences how work may be performed there. Practices and material arrangements would thus not exist without each other, but they also shape each other.

As Schatzki (2001, p3) puts it: "because human activity is beholden to the milieus of nonhumans amid which it proceeds, understanding specific practices always involves apprehending material configurations." But these material configurations also extend beyond the immediate setting. The individual classroom for example is connected to the other classrooms and facilities at the university, the campus area, library systems etc. In Schatzki's words these "Material arrangements form immense interconnected networks through which casual processes work, affecting both the arrangements themselves and the human activity that transpires amid them" (Schatzki 2013, p34). There is thus a close relationship between practices and their material arrangements.[7]

FIGURE 7 | Practice bundles and material arrangements are mutually dependent and influential.



It should now be clear how I have approached this study, how I have collected my data, and how I have worked the analysis. The next part starts to present the results of this work through my first move to approach the problem area.


I am always doing that which I cannot do,
in order that I may learn how to do it.
Picasso
3

PRACTICING

How can we understand the work engineers do when employed in creative processes? Does it really involve the application of stored up, scientific knowledge to get from a problem to a solution in the way engineering education traditionally construe it? Or is something else going on? And what does it take to actually learn how to do this?

The focus of this part is on *practicing* design work in engineering. That is, on the doing, learning, knowing and re-doing of the (perhaps seemingly mundane) elements that feed into achieving design results. First, I will position some of the fundamental theoretical concepts and discussions linked to this in the Introduction. Then, two different sites will provide the offset for my analysis of engineering design practice within the occupational and educational sphere respectively.

INTRODUCTION 3 | 1

knowing and learning

Today most of us take for granted that knowledge is a key aspect of contemporary business and societal development. In wealthy countries like Denmark we continue to increase the goals of how large a proportion of the population should complete an education at university level. A higher education equals more knowledge, and more knowledge ensures us a competitive advantage on the global markets. Knowledge, and the ability to apply it (competence), is considered vital in these societies (Alvesson 2004).

In the transformation theory you speak of a shift from an *industrial* to a *post-industrial* society that is generally acknowledged to taking place in our Western societies today. In this new post-industrial society it is no longer the *economy* (made up of physical goods and money) but the *knowledge* and expertise (which is intangible) that is seen as the central driver. Knowledge and expertise has arguably always had a central part in society even when agriculture and later industry dominated the economy, but today it seems knowledge has taken an even more significant place as an economic factor (Blackler 1995, Buch, Andersen *et al.* 2009). In the academic literature – but certainly also in the everyday discourses – we speak of the 'information society', the 'knowledge society' or the 'knowledge economy' to emphasise these new priorities (Alvesson 2004, Knorr Cetina 2001, Knorr Cetina 1999).

In this transformation process the labour market has gone through great changes to adapt to the new situation. While we have seen an increase in technologies filling our everyday lives, taking over manual labour of various kinds, then the labour intensive industries such as technological production sites have typically relocated east. Instead knowledge-intensive occupations such as consulting, research, education, media etc. have established a growing presence in the economy (Alvesson 2004). Most indus-

tries have also started expanding their research and development (R&D) efforts, requiring the kind of highly competent people that our Western societies have been known for. Countries such as Denmark have thus seen a great increase in people employed within R&D and in experts who use their knowledge and high level of competences in order to innovate and help push our technological advances even further (so-called *knowledge workers*). Where mass production and standardisation used to be the key to economic growth, now it seems success is more dependent on flexibility, service and adaption to specific needs – requiring innovation and knowledge intensive work (Buch, Andersen *et al.* 2009).

Knowledge is thus a key element to understand. But what is the nature of knowledge and knowing? Where does it reside? How is knowledge build and acquired? What is the nature of learning? And how does this translate into engineering education?

KNOWING AND LEARNING

Knowing and learning are some of the most fundamental concepts for human beings as living organisms. They play a part in our lives right from the moment we are born (some would claim even before that) and are only emphasised during our journey through upbringing, schooling, working and living in general. But we are also dealing with a complex and multiple concept. As Alvesson puts it:

> *"Knowledge is a very broad and difficult concept. It is used to embrace information (the simple, fragmented kind of knowledge), knowing (how to do), explanation (knowledge answering the questions 'why?', 'what is behind?', 'what is the cause?'), and understanding (knowledge referring to patterns, connections, providing the gestalt of a phenomenon)." (Alvesson 2004, p42)*

Therefore it would come as no surprise that a wide array of disciplines have ventured into exploring similar questions to those I just listed above – questions that are quite naturally linked in the sense that how we conceptualise knowing also has significant implications for the conceptualisation of learning and vice versa (Newstetter, Svinicki 2014, p30). Philosophers, psychologists, anthropologists and sociologists have all been working for centuries to improve our understanding of these crucial matters. As a con-

sequence the understanding of knowledge and learning has gone through several, what you might call, *paradigmatic* shifts (in the Kuhnian sense). Let me therefore venture a short recap of some of the most prominent conceptualisations of knowing and learning.

Because so many prominent scholars from different disciplines have been working with this subject, then there is a natural multiplicity in the ways you might group the individual contributions together in categories. I shall here take my point of departure in a broad classification of these perspectives found within educational research developed by Greeno *et al.* (1992): *The behaviourist perspective*, *the cognitive perspective*, and *the situative perspective*. As the attentive reader may have guessed already my perspective in this thesis leans on the situative (or situated) perspective, though for the purpose of contrast I shall give a short overview of each of them (also refer to the figure on page 5). I shall, however refrain from going into the roots of each perspective, for that see (Greeno, Collins *et al.* 1992, Newstetter, Svinicki 2014).

THE BEHAVIOURIST PERSPECTIVE

With strong ties to the psychological fields this perspective builds on empirical observations of behaviour and from these attempts to explain, predict or control/modify behaviour without opening the 'black-box' of internal mental processes (which are not empirically available). Behaviour

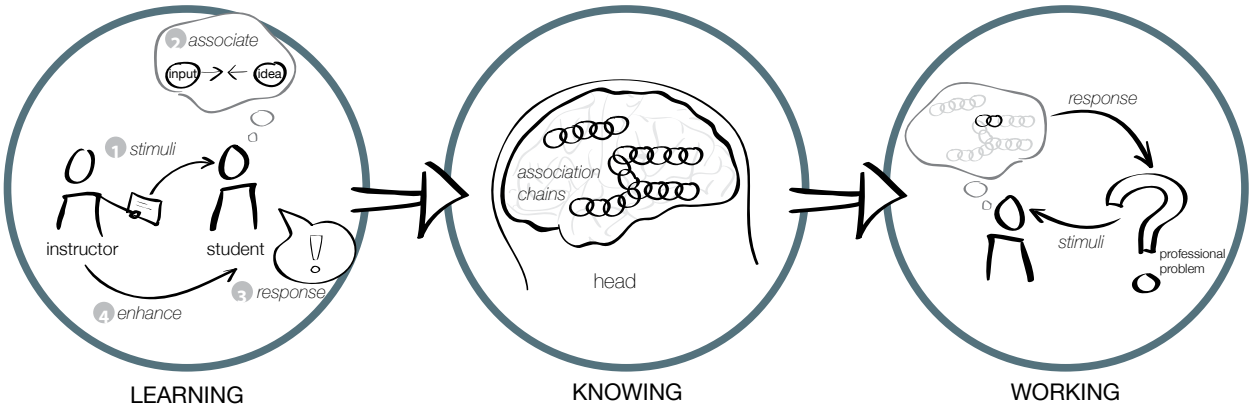


FIGURE 8 | The individual learns through exposure to stimuli and forms chains of associations that can later be used when meeting similar problems at work.

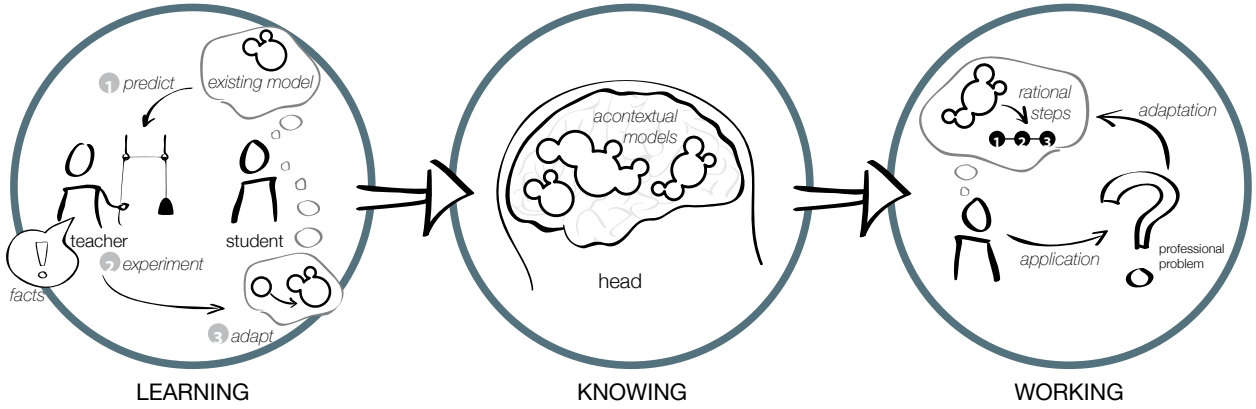


FIGURE 9 | The individual uses existing mental models to predict or react to a problem, based on the outcome the model is then adapted and ready to prescribe rational steps next time a similar problem arises.

is thus the result of being introduced to stimuli of sorts and then the response that this results in.

What does this have to do with knowing and learning? According to the behaviourist perspective *knowing* is the accumulated collection – or chains – of associations between input and simple mental ideas. *Learning*, on the other hand, is the process of constructing these associations and subsequently strengthening some (after positive outcomes) and weakening others (after negative outcomes) through continued exposure and consequences. Instruction can help this process along by arranging the sequence of exposures and awarding correct behaviour (e.g. with points).

In a professional working situation the individual faced with a work problem thus has a collection of associations to browse through in order to find the one that best fits the problem at hand and thus prescribes the correct response. If no relevant association is available, then the individual is unknowledgeable on the subject and needs to learn the appropriate behaviour (that is, form the correct link).

THE COGNITIVE PERSPECTIVE

In relation to the developments within artificial intelligence learning research also took a cognitive turn. Work with computers thus provides an important basis for establishing the cognitive perspective on understanding (and trying to replicate) the human mind. Focus is thus on the internal, cognitive, mental information processing.

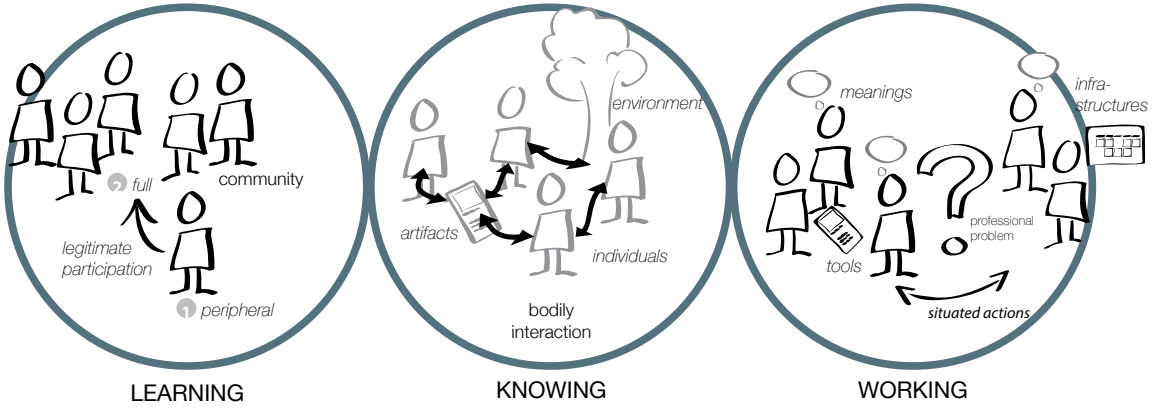


FIGURE 10 | Learning, knowing, and working is not easily distinguished in the situative perspective but continues to build on social interaction.

In the cognitive perspective *knowing* consists of mental structures of information and process stored in memory, making it possible to recognise patterns when for example solving problems. Generally, the more abstract these structures or models are, the more applicable to a multitude of problems and thus the more knowledgeable you are. *Learning*, then, is the process of constructing these mental models. Typically you will already have some pre-existing conceptions related to a subject when you begin more formally learning about it, which means that a simple mental model has already been made. Through learning this model is then expanded and most likely re-structured.

When a similar situation is later encountered, for example in a work assignment, the structure can then be recalled from memory and the information it contains be transferred to the new situation where it provides a sort of protocol guiding the individual's behaviour. The mental model will, however, continue to be adapted after each encounter with a concrete problem and the resulting outcome.

THE SITUATIVE PERSPECTIVE

Social scientists have gone in a different direction in their attempt to describe human behaviour. Instead of looking at the individual and internal processes, focus is here on the interaction between individuals and groups and the surrounding environment or context: "Rather than regarding *knowledge* as something that people have, it is suggested that *knowing* is

better regarded as something that they do" (Blackler 1995, p1023). The fact that humans are *social* beings thus forms the basis of this perspective.

In this view, knowledge is not found inside the individual's head but is distributed among people and their physical environment. *Knowing* is thus both a quality of the collective interacting with each other (collective knowing) and a quality of the individual subject participating in the collective's practices (individual knowing). *Learning* is therefore also collective in the sense that the practice is strengthened (or gradually adapted) through re-production, and individual in the sense of building the abilities to participate more fully in the practice or being initiated into the practice (Kemmis, Wilkinson *et al.* 2014).

What is learned in one community of practice can thus be hard to take into a different practice. But when a professional problem is encountered within a (professional) community of practice it is the situated actions within this community that leads to a solution in interaction with the specific context, the tools available, and the social systems and meanings at play.

Beyond these perspectives you also find theories of learning within neurophysiology, which focus on the *biological* mechanisms of learning, but that lies outside the scope of this thesis.

In the behaviourist and cognitive perspectives the processes of learning, knowing, and working are focussed on the individual subject. In both of these perspectives there is in implicit assumption that 'true' knowledge is already in the world outside the individual, and that it is up to the individual to 'uncover it' somehow through learning. Such learning typically implies interaction between a knowledgeable subject (instructor or teacher) and a less knowledgeable subject (student). In this interaction knowledge is more or less directly 'transferred' from teacher to student. The uncovered knowledge is then stored in the individual student's head – either as chains of associations or mental models – with the potential for future application. Learning thus becomes a series of discrete acquisition events where new knowledge is stocked on top of existing. In a work situation the stored-up knowledge can then be transferred, more or less intact, to the problem at hand and inform the individual's response. Somewhere in-between these two perspectives is where we will typically find our everyday common-sense perceptions of knowing and learning, which is firmly grounded in our cultural and historical traditions.

The situative perspective, on the other hand, is an open critique of this way of perceiving knowing and learning. Research leaning towards this perspective instead promotes the fundamental social nature of people and also of knowledge – both in its development, validation and use (Buch 2002). This means that knowledge is always undergoing construction and transformation through its use and cannot be seen as something that already exists out there in the world. Instead knowing emerges through collective activities in situated contexts, and the individual therefore only embodies parts of the collective knowledge within a community (Gherardi 2012, p20). This perception of knowledge – or knowing – in turn also holds implications for the understanding of learning. As Lave (1993) points out, focussing on know*ing* rather than knowledge renders the distinction between knowledge and learning obsolete. Seeing social practices as dynamic and generative makes learning both an integral and distinctive part of social interaction. Learning is in this understanding a co-production that occurs through situated co-participation with others and the material arrangements of a practice (Kemmis, Wilkinson *et al.* 2014, p59).

Professional experts of various kinds might be expected to populate a knowledge society, but with these thoughts on knowing and learning we now need to ask some questions about what the nature of *competence* and *expertise* then might be in a situated perspective.

COMPETENCE AND EXPERTISE

From the above we might conclude that to know is to be capable of participating with the requisite competence in the complex web of relationships among people, material artefacts and activities (Gherardi 2008). This term 'competence' is one we often use both in relation to education and occupation. Most people take for granted that competence is an unproblematic and well-understood term (meaning something like being able to perform what is expected), but as Alvesson points out: "People agree that core competence is important, but to actually identify it with any precision is very difficult" (Alvesson 2004, p42).

From the field of professional expertise and workplace learning Eraut has analysed the concepts of competence (Eraut 1998). He finds that, besides the everyday use of the term, there are mainly two different ways of understanding 'competence': 1) as a *socially* situated concept or 2) as

individually situated. In the socially situated understanding what is considered competence is essentially locally negotiated amongst the participants (or influencers) of a given situation. In a professional workplace it is thus typically negotiated amongst the employer, the colleagues, any clients, perhaps professional organisations, and even the government. The individual understanding of competence, on the other hand, is a personal characteristic. Eraut suggests we call this *capability* instead to avoid the confusion, understood as "what a person can think or do that is relevant to the work of a particular profession" (Eraut 1998, p135). To link these two understandings he draws up a figure, which I have adapted here (Figure 11).

The figure shows how competence in each new context is defined differently, represented by circles of different size and position. It also shows how personal and professional capabilities might extend beyond the competences, for example a child in school might be considered *competent* at reading and writing, but also be *capable* of drawing and dancing. At the same time a person might find him or herself in a new job where the local understanding of competence is only partially covered by his/her professional capabilities. This naturally opens up the local negotiation of competence, during which the new employee will begin to learn and adapt new ways of doing (in agreement with the situated perspective) but also potentially introduce other capabilities previously considered outside the scope of the local understanding of competence.

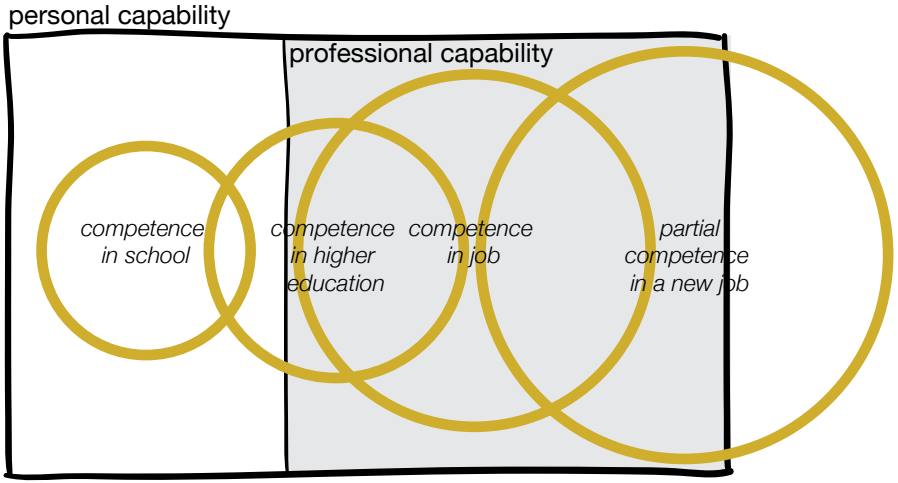


FIGURE 11 | Adaption of Eraut's figure of the relation between capability and competence (Eraut 1998).

This process of learning, moving from a newcomer within a practice to someone who is recognised as being competent is what the two Dreyfus brothers have tried to capture in their progression model. In their book from 1986 they criticise the optimisms within computer science – and especially artificial intelligence – for having led to an overly simplified view of human intelligence and expertise (as it is reflected in the *cognitive perspective* above). Drawing on Heidegger and Wittgenstein amongst others they instead recognise the use of *intuition* in human doings (Dreyfus, Dreyfus 1986) – neither as something common-sense nor mysterious or a stroke of genius, but as something which is build through an extensive process of learning, which is significantly different from the arithmetic processing models suggested in artificial intelligence.

This does not in itself place their position under the *situative perspective* (for example they maintain the largely individual view on the learner), in fact they specifically refrain from looking at learning by copying more experienced practitioners (such as children copy their parents). Nonetheless, their focus on informal learning from experience holds some useful images when we move between the educational and occupational spheres. Dreyfus describe the dynamic learning trajectory from novice to expert through (at least) 5 *stages of skill acquisition* (Dreyfus, Dreyfus 1986, Dreyfus, Dreyfus 2005), which I will (relatively) briefly outline in the following.

NOVICE

When entering a new area of expertise an instructor will typically guide the novice and provide rules to guide his/her behaviour. The novice is taught to recognise relevant elements of situations where the expertise is performed, but independently of any specific context. The rules provided (for example through manuals or lectures) then clearly and objectively states what actions should be taken in relation to these elements.

At this point the novice lacks an understanding of the entire area of expertise and thus evaluates his/her own performance based on how well he/she is able to follow the rules.

The novice driver, for example, will start his/her learning trajectory at a driving school. The driving instructor will here, amongst other things, explain the novice driver how to read the vehicle's speed from the speedometer and provide simple rules stating when to shift gear in relation to the speed travelled. Completing driving theory tests provides a way for the

novice to evaluate his/her performance, though it says nothing about his/her skills as a driver.

ADVANCED BEGINNER

Most instruction is then followed by some form of practicing on concrete examples. Through these examples the now advanced beginner starts to recognise different aspects in the specific situations that influence the actions or outcomes. The advanced beginner is thus able to recognise both a-contextual and situated elements, all of which are given equal importance. Maxims can then help him/her link these together and thus determine which action to take.

With the growing experience also comes a growing understanding of the area of expertise, though the advanced beginner still follows rules to determine his/her action.

The advanced beginner driver would by now be introduced to driving in the car on short, simple trips. Thus exposed to the feel and sound of the car, the advanced beginner starts to recognise the sound of the engine in addition to the arrow on the speedometer when it is time to change gear. He/she also experiences what the angle of the foot should be on speeder and clutch respectively. A maxim might go something like: 'When the engine sounds strained and the speedometer approaches 30 km/h, then release the speeder while pressing the clutch, shift to 2nd gear, and gradually release the clutch while pressing the speeder at a pace that seems to agree with the motor sounds.'

COMPETENT PRACTITIONER

After much practice the competent practitioner is able to recognise an abundance of both a-contextual and situative elements in the situation, but he/she lacks the ability to recognise what is actually relevant in a specific situation and what might be ignored. To deal with this exhausting number of potentially relevant elements the competent practitioner learns to draw up plans that lay out under which circumstances to pay attention to what, reflecting some understanding of longer-term goals. But to avoid mistakes the competent practitioner still seeks rules for reasoning which plan to follow in the specific situation. These rules are, however, less clear and straightforward than the ones provided to the novice because of the

infinite number of possible variations of a situation and the competent practitioner thus has more at stake in his/her choices. Reflection on these critical choices then also plays an important part at this stage – not to explicitly analyse the steps of the decision and determining what could have been done differently, but rather to let them 'sink in' and thus extend the practitioner's repertoire of experience.

Driving on an exit ramp from a motorway the competent driver will now learn to adapt a plan that pays less attention to the choice of gear and more attention to the actual speed of the vehicle. When driving through a curve the speed needs to be adapted, taking into consideration the condition of the surface, the speed of the vehicle ahead etc. Choosing the type and timing of actions for adapting the speed in the specific situation can be a nerve-racking experience and the result is bound to result in an emotional sensation of either success or failure – which either way leaves the competent driver more able next time around.

PROFICIENT PRACTITIONER

The kind of deliberately thought-through behaviour the learner has demonstrated up until now seems to match poorly with the way we conduct ourselves in everyday life. Walking from one place to another, for example, we do not deliberate where to place our foot, how much to bend our knees, at which pace to move, or contemplate how moving up a flight of stairs differs from moving down a corridor.

For the proficient practitioner the rules and deliberations will also start to fade into the background. At this point deeply emotionally invested in his/her area of expertise the practitioner will use bodily experience to form a gut feeling or intuition about what is important to pay attention to in the specific situation by association to previous situations. Intuition thus has nothing to do with guessing or supernatural inspiration. Instead it is a finely tuned way of relating a current situation to previously experienced situations and their consequences, and perceiving deviations from some normal pattern.

While the proficient practitioner thus intuitively understands the situation he/she finds him/herself in, then reacting still requires a deliberate choice drawing on maxims whose meaning varies according to the specific situation.

The proficient driver might decide to attend a skidding course to further improve his/her driving skills. Driving on the wet track the driver is then able to intuitively feel that his/her regular choice of speed when going into a curve is too fast under these special conditions, but choosing how to react he/she goes through the rules of slowing down when the roads are slippery (for example adjusting the position on the road going into the curve, using the clutch, avoiding the sudden use of the brakes).

EXPERT

The expert's abilities have become an integrated part of him/her and thus escape open deliberation. Instead the expert intuitively 'feels' what is needed in a specific situation that he/she is invested in and also how to react to it. During normal circumstances the expert does not analyse and follow guidelines, but rather exhibit instant and intuitive rules based on what usually works. The ability to discern and sort through an extensive and growing repertoire of previously encountered situations and 'simply' react thus comes with experience.

The expert driver becomes one with his/her car and enters a situation of *driving* instead of *man/woman operating a vehicle*. Approaching a busy intersection in the city the expert driver not only senses when it is time to slow down or decides to stay on the right side of the road after taking a turn – he/she simply does it without giving it any second thought.

Perhaps the difference between the competent or proficient practitioner and the expert can be illustrated by thinking of the difference between someone who has learned English as a second language and a native English speaker. Being exposed to the English language right from the beginning of your life and growing up having heard all kinds of situations expressed in an abundance of English terms gives you a unique intuition about how to construct sentences and express specific things. The repertoire of words and expressions, dos and don'ts, is extensive and grammar has nothing to do with rules but what 'sounds' or 'feels' right. The native speaker will thus have no deliberations about which stance or prepositions to use or how to construct a sentence when expressing a thought. The proficient English speaker, on the other hand, might have developed a level of intuition as well but nonetheless be compelled to consult grammat-

ical rules or dictionaries in order to get a sentence completely 'right' (typically needing to translate linguistic intuition from ones native language).

Dreyfus' model of progression through stages of increasing ability to (re)act appropriately in a given situation offers some new nuances to the discussion of competence. For one thing, it illustrates that the competent practitioner may still have room to learn, moving towards actual *expertise* where explicit deliberations are gradually replaced by a more tacit intuition. It thus gives some frame of reference when moving around the problem area between education and occupation. It also provides a first hint as to why changing established practices can be so hard: Such change involves not only re-learning new ways of doing but also un-learning the patterns of previous experience (Eraut 2008).

PRACTICING COMPETENCE

The competences we might find listed in course descriptions at the university or in job adverts from companies thus might not tell the full story of what a graduate is capable of doing or what a specific job requires in order to perform well in the everyday. In fact the whole notion of 'competence' seems multifaceted and hard to pin down properly. That is also not my intention. Instead, I would like to move on from this Introduction with a more open and flexible understanding of competence.

This part of the thesis is devoted to developing a better understanding of what is involved in practicing engineering design work, meaning progressing on the learning trajectory towards competence and beyond and actively acting competent in concrete situations.

From a practice-based perspective there are several problems in our apparent adoration of the knowledge society. Separating the head from the hand and focusing so one-sidedly on the individual basically goes against the perception of practices as social constellations of not only thinking but much more so of doing and interaction – something that happens in an interplay *between* head and hand, between different individuals, and between people and objects. Remove one of these and the practice will be crippled.

Moving on to the empirical material we are thus aware that it is insufficient to focus merely on the individual's head and list of qualifications if we want to understand the doing of engineering design practices. Instead

we need to keep our eyes open for participation in situated actions, collective knowing, negotiations of competence, and continuing learning.

In order to take the first steps towards answering my problem statement, I will here start exploring how we might understand what engineering design practices are and what they involve in the occupational sphere. My focus will be on *professional project work*. By this I refer to project work performed by people in their professional capacity, that is, something they can be expected to have considerable experience doing. Linked closely to this I will also try to form a better understanding of what role *knowledge* has to play in such professional practices.

Then, taking one step further, I will start exploring how such engineering design practices are represented and 'rehearsed' in the educational sphere. My focus will be on *student project work*, thus to some respect mirroring the occupational site. From the student practices I will try to understand how you learn to engage in design practices and what role interaction plays.

3 PROFESSIONAL PROJECT WORK

2 situated practices at work

Our journey through the multiple sites that make up the empirical basis for this thesis could have started in many different places. It seems, however, useful to start by forming an understanding of the kind of practices that the thesis circles, what kinds of expertise you might aim to achieve by participating, and the kinds of knowing that are formed. Since my focus is on engineering design work let us start by looking at an example of such work.

In this chapter I will mainly be presenting excerpts from my empirical material arranged in short episodes extracted from my field notes. The episodes will be presented in nearly chronological order compared to their original occurrences. In-between these episodes short interludes will highlight some of the more interesting observations seen from a practice perspective and relating to my problem statement. A more theoretically based analysis will build on these in the following Discussion. First of all, however, we shall start with a short introduction to what I will be referring to as *Site 1*.

INTRODUCTION OF SITE 1

The first site we will visit is a newly established *User Experience Competence Centre* (I will simply refer to this as 'the UX centre') in the Volvo Cars organisation. Most of the people in the UX centre are former Nokia employees, who worked in the Danish development department with different aspects of user experiences and interfaces – that is, mostly software related work. However, the great giant of mobile phones closed down this development department in 2011 and almost approximately 300 developers were left without a job. A great pool of very skilled people thus flood-

ed the Danish labour market and several companies saw an unexpected opportunity in this. 14 of these people were snatched up by another Nordic giant – Volvo Cars – and together (in early 2012) they formed a new centre in the traditional car company focusing exclusively on *user experience* (UX). Physically, however, they would remain in Copenhagen for this was part of the terms set up by the UX experts themselves (they did not wish to leave their homes and social networks in Denmark to work in Gothenburg with the rest of the R&D organisation).

Apart from the developers from Nokia 4 people 'from outside' were included in the new centre. The people who work here come from different educational backgrounds, including engineering, IT, graphic design, and management. Common to them all is their passion for users and experience within either user experience or interaction design of some sort.

In the fall 2013 I visited this UX centre for the first time. My objective was to study the professional practices that these 'UX experts' engage in as part of their occupation.

A SITE OF ENGINEERING DESIGN

Apart from the more pragmatic question of access, then my choice of exploring the site of the UX centre is also linked to the *type* of design work that is taking place here. To me it is interesting that the UX centre is the latest organisational 'innovation' in an otherwise very traditionally organised engineering company. It is also interesting that the employees at the centre come from different educational backgrounds but are joined by their common interest in user-focussed design. Nevertheless, it is also clear that this centre does not represent a traditional engineering workplace (however that may look), which I grant was my original 'first choice'. Instead, I take this site to be forward-looking in the sense that it captures some of the developments that are already taking place within different industries (that is, not only in the car industry) to take the *social* aspects of technology and design more seriously professionally speaking. The people making up the UX centre are all very enthusiastic about bringing a new, more socially oriented, design perspective into the Volvo organisation and they all have significant previous experience in working from such a perspective.

By the head of the centre I was granted access to shadow two of the designers and thus in effect two different projects. One of these will be the empirical focus here, while I will come back to the other one in Part 4.

THE PRACTICE CARRIERS

In this chapter we shall take a few glimpses at Jonathan's[8] everyday work on a project referred to as *the daily commute*. Jonathan is in his late thirties, yet quite accomplished at his occupation: He used to work at Nokia's Danish development department with user experience and interfaces for 5 years and he has been part of the new UX centre right from the beginning.

With the daily commute project he is part of a team of 6 people from the centre. What you might call the *core* team consists of Jonathan, Cheng, Carl, and Melvin – but there are also two others connected to the work more on and off: Frederik and Alex. The team-members are all what you might broadly call designers, though with different backgrounds. Jonathan, Cheng and Carl all have engineering backgrounds: Jonathan holds a BSc in engineering in multimedia technology and a MSc from an IT university, Cheng holds a BEng in electronics and computer engineering, and Carl holds a BSc + MSc in design engineering and product development. Melvin instead has his degree from the Danish design school. Alex is a graphical designer and Frederik has a MA in informatics.

A PROFESSIONAL PROJECT

The daily commute project is part of a strategic exploration of design possibilities for the generations of cars that Volvo will be launching in 2-4 years time. It is also the first time the UX centre is involved in such a process from the very beginning. Therefore it is a new type of approach they are developing (and negotiating) with the rest of the organisation along the way. When I started my observations the project had a deadline in February 2014 where they should deliver the results of their work and await approval of whether or not the project could continue onto the next stage. The main part of their delivery was to be a 3-minute video presenting the daily commuting experience as it could take place in 2016 and the design opportunities, which lies in this scenario. That is, they are not to come up with actual solutions or specific designs, but rather point out some directions, which the subsequent design work can then explore. This

vision-work will be used as the basis for developing several new so-called clusters of cars. These clusters have the same base and share most of the components in the design.

EMPIRICAL APPROACHES

This site has been approached as a part of my field study within the multi-sited framework. From an ethnographically inspired point of departure I have conducted field visits of half a day's duration where I have followed and made participant observations of the different activities that Jonathan has taken part in. A total of 5 visits over a 3-month period have been completed for this site.

Before starting the observations I conducted one initial semi-structured interview focusing on Jonathan's background and more overall on the work done at the UX centre. About six months after my last field visit I made a follow-up interview focussing more specifically on the daily commute project, the episodes that had occurred, and what happen to the project after I left. Both interviews were recorded and citations have been transcribed (and translated to English) from these recordings.

The first day of observations I only made crude notes in my notebook – focussing partly on understanding the project I had landed in, the people involved, and attempting to blend in as well as possible for an outsider. The rest of the time I was taking notes more openly (and continuously) and also using my phone to take a photo now and again of a situation, an object, or a context. These photos form the basis for the accompanying illustrations in the following (so bear with the quality). In this part of my fieldwork my field note technique had less emphasis on catching the *conversations* and more on describing the *interactions* in the situation. This of course influences accounts of the following episodes.[9] When visiting in the morning I also joined the lunch before returning to my own desk. This gave me access to more informal interaction amongst the different people from the UX office – not only the team members linked to the daily commute project.

After each visit I aimed to process my notes as soon after as my schedule allowed. This meant writing out my scribbled notes to more cohesive episodes and supplemented with the relevant pictures and details from my memory. These emerging 'thick descriptions' make up the foundation for

the empirical work I will be presenting in this chapter as *sketches* setting the scene and *episodes* describing the interactions (Emerson, Fretz *et al.* 2011). The episodes have been selected to illustrate the different kinds of elements that feed into engineering design work and together they can be seen as a small slice through an intricately connected bundle of practices. There are thus connections between all the episodes, but also many connections to other episodes, which I have either not witnessed or chosen not to re-present here. In the intermediate sections I will start pulling out some of the strings from these slices that will make out the basis for the more theoretical discussion that will follow in the Discussion.

FIGURE 12 | Entrance to the UX center.

FIGURE 13 | Clusters of tables in the open office space.

SKETCH 1 | the open office

On this morning in late October I leave my desk at the university campus only five minutes after arriving. I grab my notebook and pen, my iPhone and my water bottle and then hurry across the large glass bridge that connects the building I am sitting in with its neighbour. Underneath me the already icy cold and dark water is flowing in the Copenhagen South harbour. I hurry through a long corridor and reach a door leading into yet another neighbouring building. Moving straight through this one I have to go outside and cross a small yard in order to reach the building I am heading for. Once inside I find the elevator and get ready to climb to the top floor and thus leave the campus territory behind for a while. I am a bit proud that I found my way so easily through the corridors for I have only been a resident of this campus for

a year and so far I have not had much reason to scurry around this far from my own building. In fact it is not only I who am relatively new to these buildings, also the university itself is a new occupant. It took over these buildings from Nokia after they had closed down their Copenhagen office. Therefore it is not a typical campus area I have just passed through (if there is a such), but instead a former corporate complex now turned academic.

But it is not all who used to work here in the Nokia days that have left these buildings: I am on my way to visit a small group of people who found a way to keep working here, though for a different employer. They are now working for another Nordic giant, though not one typically associated with Denmark.

The elevator takes me to a small landing at the top of the building. As the doors open I am welcomed by an entire wall covered by a scenic road with a fashionably brown Volvo car parked on the side: It seems I am at the right place. The door next to this bombastic wall is much more anonymous thoug: At this point there is no sign declaring who lives beyond, just a door and a small doorbell. I check my phone to see that I am on time then press the doorbell.

After a short while a man dressed in jeans and a t-shirt opens the door with a polite nod and lets me in. Not knowing what my contact looks like I tell him that I am here to meet with Jonathan and he walks me down the broad corridor that makes out the central axis of the open office space. The first thing we pass is a small lounge area screened off from the corridor with birch trunks from floor to ceiling. Behind these I catch a glimpse of the coffee machine in front of a small meeting room. Then we enter the actual office space, which has groups of desks dispersed on either side of the corridor. There are not that many people occupying the office chairs at this time. There might be room for around 20 people here, but I only count a handful. The man who escorted me points to a chair in the middle of the room and says Jonathan is not here yet but will probably arrive shortly. Then he returns to his seat behind a large computer screen and disappears from my view.

Like most of the other desks in the open office, Jonathan's is nice and tidy. Besides his laptop, computer screen and keyboard, only a single book – "Thinkertoys" – and a set of headphones have found its way to the table. The book promises "creative-thinking techniques [...] that will help you think like a genius" and the headphones promise a private space in the open office.

After only a minute or so of waiting, another man wearing jeans and a dark blue sports jacket enters the office space. As he heads straight for me this turns out to be Jonathan, who I will be shadowing the rest of the morning.

SAME BUT DIFFERENT

As I enter the UX team's office space it initially resembles the office space where I am usually sitting at the university: It is a large, open space inhabited by a group of about 20 people, each with their own desk (though many appears to be spending their workday elsewhere). The tables are placed in small clusters screened off by shelving unites. Every workstation has a large computer screen and keyboard as their main feature. There are separate meeting rooms with doors that can be closed but also sections of glass providing a view of these rooms. All of this is pretty much the same, and yet the 'mood' of this workspace is completely different from the one I left behind two buildings away.

It is not theoretical book collections, academic journals and student reports that occupy the shelves, but rather car models and gadgets kept company by a few handbooks. It is not frowned upon to make phone calls from your desk or engage in casual conversations across the tables. The people working here do not work in isolation, but in dynamic exchange with each other, and everybody seem to have a good idea about what the others are working on.

While there is no doubt (at least in my mind) that what we are working with at the university is the production and communication of knowledge, then this place leaves me curious of the role that knowledge plays here.

In the following I will present some of the episodes I witnessed during my field visits at this site. The episodes have been selected in order to illustrate some of the different elements that play a part in professional project work in a design-oriented workplace such as the UX centre.

EPISODE 1 | management at a distance

Today Jonathan starts out by looking at a framework agreement. This agreement will put part of the user investigations required for the project he is currently working on out to tender with some external agencies. While Jonathan is changing the specifications of the deliverables in the agreement, his colleague Cheng is walking around the office collecting stuff like post-it notes and markers from the office supply cabinets. In the quiet of the morning you clearly hear him bringing these things into the small meeting room that shields off the office space from the lounge area. There are a few things that Cheng is having trouble finding, so he asks Jonathan if he knows where

they are. Looking up from the delicate formulations of which methods the agencies are required to use, Jonathan deducts the likely whereabouts of the laptop in question – he remembers that another colleague used it earlier in the week. Reminding each other of their "daily stand-up" meeting at 9.15 Cheng goes looking for the laptop and Jonathan returns to the agreement for another few minutes.

At the desk next to Jonathan we find Frederik, who is also linked to the same project as Jonathan, though he is primarily engaged with another project. He sits quietly browsing around the Internet, seemingly looking for some information. But as the time now approaches 9.15 he and Jonathan get up and head for the meeting room, picking up Carl, a fourth team member, on the way. In the meeting room they shift from their relaxed interaction to focussing on the practicalities of the meeting.

There are several parallel activities going on in order to get the meeting started: One is pressing keys at the teleconference device in the middle of the table, one is logging on to the laptop computer and activating Skype, and one is activating Skype on his smartphone: "How should we do the meeting?" seems to be the general question. While the different options are explored, the team talks casually about Beijing and the levels of pollution you find there. Between the lines I learn that this is not just due to personal interests or recent experiences, but because Chinese cities – like Beijing – is of particular interest for this project.

In the end the teleconference device is victorious and a fifth voice, that of their Swedish management representative, joins the team: The dialogue switches to English without anyone really seeming to notice. Casually going around the table the four team members one by one make a short account of what they have been doing this week and what they will be doing next week. There is no general recapture of the overall aim of the project, so I am still left deducting from the clues given in these accounts. Frederik explains how they have started mapping what they refer to as the "journey" and also started identifying different "pains" and "solutions". After working on the detailing on this, he promises it will be ready to transform into a script next week for the video they are to produce as part of the project delivery. He also explains that they will start scouting for locations for shooting the video. The team members are a bit concerned that this may turn out to be challenging as it is supposed to look like China, but for practical and budgetary reasons must be shot in Copenhagen – which is a far cry from the Chinese mega-cities.

Jonathan therefore asks if the company has access to an image bank? He would like to look for pictures and videos from China that may be incorporated into the video. The voice from afar seems to think that the Communications department might have access to such places and encourages

Jonathan to ask them. He mentions a name of a person that may be able to help. Cheng grabs a marker and notes down the name on the glass table top next to some of his earlier notes from the conversation. Jonathan writes on a post-it note. Frederik interjects that he will probably meet this person from the Communications department when he goes to London next week with the other project, so he can ask him then.

Moving on, Jonathan reports that he and Cheng are working on the framework agreements – "A very exiting task!" he remarks with an ironic glance at Cheng. Everyone laughs – this is clearly not the part of the job they value most.

Carl wraps up the status walkthrough: He is working on the money issues. He has volunteered to do the legwork on locating some money for the activities they plan to do in this initial part of the project. He is also making a "shopping list" for the items they need when producing the video and a timeframe for the actual production.

Switching focus to what they will be working on the rest of the week, Cheng explains that he has arranged for the team to talk to a Chinese contact later today in order to give their current journey understanding a "reality check". While having grown up in Denmark Cheng does have a network in Beijing, which he is now utilizing to give the rest of his team a touch of local understanding. Cheng explains that his contact may not be directly in the target group of luxury vehicle owners, but he *is* a daily commuter and thus knows about the local traffic conditions.

The management representative's voice now breaks in to clarify that the project does not have a purely Chinese perspective – in fact they should communicate a US/European or even global perspective, but just showcase it from the Chinese context. The team readily agrees and assures that they only want to use this talk with the Chinese contact for the purpose of developing the narrative of the video and not the actual solutions. Thus in apparent agreement, the conversation moves on.

In continuation of the interview discussion Jonathan inquires whether the team is able to give small incentives to the people they talk to during the process, such as the Chinese contact – movie tickets, vouchers etc. The management representative in Gothenburg sees no real problem in this, however he does not believe he is the one to ask. Instead he directs them to Noah who is heading the UX centre. Carl will be talking to him after this meeting anyway, concerning the budget, so he volunteers to ask. And that wraps up the meeting after about 15 minutes. The management representative's voice leaves the room and the teleconference device is no longer part of the conversation as the team unconsciously switches back to Danish.

THE DAILY COMMUTE PROJECT

The team that Jonathan is a part of is working on *the daily commute* project, which started up a couple of months before my first visit. In this project the team looks broadly at the commuting experience (to and from work) in large cities – like the Chinese metropolises – and take the first steps of concretising the vision for the future generations of Volvo cars that will be launching in 2-4 years time. They have been charged with producing a short 3-minute video that will communicate this vision and at the same time point towards some more specific areas where there are so-called "design opportunities" to be explored in a following concepting process. After my visits Jonathan explains that it had not been completely clear to them *who* would be the recipient of their work, but that the video had been shown to the director of their department, some people from the Product Planning department and the Brand department and a representative from the car program.

The team has actually not been allocated any budget for this part of the project. They must first demonstrate a potential, and then at the first "gate" – after approximately 6 months work – they may be rewarded a continuation of the project along with an actual budget to do some local research and development. This local research will be partly outsourced to one or more external agencies, which is a lengthy process of first collecting offers, assessing them, negotiating terms, and then planning the actual work. This is why Jonathan and Cheng are already working to prepare a framework agreement this early on.

MAPPING A JOURNEY

In this first episode we learn that the main focus of the team's attention in this project is a so-called "journey". A *UX journey* or *experience map* is a well-known UX tool, which Jonathan explains was also used at Nokia. With the establishment of the UX centre it has now been brought into Volvo. As we will see in the coming episodes it is actually very central for the kind of work they do at the centre, but especially in this project. The journey map covers both a (physical) "map" or illustration of a generic car-trip (the journey), but also a methodological approach to identify positive and negative impacts on the user of the car during this kind of trip, which can then be turned into design opportunities.

FIGURE 14 | Example of journey maps from a previous project.

The method is still being developed through the different projects that the UX centre is engaged in, and this daily commute project is the first to use it so actively right from the beginning. The physical representation roughly consists of a horizontal timeline, mapping the different touch-points between a user (in the form of a constructed persona of a driver) and the car during the journey from start to finish. This, however, may not only be starting from when the driver places himself in the driver's seat and until he gets out of the car, but also include the time leading up to and following the actual car-trip (linking to why the trip takes place in the first place). By explicating these situations that occur as part of the journey the team is able to analyse how the interaction between car and user takes place at each stage and what might be the cause of frustration or failure (pains) on the one hand, and on the other what creates a good flow or even causes satisfaction (pleasures). Through this work they are then able to start identifying some design opportunities, which might later be translated into actual design solutions. All of this, of course, is linked to the team's fundamental interest in creating good user experiences.

Speaking to developers in different parts of the organisation, Jonathan explains, the team has actually been met by an existing frustration: "They say 'I have been charged with the task of designing this feature, but I actually don't know who uses it or when they use it or why' – that is, the context is missing. And that is why we felt it [the journey map] could be a good way of providing them with this context." So the UX experts are

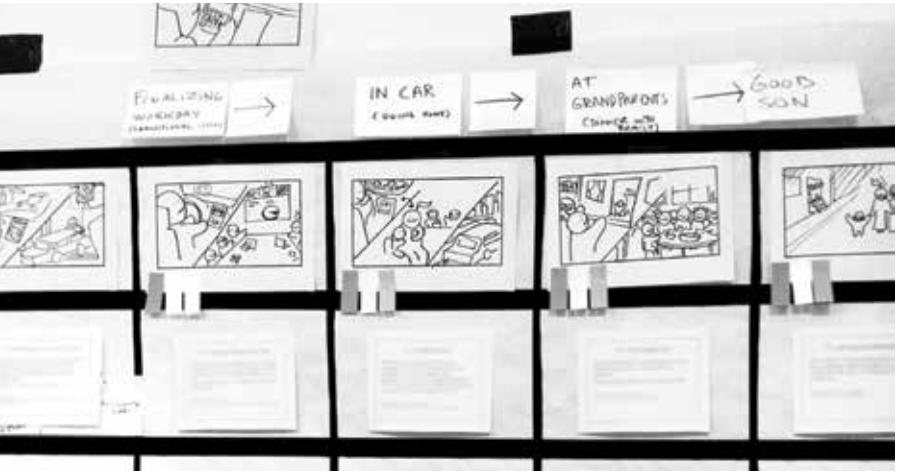


FIGURE 15 | Fragments of the large journey map from a later stage in the project.

also expecting the journey approach to help them communicate and interact with other parts of the organisation.

The video that will be produced as a key delivery in this part of the project will in fact be another manifestation of this journey. The different scenes in the video will thus take the viewer through these instances in the daily commuting experience in a Chinese metropolis and showcase some of the design opportunities that the team has identified, using digital animations of suggested interfaces on the car's dashboard and other devices connected to the car (such as smartphones). Not only is the team in charge of producing the script for this video, but they will also be shooting and editing it.

It is actually the team itself that has chosen the format of the video to convey their results. Jonathan explains that the typical format for such a delivery would be a power point presented at a meeting. But "we try to – I wouldn't necessarily say *avoid* power points – but in addition to some presentations we also do something more concrete. Or something different at least. Videos or something that can demonstrate a functionality […] And I think it is quite well received in Volvo," Jonathan states in the initial interview.

A DISTANT ORGANISATION

The main event of this episode is the so-called "daily stand-up" meeting. It is custom for the UX teams to start out each morning with such a session where they all meet up and update each other on what has been done since yesterday and what is on the program for today. The management representative in this project team is, however, not from the UX centre, but the *Digital User Experience Attribute Centre* (that includes the UX centre), which is placed at the main office in Gothenburg. So once every second week the management representative joins the team's daily stand-up session, thus getting an update on a biweekly basis instead.

But this meeting with a voice from the main office is more than an orientation of things that has been going on. Even from the few words actually uttered by the management representative, it seems fair to say that two different ways of working – two different sets of aspirations – are meeting in this episode.

The UX team is very keen on their efforts to map out the journey, and despite their lack of budget for any real research they have mobilised their personal network to set up a couple of interviews with some residents of Chinese metropolises. We shall know more about this from the next episode, but already here we hear of a great dedication to understand and represent the Chinese context satisfactorily (held according to their own UX 'standards'), which is shared across the entire team. For the team to be satisfied with the delivery they hand in at the first gate (the video), they need to collect some actual contextual and user knowledge to build on – building only on guesses, distant personal recollections, media coverage etc. simply appears unsatisfactory to them.

Compared to this, the management representative seems to represent a different understanding of the video. Hearing the team talk of their intentions of spending time interviewing local Chinese contacts to check their understanding of the context, he cuts into the meeting and voices some concern. From the way he talks of the video he appears to have a stronger focus on the market orientation that the video will portray, which is not limited to the Chinese market. In fact, it seems the Chinese metropolis setting is merely a contemporary location representing a future vision of vast traffic in gigantic cities – which is implicitly believed to be the reality that Volvo's coming generations of cars should be able to navigate. Being

caught up in Chinese culture and customs seems excessive to the management representative (no matter how interesting).

But the UX experts are not futurologists. Their expertise lies in understanding and facilitating the actual doings of people in relation to their cars. Going out into real situations, talking to actual users, that is such a great part of how they work, that they worry that 'flaws' in the contextual setting will affect the impression of the design opportunities the video should communicate. This also comes out in the subsequent talk right after this meeting: In 2010 Volvo Cars was acquired by a Chinese holding group, and the team worries that their video could end up on the top management's screens. Should that happen, they want to be sure that they have done their best to provide a competent understanding of the Chinese context. There is a particular, what you might call *professional pride* in this wish, which is clearly shared across the team: As user experts their metier is to be able to understand and represent a context, culture, and situation different to their own. This is significantly different from that of

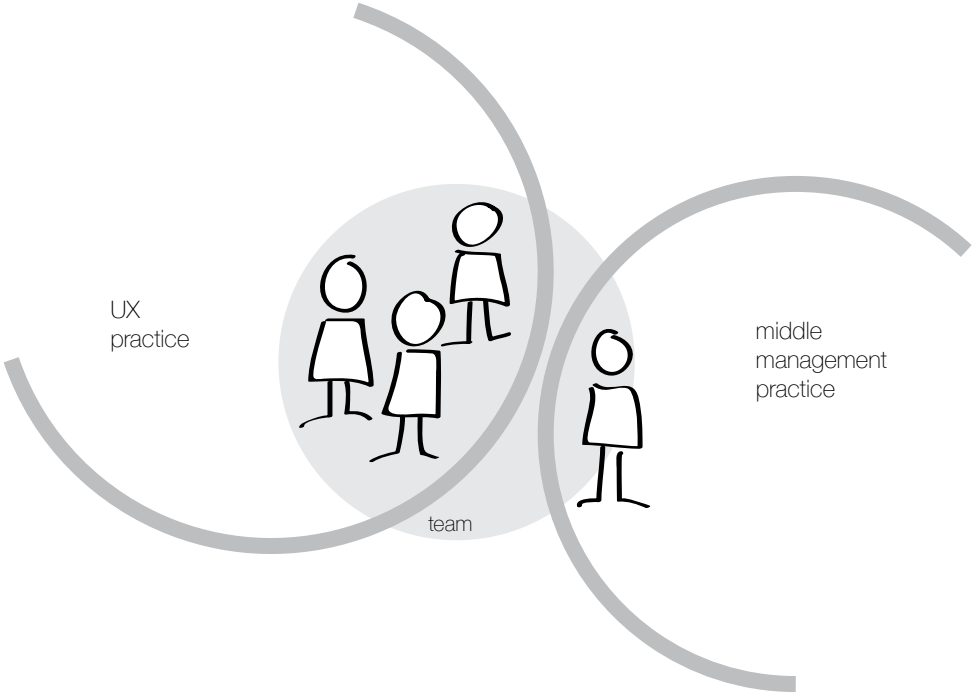


FIGURE 16 | The team's management representative participates in a different kind of practice.

the management representative, who is more concerned with representing the future market in which Volvo has to compete.

Jonathan explains that at the UX centre they want to use this project to really prove to the rest of Volvo what it is they are able to do. In previous projects they have mostly been assisting with user insights or user tests at different points in the other departments' processes. Jonathan's experience is, however, that they are somehow out of sync with the process in these other departments: "We often feel that we are too early concerning the users – that is, that we are studying something about a future – but that we are still too late in relation to Volvo's process." The major components of the hardware in the car program for 2016 is, for example, already locked down by the middle of 2014, making it hard to request changes based on user research. "And then when we believe that *this* is the right time, then we are told 'that decision was made last week!' But I think we are beginning to get better at it, because I think it has been a problem that we have not had the overview of the different decision processes and the different fora where it is relevant to present things." With this project the team is thus eager to "show that we [at the UX centre] are able to move from [user] research to a concept that actually ends up in a car."

Referring back to Schatzki's orderings (Schatzki 2001), then we can see this as a meeting between two different *teleoaffective structures*. For the team the purpose is to arrive at a *realistic* representation and only by linking it to *actual* contextual insights from China will it be acceptable for them. The management representative instead looks for an illustration of *market potential* and narrowing the focus too specifically on the Chinese context will for him not be an acceptable result.

You also get a sense from this episode that the UX team and the management representative are used to draw on different *pools of understandings*. The use of interviews, for example, seems to be very natural for the team's process where it does not appear to be something the management representative would himself have thought to engage in. Instead he knows, for example, how the organisation works and who to approach in different situations.

So what is it that these UX experts do when inviting the context and users into their work? I have not had the opportunity to witness any actual fieldwork, but I was present at the telephone interviews with the Chinese contacts, so let us take a closer look at that.

EPISODE 2 | interview from afar

2.1 Impromptu interview

After the daily stand-up meeting Jonathan, Carl, Frederik, and Cheng stay in the meeting room, sitting around the table and preparing for the informal interview with Cheng's Chinese contact. Because Cheng knows him personally he is able to provide the other team members with a bit of background information regarding his job, family etc. It turns out he is actually an old colleague from Nokia – though he works on the other side of the globe. After a few minutes Carl leaves the room with his laptop: He has an appointment talk to Noah, the head of the UX centre, about the budget and allowance issues before they start the interview.

Returning to the interview preparations, the others agree that Cheng will be in charge of the conversation during the approximately 30 minutes allocated. They start an ad hoc brainstorm on questions to ask and issues to address during the interview. Cheng wipes a spot on the table and starts noting down keywords directly on the glass table top. He is able to direct the team's attention to possible relevant issues based on his own local recollections from Beijing. Cheng also explains that when he had talked to his Chinese contact earlier to arrange the interview it had seemed to confuse him when Cheng talked about the car, so they decide to keep the conversation quite open and focus on simply getting the interviewee to go through a typical day from start to finish.

The team wraps-up their preparations and address the more practical issue at hand: Through which medium to conduct the meeting? Anticipating that there may be some language barriers to overcome they prefer to use Skype, which will give them a visual input as well as audio. But this means they have to switch to the other meeting room equipped with a large screen, which they can all see during the conversation. Unable to take the table with him, Cheng grabs his phone and takes a picture of the notes he just wrote down. Then he steps outside to call his Chinese contact in order to fix the Skype meeting. Meanwhile Carl (who has now returned from his talk with Noah), Jonathan and Frederik move to the other meeting room and Carl starts up the system linked to the big screen.

When Cheng returns he announces there has been a small change: His Chinese contact did not answer his phone, so instead he has contacted another one of his Chinese acquaintances, who he will now connect to over the teleconference system instead. Cheng places his own phone next to the teleconference device. The device quickly connects and invites the Chinese speaker into this Danish meeting room, however the connection is apparently poor and Cheng has to stand directly next to the teleconference device

to be heard across the globe. Thus leaning over the device Cheng starts to introduce the people in the room and their interest in hearing about a day in the life of a Chinese commuter. He asks a cascade of open questions to introduce the type of things they are looking to hear about, all the while looking at the mute device in front of him, offering no indication of understanding. When he stops talking, the sound that does appear conveys a certain insecurity at the other end of the connection, spurring him to return to his original question: "Can you explain what happens during a normal day from you get up in the morning?"

As the Chinese voice begins to recount his morning routines, Jonathan sits with his laptop in front of him, listening intently. Now and again he makes short notes in the blank Word document he has opened. Across the large meeting room table Frederik also sits with his laptop, but he quickly pushes it away to make room for a pad of paper as he starts to note down. Next to Frederik, Carl is sitting also with his laptop. He is writing down more or less continuously from the verbal account drifting through the air. Now and again one of the team members breaks in and asks a question, either to clarify something that has been said or to guide the account on its way. They ask about things such as whether the contact checks the weather or traffic forecasts before leaving home in the morning and if so how; how he choses his route to and from work; if he has a dedicated parking spot at work or how he finds parking when doing errands during the day. Using their notes, they also go back to things that were mentioned earlier on to elaborate or clarify.

When the interview is wrapped up Cheng explains that they do not know yet whether they are able to compensate him for his time, but they are looking into that. The interviewee does not seem too put off by this and instead asks what they will use the information for? Cheng then lays out the project once more in broad terms and finishes off the conversation: A colleague is peeking through the window, apparently in need of the meeting room.

As the team packs up their equipment and remove themselves from the meeting room they are quite excited about the new bits of information they now have to work with. They are positively surprised of how much they got from this short, unstructured interview. And then Cheng announces that his first Chinese contact has texted him that he is now free to answer the phone – so they have the opportunity of doing one more interview before lunch. They all readily agree that they might as well take this opportunity and so set up in the smaller meeting room again. Frederik, however, leaves them to go work on another assignment.

Sitting around the glass top meeting table they agree on an adapted strategy for this interview: Cheng will do the initial introduction and then the others will be in charge of asking the questions. Also, they want to focus a bit

more on the daily routines *outside* the car this time. Then it is time for the teleconference device to join the conversation. Cheng dials the number and connects to his contact. Then he briefly presents their interest in this interview before handing the floor over to Carl.

Carl starts asking questions relating to the morning routines of the interviewee and his children while Cheng wipes clean another portion of the table surface and starts making notes. Jonathan and Carl are each sitting with their laptops and make their notes on these. The three are gathered around the teleconference device on the table top while the remaining chairs are dispersed around the edges of the room. As the interview progresses the three UX team members chime in with questions along the way, allocating speaking time in this conversation without eye contact by using short outbursts like "ehm..." or "so..." to take the floor. As the interviewee answers their questions and provide new information they are all sitting and nodding, probably by reflex, as they note down the information. But such recognition of the answers do not transmit very well through phone lines, so from time to time the interviewee hesitantly stops and asks if they are still there or understand what he is saying. Despite a slight language barrier, however, the dialogue flows. When the questions start fading out the interview ends and the teleconference device once again returns to its inert state.

As they get ready to break up and out of the room, Cheng grabs his phone and takes a picture of the notes he made on the table. Jonathan in contrast grabs is laptop. Looking at Cheng's almost mind map'ish notes he recognises that handwritten notes are much more flexible and you can draw stuff but that they are never really used afterwards. His own computer-written notes

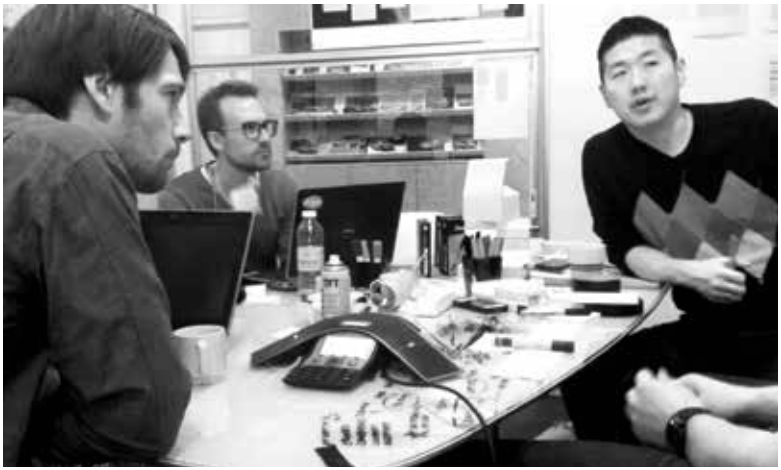


FIGURE 17 | Conducting an interview via the teleconference device.

have more limitations when making them, but he believes they make up for this by being better equipped at continuing into the rest of the process. Cheng does not disagree as he checks to see if the photo he took is readable on the small screen on his phone. Underlining his point, Jonathan returns to his desk, puts the laptop back in its docking station, and takes a look at the notes he has made during the two interviews in the Word file. Glancing through them he now highlights a few things and adds to some of the sentences. In the corner of his screen the time is approaching noon and someone soon calls out in the open office if people are ready to lunch? Grabbing a voucher for the canteen they exit the office space in smaller groups and head for the main canteen two buildings away.

2.2 Another one

One week later I arrive just after lunch to see what the team is up to now. Jonathan and three other members of the team are busy at work in the small meeting room: All four are leaning over the teleconference device on the table, alternately speaking and listening. It seems they have called up yet a Chinese contact to further enrich their local understanding of the commuting experience in China. This time the voice belongs to a young woman.

As I enter the room they are trying to wrap-up the informal interview, but they all have "just one last question" to follow up on some of the information she has given earlier on in the interview. While the Chinese contact is speaking, they are all looking either at the telecon device or at the table. A couple of the notes on the table from last week have survived, but mostly they have given way for Melvin's doodling while he listens.

When their questions are satisfied Melvin concludes by asking for a picture of the interviewee, so they can put a face to her answers when they hang them on the wall. She hesitates, unsure why this is necessary, but Melvin eventually persuades her to give them the information they need to find her on LinkedIn, so they can find her picture from there. She also asks what they will use her answers for and Melvin gives her the usual rant about their focus on the daily commute to and from the office and how they will use pains and pleasures to create opportunities for making better experiences – this is starting to sound like a standard account of the project.

After saying goodbye to the Chinese woman the team sums up, browsing through their notes: There was not that much new information, rather things are starting to reoccur. In their summation they also refer to the small journey posters from a previous project in China to emphasize their points. However Carl points out that the types of users studied may not be the same segment that this project is aimed at. Apparently they were in a more "executive" segment, though which segment is the focus now is left implicit.

Despite the reoccurrence of answers, the team discusses those answers that did surprise them and brought something new to their process. Cheng points out that one of the big recurring pains across their interviews is parking – but solving that problem will require collaboration with others and perhaps it is not what provides the 'great experience'? Carl is taking notes on his computer as they talk back and forth and draw parallels to the previous interviews. In the middle of this Melvin gets up to fetch his own laptop so he can find the LinkedIn profile and they can see the interviewee's picture.

Sensing a breakup in the process Jonathan steps up to outline what they have in store for the rest of the afternoon: He and Cheng need to talk to Noah about the framework agreements and they have to continue working on the journey map.

NAVIGATING LIMITATIONS

This episode describes two situations that occurred without much previous planning. During their initial work on the journey map the team had been discussing a felt need for some more local and contextual understanding of the Chinese traffic and everyday life in general. When I meet Jonathan the first time he explains that the process they would like to follow (though are rarely able to) is to start out in the field "pretty exploratively, […] identifying [opportunity] areas, the next study would then be to explore this in depth and understand it, and then come back and do some concepts that could address the problems and needs we have found […] and then go back to the field with them [the concepts] and have them validated."

The long-term project, of which this is just the first stage, actually does include local fieldwork. This work is what will be partly outsourced to the external agencies recruited through the framework agreements, which we shall return to in the next episode. In the coming stages of the project (given that the project is granted a continuation at the first gate) the team will thus have plenty of local understanding to work from, but that does not help them much right now. Their major challenge is that they are geographically very far away from the local context and they have no budget to work with.

6 months ago some of their colleagues had been on a research trip to Shanghai with some people from a couple of the other departments.

The team has access to the results from this previous project in the form of several simple journey maps and different power point presentations (including short videos with interviews and shots from the traffic). Using this, their own (however limited) experience, and whatever information was available online, they had started the process of mapping what plays into the everyday of a Chinese commuter in one of the metropolises. However, this project is more specific on the daily commuting experience (to and from work) than the previous project had been (which was focussed on a customer segment with professional drivers), and as we heard in the first episode, the team members thus agreed that they were in need of more specific research to match their objectives in this project. Hence they come up with the idea of utilizing their personal network to gain access even to a small fraction of local insights.

MATERIAL INFLUENCE

In this episode we catch some glimpses of how technology and more broadly *material arrangements* have a part to play in the doings of the design team. Because these interviews take place over great distances then phone connections become very central for how they are able to communicate. Their first choice for an interview like this where language may cause some problems (both parties not being native English speaking) is the Skype connection. In order to utilize the advantages offered by this they have to set up in the meeting room that houses a large screen to display the video feed and a webcam that can transmit their feed the other way. But for such a conversation to be successful both parties need to connect into the 'conversation' via Skype's website or phone-app. To coordinate this a phone call is needed. But Cheng's contact does not answer his phone at the arranged time.

Instead Cheng calls a different contact that apparently does not have the needed equipment to connect on Skype. The team thus returns to the teleconference device they are also using for internal meetings (such as the biweekly meetings with their management representative). Unlike Cheng's personal phone this device offers all of them a chance to join in on the conversation, though it cannot provide the visual information that the Skype connection would have. In the end all three interviews are conducted via this teleconference connection. The first time I visited the team these devices where newly installed and they all struggled to get

them to connect properly. By the second visit, however, they had become a natural part of the way such long-distance and team-based conversations were conducted.

Not only does this device have an influence on the way the team orient themselves in the room and practically connect to the interviewees, but it also influences the very way the interviews are conducted. Sitting in the room, what struck me most was just how much the lack of visual input meant for the interaction in the room. Getting only an audio input to interpret meaning from and no gestures or facial expressions slowed the conversation and it was clear that a lot of the team's attention was put into listening: They were all either looking at the telecon device, the table or their notes – not each other, which they would normally be doing.

The team's performances of their practices are in this way both facilitated and constrained by the *material arrangements* available in for example the meeting rooms they occupy during this episode.

SEAMLESSLY ADAPTING

Even though the team takes time to briefly prepare for the first interview it is clear that their 'game plan' is not exactly executed. But in this preparation we can find indications that the team is referring to some common *set of rules*, or in this case perhaps rather some maxims, on how you do interviews. There is for example an understanding that they should introduce the project they are working on, that certain questions should precede others, that the one that has set up the interview (Cheng) is also the one to start the conversation and so on.

Through the actual interviews we see how the team members have both a common way of acting (for example the way they interject questions during the interview) and individual ways of acting in the situation (for example around note-taking). They know how to ask questions during an explorative interview and also how to respond to the interviewee's insecurities, and they understand how to represent what they hear in a way that is workable for them (in their notes), based on their previous experiences with interviewing in other situations. Having a selection of abilities to 'chose from' helps them being more adaptable to the concrete situation and seeing each other work helps each of them achieve new understandings to bring into their work.

What really characterises their work in this episode is exactly their ability to work dynamically and adapt their ways of acting when the conditions change. When one approach fails they, as a collective, quickly find a new way to proceed. They can never be sure what the next moment will bring (if a call fails to go through, if someone else is in need of the meeting room, if the interviewee understands their questions), but this does not rattle them: They are used to act under such conditions.

But what happens when they are faced with a task that lies outside their current repertoire of experience? Next, we shall see how Jonathan and Cheng approached their work on the framework contract.

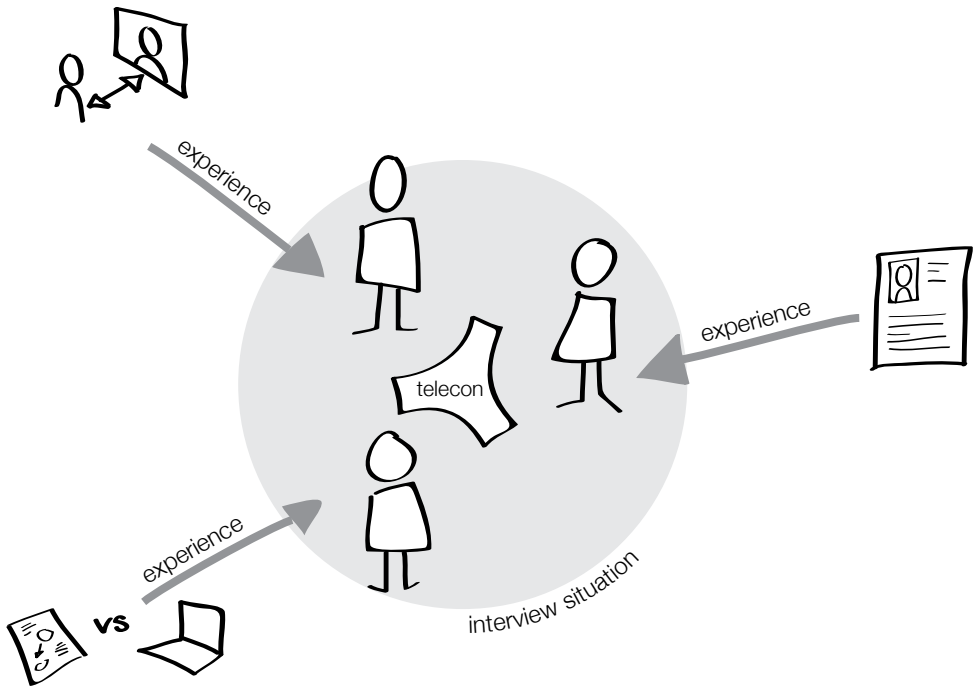


FIGURE 18 | The UX experts bring experience of for example face-to-face communication, different kinds of note-taking, and having a picture accompany the interview summary to the interview situation.

EPISODE 3 | learning by doing

3.1 Meeting with Noah

Parallel to the other, more team-focussed, activities going on in the project Jonathan and Cheng have been working on preparing some RFQs (request for quotations) for a couple of weeks now. None of them have tried to work with this before, so today they have scheduled a meeting with Noah, who has a lot of previous experience on the matter. Finishing up a discussion in the team about their interviews, Jonathan and Cheng thus excuse themselves when Noah pops in to say he is ready, and together they head for another meeting room at the other end of the office space. Jonathan brings his laptop and a small post-it pad.

The meeting room they end up in is the smallest of them all, though placed in the corner of the building it also has the best view of them all (not that any of us really take notice of the view). A round table occupies most of the space, but four chairs have managed to squeeze around it. On one wall is a whiteboard next to the door and on the other is a screen. Jonathan hooks his computer up to the screen after we have found our seats. Cheng, however remains standing and grabs a marker to begin writing a few things on the whiteboard: It seems that in preparing for this meeting he and Jonathan have come up with some points they specifically want Noah's input on. Noah's seat had its back turned to the whiteboard when he sat down, so he turns his chair and sits reclined in his navy-blue jumper, shirt-collar peeking out at the top, while Cheng goes through his points. In general, Cheng explains, they are a bit in doubt about the structure of the contract. Noah in turn starts asking them questions that challenge the practical details of the content. He points out that even though they are operating with several 'work-packages', then the fewer suppliers they end up with, the less complicated it will be to keep track of the actual work being performed.

Noah clarifies that even though the UX centre is in charge of drawing up the RFQs, then they will not be the ones having to negotiate the price in the end. The Purchasing department will manage this. He explains that in order to give them a position where they can more easily negotiate the best price, it is better to collect all the work-packages in a combined framework contract instead of several independent contracts. Laid out in such plain terms, neither Jonathan nor Cheng seem to have any trouble understanding why they should go about the task slightly differently from what they have so far been working on.

Jonathan uses his small post-it pad to make short notes while he is also trying to open up the document on the projector screen. Having navigated around his desktop to locate the newest version of the documents, Jonathan

now directs their attention to the projector screen where he has opened one of the RFQ documents in its current state. With this common reference they start going trough parts of the document in detail. Jonathan explains that they are unsure of the level of detail they need to provide in the document and points out a few examples. From his explanation it turns out that some of their insecurity is also related to who might be potential providers of the services they are requesting. There is especially one agency, which is listed as a so-called 'preferred supplier' for Volvo, but all three of them have a negative impression or experience of their work. Jonathan explains that they are unsure how the formulations in the RFQs can enable them to assess whether or not the suppliers are actually capable of doing the things they will be claiming in their quotations. Noah reads through the paragraphs in question on the screen and provides his input, also pointing out that some words are more suitable for contract formulations than others.

At the end of the meeting Jonathan sums up from the notes on his post-its: They need to be more concrete in defining the deliverables and approaches; they need to consider how the quotations will be evaluated; and finally they need to collect the different work-packages under one RFQ.

When they get up to leave the meeting room, Noah interjects: "Isn't this a great assignment?!" with a twinkle in his eye. Then he hurries off for his next engagement this afternoon.

3.2 Discussion with Cheng

While the new input is still in relatively clear recollection Jonathan and Cheng agree to go over the documents together. With the other team members still at work in the meeting room, they head for the sofas in the small lounge area next to the coffee machine. Holding on to his post-it pad, Jonathan has swapped his laptop for a printout of the documents in their current form and Cheng has grabbed a fresh cup of coffee.

With the printed document in front of them on the sofa table, they start going through each sentence one by one, reminding each other of the comments from Noah and deducting how to translate these into the individual paragraphs. As they move on, Jonathan writes notes of what they agree directly on the paper: Changing words, adding specifications, deleting sections, changing sequences etc. Some of the formulations they had simply reused from the original document on which they have based their draft, and so they are surprised of some of Noah's comments, but nevertheless adopts it to comply.

For each item in the document they take a minute to skim through what is written before they start discussing what to do with it, for example asking each other "how do we measure this?", "what is it really we are interested

FIGURE 19 | Going through the printed RFQ document and making corrections by hand.

in having delivered?" They have a pencil each, which they use to point and direct each other's attention to specific words on the page. Sometimes Jonathan reviews his post-it notes from the meeting, while Cheng relies more on his recollection of what Noah said.

Cheng's phone is sitting on the table next to his coffee cup and suddenly it starts playing a tune. Finishing the sentence he was in the middle of Cheng picks up the phone and steps away to answer the call. Meanwhile Jonathan simply continues to the next page, making a few notes. When Cheng returns to the sofa after a few minutes he optimistically asks: "So did you finish it yet?!"

They press on for another 10 minutes or so, but with the time approaching 4 o'clock it is clear that the process is coming to a halt, so they wrap up for the day and Cheng hurries off to pick up is children.

3.3 Individual work by computer

A week later Jonathan takes a break from the collective work on the journey wall and returns to his desk in order to finish the RFQs. But first of all he checks his mail: Nothing in the inbox requires his immediate attention. Then he opens a browser window and starts looking for the different agencies they are considering contacting. Going back and forth between the agencies' websites and Outlook he starts composing a mail listing the 5 different agencies he is gradually arriving at. He needs to send this mail to Noah, who will sign off on their choice before the RFQs are officially sent out. Jonathan also

FIGURE 20 | Working alone on the RFQs.

uses Outlook to check his own and Noah's calendars in order to find an open spot for a meeting regarding this decision, which he also adds to the mail.

With this mail put temporarily on hold, Jonathan is now ready to start the actual work on the five individual documents making up the RFQs, which he now opens on his stationary screen. Next to him is a small, untidy pile of post-its from a meeting earlier on the day. Browsing focused through the documents and correcting minor things here and there, he crosses out items on the post-it notes and eventually throws them out. When the table is rid of all post-its he saves the documents and returns to the mail for Noah. Then he attaches the RFQ documents and presses 'send' before leaning back in his chair and exclaiming: "Finally!"

As he starts tidying up his desk he remembers that he forgot something, which he quickly corrects in the document. But the mail has already left his computer, so he looks around the Outlook interface to figure out a way to recall it. Having no luck, Jonathan takes a quick look around the practically empty office and asks the only colleague who is still there whether he knows how to do it? The colleague is also pretty sure that it can be done, but has never tried it himself, so he suggest that Jonathan searches online for an answer. Doing just this Jonathan quickly discovers the trick, recalls his mail, reattaches the corrected files and sends the mail off again.

A NEW KIND OF ASSIGNMENT

At this point in the project what was referred to as "framework agreements" when I first started visiting, is now pretty consistently referred to as "RFQs". It took me a while to understand that this was short for *request for quotation* and that the two labels were actually referring to the same collection of documents.

A quotation is the price offer an agency can submit regarding a specific job to be carried out (it illustrates both their interest in doing the job, how they will go about doing it, and what price they are asking). An RFQ, on the other hand, is a document a company can send to agencies, requesting them to make such an offer for a specific job. What is included in this document will to a great extent be reflected in the quotations the company receives back, for example it should state all the requirements they put up in order to take a submitted quotation into consideration, any specific methods to be used, timeframes etc. Therefore it is a type of legal document, which forms a relation between the company who wants a job done and the agencies who wishes to do the job. Preparing such a document is thus no straightforward task and must be done with great consideration.

A MULTIPLE OBJECT

The RFQ itself is no simple object. In its final configuration it may best be described as a collection of interlinked digital documents. There is one central document describing the overall conditions and requirements (most of the legal content), and then there are links to separate documents for each of the work packages needing completion. These describe the details and specific requirements for each of these. The agencies submitting offers are then able to include some or all of the individual work packages in their quotations.

The RFQ document can be seen to work as boundary object between several different social entities: The UX team (needing the described work carried out), the Purchasing department (working to get the economic side to be as beneficial for the company as possible), and the agencies (needing to figure out how to sell their services – and later live up to their promises). I will not get deeper into the idea of *boundary objects* here, but return to this in Part 4.

GROWING COMPETENT

Before Jonathan and Cheng started working on the daily commute project, none of them had ever tried to draw up such a legal document. However a simple thing, such as the shift in label, now indicates how they are being absorbed into a new practice around these agreements. They are building new competences and new experience working with legal documents through the actual actions of solving this specific task – that is, they are expanding the *pool of understandings* of the UX bundle of practices to include working with this type of documents.

There is a clear lack of the same enthusiasms that characterises the other work Jonathan and the team is involved in. But at one point Jonathan also points out to me that he sees this as a learning experience for something that will be good to know about in his future work. His professional capabilities are thus currently not fully covering what it takes to be com-

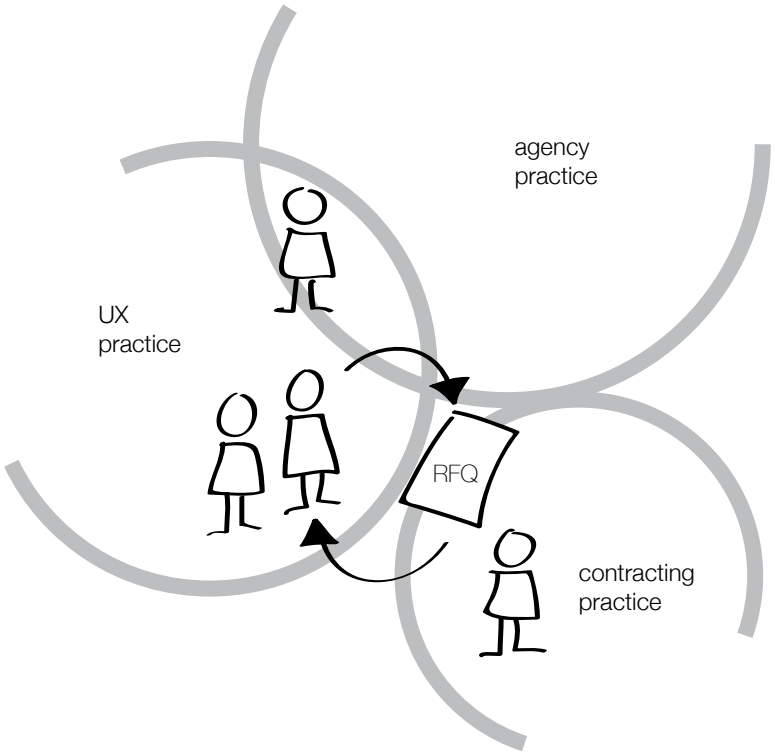


FIGURE 21 | The RFQ works in-between three different practices, which are also linked through relations embodied by different people at the UX centre.

petent at this job, but through the process of working on the RFQs he is negotiating and adapting the ways of doing such a job.

The fact that Jonathan and Cheng have been 'paired up' to do the task provides the opportunity for them to use each other to discuss and 'think out loud' when reflecting on the different elements of the complex document. But they also need to involve other relations in order to succeed in their endeavour. For one thing they have access to look at a previous framework agreement made for another project, which they initially used to set up a sort of template for the document(s) they have now been working on. They are also using the fact that Melvin has previously worked at an agency where they were replying to such RFQs. And then of course there is Noah, who embodies a great deal of experience in writing such contracts on the one hand, and on the other hand knows the internal organisation more detailed and is thus able to foresee how the processes around the document will come to unfold. From these different sources they are thus able to gradually uncover the *set of rules* that is linked the preparation of RFQs, such as which elements it is made up of, how you should phrase different things, and what needs specification.

FIGURE 22 | Inside the project room (this page).

FIGURE 23 | Transforming the paper wall to an ordered chart (opposite page).

SKETCH 2 | the project room

Since the daily commute team took over the meeting room the same week I started my observations, the room has undergone a small transformation: The noticeboard has been stripped of the concept drawings symbolizing the last remnants of the previous project and instead the entire wall has been clad in a paper cloth originally designed to free the busy family from the hassles of stains of red wine and sauce, but now transformed to work as a temporary collector of post-its – and also making it legitimate to draw on the wall. The other walls have been adorned with print-outs of various kinds: Some display characteristics of Chinese versus Western culture, some display an overview of Chinese traffic conditions, some display information about pollution levels, and so on.

The oblong glass table, which usually takes up the centre of the room with chairs placed neatly around it, has been shifted to one side, leaving the floor more open, though now scattered with stray chairs. The glass table top does not only hold the stacks of fresh post-it notes and a cup full of markers, but is also adorned with notes and a diagram drawn directly on it.

Late one afternoon during my visits the paper wall transformed from a more or less structured dipository for post-its and inspirational photos to a huge chart. Equipped with blue tape and a large ruler Carl meticously made rows from top to bottom and then, assisted by Jonathan, divided these into collums from right to left. Rearranging the post-it notes into this grid, in-

termediate stages of the journey mapped out so far now takes up each one column, such as "waking up", "driving", "go/stop", "at work", "unexpected happening", and "arrive at home". Further down the rows you also find some post-its with notes on "pains" and "pleasures" that the team is already aware of from the previous study in Shanghai. At the very bottom, outside the table, they have placed those post-its that do not have any apparent place in the newly established hierarchi above.

On the windows facing the hallway and lounge area two A2 posters are dwarfed next to this enormous installation. They show two of the condensed journey outputs from the previous study.

A SPACE FOR COLLABORATION

My very first time at the Volvo UX centre I was lead to this very meeting room to discuss the implications of my proposed study with the head of the centre. At that time this was just a 'normal' meeting room: A small room screened off from the rest of the office space by walls and a door; a centrally placed table with chairs all the way around; a whiteboard with a few left-over scribbles on one wall; a projector pointing towards a screen. Nothing out of the ordinary – a room most of us have found ourselves in a million times already, and quite frankly are glad to come out of at the end of our meeting.

But somehow, something extraordinarily happened to this room during my stay. It transformed from a place were people temporarily meet up to a place where a completely different kind of collaboration took place – a place where you actually wanted to stay, because something more than talk took place between these four walls. In fact, the whole space seemed to grow: Before only the table and perhaps projector screen were 'active surfaces' of the room, taking a part in what was going on. Now, even the walls (or actually especially the walls) were taking part in what was going on – and even the table top found a new way of contributing.

Having a designated area for each project is actually something that has become a standard practice within the UX centre, which Jonathan is quite happy about: "I think it is incredibly important to have a physical space. Because we try to get as much as possible up on the walls and on paper so that it isn't just digital. There are so many reasons for it: It's easier to share, it's easier to pass by and think of something that you wouldn't have otherwise […] Putting it up and seeing the *associations* between things, I

think that is really important." Apart from the collaborative aspects he also brings out a more symbolic level: "I also think there might be some branding in it – that is, being able to show people who come here [to the Copenhagen office] that this is what we are working on instead of having to open up computers to show it off." We will actually get a small illustration of how this works from the next episode.

This collaboratively oriented space formed the setting for a large portion of the team's efforts during my visits, which the next episodes are examples of.

EPISODE 4 | a visitor

This morning a handful of people are quietly sitting by their respective desks in the open office and getting started with their work. Jonathan has arranged to hook up with Carl over Skype because he is working from home today (later I learn his son was home sick), so after quickly sorting through the post-its on his table Jonathan grabs his laptop and moves into the project room with Frederik. While he connects with Carl via the computer and adjusts the web camera Melvin and Cheng joins in. They just passed their Swedish management representative in the hallway and invited him to join their meeting.

The management representative is in Copenhagen to attend to some other meetings this morning, but the team is quick to seize the opportunity to invite him into the project room and actually show him what they are working on. Seemingly the management representative has only just arrived for he is still wearing his dark overcoat when he enters the project room. As he scans the room he unbuttons the coat revealing a classic dark suit and white shirt underneath. The project room is full of things on both the walls, the window and the table, and the management representative looks unsure where to place himself. While Jonathan closes the door behind them, Melvin – in his t-shirt, jeans and cap – takes the lead and starts explaining the different elements adorning the walls, again switching unconsciously to English. With the focus now directed at the large paper wall to begin with, the management representative finds a place to stand and places his small briefcase in-between his feet.

Melvin explains with much enthusiasm and confidence how the wall illustrates different segments of the day and thus different "touch points" between the main character and his Volvo car. He calls these segments "journey fragments" and explains that they will help illustrate the different stakeholders and other elements at play at these different touch points. The

FIGURE 24 | Updating the management representative.

blue lines added to the paper wall have effectively divided it into a lot of small spaces. Some of these have been occupied by post-it notes with short sentences on them or pictures depicting either parts of a car (for example the steering wheel), contextual settings (for example a traffic jam), or more symbolic things (for example fortune cookies), but most of them are left blank for now. Pointing to the wall as he speaks Melvin explains that what you see now is the result of their first pass and that they will be continuing with more iterations to fill out the blanks. The result of this exercise will then become the basis for developing the script for the video, which is to be the initial product of this project. He stress that their goal is to make the 'story' portrayed in the short video believable and showcase how Volvo helps the main character through his day, thus tying to the first new car cluster's value proposition of "uncomplicating people's lives".

The management representative only makes brief comments, but eventually states that it all looks promising. "We want to embody the dream of the cluster," Melvin says. But the management representative is now slightly concerned that the team is putting too much emphasis on depicting the daily life in the video: "This is a vision video" he emphasises, it should position Volvo's vision of "simplifying people's lives" in the year 2018. Also, it is not supposed to be focussed on just one cluster of cars. None of the team members seem done in by these remarks and they each interject a few words to reassure that they will deliver what is requested.

Pressed for time, Melvin continues the tour around the room. He points to the whiteboard, which contains different notes relating to the research they hope to be doing next year. In continuation of this Cheng remarks that they finished the RFQs yesterday and will be sending them out later today. Then Melvin points to the window, which is not covered by the projector screen today, and explains that this is where they continually park their "lessons learned". Jonathan adds to the walk-through that the post-its placed next to the door contains an overview of the people they will be needing to shoot the video as extras, which also gives an estimation for the related expenses. During this the management representative mostly just nods his head and listens. Before leaving the room he explains that he will be in Copenhagen the rest of the day and also tomorrow, so it is possible for them to use him if something comes up. Then he leaves for his actual business of the day.

Once the management representative is gone Frederik adjusts the web camera in order to give Carl a better view of the paper wall. "We need to make a decision regarding agencies today," Jonathan then announces. Everyone seems to know what he is talking about. "Perhaps it would be cheaper to find one in China?" Cheng suggests and looks at the others. Frederik, who has been quiet during the walkthrough with the management representative, inquires: "So we are still hooked on China then?" The other team members seem quite set: "Considering the number of cars per person in China, then it's a potentially huge market," Cheng points out. "We just need to be able to make an argument for our choice," Frederik maintains and also points out that using translators always amounts to some difficulties and risks of mistakes in the translation that can effect the conclusions. They all seem to have had some experience with this. Whether they choose to go with a Chinese agency or not Melvin is very confident that this research done in China will have great impact in Volvo because the organisation has so little knowledge of this context to begin with – not even the Brand department knows anything, he claims: "They use curves and that kind of stuff to build their insights."

Then they return to discuss specific agencies they might approach with the RFQs based on their previous experience with different agencies.

SHOWING OFF

In this episode we get to meet the Swedish management representative in the flesh, which is also the only time I get to see him during my visits. Typically it will be the UX experts who travel to the main office in Gothenburg for meetings, but occasionally the Swedish colleagues make the

trip to this small Copenhagen satellite office. And it is on these occasions that the UX centre gets to 'show off' their different ways of working as Jonathan mentioned above.

DRESSED TO IMPRESS

Suddenly emerging as something more than a voice, it now becomes even clearer that the management representative is different to the UX experts that usually inhabit the project room. Even the way he dresses strongly suggests him being of another 'type'. Jonathan, Cheng and Melvin are all wearing jeans; Melvin has a T-shirt and cap on, Jonathan a sweatshirt, and Cheng a T-shirt with a casual cardigan. The Swedish management representative on the other hand is dressed in a dark suit, shirt and dark overcoat. He acts much the same as he does over the teleconference, leaving the team to describe their efforts without much interruption or input, but being in the project room also seems to leave him with a somewhat different impression than the phone calls. Stepping into the small room packed with information and ideas all around he clearly appears a bit overwhelmed.

This is a meeting between the 'executive' and the 'creative' and their clothes are just one indication that their priorities are different – we also hear it in the way they talk about the video. The UX team is focused on communicating a *believable* representation, and through the video they want to *embody the dream of the cluster*. In other words their professional interests do not lie in the glossy advertisements depicting utopian situations but in the average everyday life – which is also why they chose the daily commuting experience as their point of departure. This unglamorous everyday life is their starting point for finding opportunities where Volvo's coming generations of cars can support the actual life of the user and make sure he/she travels as unproblematic as possible – *uncomplicating* his life.

The management representative, on the other hand, puts a strong emphasis on the *vision* rather than the everyday. Implicitly he indicates that the vision depicted in the video should aim higher and be more versatile than the concrete design solutions will eventually be. He emphasises that the initial cluster of cars will just be the first of several generations to work from the vision depicted by the video, so the team should not become too focused on this. Nevertheless the UX team does, more or less consciously, keep this focus. Perhaps because this first of the coming clusters

is the most concrete and thus the one facilitating their way of working in the best way. It is more readily imaginable what this cluster's design will include and which technological possibilities will be available. But the format of a video (as opposed to for example an animated film) also warrants some concreteness: There will, for example, have to be a physical (and thus existing) car in the video.

At this point it might also be worth pointing out that the UX team does not consider their approach to the video *un*visionary – they simply have a different understanding of *what* visionary implies. They want the user *experience* to be the key visionary component, and such an experience is necessarily contextually situated in their understanding.

REITERATING ARGUMENTS

The question of the Chinese focus has come up before at the meetings between the team and the management representative. This is a reoccurring theme where we can see the different perspectives they work from: The management representative wants a broad, overall vision of the future Volvo cars and the UX team wants a more concrete, realistic depiction of peoples' lives. They come from two distinctly different ways of approaching the design of a car. The management representative in this situation represents the typical approach found in a technology driven company

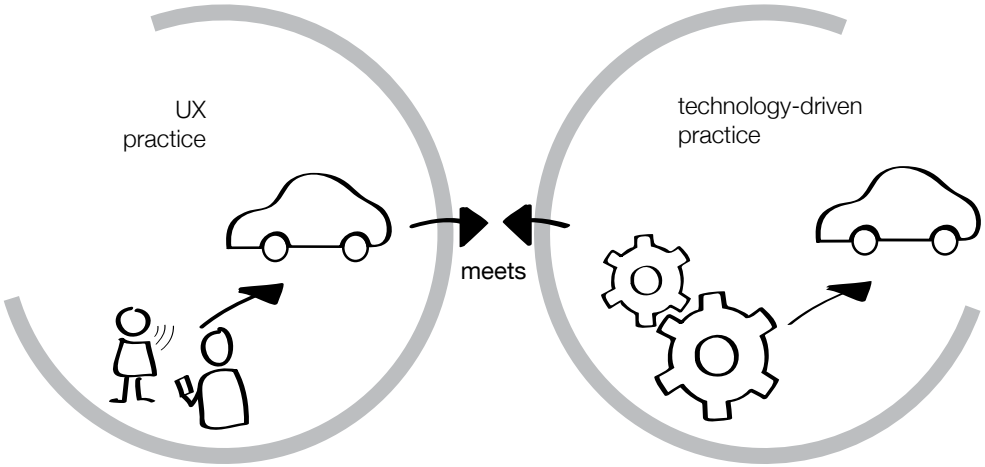


FIGURE 25 | Different approaches to design meet in the project.

such as Volvo: The design starts with the car itself and the technologies that the different specialised departments in R&D are developing.

But the UX approach is to start from the user and design the *experience* first of all, and then moving on to find the technology that might accomplish this. "I have been asked to do some strange projects," Jonathan tells me when I first meet him, "in a couple of years, for example, we are able to make a larger heads-up display – that is, where you project things on the windscreen instead of on a screen down here [on the dashboard] – and then 'could you make some studies of what you might use that for?' Of course you could do that, but I would say that goes completely against the way we would like to work. We want to start by seeing if there *are* any needs or any opportunities and then look at how we might solve them. And hopefully we already have the technology to deal with many of these needs."

In the short sequence following the meeting with the management representative we hear the team discussing their focus in the RFQs in relation to this debate. The team has planned the coming fieldwork to take place in China and thus dive even deeper into the Chinese context than they have been able to at this stage of the project. Based on their discussion with the management representative they seem to reconsider this choice. Not that any of them are interested in opening up their focus, but continuously faced with different priorities from Gothenburg they seem in need to continue reiterating and rehearsing their arguments for these choices. One argument we have heard of earlier is a wish to potentially prove their professional worth to the new Chinese management, here instead we hear of the great market potentials. Melvin also points out that the Chinese context is such an unknown territory for Volvo that the research they will be doing will undoubtedly have a great impact no matter what. Chartering into unknown territory is a rare occasion for such a longstanding and traditional company, making this is a unique opportunity for the UX centre to prove their worth in uncovering and approaching the unknown.

Again, this seems to make their approach special compared to for example the Brand department, which Melvin only attributes the use of *curves*, or statistical data, when getting to know a market. Jonathan also explains to me that their relationship to the Marketing department (of which Brand is one part) is somewhat strained: "We have had some contact to them – not a very good contact – in relation to our user studies. Because they have sort of had the position that they are the ones doing all

user studies at Volvo." In Jonathan's words the difference between what the UX centre and the Marketing department does is that "we are doing design-research and they are more doing market studies […] With a lot of what I see from them you lack a sense of *why* people say or do what they do […] I don't think you see that much of people's real world, that is, the actual context where they use the car, how they live, how they work, how they travel to and from work. So I miss some depth in the material." This depth thus becomes an important part of the ambition driving the UX practice bundle and what they hope to represent in the video.

EPISODE 5 | steps towards a video

4.1 Turning to the wall

After the team meeting with the management representative the team turns their attention to the large paper wall. Yesterday they were not all part of working on the wall, so now Melvin starts out by explaining the main journey stages that are now illustrated on the wall: At the top, some of the columns in the huge chart have received a yellow post-it with a sentence stating which stage in the journey it now represents. Pointing to some of the columns Melvin explains that they have left some open for now, since they expect more journey fragments will emerge as they continue their iterative process. In going through the rough outline of what will happen in this day-in-the-life-of-a-Chinese-commuter they also start discussing the main character, his age and job – something creative perhaps? Jonathan picks up a small orange posit-it pad from the table and starts placing these on different parts of the wall's content to indicate things that need checking or clarification.

One of them brings up that the character of the different things they want to show during the video is different: Some parts are more technology-heavy, some have to do with building the main character, others showcase the different roles that the main character takes on during the day (husband, farther, employee, son-in-law). They are already starting to develop new situations that might occur during the journey – maybe he wants to pick up his kids from school despite the heavy traffic, or maybe his wife suddenly arranges an evening with the grandparents. "This taps into the values," Cheng remarks when they start adding the new post-its to the wall.

They all work in parallel adding post-its to different parts of the wall. Jonathan has started making some green "pleasure" post-its. He steps back, looking at the post-its he just placed on the wall and asks, "what exactly do we refer to with 'pleasure'?" They discuss whether these are linked to the solutions

FIGURE 26 | Team interaction with the wall.

they will eventually be proposing or the actual instances of the journey. In the end they again agree that it is closely linked to the values they are starting to map out underneath. During this process new design ideas also emerge – the car might be able to receive updates from the wife's smart phone or maybe include projections of afternoon traffic jams when planning the trip home – so to the sound of markers writing and post-its being torn off Carl calls out from the computer screen on the table: "Remember to add these things under 'ideas'!"

Jonathan and Frederik both grab some post-its in the appropriate colour to comply with this straight away while Noah opens the door and pulls Melvin away for another meeting. As he is writing up such an idea post-it Frederik remarks that they also need to start thinking visually: "Some of these things are hard to explain," he points out. But Jonathan remarks that part of their ideas should also be showcased more subtly: "Everyone may not necessarily discover everything – and that's okay," he concludes.

Looking at the paper wall and how it has already grown Frederik exclaims: "This is a lot for 3 minutes!" The other two nod and agree that the time allotted for the video also posses some serious restraints on what they are able to show. This leads them to discuss the balance between making it visionary enough but still realistic – how much should they push what they want to showcase?

4.2 Coordinating roles

Two weeks later Jonathan shows up for work at 9 in the morning. He has been up most of the night with his sick daughter, but nevertheless seems ready to get started on his team's work on the journey map and script for the video. Frederik is already sitting in front of his computer screen next to Jonathan's table and as usual the two exchange a few comments on something they have seen or experienced. This morning the topic is the new Tesla electric car that Jonathan got a test ride in last week at an event arranged by the Danish Society of Engineers (IDA). Fredrik has tried the same car at a previous occasion and so with this common frame of reference they now discuss the design of the interior (for example the height of the backseat and the lack of support from the headrests). The car is equipped with a large touch screen instead of the central control panel, which controls most of the functionality and displays information, such as map navigation or fuel consumption. On the short test ride last week Jonathan did not get to interact with the screen, but he recognises that it would take some getting used to to navigate this big screen out of the corner of your eye while driving.

While they have been talking Jonathan has started his mail program and opened a mail regarding the RFQs that the team sent out last week. After sending them to five different agencies they received inquires back from four of them requesting some further specification. Before the end of the week the agencies must submit their offers and the team then has about 6 weeks to make a decision. But they are already preparing how to evaluate the incoming offers – and that is what this mail is about. It contains a power point with a list of pros and cons for some of the agencies based on one of Jonathan's colleague's previous contact with them.

While Jonathan starts going through this, we hear Alex and two others gathered around one of the low shelving units dividing the table clusters in the open office to look at the new camera equipment they have just received. Previously, when making videos, they have used private recording equipment, but now the UX centre has received some money to invest in this more professional equipment. For Jonathan's team this is great timing, since they will start shooting their video next week. Jonathan has no real experience in this type of work – but Alex knows a lot about it, so apart from helping them write the script for the video he will also be in charge of the actual shooting. There are several types of accessories, which attract the attention of the small group, and they are discussing what each part is for. Alex is trying to explain to the others when it makes sense to use a certain type of accessory over another while holding one of them up to demonstrate. After looking at the different gadgets for a while one of them remarks with both enthusiasm and irony "this is some cool Chinese crap!"

Later that day most of the team is gathered in the project room, discussing some new elements that have been added to the paper wall. Melvin breaks up this discussion by asking Alex how his process will be. Alex has not participated in the team's discussion. He is holding some printed sheets of A4: One representing each of the journey fragments found on the wall. He explains to the others that when he is writing the script he is only thinking about it from a *camera* perspective, so "from a practical rather than a creative space". He is specifying very detailed every camera angle, location etc. in order to make it *look* good. But in this process he may also be changing some things compared to what is depicted on the wall. Jonathan reassures him that this is no problem, because the rest of the team will go through the script when Alex is ready and make sure that their points are still intact before they start filming. In order to ensure as smooth a process as possible when they start shooting, Alex suggests to go through the entire script with his iPhone at provisional locations, in effect making a "mock-up video" to show the envisioned angles and focus points. This will enable them to take any discussions up front instead of on location when doing the actual filming, which he is confident will end up saving them time. The others seem to trust his judgement on this. So he is ready to continue working on the script – which he hopes to finish today – leaving him time to do the mock-up video tomorrow. However, he is also dependent on the rest of the team finishing defining the storyline. Melvin reassures him that the story on the wall is pretty finished and that they just need to define what will be shown on the screens in the car at various points.

Melvin and Alex continue to discuss the scripting process and meanwhile Cheng leaves the room to get a bowl of fruit, which he places on the table. Everyone immediately grabs a piece while continuing their dialogue. Alex also asks what the workshop on Friday is about and if he should be there. Jonathan is the one to put it most bluntly: The main purpose of the workshop is to create buy-in with the other participants and to have them feel an ownership regarding the video that the team is producing.

DIVERSITY OF ENGAGEMENTS

From this as well as the previous episodes it should by now be clear that each workday holds a diversity of engagements for the individual UX expert. Jonathan for example alternates between one-on-one talk with his colleague at the next desk (exchanging experiences and opinions); reading and responding to mails (interacting with his computer and (distant) colleagues); listening in on conversations taking place in other parts of the office (keeping oriented); discussing in the team (negotiating a com-

mon understanding); getting updates from his colleagues (coordinating and aligning work efforts) – and much more. Seemingly, he navigates quite smoothly between all of this.

POST-IT PUSHERS

The paper wall, which the team is interacting with in this episode, is in fact the most important work surface of this project. This is where all of their thoughts are condensed, stored, and continuously reworked as their insights and process progresses. This is also where they meet each other's input and each individual is thus confronted with the process that other parts of the team has been through. Faced with the growing number of post-its and pictures they question and reflect on the structure on the wall and the labelling they are working with. They are able to move in and out of these processes, seemingly quite seamlessly, because of their common *pool of understandings*. Each of them has an understanding of how the work progresses, or the way they are working with the paper wall. This also ensures a continuous alignment across the team and helps them gradually move from loose ideas of categories to more stable definitions.

While working side by side, they invariantly have different associations and thoughts related to the specific post-it they have just been writing or reading or the part of the wall they are looking at etc. This spurs them

FIGURE 27 | View of the paper wall through the window behind the coffee machine.

to pull the process in different directions with very short intervals, only to later perhaps circle back again to an earlier discussion. They also term their own process *iterative*, which indicates that this is not a random way of working, but something they do quite consciously. There are thus also some more implicit traces of this *pool of understandings* in their work: Working iteratively is an acceptable way of going on with their work that makes sense to them – in fact they never consider (at least what I have seen) going about it in any other way.

Due to the windows of the project room and the team's habit of leaving the door open at most occasions it is also not uncommon for other colleagues to peek in and make a comment or ask a question. In fact, the paper wall is quite visible when standing at the coffee machine (which is always a central installation in any office environment), and the whole centre thus has the opportunity to follow the team's process from the sideline. And they are quite interested in doing so. For some, such as Sebastian who we will meet in PART 4, keeping up-to-date on the team's experiences is actually quite important for their own work assignments.

LEARNING FROM OTHER EXPERTS

It also becomes clear from this episode how individual members of the team have been assigned certain roles. In this project it is most noteworthy that Alex has been given a special 'expert' role as the 'moviemaker' on the team. As such he does not participate much in the team's efforts around the journey wall or for example the daily stand-up meetings. Instead he has his own parallel process of translating the paper wall into a script for the video. We learn that he has a great deal of previous experience with the preparation and production of videos, giving him an understanding of 'what looks good', where issues may arise during the production, and how to operate the professional recording equipment. In other words, he is using a different *pool of understanding* in his work.

But even though Alex is put in charge of this part of the project exactly because of his competence to do so, it is also interesting that this is in fact not a professionalism he protects in order to distinguish himself from the others. Rather, there is some obvious learning going on where he introduces the other team members (and also colleagues outside the team) to different elements of the *doing of a video*. And they are all curious and keen to learn, asking questions, and participating on and off in Alex' process

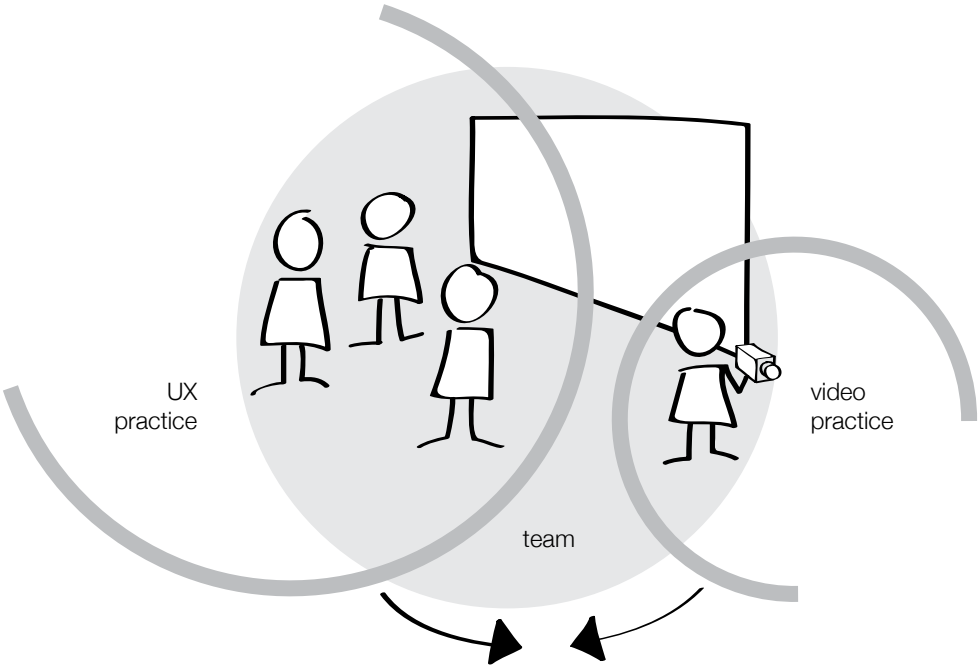


FIGURE 28 | Interacting around the journey wall the video practice is brought closer to the UX practice.

when suitable. While this may never make them 'expert moviemakers' it does help create stronger links between the two kinds of practices they represent and that are closely dependent on each other, thus forming a more dynamic bundle of practices.

At the end of this episode we also hear mention of workshop – this will be the focus of the next episode.

EPISODE 6 | preparing a workshop

5.1 Daily stand-up conference call

About one month has now passed since I first started following Jonathan. This Tuesday morning time is approaching 9.30 and Jonathan looks over at Cheng who is sitting at his desk across the open office space. The rest of the team is not in yet, but Jonathan suggests that they move into the project room for their daily stand-up session with their Swedish management representative anyway. Just as they get up you can hear the teleconference device ringing in the project room to indicate that he is already waiting for them. Without letting this stress them, Cheng and Jonathan enter the project room and press a button on the telecon device in order to greet the management representative good morning. While they are still exchanging pleasantries, Carl and Alex join them, taking a seat around the table. Jointly agreeing that Melvin will probably arrive to join them soon, Jonathan starts summing up their status. There are 3 overall focus points of their current activities: One is the process around RFQs where Melvin is now in charge of answering the queries received so far; another is the video where Alex is in charge of writing and specifying the script and practicalities surrounding this; and the last is a workshop, which the team will be hosting on Friday. Jonathan explains that people from both "upstream and downstream" in the organisation will be joining. It turns out this is the first time the UX centre will be facilitating such a gathering structured around a 'journey'. Carl and Jonathan have thus been continuing the work on the paper wall and tried to cluster some of their design ideas – but more work is needed before it is presentable. So this, Jonathan explains to the mute teleconference device, is what will be the priority today. Cheng checks their week plan on the flip chart to be sure that they are up to speed with everything else than the workshop preparations. The flip chart placed in the corner of the room contains several, coloured post-it notes placed within columns indicating each day of the present and next week. Many of the individual "to-do's" seem to relate to the workshop preparations (indicated with a yellow sticker).

Melvin has now arrived and joins the meeting, picking up a couple of post-it notes that have fallen from the paper wall on his way in. Quickly scanning what is written on them he returns them to an available spot on the wall while the conversation starts addressing a new topic: Preparing for the workshop the team has encountered the challenge that one of the participants may not be joining after all. Melvin, who has been in charge of the communication, explains the issue to the management representative: They have among others invited a participant from one of the "downstream" departments who, according to Melvin, is very interested in joining the workshop because she

has worked with some of UX's user insights on some previous projects. But her boss apparently is not interested in letting her come. Though the official explanation is something to do with the cost of participation (sending her from Gothenburg to Copenhagen), Melvin is reading between the lines that her boss would rather have her "doing actual work – none of that hippie shit they're doing in Copenhagen." Hearing this account the management representative laughs, slightly defeated. He seems a bit astonished that the team would meet such an attitude and lack of support for their work. Agreeing that there might be some more political issues at work here, he offers to see what he can do "at my end" to eliminate any "bad excuses" for not coming (such as cost and time). Melvin points out that it is important for the team that all participants are able to participate fully the *entire* day (and not for example merely over a video conference) in order to ensure any impact: "Otherwise we would rather she didn't come at all".

After this round of updates, the management representative wishes them good luck with the workshop (he will apparently not be attending himself) and arranges to talk to them again same time next week.

5.2 Updates on the journey wall

Without any delay, and even as Jonathan is pressing the off button on the teleconference device, the team's attention goes straight to the paper wall. Carl immediately notes: "There's a new pink one!" referring to a new row of post-its that have emerged on the wall. The big piece of paper lining the wall of the project room is now more or less completely covered in coloured post-it notes – there is an order to it, though, which keeps it from overwhelming you completely. Each row of the huge chart seems to have its own type of content: At the top, rough sketches are depicting fragments of the journey with a central scene and event. Under these are short outlines of what is happening and who are there, printed on white paper. Then, shifting focus from a future scenario perspective to present day, the next row lists what would happen in the respective scene today, followed by a row outlining what the users want (expressed as goals and values). The team has also mapped out the "pains" and "pleasures" relating to each scene (on green and orange post-its respectively). At the bottom they have placed their identified "design opportunities" (phrased as "how might we…") on the pink post-its and below that you find different ideas for accommodating these opportunities, which have emerged along the way. But there are still post-its floating outside the chart itself.

The ones forming the centre of the team's discussion now are three notes placed at the very edge of the wall. In fact when the door to the meeting room is closed these are covered, so the door is open while Jonathan, Carl,

FIGURE 29 | The updated journey wall.

Cheng and Melvin gather around the notes. Jonathan explains that he and Carl made these particular post-it notes yesterday in an attempt to formulate some overall "value boxes" they want to use at the workshop in order to introduce the participants to this huge wall of thoughts. Each of the three notes have been given a small sticker in red, green and yellow respectively, and looking around the wall you can rediscover these stickers on some of the pink post-its with design opportunities. Cheng, who was not part of formulating these, asks for an example of what they mean. One of them reads "Pleasure through contextual intelligence/awareness". In Cheng's opinion this is a very high level statement and could be referring to more or less anything. So Carl starts to offer his take on an example for each of the three post-its, but during the discussion they agree that they should find a different format – as the rationale goes: If Cheng (who is part of our team and a UX expert) does not understand it, then the ones coming for the workshop (who have not been part of the process and are not familiar with user experience) will certainly not understand it!

5.3 Conference call with colleague

In the middle of this, Jonathan inquires if they have a meeting at 10? Melvin confirms that he has been in contact with one of the colleagues from the Product Planning department that will be participating in the workshop.

He had expressed that he might need some further clarification on their thoughts on the content of the journey before the workshop. So they stay put in the project room and await the call on the teleconference device while Frederik also appears and finds a seat at the table (apparently this 10 o'clock meeting has been alerted in his calendar). They start discussing some possibilities relating to a new project Frederik has been informed of, while a colleague standing by the coffee machine outside the room peeks curiously through the window to see what is going on.

After passing time for about 5 minutes with no input from the teleconference device, Melvin decides to call up himself. He grabs his smartphone and calls the Swedish colleague – it turns out that Melvin has sent the meeting notification to everyone but him, so clearing up this misunderstanding they agree to just go ahead with the meeting now.

As Melvin puts away his smartphone Alex pops back in with a question for the video script. He asks if they have time to answer it now? Melvin readily complies. So when the teleconference device soon after emits a ringing tone and Jonathan, who is closest, pushes the button to answer the call, the small project room is filled with conversation and at first the team seems to forget the newcomer in the room represented by the teleconference device on the table amidst them.

However, Melvin eventually takes the lead and initiates the meeting by starting to explain the team's intention with the journey. They do not wish to cater for every possible use of the car, he says, but only the commuting experience. The Swedish colleague agrees that there is no time to do all the potential journeys. Melvin further motivates their priority of this particular type of journey in that it has many pains (rush hour, finding parking, making it in time etc.) and hardly any pleasures (such as the scenic road trips through stunning landscapes depicted in the commercials). At the same time he points out that by focusing on the entire day in the Chinese metropolis they are also introducing other types of journeys than the commuter journey (for example errands during the day and family visits after work). Though these are not the main focus, Melvin believes that they have the potential to become talking points internally in the organisation. The voice from the teleconference device breaks in to point out that the different types of journeys also cater for the different types of cars and links to commercials typically selling the different categories. Melvin then emphasizes that in UX they are not trying to sell cars to end users – with the video they are rather aiming to join internal stakeholders in order to collectively solve the issues that necessarily arise during the journey.

Carl now interrupts to hear if their Swedish colleague has any input for the workshop agenda? He does not come with any specific points but puts

emphasis on letting the participants "join the thinking", which Melvin is quick to confirm: Their purpose is to create alignment and buy-in. At the same time he brings up the small crisis of the participant from the downstream department probably not being able to join the workshop. With the same air of disappointment the voice confirms that the head of that department is very delivery focused, so "such a side-project [as putting resources into this workshop] does not fit with her gate-thinking."

After ending the call Carl muses that if she *is* allowed to come after all, then the Design department is the only one not represented at the workshop and wonders if that will be a problem? They consider back and forth if the Design department should at least be invited, even though with such short notice they will probably not be able to attend anyway – but Melvin also stresses that what started out as an informal workshop would then become more official. They agree that they are not quite geared to tackle a more official setup and leave it at that.

5.4 Refining the wall for the workshop

After the teleconference call there is a short halt while the team dissolves to deal with different tasks. Carl and Jonathan, staying put in the project room, quickly agree to continue working on the journey wall for a while. However, it is not the journey map itself they start focussing on, but some of the post-its hovering above it.

Leaning his head back Carl reads from a few of them, pen and post-it pad in hand ready to add some more. It seems they want to make another attempt at formulating some key features, which are supposed to help the workshop participants gain an overview of what is displayed on the rest of the wall. They use the pink design opportunities previously mapped along the bottom of the wall to think through what more overall 'categories' they have been working with during their process so far. The wording is carefully considered before writing it down on new post-its as concisely as possible (for example "getting there", "family", "parking").

Cheng re-joins them after a short while, scans the handful of these post-its that Carl and Jonathan have already placed at the top of the wall, and asks what these are to be called, "themes"? Going back and forth, they do not quite land on a definition, but instead end up engaged in a conversation about how this new level fits in-between the very overall "Key Communication Points" (KCP), which are defined by the Product Planning department for the initial car cluster, and then the very detailed journey outline below. The two KCP's placed at the top of the wall read: "Uncomplicating peoples lives" and "Pleasurable in all situations". They all agree that the 'headlines' at the intermediary level, which Carl and Jonathan are working on, will help

FIGURE 30 | Working to translate the KCPs.

speak to people like the delivery-focussed department head causing trouble in the workshop planning.

Continuing their work on these post-its they come and go, leaving the door to the project room open, meaning that others also interrupt along the way with various queries. When they have reached a certain saturation Carl starts splitting up the post-its in two groups: One relating to each KCP. That is, he physically moves the post-its, discerning between practical (relating to the first KCP) and more emotional (relating to the second KCP). Seeing this new clustering Jonathan then suggests that they make it more like a continuum, which will give room for those headlines that are more in-between the two KCPs. He draws a rough sketch of what he means on a post-it and Carl then moves one of the post-it clusters (which were placed above each other) down beside the other cluster and starts sorting the in-betweens with impressive speed. Thus reviewing the post-its, they discuss if some of them should be split up or rephrased. Having done this they now come to a standstill, considering their next step. As time is approaching 11.30 they agree to break for lunch and then after lunch try to map the different design opportunities under these new headlines, creating an even stronger link across.

As they stand there, looking at this large wall now fairly covered in post-its Carl and Jonathan discuss how they should 'unveil' it at the workshop. Introducing the participants to the whole thing at once might be too overwhelming and confusing, so they consider perhaps covering the bottom part (pertaining more to the future than the present) to begin with, leaving just the overall categories visible for a start.

REACHING BEYOND ONE PRACTICE

In this episode we hear that an inter-departmental workshop has emerged as an idea of an *informal* meeting point, bringing together people from different departments ranging from "upstream" (doing more strategic planning) to "downstream" (doing the actual specification and implementation). Despite of this announced informality, the amount of work that goes into planning the workshop (of which I only witnessed half a days efforts out of nearly two weeks) suggests that there is more at stake than merely meeting up and talking for a couple of hours. In fact, it is perhaps misleading to speak of 'a workshop' as some sort of defined unit, because the situated actions taking place both before and presumably also after the workshop itself seem to play just as important a part in the team's work. So let us take another look at what goes on in these preparations.

TRANSLATING TO A COMMON TONGUE

Up until this week the team's process has been very open and explorative, focussing on generating ideas for scenes as well as design opportunities and coming up with ways to depict the pieces of contextual knowledge they have been able to gather through the interviews among other things. Now, when they are faced with presenting their work (even if provisionally and informally), it instead becomes a priority for them to pause the creative flow and start making the wall more approachable, navigatable, and readable for 'outsiders'.

In other words, the team is aware that by arranging a cross-departmental workshop with participants from very different levels of R&D, they have also invited people who work differently, who prioritise differently, who speak differently and so forth: In short, people who participate in different types of professional practices than is found at the UX centre. The UX centre works with *experiences*, which naturally occur across all of the individual technical solutions making up the car. Therefore it is natural for them to try and bring all of these perspectives together. A not insignificant part of the UX practice is thus devoted to brokering between these other types of practices in the R&D departments and their varying intentions and goals.

While none of the team members are strangers to the task of planning and executing a workshop, they also share an implicit understanding that

a physical object, such as the journey map, will come to play a significant role in such a setting. At the workshop itself you could therefore see the paper wall as a *boundary object* (Star 2010), which is intended to somehow accommodate all the different priorities and understandings that are present through the individual participants. Since I have not attended the workshop myself, I shall not be going into speculations about how that worked out, but instead focus on the part of the team's practice that preceded the workshop.

In preparing the workshop the team members are forced to 'clean up' their work (in this case the journey map) and become explicit about their intentions as well as the actual content. They want the work they will be presenting to be understandable by others than themselves (as for example indicated when they chose to abandon the "value box" post-its that Jonathan and Carl had been working on). However, presenting their work to 'outsiders' confronts it (and them) with other points of view and priorities. When reviewing the elements of the paper journey wall they are thus very conscious about their choice of words and formulations (not that they have not been so before, but it is given much more priority now). In their discussions they are consequently drawing on their collective experiences of interacting with people from the other departments and channelling this into arriving at a suitable format and wording for the different elements they want to convey.

Continuing their work of formulating an extra 'layer' that mediates between the overall KCPs provided by the Product Planning department and the design opportunities they themselves are working with clearly illustrates their wish to 'translate' their work in a way so that it relates to the work the other departments are doing. When they start this process they do not have a clear idea how to do this, but through their interaction, testing different possibilities, they arrive at a format they intuitively deem satisfactory.

Regarding their relationship to the Product Planning department Jonathan explains to me that: "They do some pretty overall descriptions of what a new car model should do – very general. It could be 'active city lifestyle' and 'dynamic driving', which is quite hard to translate into something concrete. So we get these general descriptions from them and then we can try to move it forward into some concepts. And then there is another interface, which is those who actually have to do some concrete implementation of it [the design opportunities]." The UX centre thus has a kind of

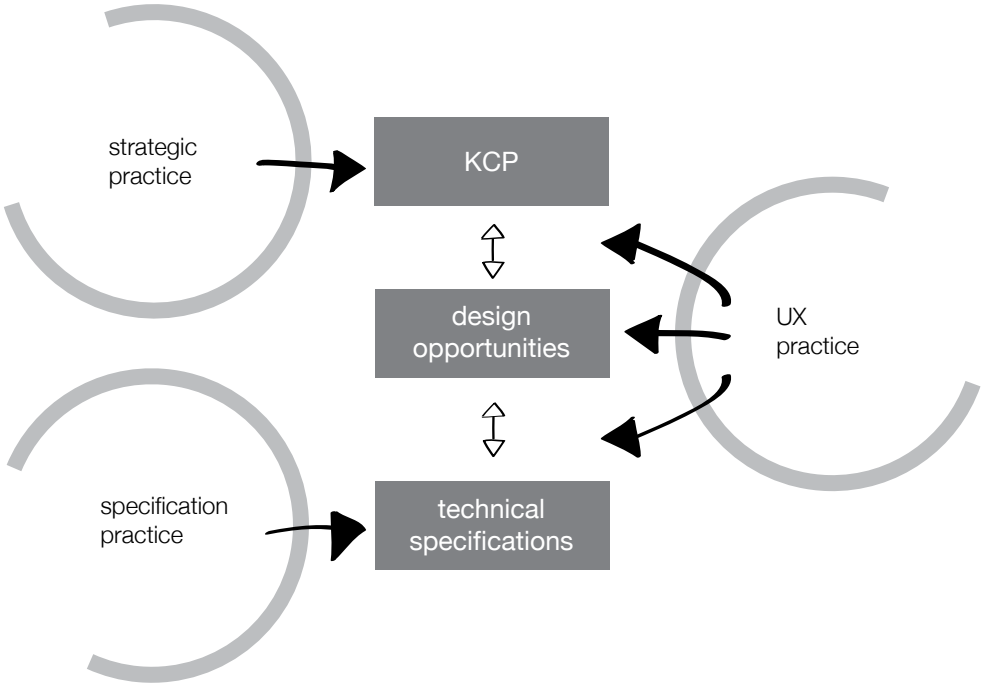


FIGURE 31 | The UX team also tries to contribute with a translation between the strategic level and the specification level.

mediating role between the very overall strategic formulations emerging from the business-oriented Product Planning department (for example in the form of the KCPs) and then the people in charge of actually implementing the design into the cars (through technical specifications).

CONFLICTING PERCEPTIONS

Just as importantly, the team is putting a lot of effort into mobilising the workshop participants and also their departments (their superiors). This is very symptomatic for the way the UX team works: Including others in their work (for example ensuring buy-in), seeking other points of view, and attempting to merge together different priorities (creating alignment). In this respect the team is also working against the contradiction in terms that lies implicit in their physical location (isolated and far from the rest of R&D) and their strategic ambition as a unit to influence the very way that the company as a whole does/uses design (which we return to in Part 4).

In this episode we hear two accounts of a conflict that has arisen during the planning process. The UX team has invited participants for the workshop directly through their personal connections in the organisation. These contacts are being gradually built through each new project that the centre is involved in. Therefore they are also starting to gain insights of who has an interest in the work they do and who might be more reserved. One effect of this is that none of the invited participants are placed in managing positions but are instead involved in actual design work at different places of the R&D organisation. While this fits well with the team's intentions with the workshop (because these are the kinds of people that will eventually be charged with incorporating the UX insights into their work) it has the downside of creating challenges of a more political nature.

In this particular situation it is a middle manager from one of the so-called downstream departments that suddenly opposes the participation of one of her employees. The invited participant is a quite important contact for the UX centre, as Jonathan puts it: "She is really good at seeing the big picture and knows what is actually happening, and has a good understanding of the suppliers, and is a really good liaison between the slightly more technical R&D and Design."

So why is the middle manager so opposed to letting this employee participate in a workshop for one day? The official explanation is neatly wrapped in some politically correct concerns about the cost of sending her employee to Copenhagen and back, but the team is certain that something else is at stake. When discussing the issue with their management representative as well as another invited participant from a third department they seem to have their concerns confirmed. There are simply different priorities at stake. Where the UX team may be working on a specific project right now that should result in a video, then their actual ambition is much more long term than this. They are aiming to use this project to develop ways of working on future projects of a similar nature and also try and start creating clearer links between the input from the different departments in the organisation.

Most of the UX employees themselves go to Gothenburg more or less regularly to participate in various meetings in connection with specific projects or more strategic efforts. Driving back and forth has been a prerequisite in their work from the beginning, so they could have chosen to simply take the workshop to Gothenburg where all of their participants already are (which they actually did with some of the later workshops).

But this, it seems, would defeat some of its purpose. This workshop is not primarily linked to the development of the script for their video, but rather to start laying the groundwork for future collaborations and a fundamental mutual understanding. Inviting representatives from the different departments in R&D to Copenhagen they are thus trying to de-mystify their own work and lay the foundation for a broader co-ownership of this work and eventually also their approaches.

For the middle manager it appears to look completely different.[10] From what I learn, that department's work is strictly organized around a stage-gate model where certain slots of time are allocated to certain tasks, and specific deliveries need to be made ready for each gate. Any time spent on something besides making these deliveries ready for the respective gates is thus seen more or less as a waste of resources. While this is just one person's perspective coming across particularly strong because of her position in the organisation, it can be seen as a sign of a significantly different kind of practice taking place at this management level (compared to the UX centre).

The very process around the stage-gate model is difficult for the UX experts to navigate. After my field visits Jonathan told me: "It is – still – not very clear to us how those gates work. Because it is not *one* meeting or *one* day, but it's rather a process over a period of time – some weeks, that

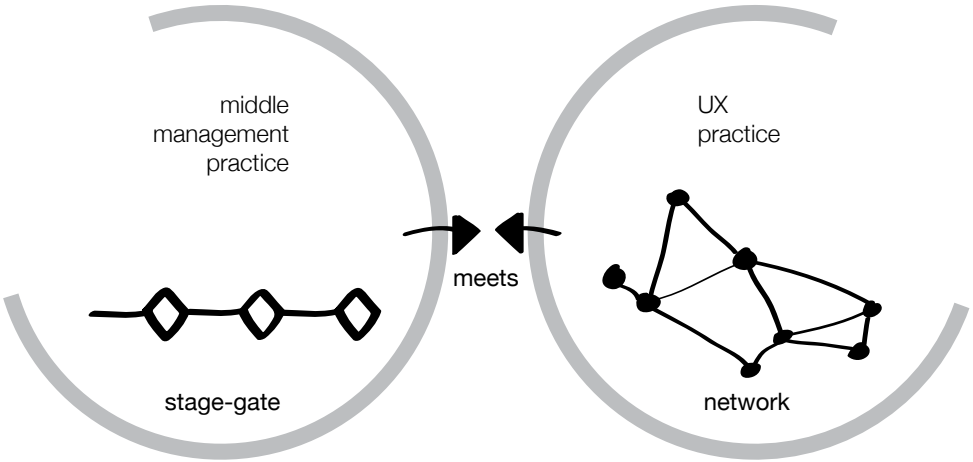


FIGURE 32 | The UX centre's network thinking meets the more formal stage-gate thinking of the middle management practice.

is, and then you have made some decisions. So I think it's about being early and talking to the right people so that they understand it […] Because it is often a pretty long process to make a decision, then you have to keep one step ahead and show 'now something is coming' and then you show a bit more, and then you show a bit more. And then people are ready to make the decision. If you wait until the formal decision time and then you come with something finished 'tadaa!' then people think it is too big a thing to make up their minds about and then it's easier to say 'no, unfortunately it's too late' – even though the timing might be right. But it's more about a tactical game, I think." Through the different projects the UX experts are thus building a repertoire of experience of how to engage with this stage-gate structure that holds a great influence on their work.

When I returned for my next visit shadowing Jonathan I learned that all of the intended participants did in fact attend the workshop. Even though it was at that time more than a month ago and both Christmas and New Year had intervened, Jonathan was still quite happy about the outcomes or perhaps rather the *spirit* at the workshop. This simply underlines the point that Melvin also stressed during the second teleconference call: Their aim with the workshop was to join the internal stakeholders and create alignment and buy-in. Using their work (specifically the physical journey map) the team wanted to provide a clearer view of how the individual contributions (from the different departments) feed into a larger whole. From the UX point of view this 'whole' is not just the resulting car, but more importantly the resulting *user experience*. Jonathan points out that part of the purpose for the workshop was to ensure that "there is someone to receive what we do. Someone who are both able to receive, but also understands the timing and understands the limitations there are and the possibilities there are."

Despite resistance in certain parts of the organisation this is generally the reason why many people in the other departments are actually quite excited about the new UX centre and would like to back up initiatives such as this workshop. We hear this when the Swedish colleague requests to "join the thinking". These workshop participants can thus be seen as some form of *brokers* between the UX practices and the more traditional engineering practices found in their own departments.

EPISODE 7 | getting at a decision

This afternoon, about 5 months into the project, Jonathan is sitting at his desk. He and Melvin have just finished interviewing one of the four agencies that have replied to the RFQs that the team sent out a month ago, before Christmas. They had already interviewed the two Danish-based agencies the previous week by inviting them to come to the office. Today, however, the interview was conducted over the phone since this agency is based in Singapore. Next week they are talking to the last agency based in Germany, but their expectations for that interview are not very high. This agency has offered the lowest price, but also what appears to be the weakest offer. No one in the UX centre has worked with this agency before, so all they are basing their current reservations on is the quote document lying on Jonathan's desk amongst the other three. Right now, however, Jonathan is focused on following up on todays interview. He is waiting for Melvin to finish what he is doing so they can meet up and 'debrief' together.

Jonathan has composed an excel sheet for their evaluation, which is now open on his stationary computer screen. It lists a range of evaluation criteria – or "attributes" as they have named them. These have all been weighted from 1-10 to denote their relative importance. For the two first agencies they have already filled out the evaluation: They have awarded the agency and their quote a number on a scale from 1-5 for each attribute, 5 being the optimal. At the bottom these numbers are summed up and the final, weighted score calculated. This is what Jonathan is waiting to do in collaboration with Melvin based on today's interview.

But while Melvin is finishing up his current task, Jonathan starts focusing on the bottom part of the evaluation sheet. For it will not solely be the evaluation scores but naturally also the asking price that they will have to base their final choice on. So for each quote the prices related to the two proposed phases should be indicated. On his laptop Jonathan navigates to the folder where the quotes are stored and opens the first one they interviewed. In the pdf-file he quickly navigates to the page where all the prices are listed. But it is not a straightforward task transferring the numbers from this page to the evaluation sheet: The page contains a chart with several numbers specifying different parts of the task. So Jonathan begins to note down numbers on a post-it and adds them by hand. The result is then entered into the two specified cells in the excel sheet. Completing this he closes down that pdf-file and starts looking for the next one. Again, he navigates to the page containing details on the pricing, this time contained in an even more elaborate chart. He now opens the build-in calculator on his laptop and starts entering some numbers. Besides adding together price elements for each phase, it seems

he also needs to convert to EUR in order to make the prices comparable. As he reaches a result he adds the numbers to the excel sheet. But this time he also adds a third number, indicating the expenses and then sums up these three numbers in a total price. So he returns to the first quote again and locates the equivalent expense number, adds this to the sheet and sums up these numbers as well.

Jonathan starts working on filling in the prices for the remaining two agencies using the same procedure: He opens the quote on his laptop screen, finds the relevant page, makes a few calculations either by hand on the post-it or using the laptop calculator, and then inputs the numbers in the excel sheet on the big stationary screen. For the agency they have interviewed today he adds a note beneath the prices that these do not include one of the work-packages since this agency has not (yet) included this in their offer. With all the numbers in place he goes to his mailbox and locates a mail from a woman from the Purchasing department, who has assisted them in the interviews and will be in charge of evaluating and negotiating the prices. She has sent them a "cost breakdown" in excel, which Jonathan now scans through on his laptop, comparing with the prices he has arrived at in the evaluation sheet. While he is still at this, Melvin comes up to Jonathan's desk declaring that he has finished his task and is now ready to go ahead with the debriefing whenever Jonathan is ready. Since Jonathan has mostly been passing time with small non-critical assignments, he is ready to start at once, and so they both move into the project room with their laptops.

Once seated in the project room Melvin casually asks about a meeting concerning financial considerations with Ella (who is lead on the project Sebastian is working on, which we shall return to in PART 4). While the team is in the process of reviewing the RFQs and deciding on an agency, they still do not have any guarantees that this next part of the project will be funded. The gate where this will be decided has been postponed up to six weeks at this point. So the team is eager to explore if there are any other ways for them to fund their activities. Jonathan and Melvin discuss this in brief, but the meeting with Ella apparently had not turned up any new opportunities.

Meanwhile Jonathan turns on the projector and hooks up his laptop in order to display the excel sheet on the big screen. The table has returned to its more original position close to the centre of the room and the two have placed themselves at opposite sides of the table at the end furthest away from the screen. Though Melvin brought his laptop and has it placed in front of him it is closed halfway down and his attention is focused on the big screen while leaning back in his chair. Jonathan has his laptop open in front of him in order to control the image projected onto the screen and thus divides his attention between the big and small screen. He explains to Melvin that he has

hidden the columns relating to the agencies they have already graded in order to avoid too much bias and keep them focused. They briefly discuss what to base their evaluation on: This agency has not officially made a quote for the entire package, but in the interview they expressed that they may consider adding the last part to their quote. In order to make the evaluations as comparable as possible across the four agencies, Jonathan and Melvin thus agree to base their evaluation on what they imagine the full quote would be. And then they launch right in.

Having done the same thing twice before, they work pretty efficiently and synchronously. They start off with the first attribute, one of them giving an initial judgment of this being either "high" or "low". This one concerns the availability in Copenhagen, which – given that the agency's office is in Singapore – they can quickly agree is "low". In the interview, however, it was mentioned that the agency might send some people to Copenhagen for a short duration of the project and so they end up awarding them a "2" on the scale from 1-5, which Jonathan plots into the sheet. They use the same procedure for the rest of the attributes, keeping in mind both the written material they have received, their impression from the interview and also what appears to be Melvin's previous experience in dealing with them. After completing the full list – which includes attributes such as "out-of-the-box-thinking", "theoretical UX know-how", "Chinese language", and "understanding of assignment and Volvo's needs" – Jonathan makes the other columns visible again. Both seem excited to compare the result. Between the lines it is clear that they already have a favourite candidate for the job, which is one of the

FIGURE 33 | Assigning scores to the different quotes in an excel sheet.

two Danish agencies. But they have known from the beginning that it would most likely not be the one offering the lowest price (in fact they were the second most expensive).

The two of them now compare the three results to see if the numbers "seem fair". Their favourite candidate has scored the highest number and the agency they just evaluated has come in third, which they deem quite reasonable. They have already worked with their favourite on a previous project comparable to the current one and they were very happy with the work the agency did – so they already know that this agency posses the skills they need. Melvin also points out that last time they got a very good price because the agency had not quite known the extent that the job would take on, so in this current offer he believes they have most likely been able to make a much more accurate price estimate. Compared to this, they do not have much experience with the agency they just evaluated. However, from the material and the interview Jonathan and Melvin agree that they do not have as much expertise within the UX area as the team would have liked, but Melvin knows them to be very professional and not unlikely to be able to do the job (though not as well as their favourite, of course).

Looking at the prices Jonathan just plotted into the sheet, it is clear that the other Danish agency is by far the most expensive. For example their expenses are almost three times the amount of their favourite. They use some time to discuss what might lie behind these numbers that could amount to such a difference. Though they have some ideas they also agree that they should set up a debriefing meeting with their colleague from Purchasing to get her opinion on the economic side of the quotes. On his laptop, Jonathan checks in Outlook when she might be free. His screen is still projected on the big screen so Melvin can keep up. They find a spot two days later where she looks to be free but Melvin remembers that there may be another meeting pending around that time, so he checks his own laptop for the mail correspondence related to this. They agree on a time that would fit them both and Jonathan sends the meeting notification straight away.

Then they discuss what they need in order to make the final choice. Besides the last interview (with the agency they have the least amount of faith in) both of the Danish agencies might be sending some extra material after their interviews, and the third agency might add the last part to their quote. They are not completely sure what they agreed with each of the agencies, though, so Melvin will send a follow-up mail asking if they will be sending more material or not.

They wrap up their meeting making a status: The Danish agency's quote has the best quality and in their opinion most realistic price. Melvin thinks they can drive down the price a bit (they did that successfully last time) – in

fact he believes they have probably added a little extra to their price in order to be able to provide such a discount. They both agree that this agency is "the obvious choice" right now. Then they go through a few places where there might be the potential to save a bit by cutting away some parts. Melvin rehearses the argument for choosing their favourite: Of the four agencies that have come with an offer, two are too weak to take on the task satisfactory (the foreign agencies) – which should be illustrated in the evaluation scores – and of the remaining two (the two Danish agencies) their favourite is actually the cheaper one! Content that they will be able to argue for the choice they want, they leave it at that for now and break up the meeting.

MAKING THE RIGHT CHOICE

This episode occurs about one and a half month after the completed RFQs were sent out and now, as one of the first things in the new year, it is the process around evaluating the incoming quotations that we get a glimpse of.

Already before receiving any quotes we heard that the team had started preparing for this evaluation process in Episode 5. Assisted by a colleague from the Purchasing department, Jonathan and Melvin are now in charge of carrying out this process. After going through the quotation documents with the agencies' descriptions of how they intend to fulfil the demands that were set up in the RFQs, there is an interview session with representatives from each agency. This provides the opportunity of clearing out misunderstandings and getting further information – and then of course putting some faces to the written words and testing the 'chemistry'. Following these interviews Melvin and Jonathan carry out a quantitative evaluation based on their overall impression.

PROCESSING ARGUMENTS

What I think comes out in this episode is another example of the ambiguity the team has to deal with. When you lay it out, then the process around these RFQs seem quite simple: The team needs a job done; they prepare an outline of what they want and their demands; they send it out to a selection of agencies that could be interested in providing this job; they decide on the best offer; they get the job done. But already in Episode 3 we learn that it is not as straightforward as all that. One thing is defining

and formulating what it is they want to have done, and in this episode it is about making a decision on who ends up getting the job. What Jonathan and Melvin are doing is to set up evaluation criteria and score the agencies to arrive at a number indicating which agency would be the better choice. But that is not all and I do not think it would be fair to say that the resulting number is the actual outcome of this process. What is valuable is the *process* of evaluation itself.

As professionals they have a gut feeling about which agency would be the best one for them to work with. They might have had this one as their favourite from the beginning, even before sending out the RFQs, but what is more important is how working through the evaluation process helps them construct arguments for why that is – arguments they need in order to convince their management that this is the right choice. Had the agency provided the cheapest offer they would not have needed as many arguments.

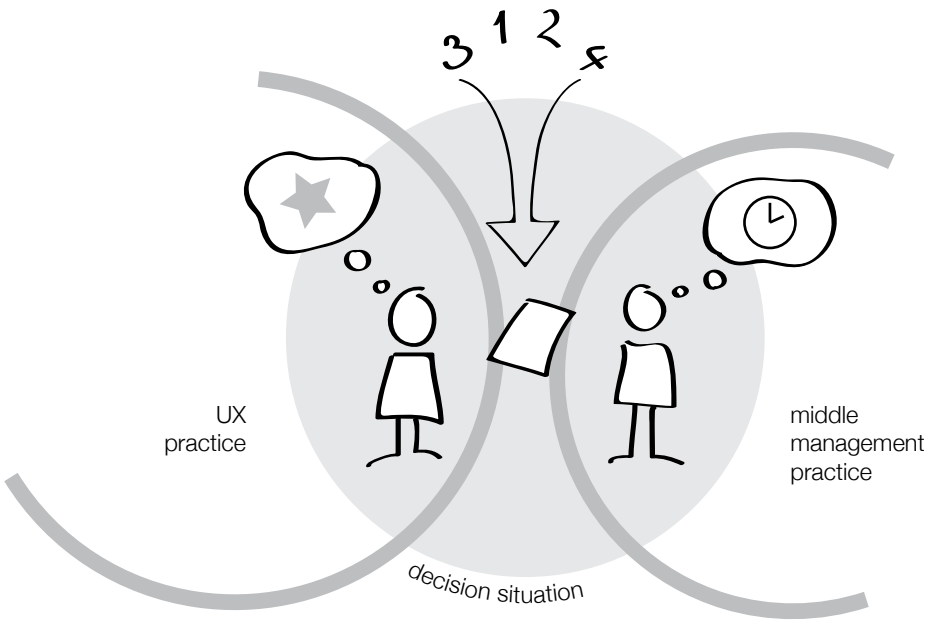
So it is not the quotes that the agencies have provided, the interviews, or even the excel evaluation sheet in themselves that form the basis for making the decision. It is how the UX experts *engage* with all of these; referring to their own previous experiences, interpreting statements, and drawing on their professional normativity in order to negotiate a shared understanding.

SPEAKING NUMBERS

Evaluating quotes is new to the UX experts, but evaluating alternatives is not. Amongst the team members they have a good understanding of how to evaluate using different methods. There are many ways they could have chosen to evaluate the quotes and informally they also go about the task from several angles. The choice of evaluation method in this episode thus tells us something about the infrastructures that the team has to navigate in order to do their jobs. The evaluation sheet that Jonathan sets up in excel is a very typical quantitative engineering method (decision-matrix method referring to Pugh (for example 1991)) used to rank alternatives based on multiple dimensions (weighted in order of importance). It is usually considered a way to make an objective choice without influence of personal preferences. Such a method also refers to a *set of rules* that must be respected while carrying out the evaluation.

But the choice of a quantitative evaluation method perhaps tells us just as much about the intended recipient of the evaluation results. Any quantitative method holds the risk of producing the illusion of a factual and objective 'truth' without keeping in mind the situated conditions under which that 'truth' was produced. Neither Jonathan nor Melvin appear to be disillusioned about what they are doing in that way. They are quite aware that any number they award could just as easily have been otherwise (for example if someone else had joined in on the scoring process or if one of them had voiced a different argument). So what do they actually gain by doing this at all? If the resulting numbers could just as well have been different then what value do they hold? Well, it seems the most important value lies in the 'language of numbers' rather than in the numbers themselves. As Jonathan later expresses it: "Numbers just speak more clearly to management levels when decisions are to be taken," and so the translation of their impressions into numbers that can easily be compared to each other is given a priority. In some way you might say that the final decision is not based on the numbers, but that the numbers reflect the final decision.

FIGURE 34 | In the decision situation the quantitative evaluation mediates between the UX practice and middle management practice.



EPISODE 8 | facing a blueprint

7.1 Collective update

It is afternoon at the UX office and, after finishing the evaluation meeting with Melvin, Jonathan finds himself without much to do. As they break up their meeting he inquires whether Melvin knows of anything he can help with for the rest of the day? Melvin suggests asking Carl about the work on the "blueprint" – perhaps he can give them both an update on what he and Cheng have been doing.

Carl is still sitting in front of his computer screen, so Jonathan goes and asks. Carl nods his head towards the unoccupied desk next to his where a plot of a large chart is lying. Melvin joins them and asks impressed if this is it? Apparently it is: This is the so-called *blueprint*. Actually, what it is, is a transformation of the paper wall into a digital format and now plotted onto a large piece of paper. Cheng has so far been the one primarily in charge of this process and so Carl suggests that he should join them for such an update – if he is still there. Cheng had mentioned that he wanted to leave earlier today, but his computer is still open and his jacket is by his chair. So they all scan the office space to locate him.

While Cheng is nowhere to be spotted right now, Carl grabs the blueprint and suggests they hang it in the project room. As he proceeds to do so, both Jonathan and Melvin – and now also Alex – gather around the large piece of paper, which seems significantly dwarfed once placed on the opposite side of the project room from the swollen paper wall. But they all appear to be quite impressed with the result. Cheng now turns up to join them, but – checking the watch on his phone – he realises that he needs to be heading home, so he suggests taking the walkthrough tomorrow morning instead. Everyone readily accepts his priorities, but at the same time they are all very excited about the physical summation of their work so far now hanging on the wall, so, huddling around it they cannot help but start asking questions regarding the elements that have appeared since the paper wall version. Cheng thus agrees to give a super quick introduction to the top part of the chart, which he has added in this excel version.

Encased in a blue frame at the very top you still see the different journey fragments – now represented by a number, a name, and a small photo. Next are four rows where each stage has been awarded a number pertaining to "pain", "pleasure", "feasibility", and "viability" – and then a resulting value named the "Keeley indicator". Cheng explains that based on Melvin's earlier mention of the "Keeley triangle" he has made some calculations that are plotted into the next rows of the table. This part is what first catches the eye with bright red and green colours. First, a bar chart illustrates the pain (red

FIGURE 35 | The new blueprint on the project room wall.

bar) and pleasure (green bar) level at each journey stage. Below this, a curve is moving up and down through an area ranging from red at the bottom to green at the top. This is where the team's discussion is focussed as they each lean forward to discern what is written on the poster. Cheng cannot quickly explain the calculations behind the curve – just that they are relating to the numbers above. After looking at the two graphs Jonathan suggests that rather than showing the level of satisfaction for their main character (which was the spontaneous perception) the bottom curve might illustrate where there is potential for "doing something"?

Carl, who has been assisting Cheng in the blueprint work, asks: "Alex, what do you think?" Alex is standing a bit further from the wall than the other team members, but he is clearly impressed by the result like everyone else and asks how it was made? His reply to Cheng's answer is simply: "Cool, excel!" Then he asks if the bars are illustrating pains and pleasures – which they are – and then he asks if the curve is also showing this? Since that is not the case, he suggests that the choice of colours should then be different, because he links these two together when both are using the red/green colours. He also suggest that they should use the colours on the graph to help direct attention to what is important: They want to identify the places where the potential – that is the curve – is high, so Alex suggests only giving this part of the curve a colour. Still looking at the blueprint, the others nod their heads, not refuting Alex's input.

Cheng now leaves the group to head home and also Melvin and Alex break up, leaving Carl and Jonathan to continue pondering the blueprint. After

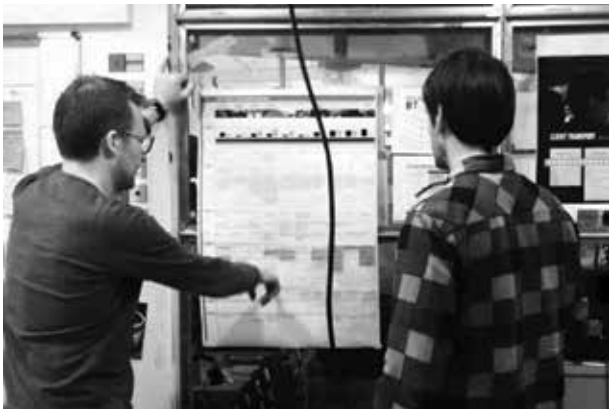


FIGURE 36 | Debating the content of the new blueprint.

looking a bit more closely at the poster Carl points out that this version only includes the design *opportunities* they have identified and not the *solutions* that they have also been brainstorming on. This results in a short discussion on what it is they want to show with this blueprint.

Looking at the lower part of the chart where a row is dedicated to these design opportunities, Carl suggests they try to sort them out, only keeping those with the most potential – which can then be offered at the coming gate as examples of what the project might focus on. But looking through the cells with these opportunities they agree that they are hard to rate. Jonathan instead suggests that they should try to ask themselves where they want to be "lead" (that is, the best) and highlight those areas at the coming gate.

Then, looking again at the blueprint overall, Carl asks: "Do we have everything here?" Jonathan scans through the large chart again and sidesteps the question by returning to the curve at the top, suggesting that it should be relabelled to something with "innovation potential" in order to avoid misinterpretation. From this they move back to discussing the three key concepts of "desirability", "viability", and "feasibility" that now permeates the representation. Carl suggests the perspective that *desirability* relates to the customer (implying the user-centred perspective is dominant) and *viability* is relating to Volvo (from a more business-oriented angle). They agree that for now these are the two main parameters they should be interested in, for as Jonathan puts it: "It is not our job to assess the *feasibility*".

Carl grabs a post-it note from the desk and starts composing a new title for the curve and also tries to write a simple formula for what it shows. Looking at his guess, however, Jonathan points out that it is not just a summation of opportunity – in that case 10 mediocre ideas would count for as much as 1 really good one. So they discuss how you might assess the level of opportunity more quantitatively. Carl ends up suggesting some kind of an exponential equation, but none of them can really guess from the curve itself how Cheng has arrived at it.

To conclude this short, spontaneous session Carl states that he will make an alternative version of the excel chart based on their discussion. Jonathan further suggests that they should approach someone from the organisation to "test" if the format makes sense to people outside the centre. Then they turn their attention to the 2-week plan. From its original position on the flip chart, the week plan has now conquered the whiteboard on the wall instead.

They are scouting for something imminent that Jonathan can busy himself with the rest of the day – but first off they are updating the position of the post-it notes symbolising each task. Most of those relating to last week are quickly moved down to the area labelled "done", while a few are moved to one of the coming days this week. It appears that they have a lot of work cut out for them on Friday, but none of these tasks are anything Jonathan can start working on here and now. So instead they agree that he can continue looking through the blueprint chart in its digital form and provide his comments to the content and format.

Before leaving the room Carl glances at the projector screen, which is still on. Jonathan quickly asks if he has seen their evaluation sheet? He wakes

FIGURE 37 | Updating the week plan.

up his laptop, which is still sitting on the table, and shows Carl the results of the evaluation thus far. While Carl scans through the numbers on the screen Jonathan explains how they have been inputting numbers for each agency without looking at the others. Carl is nodding his head and seems to agree with the result offhand.

7.2 Work by computer

Unplugging his laptop and turning off the projector Jonathan then returns to his desk. With his laptop placed in his docking station he starts by checking his mail. He looks for a mail that might share the blueprint file or location, but without any immediate luck. So he stretches his neck and looks to see if Carl is sitting at his desk. He is not, so Jonathan takes a different approach. He navigates through their file sharing folders and eventually discovers the excel file he is looking for. He opens the one labelled with the highest number, reasoning that this would be the newest version. The large excel sheet now opens on his stationary screen – but the letters are still relatively small in order to fit the entire breadth of the chart in the window. Jonathan scrolls a bit up and down to orient himself in the sheet and compare it to the printed version. Back at the top he reads the comments that Cheng has added to the first rows (that were not visible on the printed version). Then he turns his attention to his laptop screen where he has opened a note-taking program and now creates a new note before starting writing some of his initial thoughts related to the chart. He continues like this for a while: Reading the contents of a few cells, and then making a note. After a while he asks Carl (who has

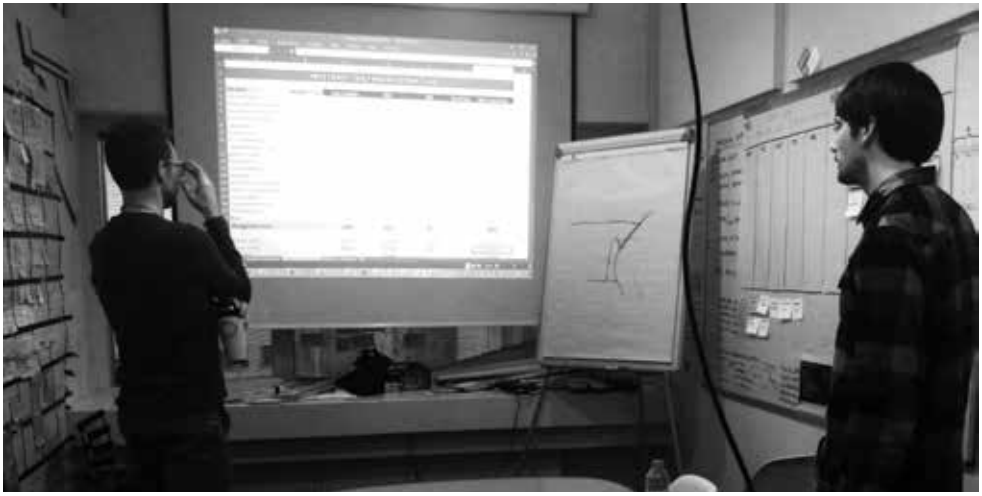


FIGURE 38 | Reviewing the evaluation sheet of the RFQs.

FIGURE 39 | Going through the excel sheet on the big stationary screen while making notes on the laptop.

now returned to his desk) across the room about the figures assigned for pain and pleasure. He is unsure whether these are the number of individual pains/pleasures they have identified or is calculated somehow? Carl is not sure, he tries opening the blueprint himself to see if that triggers his memory, but there is some confusion about the versions. It turns out he had not discovered the newest version that Jonathan has opened when he printed the copy now hanging in the project room. Apparently Cheng has made some changes since that version, though a final answer is never provided. But Jonathan continues to explore the document.

He clicks on one of the tabs at the bottom of the screen and is taken to another sheet dedicated to "design opportunity #1". A large arrow at the top makes up the way back to the main sheet. Jonathan continues making notes after adding a headline referring to the design opportunities. For a long while he sits pondering and reading this sheet, which he had not previously encountered (it was not represented in the printed version in the project room). Scrolling down to the bottom he finds some new links, which he tests and is taken to a new sheet shortly explaining the Keeley triangle. In this way he explores the rest of the document.

In the corner of the office Ella is getting ready to leave, which Jonathan spots from his desk. So to wrap-up a conversation they had started earlier in the day he asks her about a HMI evaluation that they have been asked to partake in. It seems both Ella, Melvin (who also joins the conversation) and Jonathan are going, so they try to coordinate their trip to Gothenburg. During their conversation both Ella and Melvin have moved from their desks to stand leaning on the low shelving unit shielding Jonathan's desk from the

isle dividing the open office space in two. They conclude that Ella will leave already the morning before the meeting while Jonathan will most likely not be leaving until that evening. Melvin is then free to decide which option suits him better, but he will see if he can combine the trip with some other meetings in Gothenburg or not. With this more or less settled Ella casually inquires what they will be doing tomorrow. Melvin explains that it will be a day dominated by evaluation and recapitulation of the different streams they have been working on in the project. Ella is happy to hear the project is progressing and asks if they will have a video ready for the rest of the office to watch soon? But it seems there is still some work to be done before it is showable.

Time has now passed three thirty and more and more of Jonathan's colleagues are leaving for home. But Jonathan presses on with the blueprint. He has now opened the second design opportunity and continues to make notes on the small laptop screen. The sleep inducing humming from the ventilator and the rush hour traffic whizzing past outside the windows are the only sounds filling the office this afternoon. Melvin is also getting ready to leave and while he puts on his jacket, Jonathan asks if he has seen the video today? He has not – but from Alex, who is currently the one working on it, he knows that the rough parts are coming together quite quickly. It is the last 20 %, Melvin predicts, that will take the longest.

With Melvin out the door Jonathan is also closing to an end. He finishes off by saving his notes and closing down the blueprint. And that is it – time to go home.

TAKING IT TO THE NEXT LEVEL

In this final episode from Site 1 we see an interim culmination of the team's work: The new blueprint. The by now very elaborately decorated paper wall has been translated into a digital format in excel and thus emerged in this new, printed, representation on the wall in the project room. Jonathan explains to me later that this has at least two purposes: The journey is 'preserved' and thus more stably documented for future use, and it is made more mobile (for example they brought a later version of the blueprint to China for the research trip).

ENGINEERING AN INDICATOR

This is actually one of the episodes where some of the residual engineering identities surface most clearly. The two people that have been working

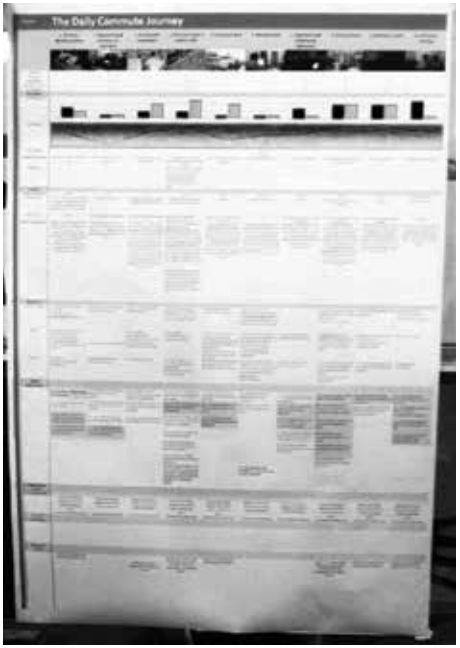


FIGURE 40 | The contents of the large paper wall is translated into the excel blueprint.

on the new blueprint format are the IT engineer and the design engineer with Cheng, the IT engineer, taking the lead.

From the team's conversation I learn that Melvin, the communication designer, had at some previous occasion mentioned the so-called *Keeley triangle*. This model by Larry Keeley is based on an observation of how successful businesses are balanced in the concerns about *desirability*, technical *feasibility* and financial *viability* of their products – these three parameters thus making up the three sides of the triangle (Cronin 2010).

It is actually an understanding that IDEO's Tim Brown has also been promoting (for example Brown 2008) and is often referred to in discussions on *design thinking*. But while the triangle can be claimed to reflect three important parameters to consider during a design process, then it hardly provides any actual ways of determining whether a design solution satisfied these 'well enough' – at least not in any way that matches the engineer's quantitative evaluation schemes. So what is interesting here is how Cheng takes it upon himself to translate this triangle into an *indicator* instead.

All through the journey mapping process the team has been talking about "pains" and "pleasures" as an integral part of their analytical work. In the blueprint version these have been given a numerical value instead of the written statements, and two extra categories have been added: "feasibility" and "viability". Figuring that the *pains* and *pleasures* must somehow make up the *desirability* factor in the Keeley triangle, then the team actually has scores for each side of the triangle. Cheng has then found some way – which cannot be explained in 5 minutes – to calculate an indicator value based on these.

What you might call the design philosophy of the Keeley triangle is thus translated into a quantitative indicator of the innovation space, which can be represented by numbers and a curve in an excel sheet – and thus help facilitate the decisions that the team is facing. But do the numbers in the chart enable the team to make this representation? It seems there is some confusion concerning what exactly the numbers represent. When looking more closely at the digital document Jonathan is thus in doubt about the numbers assigned to pain and pleasure. Though the team has been through an extensive iterative process in order to reach this point, then it would be rash to claim that they have discovered *all* the possible pains or pleasures or design opportunities. When I returned for the follow-up interview Jonathan also explained that the curve had subsequently been left out of the blueprint. While it was a strong visually communicative element on the blueprint then, as it turned out, what it communicated did not make sense to the UX team. This quantitative element had also not entered the work on the paper wall previously, so it is interesting to see how the change of format (from post-its to excel) now suddenly spurred efforts to attempt translating the work into numbers or grades. This indicates that the spreadsheet comes with a different *set of rules* and *teleoaffective structures* requiring the designers to draw on a different *pool of understanding* to do their work. When they resist this in the end they are thus also defining a clearer distinction between the UX practice and other, more quantitatively guided adjoining practices.

SELF-IDENTIFICATION

Framed by the three parameters in the triangle we also get another fraction of their self-understanding. In their discussion Carl and Jonathan quickly agree that the *desirability* parameter is the one the UX centre is governing

in the organization – and *feasibility* is taken care of by others, that is, it is the 'actual' engineering departments that govern the technical insights of the company. Even though they both posses engineering profiles, they are thus more interested in the experience dimension than the technical feasibility. This, however, does not mean that the *pool of practical understandings* that guide their practice does not resound with engineering elements.

When trying to figure out just how the curves have emerged at the top of the blueprint, for example, Carl starts writing a formula on a post-it – almost without thinking about it – in order to provide the description they both feel is missing for the curve. A mathematical equation thus seems to be considered a more correct description than the label provided in this initial version of the blueprint.

DIFFERENT FOCUS

While most of the team is thus involved in discussing what the numbers and curves at the top of the blueprint represent and how they have emerged, there is particularly one who do not contribute to this talk. When asked to join the conversation then Alex, the graphical designer, clearly refrains from getting into the technical number discussion and instead stick with his professional domain. He comments on the overall visual impression, the use of colours, and how the communication might be improved using some specific 'techniques' (for example using colours both to differentiate and guide the readers' attention). Everyone in the room readily accepts Alex' input, indicating a recognition of his more expert competences when it comes to these visual and communicative refinements. Cheng does not even try to defend his choice of colours – this is not his professional domain and not where he has put his main efforts.

You could say that Cheng and Alex draw on different *pools of understanding* (Cheng knows how to calculate, Alex knows how to visualise) and comply with different *sets of rules* in their work (Cheng's relating for example to mathematics and Alex' to graphics). However, coming together in a project like this, their *teleoaffective structures* are more closely linked, which also ties together the practices they are part of in a more tightly knit bundle.

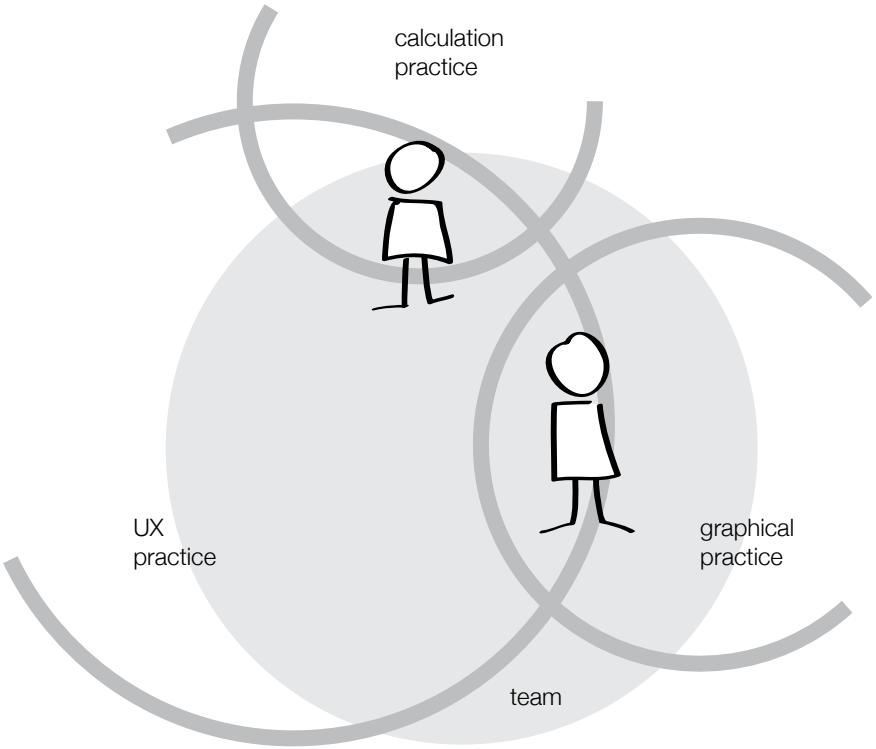


FIGURE 41 | The individual links different practices together through the work.

SUMMING UP

From the thick descriptions of these different episodes we see that a lot of different elements take part in and give shape to what we might refer to as 'the UX bundle of practice'. Embodied doings and sayings take place in a sociomaterial entanglement that can appear chaotic for the outsider, but nevertheless makes up the everyday for the professional practitioner.

The people we meet from the UX team may not all be equally strong participants in the UX practice or in the entire *bundle* of practices. Alex, for example, appears to be a more peripheral participant in the actual UX design work, whereas he is otherwise centrally placed in the efforts around the doing of the video. The other participants seem to be especially united through the common forms of know-how they draw on and their abilities to do certain things (such as asking explorative questions, identifying

pain-points, and mapping journey fragments). This forms part of the *pool of understandings* linked to the UX practice. While this know-how is clearly something carried by the individual, then we also see in the episodes that the more collective *pool* is dynamically kept up-to-date and expanded amongst the individual participants during their work. Some participants may embody know-how related to the practice that others do not, but working together there is also learning taking place, which helps establish this know-how more broadly within the team. Through their interactions and negotiations they implicitly determine which understandings fall within their practices and which do not, and they collectively find ways to respond to the actions they meet from others (placing them either 'outside' or 'inside' the practice). In Episode 7, for example, we hear how the ability to assess and negotiate pricing issues is clearly left to participants of another practice (typically carried by those in the Purchasing department). Similarly, in Episode 8 the issues of assessing the technical feasibility are left to the engineers of the technical specification practices.

What is somewhat striking for the empirical material is the lack of explicit rules the team's work seems to be subject to. This can be due to the fact the UX centre is still new to the organisation and they are actually still in the process of discovering these rules that might appear explicit to the insider, but can be hard to grasp for the newcomer before actually feeling their consequence. The *set of rules* governing the UX practice is thus mostly made up of maxims relating to certain parts of their work, for example dictating what should make up the elements of a journey map (pain, pleasure, opportunities etc.) or what should characterise good research (user observations and interviews, local field visits etc.). But there are also other kinds of rules that they must relate to in the UX centre. These are related to the organisation of their work in relation to the work taking place in other parts of the organisation. We learn that the entire R&D organisation is organised around a stage-gate model, which helps organise the work across the individual departments assigned to specific parts of the car design. Such a model contains many levels of 'rules' pertaining to for example how decisions are made and by whom. Within the UX practice at Volvo the participants relate to these rules, but they are also seeking ways to break with them (which we shall return to in Part 4). This also makes it clear that such rules do not determine their actions, but they do hold consequences for the way they act.

The special 'mood' of the UX office space I encountered when I first visited seemed to persist throughout the different episodes I have witnessed during my visits. Everybody at the UX centre appears to have strong intentions with their work and they are emotionally engaged in the user-centred design approach they are embodying as a collective. In the specific work of the UX team these *teleoaffective structures* hold great bearing for what it makes sense for them to do and how to do it. Their whole way of approaching the daily commute project holds testimony to this. For example when the team uses maybe an hour in Episode 6 to formulate some overall 'thematics' for their journey map, then it is not just in order to fill out an apparent gap on the wall. It *makes sense* to them because bridging divides to other parts of the organisation is important for their intentions of expanding their user-centred approaches and gaining influence on the 'final' designs. It is also apparent, when they insisted on collecting some user insights through the phone interviews despite this type of research actually being outside the scope of the first part of the project. Their sense of purpose in their work is reliant on these strong links to the local doings of actual (or potential) users of Volvo's cars. This is what it *makes sense* to do within the UX practice, whereas it clearly makes less sense within the middle management practice. Instead the middle management practice finds purpose in navigating top management demands and the more operational realities (this is where management tools such as the stage-gate model prove their worth and starts setting demands across the bundle of practices in the organisation).

Keeping these observations in mind, we shall in the next chapter take a closer look at the role that knowledge plays in this kind of design practice.

DISCUSSION

design as epistemic practice

We have now been on a small tour through some of the episodes that have occurred as part of what you might call the UX experts' design practices during my field visits at the UX centre. Needless to say that these are only a minute fraction of what takes place at this workplace, but nevertheless I do believe that such traces of local doings and sayings can help us form a better understanding of what professional engineering design practices encompass.

I take this particular site to be exemplary on some level for the overall discussion in this thesis because of its composition, placement and approach. First of all, the people we find at this site have a mixture of educational backgrounds ranging from electrical engineering, industrial design, and multimedia to design engineering. The 'actual' engineers we find at this site thus work closely with other but related professions within the UX centre. But they also interact with more distant professionals organisationally placed in other departments, such as the Communications department or the Brand department. In this respect the site embodies the idea of multi-disciplinary work, which is greatly promoted in the knowledge economy.

Second of all, the UX centre is organisationally placed as part of R&D within an otherwise largely traditional, private sector, engineering company. The car industry has long been an important industry for engineers and a significant part of what goes on in such a company is related to R&D. Vast amounts of the company's budgets are dedicated to develop the new generations of cars, or more specifically the new technical components that will make up these new cars. Ever since the era of Ford and mass production the development of a new car has been a strictly systematic and controlled process where engineers of various kinds have played the lead role. The site therefore represents a 'typical' engineering occupa-

tional site – even if it is a new version of this (with its focus shifted from technological possibilities to the *experiential* possibilities of technology).

Third of all, when we look at what it is they actually do at this site, then you might overall describe it as developing ideas and solution concepts for problems originating around the car. That is they *design* in a traditional engineering 'problem-solving' understanding of this – though the UX approach to the design work may be considered less traditional.

Furthermore, you could also claim that the people inhabiting this site are recognisably competent at what they do, even experts (as there job-titles also claim) in the understanding laid out by Dreyfus – which we shall return to in the following. The majority of the employees were also acknowledged UX experts in Nokia's old R&D organisation and brought to Volvo with the specific aim of translating that work to the car industry. The rest have been brought in to strengthen their capacity and broaden the centre's areas of expertise. All in all I find it an interesting example of engineering design practice in a local manifestation.

TRACES OF KNOWLEDGE

Knowledge is undoubtedly important in the work that goes on at this site, though we might be in need of a different way of understanding just *how* it is important. Typically, a study like this one – looking for opportunities to improve the educations we offer to future students – will look for the actual 'components' of knowledge that are successfully pieced together in for example the experienced engineering designer's head and applied in the work at hand. So far, however, that approach does not seem to have resulted in any really successful reforms of our educations. In this thesis – and in this intermediate discussion – I would therefore like to move away from these more cognitively oriented perspectives and instead see were the situated perspective can take us. Looking at the traces of knowledge in the work that we have now seen, I am interested in forming a better understanding of how engineering design experts *know in practice*, or what knowledge actually does in the kinds of situated design practices that we have seen.

AN IMPORTANT JOURNEY

Right form my very first day of observations at the UX centre I have heard references to "the journey". During my visits this has been the central design object that the UX team has been working on. When prompted to explain what it is, different characterisations emerge at different times: The journey is a representation of situations encountered by the user of a car when traveling related to a specific type of occasion; it is an identification of problematic situations occurring in relation to a generic car trip in present day; it is a display of how different features of a future car can improve a user's experience; it is a manuscript for a video specifying locations, actors, props, lines and actions; it is a collection of inputs and meeting point for different departments; it is a way of working; it is a way of communicating; it is a way of documenting; it is a way of deciding – and probably many more versions.

Overall, you might understand this journey as a condensation of the knowledge and insights that the UX team is gathering through this project (and bringing in from previous projects). These are collected in a kind of 'short story' of an imagined car trip consisting of different kinds of situations where the user/driver interacts with his car (directly or indirectly). In many respects it is thus comparable to the process of making up a *persona* (see e.g. Pruitt, Adlin 2010), which in the course of the design work can represent all of the different user (or other stakeholder) insights that a design team might have collected. The kind of things that the UX team seems to thus 'transport' from their various activities and onto the physical journey map on the wall are pieces of information about the traffic conditions (level of traffic congestion, pollution), kinds of considerations the user might engage in (taking public transport or car), infrastructures that might influence the journey (GPS, parking spaces), values that are culturally cherished (being a good parent/son, being on time), stakeholders that might intervene (employer, family), objects that might travel along (phone, work assignments), habits drivers may already have (checking traffic forecasts, leaving before rush-hour) etc.

But as we have seen the journey is also not a specific physical object, though it does find a range of physical representations along the way. The most central of these is the great paper wall that was installed in the project room almost right from the beginning. But even this is not one but many manifestations of the journey, changing continuously through-

out the project. Day by day – even minute-by-minute at times – elements are added, removed, adjusted, rearranged. Words, pictures, drawings, and colour-codes all make up a changing mosaic on the wall. In parallel to this it emerges as a document on Alex' computer with different scenes for the video on each page and an evolving specification of dialogue, locations, camera angels, graphic additions etc. We also hear of a mock-up video that will precede the actual video, and a "blue-print" drafted in excel. All of these embody the journey in some way, yet none of them are able to fully represent what the journey is on their own.

It seems clear that this journey holds a special role in the work that is carried out during the project, and that this is where most of the team's professional efforts are channelled in one way or another (in the part of the project we have witnessed). So how do we understand this from a practice perspective? Clearly there is more going on than routinised sets of behaviour when the team suddenly decides to do a phone interview, when they write and rearrange post-its on the journey wall together, or when they prepare a cross-departmental workshop. Though they do refer to previous experience, all of the team members seem to be doing these things in this way for the first time. So how are they able to arrive at a result? And how can we claim this to be competent behaviour and not just chance?

First of all, let us take a look at the kind of practice we seem to be witnessing.

EPISTEMIC PRACTICE AT WORK

If we, for a brief moment, turn to an everyday practice that most of us can easily relate to – such as driving a car – then we see a particular connection between the subject (the driver) and the object (the car and all of its parts). While driving from one place to another the driver will not pay explicit attention to the steering wheel in her hands for example, the pedals under her feat or the seat she is sitting in. In fact all of this somehow disappears while driving and instead gives way for attention to the traffic, the streets, perhaps the weather, and how to act according to all of this: It gives way for the *practice*. When we do things with things then – in the Heideggerian sense – we melt together in some new symbiosis of car-driver. Both the driver and car thus disappear for a while as distinct entities in

themselves. The expert driver 'feels' when action is needed during his ride and intuitively knows what to do (Dreyfus, Dreyfus 2005). The practice, as the routine of alternating between clutch and speeder, shifting gear when appropriate, turning the wheel, and so forth thus comes to the fore – in other words the *doing* of driving. Only when something unexpected happens does the driver step outside of routine and start actively considering what to do.

Now, let us return again to the practice of the UX team at Volvo. Going through the episodes it is clear to me that the practices we find here are different from this kind of everyday practices guided by routines and stability. The episodes are not extraordinary events at the UX centre but representations of the kind of events that take place in the professional everyday life of the UX experts. But they are, I think, distinctly different from the kind of practices that the same people engage in outside their work life, such as cooking, surfing the internet, watching TV – or even driving their own car to and from work. These kinds of habitual and reoccurring activities are often what are referred to when speaking of *practices*. Reckwitz, for example, describes practice as "a routinized way of which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood" (Reckwitz 2002, p250), which is very well when speaking of more or less mundane everyday practices. But a design practice, such as the one evolving around the journey, is instead creative and dynamic. In the episodes we see some of all the contingencies that make up the workday of a design engineer. Nothing is certain when the team starts out the project or when they move towards a result; it is not even known beforehand what a 'good' result would be – just that, for now, it needs to be in the format of a 3-minute video. Instead, they have to continuously figure out what the 'right' next step will be and when their result is 'good enough', which puts them in an insecure and open-ended position. There are no given procedures or pre-defined steps that they can simply follow and then be assured that what they arrive at will be the 'right' result.

Knorr Cetina (2001) points out that there are these other kinds of practices, which are not satisfactorily understood through routines and stability: These are what she calls *epistemic practices* (or knowledge practices). Unlike everyday practices they are characterised by the creative and knowledge-centred, constructive processes that occur when we are faced with unknown (or 'wicked') problems. In these situations it is not habitual

but innovative and dynamic approaches that are required. I believe this is a more appropriate way of capturing what takes place in most engineering workplaces (at least a significant part of the work that goes on – no doubt routine assignments also have their place). From his studies of engineering design projects, Bucciarelli also ends up characterising what takes place in these words:

> *"The process of designing is ambiguous and uncertain […] Ambiguity and uncertainty are especially evident at the interfaces where participants from different object worlds must meet, agree, and harmonize their proposals and concerns. Ambiguity serves them well in this regard. It allows them room to manoeuvre, to reshape, to relearn and come together again." (Bucciarelli 1994, p188)*

Bucciarelli uses the notion of *object worlds* to capture the different domains of thought, action, and artefacts that different participants bring to a design project (Bucciarelli 1994, p62). The object worlds have a personal character as they are shaped by an individual's professional discipline and personal perceptions – but in a design project the challenge is to bring these object worlds together in order to construct a collective 'story' through negotiations and trade-offs (Bucciarelli 1994, p83).

In other words, when engaging in a design process you are faced with something quite different from driving your car to work: You have to constantly be able to deal with *ambiguity* and navigate through different meanings and preferences in order to succeed with a design solution. Alvesson describes the notion of ambiguity this way:

> *"Ambiguity involves uncertainty that cannot be resolved or reconciled – absence of agreement on boundaries, clear principles, or solutions. Ambiguity means that a group of informed people are likely to hold multiple meanings or that several plausible interpretations can be made without more data or rigorous analysis making it possible to assess them." (Alvesson 2004, p48)*

So ambiguity is not just an uncertainty that can be clarified by more information, it is an inert multiplicity in the situation that cannot be resolved but instead must be navigated or even negotiated.

This means that when the management representative both supports and starts voicing concerns about the focus that the UX team has chosen or when a middle manager somewhere else in the organisation intervenes

in a collaborative effort, then the UX team has to utilize their collective repertoire of experience in order to continue doing their jobs. They cannot afford to be paralysed when their plans do not hold up. Instead they have to maintain a level of flexibility in their object of design to be able to accommodate changing and multiple agendas, they have to keep track of the kinds of priorities that are made in adjoining practices, and they have to be able to translate their work and priorities into the different kinds of 'languages' that are spoken throughout the organisation.

The reason why the UX team seems to be doing this work for the first time is thus not just because the UX centre is still new, but because no two design projects are the same. The ambiguity and uncertainty pertains to the situation and the participants involved, which is always unique. This is not a routine task, but an open, complex and challenging project. It is not an everyday object, such as a (finished) car, that makes up the counterpart to the designer subject. The journey is rather an *epistemic* object in the sense originally introduced by Rheinberger (1992, 1997). He defines this as a research or scientific object embodying that which one does not yet know.

Knorr Cetina claims that creative and constructive practices, such as knowledge producing practices, do not evolve around static material objects, such as tools or instruments, but rather around these epistemic objects, which she characterises in this way:

> *"the defining characteristic of an epistemic object is this changing, unfolding character - or its lack of 'object-ivity' and completeness of being, and its nonidentity with itself." (Knorr Cetina 2001, p182)*

That is, these objects are always incomplete, constantly insisting on further exploration, never quite embodying themselves. Epistemic practices are thus always dynamic and potentially filled with conflict, which is in stark contrast to the habitual and unproblematic everyday practices.

The UX team has been charged with the task of showing a potential for developing new and improved user experiences in coming generations of cars to be sold in a near-future scenario. Facing this, they draw on a common *pool of understandings* where journey mapping for example is a way to get started – some of them have much experience with this approach, others less so, but to all of them it makes sense to structure their work around this. It also makes sense for them to look for example for the problematics

arising in different situations where user and car interacts and to make a visual documentation of their work. As part of the *teleoaffective structures* of their practices they engage in a common project of facilitating good experiences for the future users of the coming generations of cars. The journey frames all of this, guiding their efforts (for example helping them stay focused on interaction revolving around the car), yet it still remains open and fluid. Making the journey map may seem like a concrete task for the team to carry out, but in reality it is very hazy and unclear – and that is exactly why it is a powerful epistemic object for the team in this part of the project. Being open-ended and always not fully unfolded or defined the journey helps them drive their creative and explorative process, and yet it also continuously maintains a certain framing and focus on the *user experience* and the *course of use*, which gives the process a specific direction and thrust.

From this perspective it is not the UX experts' stored-up knowledge-reservoir that makes them competent, but rather their ability to navigate and tackle the ambiguity of their work. When faced with the mixed signals concerning their Chinese focus in the research, the team does not freeze or even loose momentum. They rehearse arguments among themselves, they confirm their personal intuitions concerning this choice in the *teleoaffective structures* guiding their collective practice, and they find small openings to negotiate and prove the potentials of their choice.

Over the course of the episodes we have been through at Site 1 we have moved through this landscape of ambiguous situations: There was the status meeting where the team could choose to bring up different kinds of issues, focus on different parts of their work, use different kinds of formulations to describe their efforts etc. There was the phone interviews where the team could choose to use different media of communication, focus their questions in different ways, keep track of the input by noting it down differently etc. There was the work on the journey wall where the team could choose to focus on different parts of the wall, draw on different kinds of insights, use different kinds of wording on the post-its etc. And several others as well. What makes these situations ambiguous is that the participants are facing a multitude of possible ways to proceed and the hard choice of finding the 'right' alternative.

But what makes a choice hard is the way the alternatives relate – no one alternative being better than the others overall (Chang 2001) and thus in itself more 'right' than the others. You cannot assume that the pros and

cons of each alternative in such situations can be quantified in numbers for the sake of comparing them (one being higher and thus better than the other, or the two being of equal value). The philosopher Chang, studying decision-making and hard choices, suggests that you can instead consider the alternatives in these hard choices or ambiguous situations to be *on a par*, meaning that they do make valid alternatives in the given situation of choice, however none is in itself better than the other overall (Chang 2001). Rather than assuming that alternatives thus already have some inherent reasons attached to them, you have to use your normative powers to *make reasons* for your choices yourself. The expert will be able to do this based on his intuitive expertise – that is, drawing on his extensive experience from making similar hard choices in the past (with good as well as bad outcomes). Chang (2001) argues that constructing these reasons is what enables us to become who we are, thus implying that we are essentially free to make up any reason we like. Within the practice perspective, however, the *teleoaffective structures* will naturally hold a great influence on what it *makes sense* to use as a reason – even what are acceptable alternatives.

The UX experts' navigational strategies in these situations thus rely heavily on their intuitive expertise, which includes a large repertoire of different ways of articulating, attending to, and engaging with the ambiguities of their work (favouring some alternatives over others in certain kinds of situations). Their competent behaviour thus seems to be linked to the fact that they are able to *act* in these situations. Let us take a look at what that means for the understanding of knowledge.

KNOWING MEANS ACTION

So we might best understand the work that the UX team does as epistemic or *knowledge work* in some form. But where knowledge work has typically been associated with individual and abstract manipulation of symbols (such as the scientist's manipulation of formulas or the engineer's numeric calculations) (see e.g. Reich 1991), what we see at the UX centre is that such abstract symbol manipulation only takes up a fraction of what they do. Instead most of their work is much more multifaceted and somehow linked specifically to the current situation. The epistemic practice perspective now allows us to weave *knowing* together with *action*.

From Suchman (2007) we already know that a situation is open and modified through the interaction going on in it. Through our actions we make sense not only of ourselves but also of the world (seen as an intersubjective and not a personal 'space'). From this perspective the context is not merely a container of activities but rather a situation where the interests of different people and the opportunities in the environment and objects in it meet and are reciprocally defined through action (Gherardi 2012). The UX centre is not merely a physical office, but an environment made up of interacting objects and people. The walls of the project room do not only contain the UX team they also interact – which is perhaps especially clear in the daily commute project.

But it is not some random interaction that we are witnessing at the UX centre. Rather, it appears to be knowledgeable. Gherardi suggest the term *knowing in practice* to capture the nature of knowledge in work:

> *"This signifies that knowledge is studied as a social process, human and material, aesthetic as well as emotive and ethical, and that knowledge is embedded in practice, as the domain where doing and knowing are one and the same." (Gherardi 2006, p xii)*

In this respect epistemic practices are not founded on codifiable and stable knowledge, but somehow on an always present ambiguity and *not* knowing (for sure) and nevertheless finding a way to act (Buch, Andersen & Sørensen 2009). Everything can be disputed and brought into play, yet somehow the practitioners do find ways forward – and it is in this acting that new knowledge is also formed. As Gherardi (2012, p20) puts it: "knowledge emerges form the context of its production and is anchored by (and in) material supports in that context." In such practices 'competent' behaviour is not determined by the ability to apply the 'correct' knowledge or method to a given problem, but rather by being able to *act* in a given situation.

From her study of global product development Orlikowski concludes that:

> *"Recognizing knowing as an enacted and provisional capability means that it is inappropriate to treat knowledgeability as given and stable, as always ready-to-hand. In particular, it suggests that continuity of competence – whether individual or collective – is never given, only achieved." (Orlikowski 2002, p269)*

Competence, she continues, is instead constituted every day through on-going and situated practices. Not only is competence not the application of knowledge then, it is also not a stable property of the individual. You have to continue participating in the practices to be able to continue displaying competent performance.

Let us therefore for a moment return to the idea of expertise.

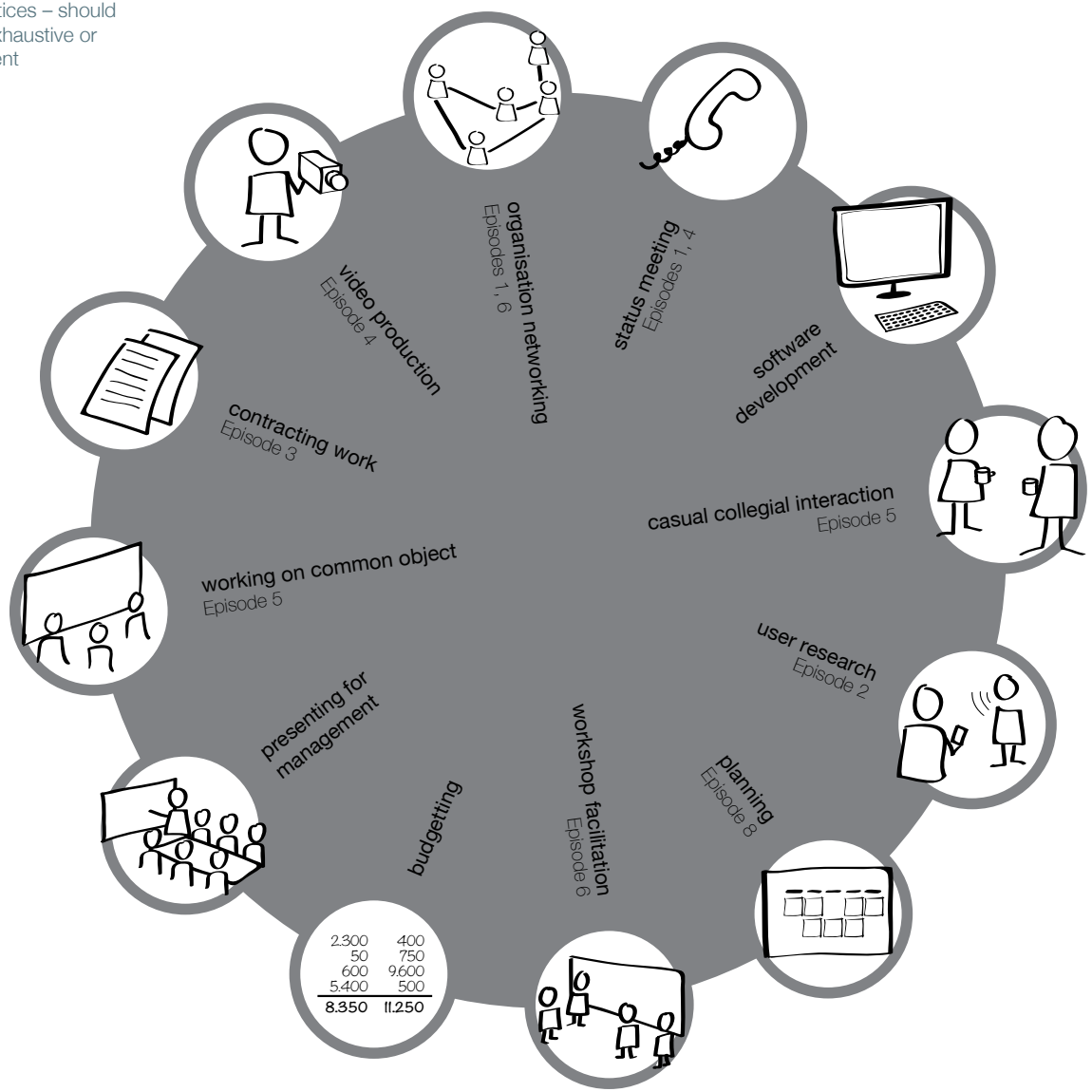
INTUITIVE EXPERTISE

With roots in the cognitive perspective it is common to believe that experts do their jobs based on reasoning and specialised rules within their field of practice. But what is apparent, both in this study and previous ones (e.g. Dreyfus, Dreyfus 1986), is that rules actually fade into the background when experts act. Instead, they rely on what you could see as a finely tuned intuition, which is built on extensive experience and reflection on previous successes and failures as laid out in the Introduction.

Faced with a concrete situation it is thus not more or less explicit rules or maxims that expert designers like Jonathan draw on, but rather what *makes sense* under the given circumstances. As Dreyfus & Dreyfus put it: "No amount of rules and facts can capture the knowledge an expert has when he or she has stored experience of the actual outcomes of tens of thousands of situations" (Dreyfus, Dreyfus 2005, p788). Expertise is not build through studying extensive rulebooks; expertise is build through extensive *doing*. To Dreyfus & Dreyfus the notion of expertise is thus best understood as *intuitive judgement* or "the making of immediate, unreflective situated responses" (Dreyfus, Dreyfus 2005, p779).

When Dreyfus & Dreyfus (2005) speak of expertise in this way they are considering the individual, though I would venture that something similar is at play when considering an expert *team*. Here, the experience is simply dispersed among several expert participants (making it potentially that much more extensive). But the intuitive reaction may also require some more internal negotiation (making it 'slower'), though with the potential of avoiding 'tunnel vision' because of the diverse perspectives brought together. The UX experts intuitively respond to the situations that occur during the project. We do not see them consulting rules or prescriptions of how to do for example an interview or prepare a workshop. These are not new tasks for them – though the specific situation (this project, at this

FIGURE 42 | Bundle of professional practices – should not be seen as exhaustive or mutually dependent



time, in this team) is new – and so they are able to intuitively discern what makes sense to do because it usually works – and it works, as usual.

However, when assigned with a new type of task something different happens. When preparing the RFQs we see how Jonathan and Cheng sought something more specific to guide their work. Talking to Noah (acting as a kind of instructor) they where given some maxims, such as what types of words to use for certain purposes, and from this they were able to deliberate and decide on the configuration of the documents.

Participating in epistemic design practices is nothing new for the UX experts, so they intuitively know how to go on in most of the situations they encounter. They have already experienced ambiguity in many different constellations and (re)acted with some level of success in those previous situations, providing them with a collective repertoire of how to navigate through this and arrive at a result.

UNDERSTANDING DESIGN PRACTICES

Based on our visit to Site 1 it now seems safe to claim that participating in design practices can be seen as participating in a complex *bundle* of interrelated practices. Jonathan does not do one thing during a week's or even a day's work: He moves between participating in status meetings, working collectively on an object, doing contract work, casually interacting with colleagues, doing user research, etc.

When Jonathan navigates between these different parts that makes up his work on the daily commute project he is embodying a kind of intuitive expertise. He does not have to consult manuals or recite maxims to decide what his next step will be. Interacting with his colleagues they collectively have a *feel for* what is the right way to proceed. It is *in* their work and *through* their actions that they can be considered knowledgeable – not as some pre-given state defined by their individually stored-up knowledge or list of qualifications. They continually 'test' their work on each other and pay much respect to being able to challenge each other's assumptions and reasoning. They are thus working from a fundamental perception that the individual cannot accomplish the job alone but instead it is in the interaction between them that things start taking shape and moving forward.

Based on these observations I would therefore venture that it makes sense to treat engineering design practice as *epistemic practices* due to the in-

ert ambiguities and distinct knowing in practice. The participants of such practices can be seen as experts drawing on intuition to cope skilfully with the work at hand.

So what consequences do this hold for engineering education? What will it take for the new graduate to be able to participate in a professional engineering design practice?

If anything this site has shown us that there is no simple answer to this question! Even so, let me try to recap what we might take with us from this site:

- Practices are constructed through a constant (bodily) exchange of experiences, a re-production of common routines, and re-negotiation of norms for acceptable solutions.
- It is not the participants' educational profiles that are at stake in the everyday work, but other kinds of rationales embedded in the practices and organisational infrastructures.
- It is in fact not the knowledge itself, but the acts of know*ing* in collaboration that holds the greatest influence on everyday professional practice.
- The participants display an ability to navigate ambiguity and accept that it could always be different (compared to 'there is one true solution').

This does not make knowledge irrelevant to engineering practice or education. But what it does help show us, is that our common understanding of what knowledge *is* or how knowledge *works* (as we find in for example 'traditional' engineering education) is somewhat out of sync with what actually takes place in epistemic practices. This, as I shall come back to later, naturally has consequences for the way we think engineering education.

But let me expand a bit on these points before moving on to the next – educational – site on our journey.

CONSTANT RE-PRODUCTION

Even though each project is new and unique in itself it also always builds on the previous projects that the team members have been involved in. Melvin, for example, had worked a lot with the journey approach on previous occasions – an approach that has now been re-produced and re-fitted

into the local UX practice that the centre is building. And it is not just within this specific team because others outside the team are also following the process, and later – in other team constellations – the participants' experience will feed into new projects, thus re-producing the journey approach again. The team-structure of the UX work activities promotes this close interaction between the individual participants. Informal exchange of experiences takes place all the time (another example is the short discussion on note-taking after the phone interviews).

But it is not just experiences that the UX experts exchange through their work practices. Every time the team meets, an important yet implicit element of their interactions is also to agree on what is acceptable or appropriate in the given situation: How should something be handled, how should something be formulated, who should be involved, how should a decision be reached etc. For every step forward they have also had to negotiate amongst themselves (and at times with others) what norms they are abiding to in their work. Their process around 'translating' the market-oriented KCPs into their journey map is one example of this. This process was not only about writing some words on a couple of additional post-its, but it was about agreeing on the focus of their own work, identifying some recipients for their input, and arriving at a good way of communicating with this other group of people.

EDUCATIONAL INFLUENCE IN SITUATED ACTION

Multi-disciplinary work is a highly praised constellation in the contemporary knowledge society: Coming together and contributing to an assignment with the best of several worlds or areas of expertise. The UX team can be seen as exactly such a multi-disciplinary constellation. This team was comprised of a multimedia engineer, an IT engineer, a design engineer, a communication designer, an informatitian, and a graphic designer. So which implications do the different professional profiles they each carry into the work at hand have?

From my observations it turns out to be hard to distinguish exactly where the different engineering competences or knowledge makes a difference and in what respect. These 'knowledge workers' do not appear to be using abstract and codified knowledge stored either in books or the back of their heads. Not even the engineering identity seems to be impor-

tant – in fact I have not once heard any of them refer to either themselves or others in the UX centre as 'engineers'.

What matters is instead experience: Who have tried what in the past and who have proved successful at completing certain types of tasks. This naturally has some links to people's educational backgrounds (providing them with some repertoire of previous experience with certain kinds of tasks), but it actually surfaces most clearly around specific graphic tasks or the video production (editing and animations) where certain specialised techniques are required.

So does this mean that they are failed examples of engineers? That they have forsaken their education and professional titles? Or perhaps it is the other way around. Perhaps these engineers are very accomplished exactly because they are able to 'blend' so well together with other professions. It is actually a general policy at the centre that everybody should have at least some level of familiarity with all the kinds of assignments they are working with. For this very reason new teams are compiled for each new project and they all take turns being for example the team leader (who officially refers to the management).

But their work is not only dependent on what they are able to do or what they know. To a significant extent it also depends on the external rationales that are imposed on them. The lack of a budget for researching activities (or anything else for that matter) in this initial stage of the project for example clearly affects what they are able to do and the results they are able to arrive at. This is again linked to the project infrastructure build on a stage-gate model. All of this lies beyond their immediate influence within the UX centre and it is to a greater extent these rationales they have to adapt to in order to be productive as opposed to their individual educational backgrounds.

KNOWING IN COLLABORATION

Throughout all of the episodes we only see minute references to actual codified knowledge. In fact what is characteristic about the work that the UX team is doing is that they do *not* know anything about the Chinese commuting journey when they start their work – and neither does Volvo as such, which is why it is deemed an interesting project to begin with. They do *not* know how to best represent the commuting journey, they do *not* know how to structure the video, they do *not* know who the recipient

of the video will be, they do *not* know if they will be able to continue the project, they do *not* know what kinds of solutions they might arrive at etc.

But they *do* know how to go on. As expert practitioners in the UX design practice they know how to take action. And it is this *knowing in practice* that enables them to charter into unknown territory. It is only through acting and inter-acting that they can know what is right to do in the situation; that they can see what works and what does not. In an epistemic practice with its significant unfolding ontology the *not* knowing is what drives the process and the ability to nevertheless *act* knowingly is what marks the professional.

NAVIGATING AMBIGUITY

The UX experts have to adapt on the fly to changing conditions. We see this clearly every time they start laying out plans for their work – for example when planning the phone interviews or when preparing the workshop – they have to reinterpret their intentions and translate these into the particular situation they find themselves in (which is never exactly as imagined).

But they do not stop and think when faced with these ambiguities; they act based on what you could call 'gut feeling'. Their *expertise* allows them to react without consulting rules or manuals. All of them have found themselves in similar situations at previous occasions and have thus build an extensive repertoire of possible actions and possible outcomes, giving them a valuable intuition about what might work under the given circumstances. So it is not because they have rehearsed doing the *same* thing over and over again that they are now able to expertly navigate the ambiguity, but it is rather because they have worked through many variations of *similar* things that they are able to tackle the unique situations they find themselves in and act professionally.

It is never completely clear or spelled-out what a given assignment involves. When developing the journey it is only through all of the different interactions that take place around the journey that it starts finding its shape. If other people had been involved, if the team had had access to other resources, if the deadline had been earlier, if they had used a different format etc., then it would most likely have found a different form. So did they arrive at the 'right' answer to their problem? Well, they arrived at the result that the particular situation and the practices they are engaged

in enabled them to arrive at. Seeing the process as a search through a (demarcated) solution space and arriving at the best possible solution seems an unproductive representation of this work. The practice perspective instead allows us to see all the contingencies such a process is wrought with, how ambiguity is lurking in every conversation, every post-it note, every alliance. And yet the orderings of the practice is what prevents it from being complete chaos and chance; they have certain understandings enabling them to do certain things, they have rules to consider, and they have a strong sense of purpose in what they do.

Engaging in a design process thus requires the ability to navigate in an intricate social landscape filled with material as well as institutional infrastructures. All the practices that inhabit this landscape bring their own (possibly overlapping) pools of understandings, sets of rules, and teleoaffective structures, which guide the individual doings and sayings but also create the multiplicity and ambiguity across the landscape. Such a landscape is not foreign to us as humans – we navigate it every day of our lives – but the difference here is that the designer also has to live up to the expectation of producing something new in the process.

From the situated perspective then framing engineering design practices, such as the UX team's professional project work, as *epistemic practices* appears to better capture the complexities of this kind of work than the more traditional ideas of symbol manipulation or rational problem-solving. What appears to help the UX team get the job done is thus not some well-stocked knowledge reservoir, but their constant interaction, their mutual probing, their ability to navigate ambiguity and in fact *not* knowing exactly what to do. We also see that working professionally does not mean that you have stopped learning – quite the contrary actually. Being able to participate in epistemic practices implies that you continue to learn through every interaction, building a gradually more extensive intuitive expertise. I do not think this will come as a particularly great surprise to anyone having worked professionally (within any profession). In fact, learning is a natural part of our way of living as human beings – but for some reason we are not that used to explicating this in our understandings of professional work. Sure, we often hear of 'life long learning' and keeping up with the rapid technological and methodological developments, but still it is often seen as something accomplished more or less separately

from the work itself – like attending courses or getting an extra degree. Site 1 instead shows us that working and learning are deeply entangled.

This leads us to the next chapter, where we will focus more directly on learning from the situated perspective and how education facilitates this.

3 STUDENT PROJECT WORK

3 learning in practice

In the previous chapter we came to see professional engineering design practices as epistemic practices full of ambiguity and as a place where expert intuition played a central role for getting the job done. Now it is time to take a look at how engineering students 'practice' their work within the educational sphere.

This chapter also predominantly consists of excerpts from my empirical material arranged in short episodes extracted from my field notes. The episodes will be presented in nearly chronological order compared to their original occurrences. In-between these episodes short interludes highlight some of the more interesting observations viewed from a practice perspective and relating to my problem statement. A more theoretically based discussion follows at the end. First of all, however, we shall start with a short introduction to what I will be referring to as *Site 2*.

INTRODUCTION OF SITE 2

Please allow me to invite you into a site, which I myself used to occupy. In 2009 I graduated as a MSc in Design & Innovation from the Technical University of Denmark (DTU). Prior to this I had spent 3 years as a student on the bachelor's program and then another 2 years (plus a little extra) on the master's program in Design & Innovation (D&I). D&I was a very young program when I first started – only one generation of engineering design students preceded mine – but it was also a quite new way of educating engineers in Denmark. The D&I program was first launched in 2002 with the aim of educating innovative and creative *design engineers* capable of meeting the contemporary demands from industry and society and to engage in new structures and cooperation in product development

and innovation efforts (Boelskifte, Jørgensen 2005, Jørgensen, Lindegaard & Brodersen 2011). In other words, the educators behind the new program wanted to give the creative, social, and synthesis elements of engineering design a renewed focus.

At the same time this program is also an example of an effort to strengthen the *practical* pole of the engineering profession. The program is thus moulded around some of the same pillars that define *problem-based learning* (PBL). Most of the courses apply elements of PBL, such as working with contextual projects, working in groups, and collectively communicating results. As you would find in the (Aalborg) PBL model it is also project work, which is the central cornerstone of the program. Each semester the students complete a 10 or 15 ECTS project course with themes varying throughout the program and linking to the other courses of that semester. From my own experience as a student of this program I know that these semester projects are perceived to be the heart and sole of the program. As a student you put a lot of work into them – often far beyond what is assigned via the ECTS points – and you go to great lengths to produce results that not only enable you to pass the course, but also has the potential to create value for the collaborating partners that are often involved.

In 2014 I returned to DTU, this time not as a student but as a researcher in my capacity as a PhD candidate. My objective was to study the practices that design students engage in when working on a characteristic D&I semester project.

A SITE OF ENGINEERING EDUCATION

Through my network amongst the educators at the program I was granted access to observe the 2nd semester project course titled *Product Analysis and Redesign*. This project captures many of the elements that distinguish the D&I program from more traditional (mechanical) engineering design educations: It takes its point of departure in not only the *technical* qualities of the product that is to be redesigned and the technical processes needed to make it, but also in a *socio*technical understanding of the product; it emphasizes analysis and communication of the insights developed; and it uses creative methods to create solutions for the sociotechnical problem areas identified (Lenau 2014).

The program was originally developed in collaboration between active STS scholars, engineering design researchers, and educators from mechanical engineering fields. Because of this I believe that this is as close as we can get to an engineering program in Denmark that really tries to incorporate an understanding of everyday engineering design work in an engineering education. With the PBL inspired approach ambiguity and social interaction is allowed into the curriculum and the students are not only evaluated on written exams but also on oral presentations and communication material such as visual posters and power point presentations. This site will thus give us an idea how all of these elements play out in the educational sphere.

THE PRACTICE CARRIERS

The project teams were formed at my first day of observations. At this occasion I got the opportunity to follow the work of one of these teams. During my subsequent field visits I thus primarily followed the work of Emma, Elliot, Sarah, Leo, and Thea[11]. These were part of a team with ten members the first half of the semester (team 3) and then became their own team for the remainder of the semester (team 3a). All of the team members were on their 2nd semester of the D&I bachelor program

EMPIRICAL APPROACHES

This site makes up the second 'stop' in the multi-sited ethnographic fieldwork. The spring semester project runs from the beginning of February and until the beginning of June in which period I was able to follow the design student's project work. For the first half of the period I visited approximately once a week for half a day, and during the second period I visited a few times including the finishing presentation for the representative of the company who's product the team had been working with. In total this amounted to 9 visits over a 5-month period.

The fieldwork was conducted as ethnographically inspired close observations of the team's doings and sayings in the studio setting (their work also included ethnographically inspired fieldwork of their own, but this was not observed). Unlike at Site 1 I thus did not follow and participate in the everyday of *one* person (including interaction with several other people), but instead focussed on the *collective* efforts of the team.

Apart from the direct observations at DTU I have also had access to the online platform, which the team used to share the different documents they were working on, and the official description of the project provided to the students. Earlier, before my observations started I had also conducted four semi-structured interviews with key educators involved in the development of the D&I program, among these Tom who were in charge of this project course. These interviews have mostly been used as basis for my own understanding going into the studio as a researcher and not a student.

My presence and overall interest was introduced to all of the students on the first day of the semester in order to make sure that my presence was 'demystified' and thus more easily 'ignored' in their daily work. When observing the team's work I typically placed myself on a chair or edge of a table in the vicinity of the cluster of tables occupied by the team. I then noted down short scribbles of what I saw, heard, and experienced in my notebook. But I also circled around the team now and again to get a different or simply better view of some of the objects they were engaging around (such as computer screens and sheets of paper) and took pictures now and again as a kind of visual notes, reminding myself of the details of a situation. These form the basis for the accompanying illustrations in the following (so again, bear with the quality). For this part of the fieldwork I also made short video sequences where intense interaction was going on that was difficult to condense on note-form. Compared to the observations at Volvo I aimed to catch more of the *conversations* going on in this part of my fieldwork, though my focus was still primarily on the *interactions* of the situation.

After each visit I wrote out my scribbled notes to more cohesive episodes and supplemented with the relevant pictures or details from the video sequences. These emerging 'thick descriptions' make up the foundation for the empirical work I will be presenting in this chapter as *sketches* setting the scene and *episodes* describing the interactions (Emerson, Fretz & Shaw 2011). Each of the following episodes has been selected to illustrate some of the different elements of the practice bundles that exist here and as a whole present a situated view of the social learning that takes place. Just as the last chapter I will pull out some of the more interesting elements in the intermediate sections and analyse these in the following Discussion.

SKETCH 1 | design at DTU

It is early February and I follow a couple of students onto the DTU campus area, navigating my bike down the broad, straight boulevard that makes up the huge central axis at the heart of the campus. Ever since the 70'ies Danish engineering students have been coming to this plain, occupied by the characteristic three-story, yellow-brick buildings that make up Denmark's largest site for engineering education. Halfway through the campus area the boulevard is crossed by another road making up a second axis and effectively dividing the campus area in four large 'quadrants'. Each of these quadrants was formerly dedicated to one of the original four engineering specialisations: Civil, chemical, electrical, and mechanical engineering – though today the 19 specialized institutes housed here have to share the space. My destination lies within the 4th quadrant housing the mechanical, management, and design engineering programs and research departments.

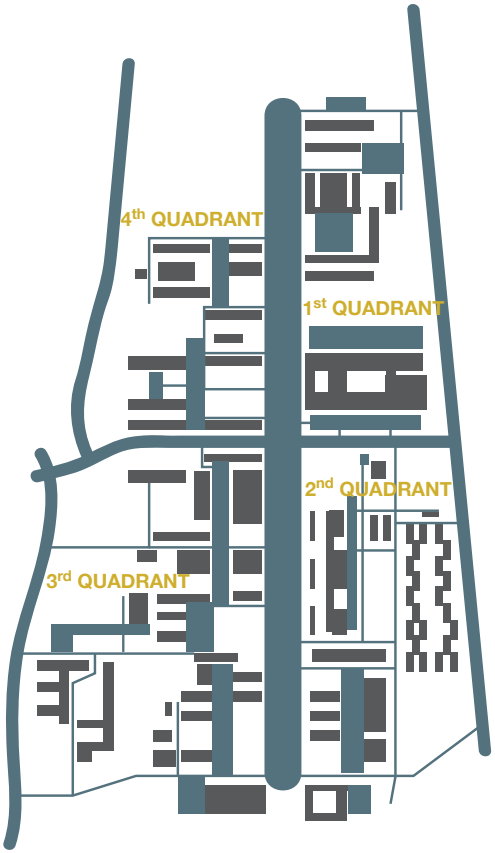


FIGURE 43 | *DTU campus* (adapted from Rambøll 1974).

FIGURE 44 | Inside the 1st year students' studio.

I know where I am going for I have spent many hours here as a student myself. Therefore I know where to park my bike outside the large grey addendum to one of the yellow-brick buildings and to go through the heavy metal door (which is painted the same characteristic DTU-red as all other doors on campus) in order to find the home base of the design students.

Just before 9 o'clock on this Wednesday morning I thus find myself in a sleepy corridor with fluorescent tubes providing the only light. The building seems all but empty. It is strange to be back here. While I walk down the familiar corridor I have to remind myself that I am not there to attend another lecture or work with my fellow design students. In fact I will not know a single person there – except for the teacher, Tom, who is in charge of the project course I will be observing this semester. When I did the same project course 10 years earlier he was also in charge.

All of the bachelor design students have their home base inside this large grey building. It consists of three large 'studios' connected by a central hallway, which also provides access to a small kitchen. Each generation of design students progress through these three studios, spending one year (two semesters) in each studio before they have to make their minds up whether they want to continue on the design master or try their luck at a different one (only a few stop at the bachelor level).

From the hallway I can see through the panel of glass next to the bright yellow doors that there are already a few students sitting in each of the studios. There are no signs on the doors revealing to outsiders what hides behind the doors, so I remind myself by thinking back, which one of them houses the

1st year students and enter that room. The studio still has the characteristic high ceiling and exposed beams from the original workshop facilities it used to house, but apart from that there is no doubt that this is now a space for students: Tables are scattered around the room in a combination of rows and small clusters and office chairs fringe their sides. Next to the entrance door, at the front of the room, there is a wall devoted to blackboards and a projector screen. Tall windows pierce the opposing wall, which allows the morning sun to enter the room, and two emergency exits lead to the parking lot behind the building. Along the two remaining walls you can see the posters and models from the students' last semester project.

As I arrive so does a growing stream of students, so I find a chair at the side of the room in order to observe what will take place here this morning. About 12 students have already found their way to the room and installed themselves by some of the tables in the middle of the room. Most of them retrieve a laptop from their bags and place it on the table in front of them.

About 5 minutes before this morning's introductory lecture is scheduled to start a man dressed in dark jeans and a dark jacket arrives with a dark backpack over his shoulder. I recognise him as Tom, the associate professor in charge of the project course. He informally greets the students that are already there and then steers toward the corner of the room by the blackboards where a computer screen is visible and starts setting up his laptop. Shortly hereafter the second associate professor and the teaching assistant (TA) linked to the course also arrive. While the last students seek out an open spot in the now relatively crowded room the three educators discuss the program for today. The students engage in quiet informal discussions in small bunches. They seem to know each other, but also steer towards those they know the best.

At some point Tom claps his hands to get the attention turned towards the front of the room, which everybody quickly responds to and sits down: The semester project has officially started.

ANOTHER KIND

Of the approximately 9.000 students that study engineering at DTU's campus the design program makes up about 250 students. A maximum of 60 students are allowed into the program each year, forming a tight-knit 'class' – here referred to as a *generation* (årgang). Through the bachelor part most of the courses are mandatory, meaning that a generation of students goes through each of the semesters together. Not all make it to the final graduation, of course, but the program has a very low dropout rate com-

pared to other engineering programs at DTU (Jørgensen, Lindegaard & Brodersen 2011).

What we meet in this sketch is not a typical setting for students at DTU. In fact – with the exception of the building design program – the design students are the only ones working in studio facilities. These rooms are designed to be flexible enough to facilitate the majority of the activities that the design students will be engaged in during their studies: Lectures, exercises, and project work. In other words, these studios quickly become the home base for the students and the room quickly starts reflecting what is currently taking place during the semester.

While I used to occupy this place myself as a student, my return is now with a different purpose in mind: I am curious of how students actually learn to do the kind of design work that goes on here. In the following I will present some of the episodes I witnessed during my field visits. They have been selected from my close observations to illustrate some of the different elements that play a part in design-oriented student project work.

EPISODE 1 | getting started

1.1 Introductory lecture

This morning it is time for the introductory lecture, which officially starts off the project course. Tom projects the introductory document on the screen and dwell on the places where he has highlighted some important information. While he is speaking the students are listening, though sitting reclined on their chairs without displaying much enthusiasm. Tom emphasises the two main parts of the course: That they must learn to make a multi-dimensional technology analysis and learn to use creative methods in a systematic way. Highlighting this he also gives reference to some of the things the students have already been confronted with on the 1st semester. For example he links the multi-dimensional analysis component to the so-called "flower model" that illustrates the D&I candidates' aspired competences.

Tom explains that the first 6 weeks of the semester will be devoted to this product analysis. He warns the students that when they enter a company after graduation they will probably not be allowed to use as much time on this type of analysis, for out there it is considered an expense, whereas the design part is where money is made. One of their future challenges will thus be to prove the value of initial analytical research. Here in this project, however, their immediate challenge will be to coordinate their work in the teams. Dur-

ing this first stage of the project they will be working in groups of 10, meaning they have to delegate assignments and assign roles: "Very real-life," as Tom puts it. At the end of the 6 weeks – at the first milestone – they will hand in a short report to the supervisors and present their work using the "worksheets" they will have developed throughout the process.

After this, a short period of about 2 weeks will follow where the teams are each split into two smaller teams of 5 that will continue working on the redesign part. But first they will need to agree on a problem statement and make a plan for the last 5 weeks of the project. The supervisors will give feedback to the teams on this at milestone 2.

The final period of the project is devoted to redesigning the product using the findings from the initial analysis and keeping in accordance to the problem statement. The final design and the process to reach it will be presented in a report and at an oral examination, which will be assed by the supervisors and an external censor. Tom points out that the use of a report format for the final output is maybe not in keeping with the typical practice in companies: "You would typically use power points to sum up the findings in a compact format". He also points out that the majority of the workload will not be completing the report itself, but rather making the collection of worksheets that will accompany it as appendixes.

Tom now mentions that he has successfully secured some funds for excursions as part of this course, so already next week the first teams will get on a bus and visit the companies linked to their respective products. This is news that brings some instant enthusiasm into the student audience, who starts sitting more upright in their seats.

During the first part of the course there is also some time allocated for a so-called "worksheet review". Daniel, a master student at the D&I program, will attend to this, which is to bear resemblance to a design review. Tom again emphasizes the importance of using this technique in the course: "Really try it out, and if it doesn't work for you, then you can discard the method afterwards." The students are encouraged to do a good job at drafting the worksheets first time around, ensuring that the background documentation of the projects is in order. The review will be performed in pairs just a few weeks into the semester and Daniel will provide critique and tips for improving the drafted worksheets at that time.

Other than that the teams will meet with their process supervisor once a week, but the three supervisors (who have expertise within different fields) are all available for questions and discussions on Wednesday mornings or via email.

Looking at the room throughout this introduction it is clear that not much has changed since I myself sat as a student in these halls: Those sitting at the

front are focusing on the presentation and listening more or less intensely, while the further back in the room you look students are more focused on looking at their own laptop or mobile screens.

Even though it would be time for a break now, Tom decides to go ahead and introduce the companies and products that the students will be working with. He shows a slide introducing the first product: A (mobile) welder. The slide shows a large photo of the product and some small pictures of the product being used. He explains that this company is very interested in the students looking into redesigning their product, as they will shortly be launching a redesign project themselves focusing on this model. Without revealing who is on which teams he informs that team 1 and 2 will be working with this product. Next product is a professional food mixer. On this slide he again presents a big picture of the product and then some other pictures of the larger model, which has already been redesigned by the company. He starts by asking where the students would imagine such a product being used? A few raise their hands to venture some guesses: At schools (boarding schools), in restaurants and bakeries, at hospitals. He highlights that there may be some issues regarding how to carry the large bowl when it is full of ingredients, and how do you clean such a large bowl? This is up to teams 3 and 4 to explore. The final product is a kia aspirator. This is a product that does not immediately reveal its use and no pictures involving people are shown, so Tom presents some examples of what it might do: It could for example sort label fragments from re-processed PET bottles. Team 5 and 6 will be redesigning this product.

The appearance of some concrete products on the projector screen seem to have enlivened the audience and they are now ready to find out which one of these products they will be working to redesign for the rest of the semester. And so Tom reveals the slides containing the team division he has prepared. The students seem to quickly identify their own name on the long list and start forming eye contact with some of their new team members or friends. Then it is time for a break and talk breaks out across the room. Most of the students get up and start manoeuvring around the room to discuss the products. Some leave the room only to return a few minutes later holding a paper cup from the coffee machine and engaged in talk with others having made the same trip; some reach in their bags to retrieve a snack. Meanwhile the three educators continue their coordination, now discussion how to approach the supervision. Since the TA has not supervised on this course before he asks for the other's advice.

1.2 First team meeting

After the break the students are instructed to place themselves in the teams, distributed clockwise around the room. Everyone quickly gets up and starts

FIGURE 45 | Re-arranging into teams of 10.

moving their things and setting up the tables in clusters fit for about 10 people.

I move to sit by team 3 who I will be following from now on. They sit at the back of the room on opposite sides of a row of tables – as the only group they have not moved the tables into a cluster. The first thing they do is to sort out who everyone is on the team. Tom has deliberately combined all the teams to ensure that none of the students who worked together on the 1st semester project will be working together in this project. Therefore when one of the team members is given the challenge of indicating the names of all of the other team members he has some trouble completing the round. But of those who are present (Frederik is missing) we have: Leo, Elliot, Thea, Caroline, Oscar, Simon, Sarah, Brian, and Emma.

They have been asked to start drafting a collaboration contract, meaning they need to start writing some things down. This gives rise to an initial discussion on roles, first of all who will be the secretary? Emma volunteers to take on the role – but only if they agree that they will take turns doing it. No one objects openly to this, so they proceed to figuring out how they should note things down. Emma does not have any paper with her, but they also agree that it would make sense to write everything down on the computer from the beginning. So she retrieves her laptop from her bag. Someone mentions that they should make a Facebook group and a DropBox or Drive account. Apparently these are platforms that they used in connection with the previous project. For now there is agreement on this, but the discussion also quickly moves on. They discuss what it is they need to sort out today.

Emma has created a document on her computer and with Brian, who is sitting next to her (and therefore the only other person able to see the screen), she has started noting some things down. But the conversation seems to split in two – one at each end of the elongated table. At one end they have started discussing how elements of the work should be carried out while at Emma and Brian's end they are trying to figure out which elements should go into the contract. When they become aware of the different turns of the discussions, they try to coordinate and agree first to come up with the 'headings' of the contract and then agree on the actual content. To get some inspiration Emma finds the contract that her team made last semester. Meanwhile the discussion continues around the table and quickly returns to negotiating the content. One of the first things they talk about is when to meet and agree on some weekly working hours that everyone should keep clear of other appointments.

Thus well on the way, Tom again claims the students' attention: He requests two from each team to join him and help move the products to the workshop where they will be working. Meanwhile the rest of the team should continue working on the contract. In team 3 Emma and Brian readily volunteers and move to the front of the room with the other volunteers from the other teams.

THE REDESIGN PROJECT

In this first week of the 2nd semester the students at the D&I program are introduced to the project course that will be taking up the majority of their time over the next 13 weeks. Working in teams the students are charged with redesigning an existing industrial product through three stages: Product analysis (6 weeks, resulting in milestone 1), objective for the redesign (2 weeks up to milestone 2), and redesign (5 weeks, presented at milestone 3, which is also the exam). As Tom points out – and as the semester structure also indicates – it will be the students' fieldwork and analysis that plays a large part in enabling them to arrive at a satisfactory redesign proposal. In the introductory document it reads (translated from Danish): "You will practice skills in carrying out a *broad-spectrum, multi-dimensional technology analysis*, and you will learn to attack and carry out *creative problem-solving in a systematic manner*, so that you with reasonably certainty will be able to reach sound results within a limited timeframe" (Lenau 2014 (original emphasis), p1).

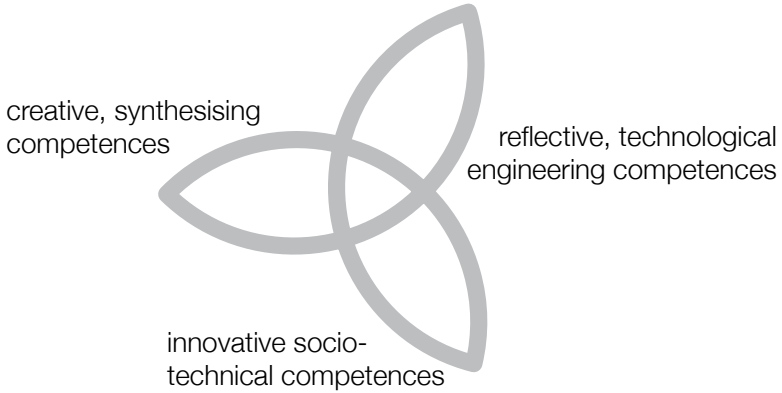


FIGURE 46 | The D&I flower model combining three competence areas.

In his introductory lecture Tom relates the focus of the project to the "flower-model", which is a general description of the ambition of the D&I program. Each 'leaf' in the model illustrates an overall type of competence that makes up the D&I profile: 1) technological engineering competences, 2) creative synthesising competences, and 3) innovative sociotechnical competences (strongly resembling Figure 4 in the Problematisation). While other projects during the D&I education focus on one or two of these areas, this course aims to cover them all, making it a good example of the ideas that have gone into the education as a whole.

TEAMWORK

In this episode we meet team 3 for the first time. All of the teams have been composed by the course responsible – this one consisting of 6 male and 4 female students, which represent the general gender distribution at the D&I pretty closely. None of them have been teamed up before, but some of them do seem to be more closely acquainted than others.

In the educational sphere (at least in Denmark) you would usually refer to activities where more than two students are working together as *group work*, whereas *teamwork* is typically something practiced within the occupational sphere. Here at the beginning of the semester the students were also frequently referring to themselves as "group 3", clearly drawing on their previous experiences of being grouped together for assignments at school. Even though this is only their 2nd semester, working in groups is no new experience for the students. At the D&I program they have all

completed one semester project in teams and teamwork also plays into other courses, though less extensively than in the project courses. They are therefore quite conscious that the first step in a new team is to establish the names of everyone and then start discussing some common ground rules for the coming work. In this project they draw up an actual team contract in which they agree on things such as which days they will be working and for how long, how information is shared amongst team members, and who are responsible for the contact to the company etc. Though this contract does not appear to be used for much during the project it clearly draws on some *set of rules* that the students have already been acquainted with – and it makes up a tangible task on this first day in a new team constellation.

THE OBJECT OF DESIGN

Not only has Tom decided who is teamed up together, but he also decides which product they will be working to redesign. Team 3 is thus assigned to work with the professional food mixer – a product that none of the team members have ever been in contact with before. This sturdy looking machine is used in various semi-professional kitchens, such as kindergartens, cafés, and galleys. The mixer is designed and produced in Denmark and the company's portfolio includes both larger and smaller models of similar professional mixers, making this middle-sized mixer a relatively marginal product for them.

Each team is also assigned one of the three educators as their supervisor. For team 3 this will be Tom, who they will thus have regular meetings with during the semester. The student team thus exist in-between several practices, which we shall see more examples of in the following episodes, but for now we have seen traces of the students' emerging project practice and the educators' teaching practices.

The mixer that will be the object of design in this project emerges from these teaching practices as a suitable object. Tom explains his reasoning behind choosing these products in this way: They must be of a certain physical size to enable manual separation in the workshop and offer a certain level of complexity of the components; there must be a multiplicity of actors surrounding them (such as users and repairmen); and they must be for professional use (not consumer products). He builds these require-

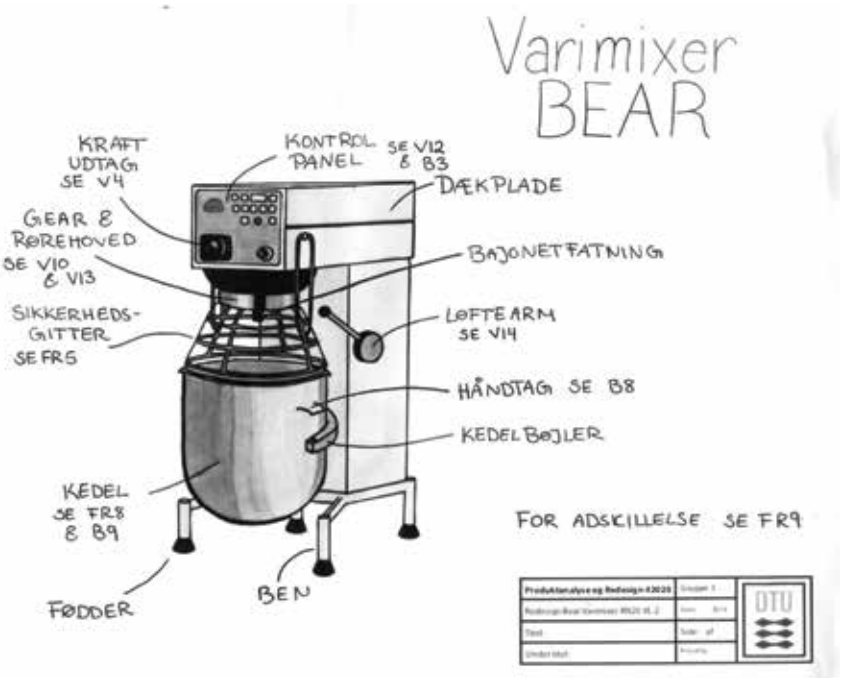
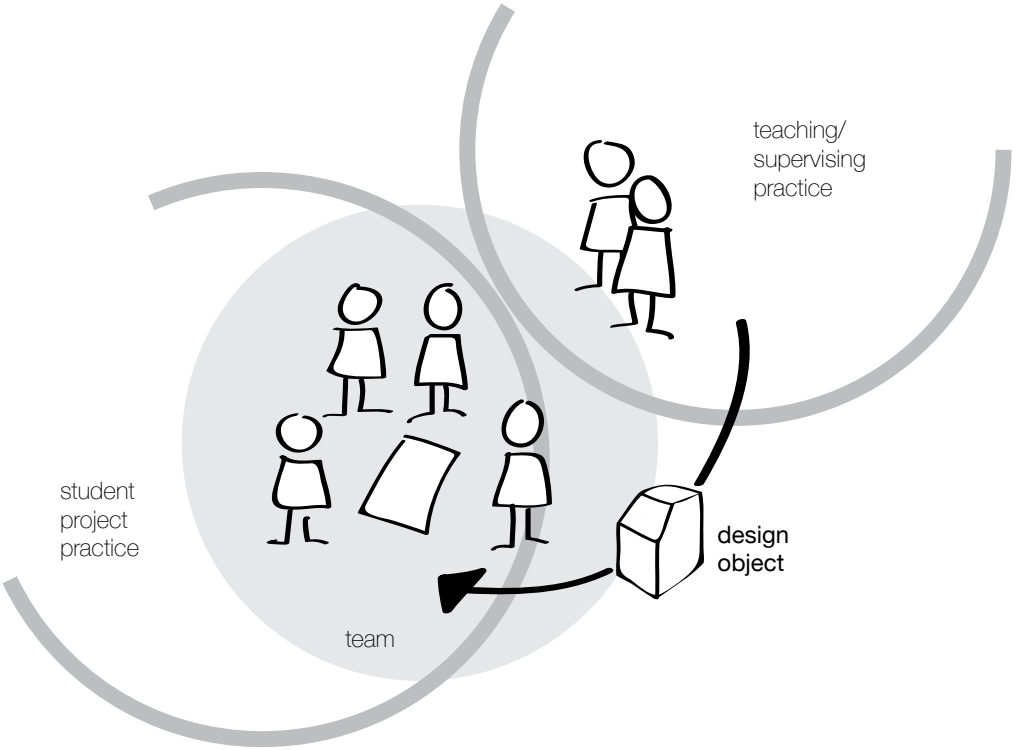


FIGURE 47 | Worksheet introducing the "bear" mixer (part of the team's final report).

ments on his experiences running the course for 10 years (Thorp Hansen, Anker Lenau 2013).

While the teaching practices thus appear to be (more or less) clearly guided by some ambitions and ideas of acceptable ways of doing a redesign course, the students' practices stand out less clearly from this episode – but before we go deeper into their project practices we shall take a brief look at some of the other activities that take place as part of the course in the next episode.

FIGURE 48 | The student team meets around the team contract while their object of design is assigned from the teaching practice.



EPISODE 2 | practicing techniques

A week later Tom is standing in front of the projector screen at the front of the room, pointing to the slide shown: It displays examples of so-called *worksheets* made by previous students attending this project course, he explains. The students are all facing the front of the room, looking at the screen during this short lecture. They seem to all be aware that the technique Tom is presenting now will be very central to the work they are expected to complete during this semester. Tom flips through a couple examples more on the screen: "As you can see, the sheets should really contain a mixture of text and illustrations," he points out. He shows examples of worksheets using different approaches to illustrate different kinds of points, but also some that he does not find particularly successful (typically ones containing only text).

Later, he starts going through some of the technical terms and concepts that the students are expected to use when doing their analysis and prepar-

ing their worksheets. "You should develop a *terminology* that can help you describe the mode of operation for the products you are working with," he emphasises. The key terms are: *components*, *functional elements*, *organs*, and *systems/subsystems*. He presents all of them through a concrete but simple example such as a bicycle chain (which could be both a component and an organ or part of a system) and part of a blender (where he asks the students to name some components).

After introducing some different drawing types (such as exploded view, diagrams, perspective drawings, sequential steps) that the students could use for their worksheets, Tom puts the students to work on an exercise. The exercise is to choose a type of drawing and represent the product now shown in a series of pictures on the screen: A so-called "knee-shoe" that some of Tom's previous students have designed. Tom instructs the students on every other row to turn around and couple up with those sitting behind them. Brian is one of the students sitting at the back of the room. He is now coupled with the girl that has been sitting in front of him. She turns her chair around and places her paper and pencil case on the narrow table in front of Brian. In these pairs they start discussing how this product – which they are all seeing for the first time – may work by looking at the pictures on the screen.

While they discuss, Brian quickly grabs his pencil and starts drawing a sketch of a bended leg in the corner of the A3 paper he has in front of him. As he adds more details by inserting parts of the knee-shoe they use the emerging drawing as part of their discussion, pointing to elements of it, inserting

FIGURE 49 | Joint exercise on worksheet technique.

arrows and bits of text. As their drawing reaches a certain level of detail, they find it hard to refer to the pictures shown on the projector screen at the other end of the room. Instead Brian retrieves his tablet from his backpack and finds the presentation slides with the pictures online. Now they are able to point directly on the screen as part of their discussion and zoom in while referring to the drawing.

Everyone in the room seems caught up in the exercise – also Emma who is sitting next to Brian. She and her partner are working collectively on one piece of paper, which they quickly fill with a type of exploded view of the product. They are using a coloured pen each and adding different elements at the time.

As the break approaches, Emma's partner asks Tom if people can leave their drawings out so that they can look at each other's drawings and see how others have approached the task? Tom takes this as a cue to urge all of the students to make room for placing the drawings on the walls. During the break most of them comply and especially one section of the wall is attracting a number of drawings hung by magnets. Most of the students just hang their drawing and hurry off for their break, but some linger a bit and scan through the other drawings.

After the short break the students are instructed to pair up in groups and present their drawings to each other, giving critique on the drawing technique chosen and how well they convey the functionality of the product. Brian and Emma's groups pair up in the corner of the room, hanging their drawings next to each other. Brian's partner starts explaining their resulting

FIGURE 50 | Presenting worksheets in pairs.

drawing to the other two. She has to fight a bit to keep the attention of the others as there is quite a lot going on in the room now, but she seems determined to give a good walkthrough of their product and thoughts. Emma and her partner pose a few questions, pretending never to have seen the product before. In this way they push Brian and his partner to explain in more detail the workings of the product.

With the drawings placed on the wall the four students are standing in front of them, close together in order to hear what is being said. They also use the drawings to point to when they ask questions or come up with answers. Along all the edges of the room you see students standing grouped together doing the same.

Afterwards they switch and focus on Emma and her partner's drawing. Both pairs seem to use a note of irony when criticising each other's work, almost as if taking on a role and wanting to underline that they would not ordinarily offer such types of critique.

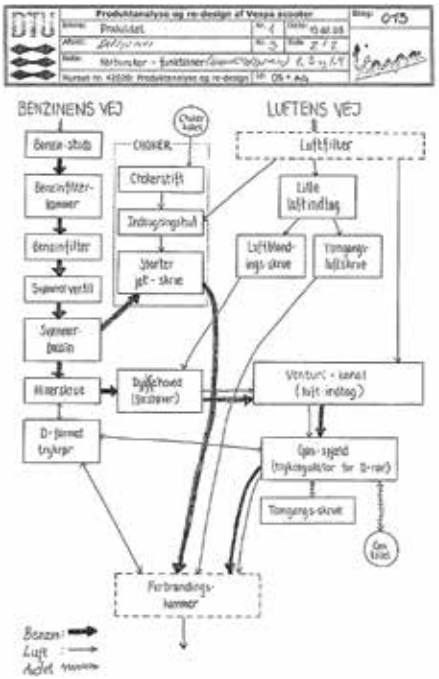
STARTING AS NOVICES

In this episode we get at short glimpse of what takes place in parallel to the project itself. Within the project course there are some 'theory blocks' including these kinds of short lectures with practical exercises and matching reading-material. Most of these blocks are placed at the beginning of the semester, reserving the last part for more intensive work in the project teams.

A CENTRAL TECHNIQUE

I have included this episode because the 'technique' introduced at this lecture and practiced through the subsequent exercise is very central to the work that takes place in many of the following episodes.

The worksheet technique, as it is practiced at the D&I program, was developed by two of the educators (Hansen, Andreasen 2003). In its completed form a worksheet will typically be in the format of A4 or a folded A3 paper with a standard header specifying which project the sheet relates to, who is in charge of the content, when it was made, and what it depicts. The content itself can be many things (descriptions, calculations, ideas, documentation etc.) and it can take many different forms (including text, diagrams, photos, and/or different kinds of drawings). Perhaps most im-



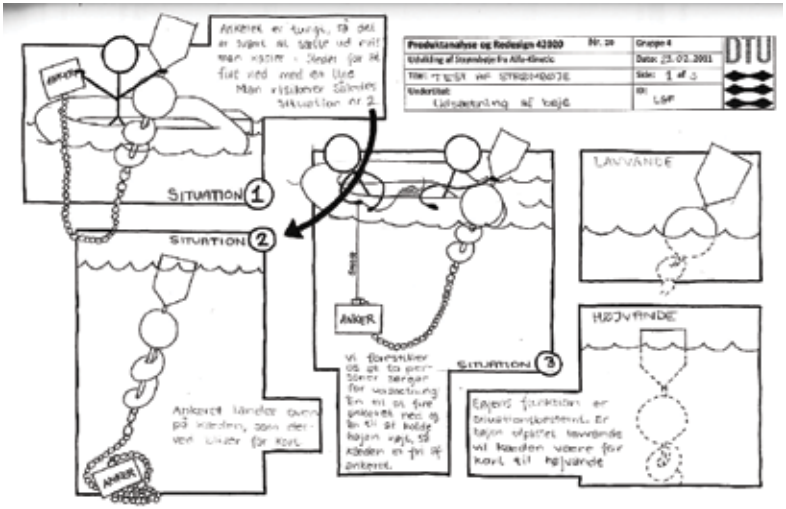


FIGURE 51 | Examples of worksheets shown for inspiration during the lecture.

portantly a worksheet is not *one* specific kind of document, but it is flexible enough to adapt to individual preferences and project needs. As such, the worksheets form a flexible standard for representing diverse types of observations, experiments, various considerations, ideas and solutions throughout the design process, making them an important means of communication in the projects – both internally in the group and externally with for example supervisors or collaborating partners.

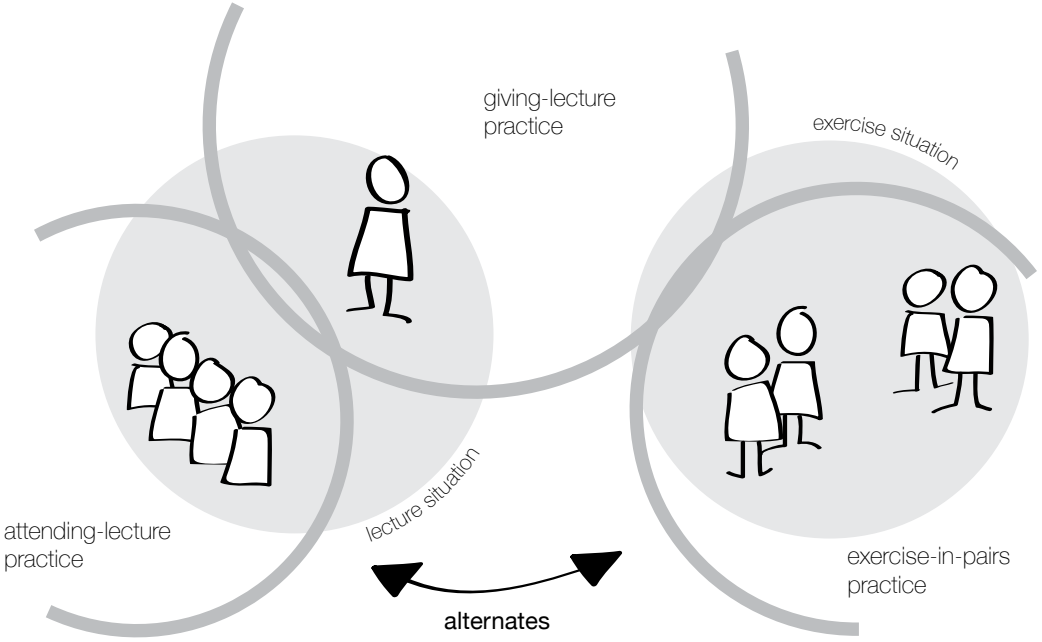
But this initial exercise in the episode gives an indication that the real value of the worksheet lies not exclusively in the resulting piece of paper, but just as much in the *process* involved in producing it. We see how the process of *making* the worksheets actually includes a lot of interaction between the paired-up students but also between the students and the emerging drawings on their paper and the design object (in this case represented by photos). The worksheet forms the centre of a discussion when deciding what is put on the sheet, how it should be conveyed, and then in the process of executing this it helps establish a deeper understanding of the subject conveyed (see also Juhl, Lindegaard 2013).

LEARNING BY DOING

Tom is thus introducing a bundle of practices well-know to most educators today, which combines a more 'theoretical' introduction to the subject (in this case a technique) with a simple hands-on exercise related to this subject (in this case using the technique). Actively working with the technique provides the students with some initial experience of using the worksheet technique, which they can bring with them into the project work. In Dreyfus' terminology they start to move from novice worksheet makers to advanced beginners as they start practicing their worksheet doing on these concrete examples. The subsequent walk-trough of their results helps them recognise some of the different aspects that influence the communicative power of the resulting piece of paper (for example choosing different drawing techniques or focusing on different parts or aspects of the design object).

What you could also note here is that peers, who are equally inexperienced in the art of making worksheets, provide the feedback and critique. The examples provided in the lecture slides are the only source of input

FIGURE 52 | Different practices come out in different situations.



the students get from more experienced 'worksheet makers'. The rest is very much based on their own brief experience from this and a previous exercise that same day.

In later episodes it becomes clear that this way of working with worksheets is brought into the project work, but it is also adapted and reshaped as it is re-produced by the students in specific situations.

EPISODE 3 | meeting the real world

3.1 Getting there

About a week and a half into the semester Tom has arranged for the students to go and visit the company that has provided the product they have been assigned. At 12 o'clock I enter the hired bus after the bulk of the students have already gotten on: They have all made their way to the back of the bus and there is an air of primary school excursion. The only exceptions are Brian and Emma who seat themselves at the very front of the bus right behind the bus driver. Tom sits at the front seat on the other side of the isle in order to easily communicate with the (quite talkative) bus driver, and I sit behind him. It is a large bus and we are only around 20 people (two teams) going on this visit, so there are several empty rows between us at the front and the students occupying the rearmost part. A lot of chatter and laughing is going on at the back of the bus. After everyone have been accounted for and the bus driver instructed, the bus leaves the campus area behind and take us to visit the company producing the professional food mixer about 20 minutes drive from the campus.

Arriving at the office we are greeted by a woman who seems to appear from behind a desk at the farthest end of the reception room, probably the receptionist. She is holding a small stack of papers and seems a bit overwhelmed by the sudden influx of young people in the small waiting area, which is clearly not designed for such a crowd. As she tries to make her way through the crowd she asks if we have an appointment? Without answering her everyone turns towards Tom who is standing at the back of the group, he responds affirming and nods his head. But her next question, "who are you supposed to meet?" he has no ready answer for, so he starts looking for his laptop in his backpack. In the meantime, the receptionist finds her way through the crowd and disappears through a door. Tom finds his laptop, gets it started, and finds the name on the person we are supposed to meet: His name is Kurt.

Meanwhile the students are looking around the waiting room, still wearing their winter coats and backpacks. On the walls there are some posters introducing a couple of the company's products. There is also a demo-model of the smallest of their food mixers on a low shelf. Next to the door where the receptionist disappeared, you see what appears to be an early model of one of the big mixers in a very industrial look, giving stronger associations to drilling than whipping cream. Before long you can hear the students discussing whether this is a picture of that model or this and studying details of for example how the bowl is attached to the small mixer.

A short while later the woman returns through the door and Tom is able to give her the name he retrieved from his computer – but apparently she has already found this out on her own and says that Kurt will be with us in a short while. And sure enough, a tall man wearing a chequered shirt and traditional jeans now appears from the door next to the large mixer in the corner. He is also looking a bit taken aback by the apparently unusual number of people waiting for him, but greets us with a smile and nod while scanning the crowd for someone who looks to be in charge. Tom steps forward and they shake hands while exchanging polite greetings. It seems this must be Kurt who Tom explained on the bus ride is the technical manager of the company, and he will now be our host for the next couple of hours. First of all he leads us to the meeting room where we will start the visit. On the way out of the reception area he points to the large mixer and comments to those within earshot that this was one of the company's very first products.

3.2 Company presentation

Once we have arrived in the meeting room Kurt asks if this is more than one class? Tom then explains that this is actually one third of the students from this generation. As the students have now settle in their seats and the sound level gone down, he continues to explain to Kurt – standing by his laptop in the other end of the room – how there are two teams of students represented here today that will both be working on the food mixer, but that these teams will eventually split into two each, meaning that the company will eventually be receiving input from four teams. Kurt nods while Tom is explaining this, but also uses the time to wake up the projector so that his prepared slides are shown on the project screen at the end of the oblong table.

Everyone is facing the projector screen and looking at what Kurt has chosen to show them. Most are sitting casually leaning back in the comfortable chairs, but about 4 have taken out different kinds of notepads and pens and are leaning towards the table, ready to make notes. Brian is sitting with a printout of some questions they have prepared in team 3, and I recognise the same paper emerging from a few of the other student's bags.

In his presentation Kurt introduces the different types of mixers that the company is producing and a bit about the historic development of their products. A short while into Kurt's presentation, one of the students raises his arm. Kurt does not notice this at first, but then detects the slightly awkward position out of the corner of his eye and pauses while looking inquiringly at the student. The student then asks where the company's largest market is found? Kurt provides an answer and then calmly resumes what he had been saying. From this point on the students are asking more and more questions and Kurt gets more and more acquainted with their signals of raising an arm.

Over the next hour or so the students ask many different questions, many apparently drawing on the desk research they have managed to complete before the visit, for example looking at the company web site, looking through the manual for the mixer, looking at competitor's models, and the new models the company has recently introduced. But they are also reacting to some of the things that Kurt shows that seem to surprise or puzzle them. For example Kurt shows a slide with a star-like pattern, which he explains – quite matter-of-factly – is the so-called "planetary movement" that all their mixers use (the tool rotating around itself is mounted onto a disk that also rotates, creating the pattern). Several of the students sit a bit uneasy in their chairs at this point and a couple of them raise their arms. When given the floor by Kurt one of the students then asks if they have tried to optimise the movement? Kurt answers a bit vaguely that this pattern has been used for a long time, as if to indicate that it is already as optimal as it can get. The students, however, seem a bit dissatisfied with such an answer.

One of the products that Kurt shows is the larger model of the mixer that the students will be working with. The company has just themselves completed a redesign process on this product, which has resulted in a product launch this January. He points out that their next task is to begin redesigning the student's model after the summer based on what they have done with this model – which is also why they are interested to see what the students might come up with that could potentially be incorporated into the design. He then goes into detail about some of the things they have chosen to change (though without showing the original design) and how they have gone about doing it.

When there seems to be no more pressing questions from the students Tom raises his voice to ask a concluding question: He asks Kurt what the company's expectations are for the outcomes of the students' projects? Kurt answers that they are very much looking for fresh eyes on their design and preferable some crazy ideas, for these could be the basis for new innovations. But they are also expecting the students to be good at communicating

their input. And then they should incorporate the economical aspects of their proposals ensuring that they are competitive.

This concludes the presentation/question part of the visit and it is now time to have a look at the production part. Kurt leads the way out of the meeting room and down the stairs while the students gather their things together and return the chairs around the table.

3.3 Tour of production

We enter a large, high-ceilinged space filled with loud noises from machinery running somewhere. Men dressed in blue overalls can be spotted in-between the tall shelving units that form passages in various directions. The shelves are all stacked with raw wooden pallets labelled with numbers. As we walk through one of the passages Kurt grabs a part from one of these pallets and starts explaining something. The students huddle together in order to hear what he is saying and see what he is pointing to, but because of the noise level only those at the front can hear anything. Those standing at the back of the crowd with me is instead looking around in the large room and peeking into the wooden crates on the shelves next to them. Some have kept their notebooks out and are attempting to make small notes along the way (in this way I blend in well, in fact I do not even think Kurt notices that I am a different kind of 'student').

FIGURE 53 | Students asking questions and documenting their visit at the production site.

In between the shelves are also different types of workstations equipped with various forms of machinery. Kurt points out some of them and explains to those closest by what takes place here. Simon has produced a camera from his shoulder bag and is taking photos of all the things Kurt is pointing to. It would seem like he has been assigned the role of photographer, for none of the others in team 3 are taking photos. From the other team several are using their smartphones to take a picture here and there where opportunities arise.

We complete the tour by the workstations where the mixers are finally assembled and packed for shipping. By now it is past 2 o'clock and the blue workers who work here have all left for the day, so the students can look around without disturbing. Even though they have their own mixer specimen back at DTU, they are quite exited to see it here in different stages of completion. Several of them have questions for Kurt regarding certain details they have noticed (either during this visit, from their desk research, or from looking at the mixer in their own workshop).

After completing the full round of the production site we bid Kurt farewell and return to the bus.

MEETING A CLIENT

When Tom first announced that the students would be going on these company visits there was a great air of excitement in the studio at DTU. Projects evolving around 'real life' problems are a special trait of the D&I program, though also being allowed into a company and seeing a production site is more rare. Tom explains to me that he puts a lot of efforts into ensuring these company visits in the redesign project because it helps the students form a better understanding of how the product is produced – which is a significant part of the multi-dimensional technology analysis. The prospect of their design efforts being potentially useful in real-life also significantly increases the motivation for the students and the level of ambition in their work.

NOT JUST AN EXCURSION

On the way to the company visit there is a distinctive air of *school excursion* emanating through the bus: People are talking and joking at the back, and it is left up to 'the teacher' to take the lead, making sure the group is on time and fully attended. Going on such excursions is clearly something

that all of the students have tried previously and they quickly fall into the doings that come with it.

But this is not a school excursion to a museum or historical site. This is actually a part of their fieldwork in the project. Once we are inside the meeting room and Kurt starts his presentation it seems as if the students shift to another set of doings and sayings – on that resembles their practice when attending lectures at DTU. They start raising their hands and asking questions, and they are referring to things they have read (mostly on the company web-site) before hand. The small awkward situations that arise at the beginning of the visit can be viewed as indications that different kinds practices are actually meeting, with the differences in how you act, what you say, and what you mean that this implies. While the students are bringing their bundle of practices from the educational sphere then Kurt is the carrier of the kinds of practices that reside within the occupational sphere. In this instance he is attempting to carry out the

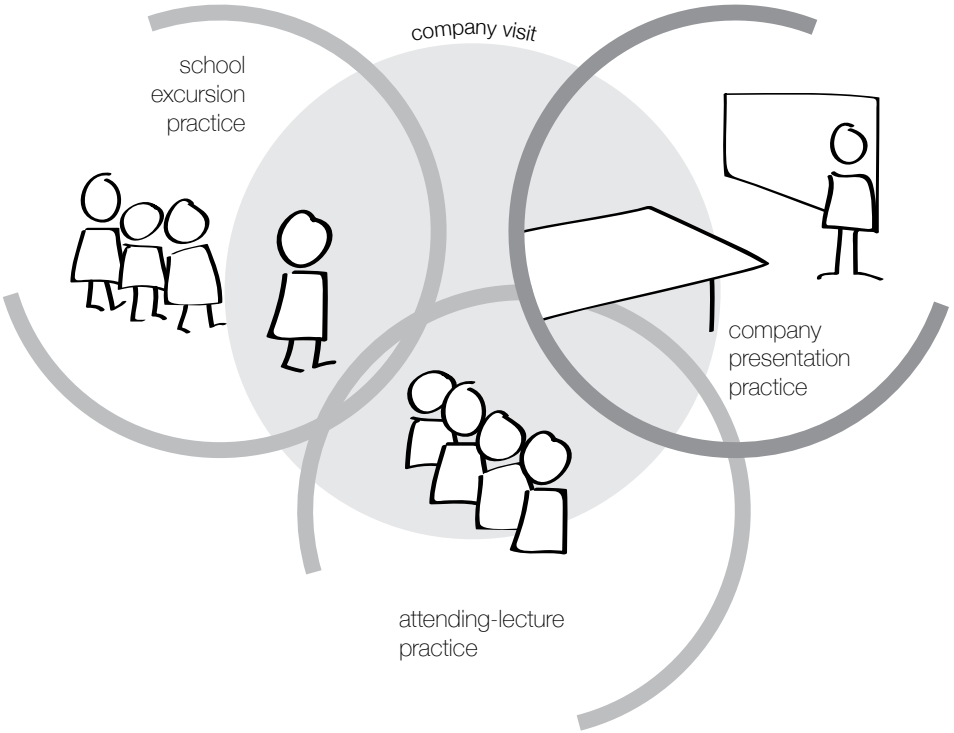


FIGURE 54 | At the company visit the student's learning practices meet the company's practices.

kind of presentation practice that the meeting room would traditionally be accommodating.

We will meet Kurt again at the end of the semester when the students have completed their redesign in Episode 11.

SKETCH 2 | a space for projects

A few weeks into the semester I arrive just before the official lunch break is over. A lot of students are leaving the studio (later I find out they are heading for their workshop course). This leaves only what appears to be two teams in the room, identifiable as such because they are sitting around clusters of tables in the large room, even though several of them are still finishing their lunch. The entire room is now occupied by these clusters of tables; some just made up of two tables put next to each other, others made up of three or four tables. Even though most of these are now unoccupied it is clear that the students have only left them temporarily: Paper, pens, coffee cups, and other items are left lying on the table surfaces and the chairs encircling them are left scattered aimlessly around.

Looking around the room it seems like the teams have now effectively occupied each their fraction of the long walls at either side of the room. These walls are naturally divided into three sections each by protruding pillars

FIGURE 55 | Wall sections for each of the student teams in the studio.

reaching all the way to the ceiling far above. Each of the six teams thus gets an equal fraction. Their first claims over the respective wall sections have been achieved by hanging up large signs with their team number – when I was here last time only one of the teams had made such a large A0-sized sign hung up high on the wall. Now all of the wall sections display similar signs, though adopting each their individual style. Team 3 has chosen a large photo of a bear family, clearly playing off their company's nickname and logo, which is a *bear*.

Underneath these large turf markings several of the teams have put a printed calendar of a similar size. All of the teams apart from one have also begun hanging worksheets related to their project on the walls. These are sheets of A3 paper filled with different types of hand-sketched illustrations and/or text.

FLEXIBLE

With the semester now well on its way the studio also starts revealing its flexibility and ability to adapt to different occasions. Compared to the lectures and exercises we witnessed in Episode 1 and 2 the student's project work fosters a different kind of organisation in the room. Each team has their own area, with the wall section becoming a kind of depository for

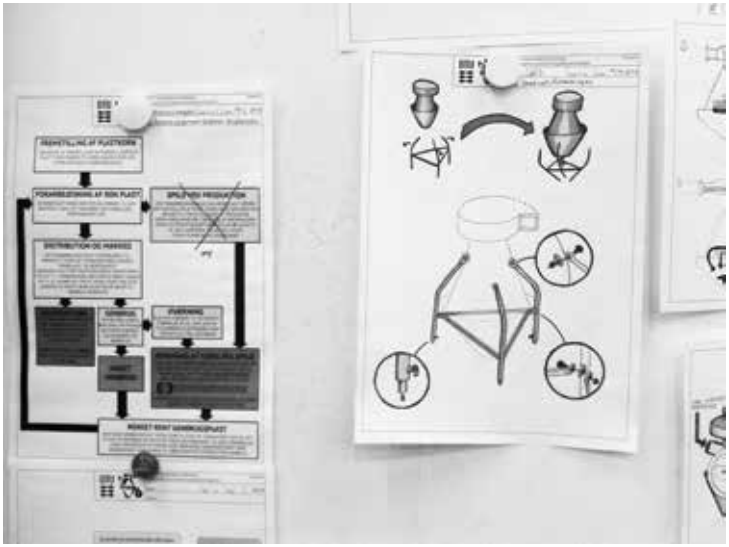


FIGURE 56 | Initial worksheets on the teams' walls.

their compiled work and the table clusters facilitating talk between members of the large groups.

The studio thus seems to go through a transformation parallel to the one we witnessed in the UX team's self-proclaimed project room. In the next episodes we will see how this newly configured project space also interacts with the students' work.

EPISODE 4 | guided by supervisor

The week after team 3's visit at the company Tom sends them a mail regarding their next supervisor meeting. He is going with two of the other teams for their company visit this week, so he proposes a meeting with team 3 on Thursday at 1 o'clock.

It is now 1 o'clock and all of team 3's members are sitting around the cluster of tables at the back of the studio, but there is no sign of Tom. Leo is sitting with a drawing on a piece of A3 paper in front of him and asks the others if there is time for him to go and print something? Brian replies "Sure – if you can be back by," he looks at his watch, "by now!" Leo shrugs his shoulders and stays put. Meanwhile the girls are looking around at the walls: It seems they have just hung up their first worksheets and not had time to go through them together. Now they start to compare with their impression of those hanging on the other wall sections: "If you look at the other's then they are more into the details," Emma says as she points to the opposite wall, "– ours are more general." Thea nods as Caroline replies: "But it's okay to have some general ones and then go into the details, I think."

The individual conversations around the table seem to conclude when Oscar loudly proclaims: "He writes that he will come at 1 o'clock!" after checking his laptop in front of him. With Tom still nowhere to be seen Thea suggest that they start up themselves, and just like that the conversation switches to what has been going on the past few days. From their logbook I later learn that they had split up the day before with two working on the disassembly of the mixer in the workshop, two visiting a small bakery, two talking to a dealer, and two visiting a kindergarten. Conversations now run across the table cluster several at the time and Brian leans towards Sarah saying: "Remember, you're the moderator today, so you must tone down the temperaments!" Sarah jumps in her chair and turns towards the chaotic scenery around the table.

FIGURE 57 | Supervisor meeting around the table cluster.

By now Tom has actually arrived, standing behind the table, probably waiting for the students to invite him into their conversation. At an opening in their round of updates one of the students makes eye contact with him and then looks around the table as if to spot a place to invite Tom to sit down. There is an available chair between Oscar and Simon, which Tom makes his way to and sits down. Then there is a moment of hesitation where neither part takes the initiative to start the dialogue. Eventually Tom refers to his mail by saying that he has requested an outline of their work and would like to hear about their plans. Simon takes the cue and explains that they are using the calendar on the wall to plan their work and then they have made a list of the worksheets they need to make for milestone 1. Henry gets up and retrieves an A3 paper displaying this list from the wall.

"Should we document the field work on the worksheets?" Emma asks. "Of course, where else would you do it?" is Tom's swift reply: "You only have 5 pages for the report, so that leaves no room to document it in there." This spurs a discussion on the aim and format of the worksheets. Brian was under the impression that the worksheets had to be more processed somehow, but Tom explains that they will probably end up with both types – some simply referencing the different field visits and the information they got from them, and some looking into more thematically framed subjects. "But then," Brian

objects "many of them will end up being just text!" Tom suggests that they discuss this challenge with Daniel at the worksheet review next week. "Did you take any pictures at your visit yesterday?" he asks and looks at Henry. "Yes – a lot," he replies. "Well," Tom elaborates, "you can easily spice it up with some pictures," and then he explains that they should try and emphasise what were the significant points from each of their visits.

Seemingly inspired by this talk, Leo suggests that they might make a worksheet with a picture of the machine and then add the different comments they have collected from the different visits, for example related to cleaning the machine. But Tom stresses that they should also have sheets devoted to document the individual visits. At the same time, however, they should keep in mind that all sheets must be used for something – that is, be referred to in the report. "Like appendices?" Simon asks, "Yes, worksheets are appendices," Tom clarifies. Brian and Emma still seem unsure how to focus the worksheets, so Tom continues to explain that they should try and focus on "What is the point of making this particular worksheet? What do you want to say with it?"

During the discussion almost everyone is starting to engage actively, especially referring to the things they have just seen on their different visits, which they have not shared amongst themselves in detail yet. Thea is sitting quietly and noting a few things down on a laptop – she was assigned to be the referent today.

Towards the end of the meeting Leo pulls out his worksheet as an example of their work (he had not hung it on the wall yet because it was not finished). He explains: "I want to show why they use screws where they do and welding where they do." Tom takes a look at the paper in front of him. It contains a crude pencil sketch of the back of the machine with several empty call-out bubbles surrounding it. Leo explains that these will be filled with pictures of the actual joints because he found it too hard to draw them by hand. Next to each of these circles he has drawn a box and written some notes by hand explaining the type of joint. Tom suggests this sheet would fit somewhere between the *mode of operation* part and the *processing* part of their analysis. Leo seems to agree and explains that he would like to take his starting point in the actual joints as he has found them on the machine, and then work from there (processing) to try and find out why (which is more operation related). Tom has no objections to this approach and turns his attention back on the list: "Next time you will have updated this one?" he asks and urges them to indicate on their list when the individual sheets are done. Then they arrange to meet again next week.

FIGURE 58 | Leo shows his worksheet to Tom.

INSTRUCTIONS TO PROCEED

Supervisor meetings, like the one we witness in this episode, are a normal part of the students' project work. They usually meet up with their supervisor once a week for short meetings, providing the supervisor with an update of the progress and providing the students the opportunity to address any questions or concerns they might have in relation to the project. Most of the time these queries relate to specific techniques that have been introduced to the students (such as the worksheet technique in this episode) or requirements for a delivery that is to be made as part of the project (for example the milestone report and presentation).

In this episode we get a sense of the relationship between the students and their supervisor and the kind of things they are concerned with in their work. It is clear that this is a meeting initiated by the supervisor and not the students: They have not prepared any specific topics they would like to discuss or even sent any material for Tom to comment on. Instead they inquire about what is immediately on their mind: How to do the worksheets.

RULES OF THUMB

Even after working with the project for some weeks now and having produced at least one worksheet each the students are still unsure about the worksheet technique: What exactly should they contain and how do you 'do' them in practice? While discussing the worksheets none of them are directly referring to the sheets they have already hung on the wall – and their supervisor has not had time to look at any of them, though from his place at the table he is able to glance at the wall. Tom's input to their frustrations thus remains somewhat general ("use them to document field work", "use pictures to spice up the text", "remember to refer to them in the report"). Leo is probably the one who gains the most from this discussion, as he is the only one showing his actual work and receiving some more concrete comments.

The students can comfortably be described as *novice* worksheet-makers moving towards *advanced beginners* in this episode. They are looking for specific rules or maxims that can direct them when trying to apply the doing of worksheets to this particular project. They have all seen the (many) examples that Tom showed of different kinds of worksheets at the lecture in

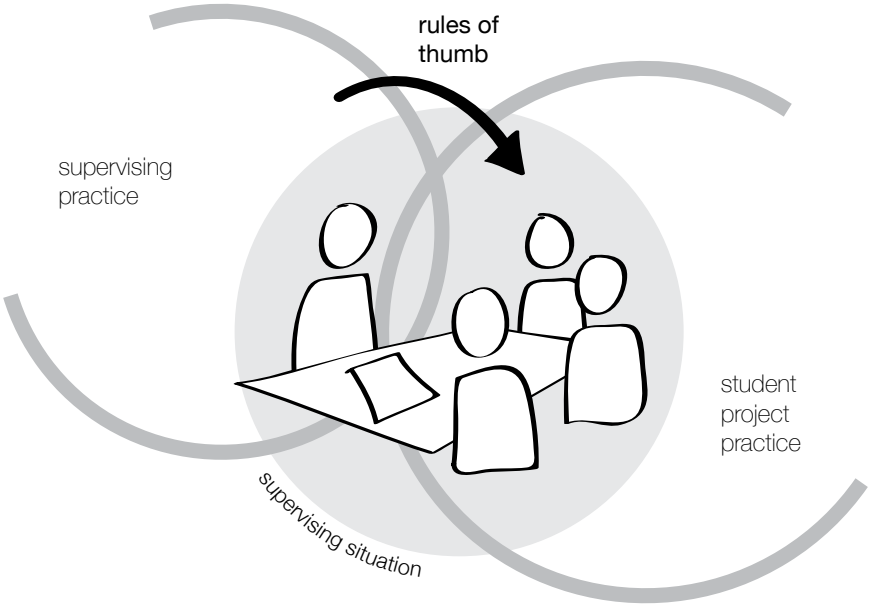


FIGURE 59 | The supervisor provides rules of thumb to the students.

Episode 2 and they all participated in the exercise. During the lecture and exercise the worksheet technique was just that – a technique; a sequence of steps guided by some overall rules to produce a piece of paper with a certain type of content. But now they have been working on their first worksheet as part of their project work and suddenly they are unsure how to progress. They seek guidance, they try to relate the worksheets to other kinds of documents they have some experience with in a project situation (such as appendices and fieldwork documentation), and they struggle to build a practical understanding of how you make a worksheet and how you use it.

The rules of thumb that Tom offers them emerges from his own experience of what has proved to be 'successful' worksheets in the student projects he has seen in the past, but also from his intentions of what the students should be able to do.

POSITIONING THEIR EFFORTS

At the beginning of the episode we also see how some of the students in the team relate to the work of the other project teams that is now appearing on the walls around the studio. They seem to try and position their own work in relation to the worksheets they see. This is actually one of the dimensions that the studio model is intended to support. Being co-located in the same space and being encouraged to use the walls to display and share their work in the teams, the students have the opportunity to get a sense of how things are progressing in the other teams and find inspiration from each other. The open physical space thus helps facilitate that the students start to build a common understanding of their work, for example what is 'acceptable' formats to use and how it makes sense to approach the project work. In this way the *material arrangements* link to and facilitate the practices that the students are participating in.

While the girls in team 3 do not readily recognise their own way of approaching the worksheets in what is displayed on the other team's wall sections, then they are able to start formulating some ideas about the way they are working and how they want to progress. Some intentions are forming about getting more into the details of their product.

In the next episode they get some more specific feedback on their own work at the worksheet review.

EPISODE 5 | experienced peer review

This Wednesday it is time for the first half of the students to go through the announced worksheet review. Daniel, who is a master student at the D&I program, has been brought in to conduct this. A couple of days ago he sent out a timetable for the review where the students were paired up with a team member and encouraged to bring different types of worksheets for the review.

The studio is now filled with talk and commotion since the students are getting ready to transfer from lecture mode to project mode. This means first of all taking a break, walking around, and interacting socially with the other students. But it also means rearranging the tables into clusters that will fit their large teams and clear the walls of any irrelevant elements that have been stored in front of them since they last worked here. During all of this Daniel has found a table by the edge of the studio where he sits down with his laptop showing the program for the review.

Leo and Oscar are the first ones up, so they find some chairs and sit down around the narrow table with their neatly folded worksheets. Without introducing their assigned product Leo begins the conversation by stating that they have made their worksheet design according to Danish Standard (Dansk Standard). Daniel seems a bit unsure what he means by this and grabs the paper to investigate it further. It turns out Leo is implying the specific type of

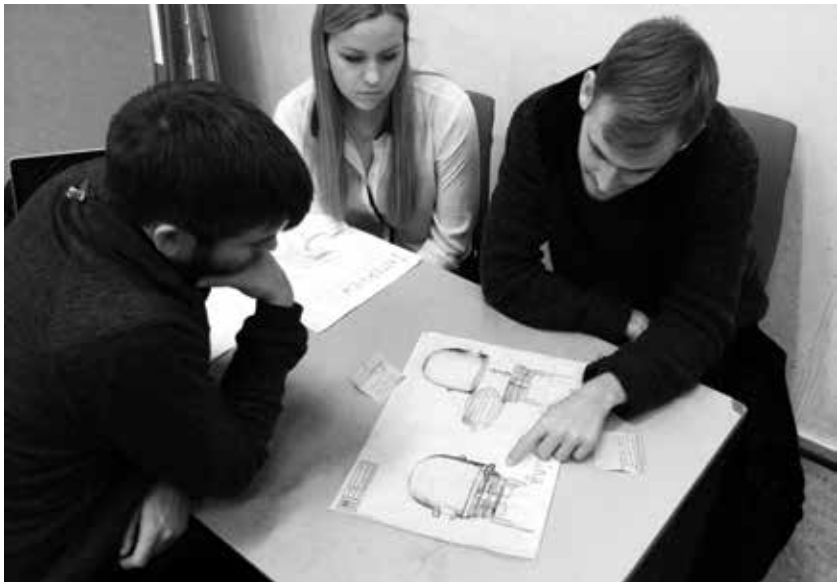


FIGURE 60 | Students showing their worksheets in the review situation.

folding they are using – so that the A3 papers can fit into a normal A4 binder – and the page header, which they have designed to fit within the folded page's dimensions.

Since Daniel is already sitting with Leo's first worksheet this is the one they begin to discuss. Not having seen any of the worksheets before hand, Daniel skims through the worksheet and asks: "What is it you guys are working with?" hinting at the assigned product, which does not directly read from the sheet. It is the sheet that Leo was working to complete last week, showing the different types of joints on the mixer. Leo explains that when he looks at it now he would have liked there to be room for a heading: "But there's no room for that now – I just sort of went for it." Daniel agrees that a heading would be nice next time, but also appeases him by saying that worksheets are supposed to show a process and are meant to develop over time, so it is okay that the sheets also reflect this. In fact, he praises Leo for using a pencil and leaving the more muffled parts from previous attempts on the drawing.

Then Leo enquires about the purpose of the worksheets: "Are we supposed to be able to pick them up and use them as notes ourselves, or are others supposed to be able to read them?" Sitting with the large sheet of paper in his hands Daniel explains that the way he sees it there are three uses of the worksheets: For one, a worksheet should be useful for the person who made it, enabling him to go back to it and find a collection of knowledge summed

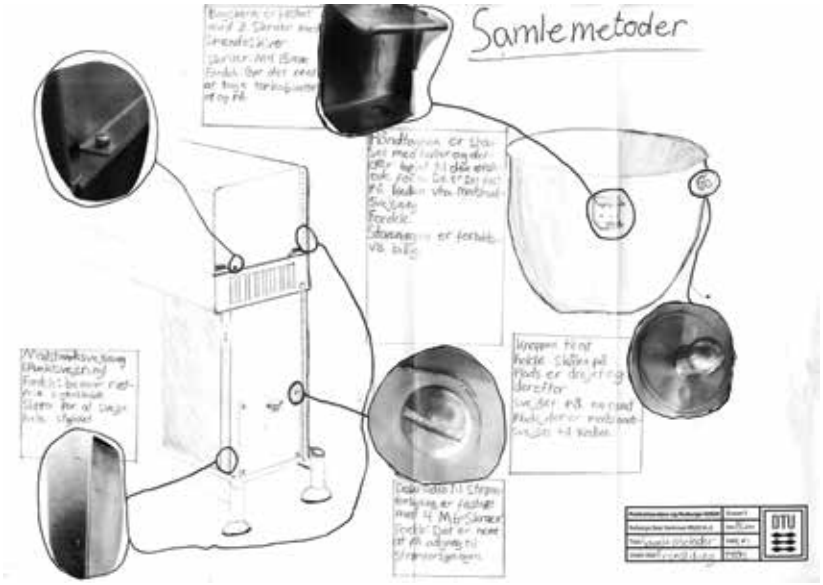
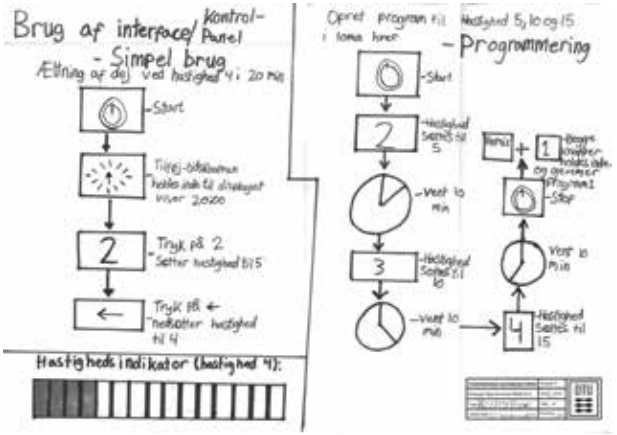


FIGURE 61 | Final version of Leo's first worksheet (completed version from milestone 1).



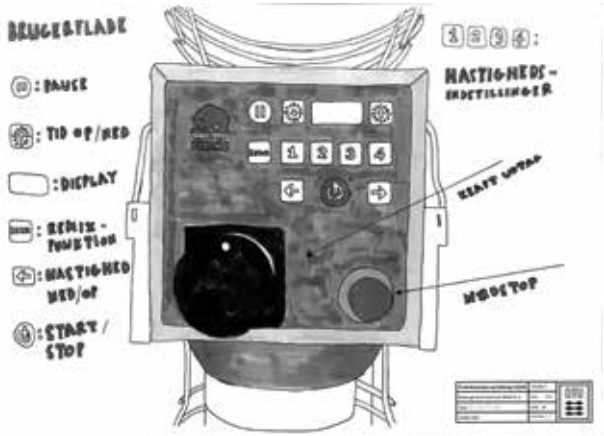


FIGURE 62 | Final version of Leo's second worksheet (completed version from milestone 1).

FIGURE 63 | Brian's worksheet of the interface (completed version from milestone 1).

up on a single piece of paper; second, it should be useful within the team in that you can show the sheet to the others and thus share some insights you have acquired; and finally, it can also work in a situation where you need to present some insights to people outside the team. But he seems to stress the first two as the more important. Leo makes some notes along the way on his laptop.

Daniel provides some different input to techniques they might apply on their worksheets using the worksheet that has been placed in front of him, for example relating to use of colour and adding versions to their header. He also suggests that they place all of their new worksheets on the wall and offer each other critique, pointing out if there is something they do not understand. Oscar and Leo seem a bit proud to point out that they are already doing this. But based on their talk, Oscar suggests that they might try and let each other figure out what is on the worksheets before providing an explanation. This would make it clearer if they "work" or not.

After going over Oscar's two worksheets Leo shows his latest production. This paper is filled with simple boxes and icons connected with arrows into two separate sequences. Next to each icon he has written a short text. He explains that this is to illustrate two different scenarios for operating the machine: The first, shown to the left, is the basic approach; the second, shown to the right, is how to set the so-called "remix" function on the machine. They have observed that the people they have been talking to all seem reluctant

FIGURE 64 | Brian showing his worksheet of the control panel.

to use this function, so he wants to show how much more it requires from the user. Some of Daniel's suggestions for improving this worksheet are to make it more clear that two different ways of operating the machine are illustrated and then to add the compiled operation times at the bottom to make this point stand out more clearly. Also he suggest that Leo might want to add a drawing of the control panel in order to make it clearer which buttons he is referring to in his diagram.

Next up are Emma and Brian. They have also brought two worksheets each. After going through Emma's worksheets, Brian starts with his overview of the control panel. This worksheet shows the different buttons and their relative placement on a large colourful marker drawing with text on either side. He explains to Daniel: "I wanted to define what the different buttons are first. Then there will be a second worksheet, which elaborates – for example the "remix button"." He points to one of the buttons on his drawing and goes on to explain how this is actually being outfaced by the company and how their own fieldwork has shown that this function is not used at all: "People think it's redundant."

Daniel obviously recognises this "remix" term from his conversation with Leo. He points out that this worksheet is exactly what he had suggested to Leo should precede his in order to make it more clear which buttons was referred to on his diagram. But Brian seems a bit taken aback that Leo has already made something resembling what he had intended to proceed with, so

Daniel emphasises that it is great how they fit together! And then he repeats his suggestion of hanging the worksheets on the wall and going through them collectively: "Because it is important to get someone else to look at them too – it's just different from working on them alone and thinking "this is really great!""

Both Emma and Brian express some reservations about the process of working with and using the worksheets. Emma says for example: "The two of us have discussed that it can get really diffuse: "do a worksheet on hygiene" – but you don't really know in which direction to take it." Daniel conveys understanding of this frustration, but assures them that the worksheets can help them more than they might think offhand. Pointing to the sheets lying between them he says: "This isn't simple stuff – maybe it is for you at this point, but if you don't know anything about food mixers then this is quite complex."

WORKSHEET REVIEW

In this episode we meet Daniel. Daniel is not an educator but also a student at the D&I program – though he is doing his master and so he is around 3 years the senior of the students in team 3. This means he has completed at least 6 more projects than they have, during which he has most likely been using worksheets to some extent. Tom has arranged this review in order to give the students an opportunity to receive feedback and tips from someone who is thus used to (and presumably accomplished in) making worksheets. Though Tom lectures the students in the worksheet technique and eventually assesses their work when the final report is handed in, he has never himself participated in the practice of *making* worksheets in relation to a design project (as is the case with the other educators at D&I). Talking to someone who has a different kind of hands-on experience thus appears to provide the students with something else.

AN EXPERIENCED PEER

Even though Daniel is a student himself, he is put in a situation much like an educator. He has a certain amount of time for each pair of students (20 min.), during which he is expected to be able to respond to some work he is seeing for the first time and provide constructive feedback. In this setup the students never see any of Daniel's own work or experience how he would work on or engage with a worksheet. All they have to base their

dialogue on are these intermediately finished worksheets and what both the students and Daniel express about their experiences.

In his feedback Daniel draws on his own experiences as a D&I student, recollecting what he has found to be useful or frustrating. Overall, his advice falls in two categories: On one hand he tries to encourage the students to keep exploring the possibilities that worksheets as a technique offer them in their design work and project organisation (for example being able to think across the individual worksheets and link them together); on the other hand he is also able to offer them hints to what 'counts' when the worksheets are being evaluated at the end of the course (for example that the worksheets reflect the process-focussed approach to working with them and being meticulous with the number references). Not that Daniel or the students make this distinction in the situation, but it bears witness

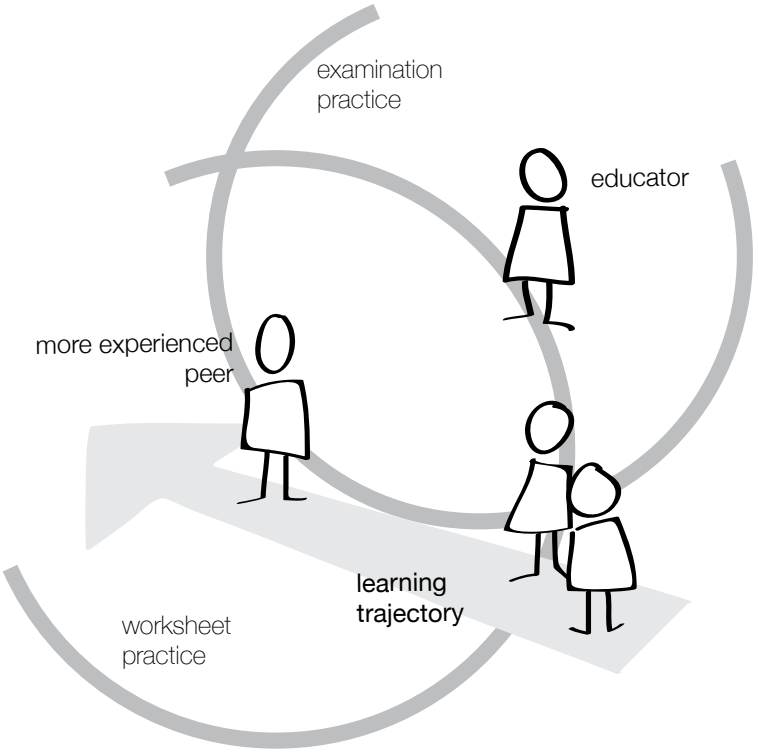


FIGURE 65 | A more experienced peer guides the students on their learning trajectory.

to the different kinds of practices the students are engaged in during such project work.

As an experienced peer Daniel is thus able to guide the students along their learning trajectory into the new worksheet practice in a way that Tom would not be able to do, because he is placed more peripherally to this practice.

LOOKING FOR MEANING

Though we still see the need to cling to rules in this episode (for example Leo's proud reference to Danish Standard for folding an A3 paper into A4), then the students also seem to be looking for something more than that. Many of their questions circle around the *purpose* of the worksheets: It is one thing figuring out the elements a worksheet should include, but something else to figure out how the resulting piece of paper fits into everything else that is going on in the project and why you should really be bothered to put time and effort into it. Clearly the worksheets must be perceived by the educators to hold a central part in the project work when so much of the final evaluation is based on these. But at this point the students are still mostly complying with external demands when working on the worksheets – they have not experienced this purpose themselves, which is the cause of their emerging frustrations.

The meaning is, however, gradually being constructed through their internal interaction within the team and across the different teams, but also in situations like these where they have access to insights from someone who has had a chance to grow more experienced in the use of worksheets. And to Daniel there seems to be no doubt: Worksheets *are* a valuable technique that enables you to distil insights and to share and communicate them to others. Just how important the more communication-related parts are is perhaps something the students at this point remain to experience themselves, but Daniel's assurance seems to be enough for the students to press on after the review.

In the next episode we shall take a closer look at how the students interact internally in the team and provide feedback for each other.

EPISODE 6 | sharing individual work in the team

6.1 Walkthrough before worksheet review

After their supervisor meeting with Tom the team agree that they should probably go through the different worksheets they have each been working on. "Should we get up and take a look then?" Brian asks pointing to the wall behind him, which displays a long line of A3 papers filled with different kinds of illustrations. The entire team gets up and groups themselves in front of the wall. All of the team members are a bit curious to see what the others have been working on.

Sarah has been appointed moderator for the day, so she positions herself closest to the wall. She is really trying to embrace the role now, though she found it hard during their discussions around the table earlier today. She looks around to see if everyone is ready and then points to the worksheet hanging furthest to the right while asking: "Who made this one?" with a big smile. Everyone laughs a bit as they look at the paper held up by two magnets. In the top leftmost corner it shows a crude sketch of what appears to be the mixer bowl and protective grate and the whipping tool at an angle to these, seemingly trying to get in-between.

Simon steps out from behind and acknowledges this piece of paper: "What's wrong with it?" he says with the exaggerated toning that signals irony, "It's almost – *almost* – finished," recognising that it is not nearly finished at all. He then explains that his idea is to illustrate how you fill up the bowl. "You haven't finished it completely I think," Sarah says. "Nyaa, well it's a ghost filling it up," Simon says as he moves closer to the wall. Then he explains that they do not really know yet how people add ingredients to the mixer-kettle, so "there's room over here to draw a man that fills it up," he says pointing to the blank right-hand side of the paper. Sarah then indicates some of the things they *do* know about this process already by showing some movements with her own body, and Simon gives in: "I know – that part I didn't finish!"

Moving from the blank side of the paper to what he actually did draw, Simon now points to the whip and explains his thoughts behind this. By moving his finger he indicates the movement of the whip when it is inserted into the machine and with a large hand gesture he then illustrates how it is propped up into the head of the machine. The girls do not seem satisfied that the drawing is portraying the same points that Simon is now explaining, so they start making suggestions: Caroline raises her hand, but both Emma and Thea just speak out. Thea ends up being the one you hear: "Then you might just want to write "there is no room for the tools to pass", just to make sure that everyone understands it." Simon nods his head and looks at the draw-

FIGURE 66 | Pointing and using the drawings when providing feedback.

FIGURE 67 | Struggling for attention.

ing. Brian, standing to the back of the group, breaks in to ask: "But Simon, you're going to continue working on this one right?" Simon confirms. With her arm now stretched demonstratively straight in the air Caroline bursts out: "We have a moderator!" So Sarah nods her head in Caroline's direction, thus officially giving her the floor.

Caroline feels quite strongly about the proportions on Simon' drawing, in her opinion the whip has to be much bigger. Thea raises her hand as Caroline is explaining her views by measuring out sizes on the drawing with her fingers. While several people chip in with amusing comments to this, Sarah turns her head towards Thea who still has her hand slightly raised. As a short pause arises, she points to Thea and now gives her the floor. Thea wants to remind them of something Tom had just said at their supervisor meeting, which she found to be a nice point: "This thing that the worksheet should have a purpose. We need to go through the list again, be sure that there is a *purpose* and that it comes out clear through a headline and that you can see it straight away." She looks around at the other sheets hanging on the wall: "I can see now, that we haven't thought about it before – that you don't really know what it's about." She holds up her hands in front of her as if looking at an imaginary worksheet and puts on a puzzled face: "What should I get from this? We need to be more clear, more focussed." After delivering her point she looks at Sarah who nods her head and then turns to the wall, pointing at the next worksheet: "Oscar, you're up."

They proceed like this through all the sheets hanging on the wall. The one who has made the sheet explains his/her ideas, pointing to elements of the drawing, also pointing out what they may intend to add to the sheet. The others ask clarifying questions and come with suggestions for improving it,

FIGURE 68 | Taking notes during the collective feedback.

for example by adding a second page to the worksheet with more information or pictures.

6.2 Walkthrough after worksheet review

About one week later the team convenes after half of them have been through the worksheet review with Daniel. They arrange the worksheets in a large group on the wall in order to maximise the range of the available magnets.

Oscar, who is the moderator for the day, suggests that they take a few minutes to look at the new worksheets before they start going through them one by one as they had done last week. The others agree to this and in relative silence they lump together in order to see what is displayed. Brian grabs a post-it pad and starts taking some notes as he reads. Simon is also holding a post-it pad but he seems more unsure what to write down, so he just skims through the sheets. During the next couple of minutes they shift around a bit in order to get in sight of the different sheets.

After a couple of minutes they all seem fidgety and someone suggest that they start going through the sheets now. Oscar decides that they will start at the top right with what is a new version of Simon's worksheet from last week. This week Simon has drawn two large sketches of the mixer bowl in different situations. At the top he has made a heading in handwriting saying "Filling up". Simon simply starts by introducing the title of the worksheet and mentions that he has been talking to Daniel about some changes during the review earlier in the day, but then quickly opens the floor for comments. Oscar keeps to the back and simply lets the dialogue flow without intervening much; now and again he gives a nod if one of the others have raised their hand during a dialogue to indicate when they can speak.

While Simon is writing down some of the input the others are providing on a post-it, Sara asks: "One question: That grate, that's there so you can't stick you fingers in, right?" "That's right," Simon confirms and several of the others nod their heads. "Then you might want to make a small note on that, saying that the grate is used with regard to safety," she suggests. This spurs a short discussion on which terms they are using to denote the different parts of the mixer, for example if it is simply a "grate" or a "safety-grate".

To get the discussion back on track Caroline suggests that Simon makes two worksheets instead: One focusing on filling the bowl and one on changing the tools "Because that's actually what you're doing," she points out. While Simon is busy noting down the input on post-its Sarah interjects that they had also been talking about splitting it in two with Daniel at the review. Then Leo adds a point from one of the field visits: That the woman they had talked to actually had a lot of trouble attaching the tools even though she had used the machine for 30 years.

On the second sketch Simon has attempted to illustrate a plastic part, a kind of chute, which can be mounted on the protective grate in order to enable adding ingredients while the machine is running. On his drawing it looks very small and practically useless for this purpose, so they spend some time discussing if he has the right proportions or not. Henry suggests adding something to their drawings in general to indicate the relative size, for example a hand. Brian points to this small chute on the drawing and emphasises that the relative size is quite important on this drawing "If it really is this small then they have made a mistake – you can't put anything into that!" So they agree that Simon should adjust it to become more representative of the physical chute that came with the machine.

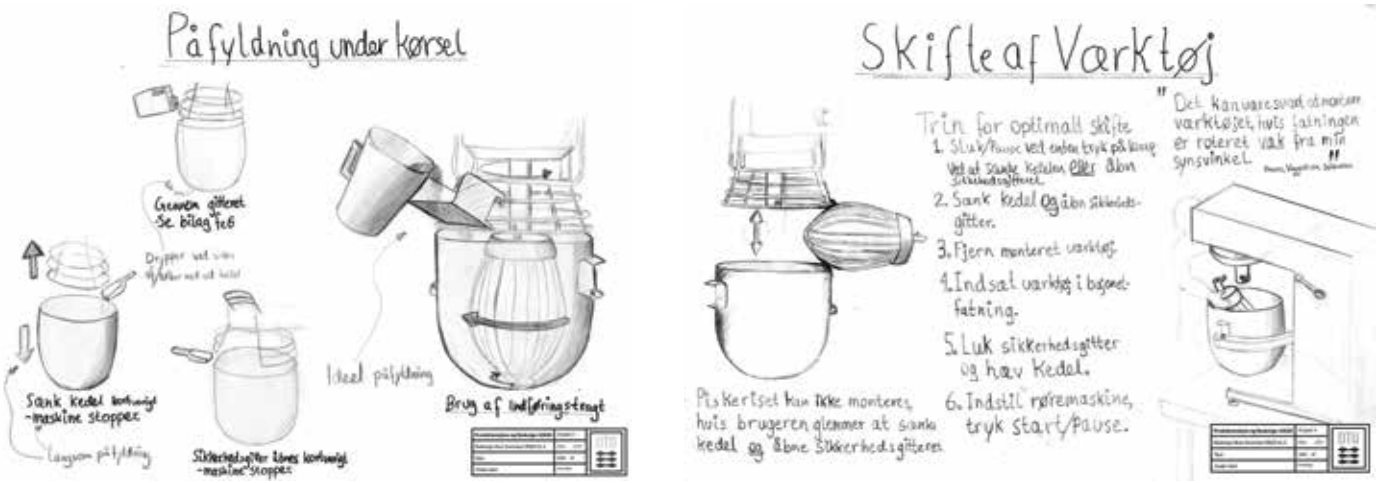
"I actually also wanted to show that some people lower it down in order to pour ingredients into the bowl," Simon explains while showing the movements with his hands. Oscar gives the floor to Emma. She has an idea that it would be interesting to list how many steps are actually involved when filling the mixer: "You have to turn it off, lower the bowl, flip up the grate... there are quite a lot of steps – and then you have to put it all back again!" Oscar readily agrees with Emma's suggestion and adds: "So you could list the steps underneath the drawing." Caroline's hand is now stretched in the air again, so she is given room to present her idea that they try to link more to each other's worksheets: "If you do the list of steps, then it is actually an extension of the steps that are listed on this sheet." She points to a colourful worksheet that Emma has been working on, which goes through the process of using the machine. "It would be really nice if you could see the connection across," she makes clear and Simon continues to write down notes on his post-its.

COLLECTIVE UNDERSTANDING

The team alternates between working individually and collectively – the walkthroughs depicted in this episode are examples of the more structured collective work. Preceding each of these the students have been working individually on one or more worksheets each (who does what is decided at a team meeting). At the walkthroughs they all gather together, focus on one worksheet at a time and then provide their input and comments to what they see. At the first walkthrough they appeared to be going through their work in this way mainly because they had been encouraged to do so by their supervisor. It thus feels a lot like the exercise they had done in pairs in Episode 2. But already the second time around they seem to be engaging more seriously in the dialogue – though humour still has a part to play when giving critique.

In this episode I have focussed on just one of the many worksheets that the team went through (approximately 10 the first time and 15 the second time) in order to give a sense of the progress that is continuously being made.

FIGURE 69 | The two worksheets that Simon ended up making after the feedback received from both the team and Daniel: One showing how ingredients are added (right) and one showing how tools are changed (left) (completed version from milestone 1).



A MEANINGFUL WORKSHEET

An important part of these coming design engineers' practice is to be able to compile what they have experienced and been told during their fieldwork and link this to the concrete design object they are working with. Already in Episode 1 Tom warned them that fieldwork and analysis will be less appreciated outside the educational sphere, so it is important that they learn how to make such efforts valuable and communicable to others. The worksheets promise to facilitate this process in two ways: There is the oral (and bodily) interaction we witness in this episode where the students are exchanging what each of them have experienced and reflected on, and then there is the act of pinning this down to a piece of paper, which is able to communicate 'in absentia'.

We see how all the members of the team are negotiating how different points from their research should be communicated. In this negotiation process they are also all brought up to speed on the thoughts and ideas that the others are nurturing as part of what they have been working on. But it is also quite symptomatic that none of them have the 'right' answer or really knows what does or does not work. They are all simply drawing on their own ideas of what a worksheet should include or portray in order to 'work'. Some have an inclination towards drawings, some towards text, and some (actually most of them) like the diagrammatic illustrations.

MATERIAL INTERACTION

The anonymous stretch of wall obviously has a part to play in these walk-throughs. It helps the team create a space that facilitates the situation of providing feedback. Instead of sitting around a table where someone will have to look at the worksheets either upside down or sideways, the wall provides an 'equal viewing' for all of them and makes it possible to view all of the large worksheets at the same time. Being on their feet for the walkthrough also enables them to move around more dynamically – thus 'zooming in on' (moving closer to) a single worksheet or 'zooming out' (moving away) to see for example links to other sheets. A process not unlike what we saw in relation to the UX team's journey wall.

Through the exchange of insights and dialogue that the wall facilitates the students are thus gradually building, adapting and expanding a collective understanding of their product and its use (and the problematic issues linked to this).

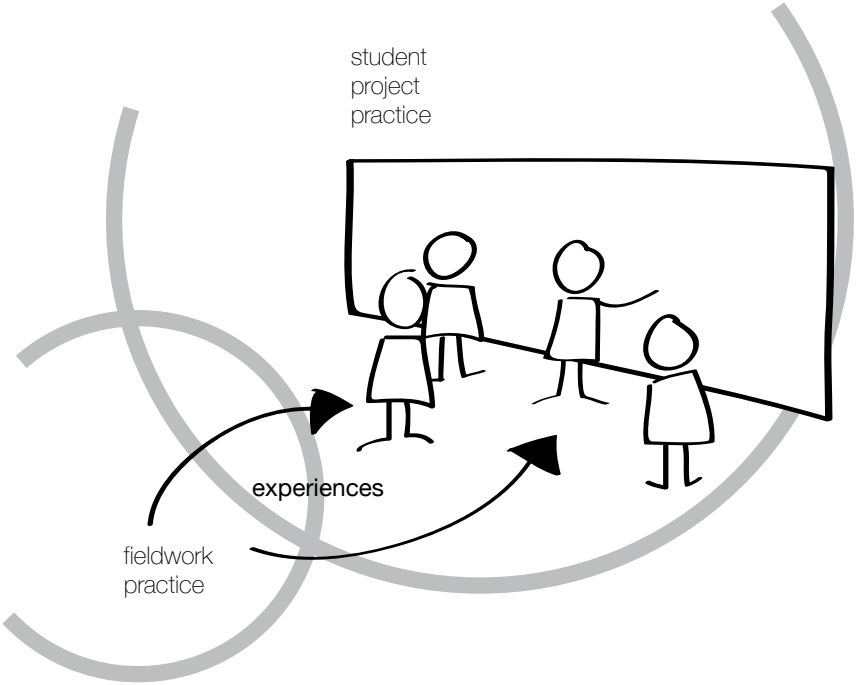


FIGURE 70 | The students bring individual experiences from the fieldwork into the discussions by the wall.

EPISODE 7 | working together

5 weeks have now passed since the team started working on the project. The cluster of tables they are occupying is covered in sheets of paper, binders, backpacks, markers, coffee cups, water bottles, pastry, pencil-cases – and of course laptops. All 10 members of the team are busy at work, some working on their laptops and others drawing on one of the large sheets of paper.

Caroline is also sitting with her laptop open in front of her. She has started on a new document where she is slowly listing the problematic areas that they have come across in their fieldwork. For the approaching milestone they are expected to identify 3 focus areas that could each on their own point to possible improvements in the redesign of the mixer. Brian sitting next to her on one side and Henry on the other side participates on and off in her brainstorming process while they also work on some drawings for their work-sheets.

"What did you write about accessories?" Brian asks. "Just something about water supply – the bakers really wanted this when we visited them,"

FIGURE 71 | Caroline by her laptop at the table cluster.

Caroline replies and Brian muses: "There's actually not that much difference between the individual machines." They discuss how all of the mixers in the company's portfolio are supplied with the same type of accessories and basically only the size varies. "What about the spatula – that it isn't part of the standard equipment?" Henry asks, but he does not receive a reply. "Now I've written: "specialisation of machine for the user"," Caroline sums up reading from her list on the screen.

Oscar, sitting across the table, now jumps into their discussion and it takes a turn to focus on the materials used. They are concerned about the weight of the machine and are wondering why most of the parts are made in metal of various kinds. It seems some of them have previously discussed converting some of the main parts into plastic. Henry looks doubtful at the thought of this, "I don't think they would like that." "But we can do whatever – that's what is so cool about going to school!" Caroline says encouragingly. "We could really try and challenge the materials they use," Brian joins in. Henry does not look encouraged though. "You're not very keen on that?" Caroline remarks, "But that's exactly what we as engineers should challenge; to say that there's an entire bridge in Britain made out of plastic, so of course we can make this mixer out of plastic!" Simon then quietly chips in: "Then you probably shouldn't call it "plastic"." But Caroline simply replies: "Then we just call it "polymer"." In the end Caroline makes a note on her list stating: "design expression (plastic…) push the design expression."

People jump in out of this discussion and at times Caroline is left looking at her computer screen on her own. After a while she consults the table again if they have some input for the focus areas. Oscar is not working on anything in particular right now, so he asks what it is she is looking for. Brian explains: "Right now it's just name-dropping stuff. That is, problematic things that we've come across in the fieldwork." Henry, Elliot and Oscar then start naming different things off the top of their heads: "We have that one," Brian says to all of them.

After working on the list in silence for a while Oscar asks Caroline to read out what she already has on her list. "There is accessories; fixation of the kettle; hygiene and cleaning; then there's ergonomics in relation to the kettle and generally the mobility of the mixer; the control panel; regulation of speed; there's storing the tools; the overall design; the handles; there's the thing that the whip tends to spurt; and then there's pouring from the kettle or just getting things out of it," she reads from her screen, "This is as far as we are." "Seems like you've covered it pretty well," Oscar remarks and appears to be thinking if he has anything else to add. "A lot of them can actually be put under the same label," Caroline points out, "we just need to come up with some good 'umbrella' words." She elaborates that if they collect the problematic issues they have uncovered under broad labels such as "equipment" or "safety-grate" this will give them more freedom in the next part of the project because there will be more than one problem under each of them.

"What about indication of user-interfaces? They could for example be black," Oscar then suggests looking at Caroline. "Now you're doing the actual redesign – we are only to *analyse* the problems right now," Brian interjects from the side-line. "So the focus area could be "user-interfaces"," Oscar insists. Caroline adds "indication of user-interfaces" to the list while the rest of the team grows silent. After a while Brian exclaims: "I think I'm stuck on this. Don't really know how we are to progress from here." So they seem to leave it at that for now.

A bit later, though, Caroline spots one of the supervisors in the room and she goes to ask him how they might proceed. When she returns to the table she proclaims that the supervisor had suggested writing down all the problem areas on post-its and then start grouping them. The team has dispersed: Some are busy scanning worksheets in another room, some having gone to buy supplies, so there are hardly any left to listen to her. But Caroline still locates a post-it pad and goes to work on this straight away on her own. She pushes her laptop away to clear a corner of the table where she is able to place the post-its and thus start making some groups of related problem areas. When I leave them she is still working on this.

A TEAM EFFORT

In this episode we see a strong example of the team efforts that dominates the way of working on the student project. Even though the individual team members are working on their own assignments they are still engaged in an on-going dialogue across the table, thus pulling them into each other's work.

Identifying the different problem areas that the team could focus on in the remaining part of the project is essentially a collective task. It requires that all of their experiences from the fieldwork, their work to understand the machine's functional components, their research on production methods etc. is brought together and somehow distilled into some manageable focus areas. But at this point the students have already learned that they have to distribute the different tasks amongst them in order to meet the deadlines. Given the amount of work still needing to be done on other parts of the first milestone report, Caroline has thus taken it upon herself to make an initial list of possible problem areas. In this episode she is thus the only one working focussed on this task, keeping the brainstorming process going on and off while the others move back and forth between this brainstorm and their own individual tasks.

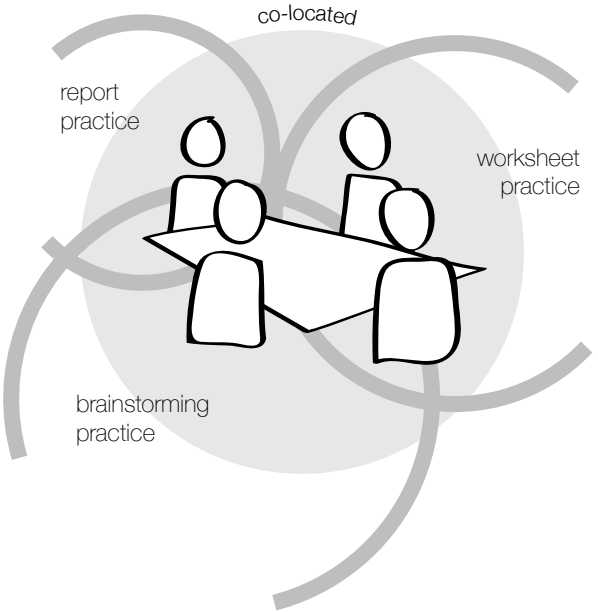


FIGURE 72 | Practices overlap around the table cluster.

IDENTITY

From the dialogue in this episode we get a small glimpse of the identity work that continuously goes on here in the educational sphere. These students are still on their first year and are thus still adapting to being just that: Students at an engineering university. Through their mutual interaction within the studio, but also with their families and friends outside the university, they are 'testing' what it means to be a student, what kinds of privileges this assumes and what kinds of requirements. Caroline here openly expresses her idea of being a student: That you have the freedom to move in whatever direction you like in a student project (not restrained by for example economy or marketing demands as a professional would be). Here it is acceptable (sometimes even encouraged) to disregard the 'client's' wishes and instead charter into new areas.

At the same time, there is also identity work related to being an engineer going on. Again Caroline is straightforward: Being an engineer implies pushing the boundaries of what seems possible and challenging traditional ideas of for example which materials to use. I am only able to guess at how she has constructed this image of an engineering identity, but in a situation like this we see how it feeds into a discussion and thus enters some on-going negotiation amongst the students. For now, none of the others seem able to come up with a better characteristic of engineering work – apart from the fact that the term "plastic" should maybe not be part of an engineer's professional vocabulary.

SEMANTICS

Language, formulation, and categorisation thus play a large role in the students' work. It is not enough that they have observed things in the field; they also have to capture this in words. And these words need to be able to delimit and specify while at the same time keeping their options sufficiently open in the following design work. This might appear trivial, but playing with words in this way also holds importance for how the team as a collective views the problematics and the opportunities they hold.

Henry is having difficulties arguing for his concerns about shifting to polymers instead of metals. He senses that a 'plastic mixer' would not be something that the company would find satisficing – which does not seem unreasonable based on the portfolio of products and the visual identity of these along with their image of being "strong as a bear". But being unable

to voice anything but hesitation he is overruled in the dialogue. Contrarily, Oscar is able to come up with a seemingly acceptable term for his idea concerning the user interface, which ensures it a spot on the short list of problematic areas. It all happens very fast and without much deliberation.

This work can be compared to the UX team's efforts to identify pains and design opportunities on the journey. At the milestone presentation the students also need to demonstrate that they have found areas that makes it worthwhile pursuing a redesign of the mixer and the supervisors must be able to see the design potential – that is, that the students have enough to work with for the rest of the project and that they have the prerequisites to do so. To some respect the milestone presentation is thus comparable to the UX team's journey video at the coming gate – of course with the difference that the UX team is not guaranteed a continuation of their project and that their work is being assed based on different kinds of criteria (especially economic).

Next, we shall move on to hear how the milestone presentation proceeded.

SKETCH 3 | presentation mode

As I arrive today the mood is a bit different amongst the students. Today is the time for milestone 1 and I am here to observe the two final teams of the day give their presentations. I am stuck waiting in the small hallway outside the studios while the previous teams finish up. The other team that will be presenting at the same 'slot' as team 3 is arriving at the same time as me. While we are waiting they talk to three girls from one of the first teams to present that day about the presentation. After asking how their presentation went and why they seem to be a bit down, they start inquiring about what kinds of questions the supervisors are asking and what you should say. The girls explain that the supervisors are apparently calling a lot of attention to the use of references, so their advice is to include their sources in the presentation. Also the process of splitting the teams in two gets some attention. The girls explain that they will draw lots with some small pieces of paper that Tom has prepared.

A bit later than scheduled you can see through the tall window next to the door that the team that had been standing at the front of the room, close to the window, is now leaving this position and collecting their things. The waiting students construe this to be the signal that it is now okay to enter the

room and starting to setup up for their own presentation. We thus move into the room as the members of team 3 are also arriving.

Even though it is now only about half of the students that are present in the room the amount of conversations going on seem to be more significant than usual. The mood is both a bit tense, but also excited: To me it feels obvious that this is a day that marks a change for the students, though they are not quite sure what to expect of it.

The room itself is also slightly different from last time I was here: The tables have been lined up in rows again and all the chairs are facing the front of the room. The three supervisors are sitting at the front row with a pile of reports placed in front of them.

The members of team 3 distribute themselves comfortably on the two rows in the middle of the room. They have already retrieved their selection of worksheets from the wall section at the back of the room and are now sitting with one or two each on the table in front of them. The first team, on the other hand, starts putting up their selection of worksheets on one of the blackboards and when all 12 sheets are in place the team members gather to one side of the blackboard, waiting for a cue to start. When Tom re-enters the room with a fresh cup of coffee one of the girls on the team asks: "Are we ready now?" "I'm ready," Tom replies as he sits down, "you can just start when *you* are ready." The entire team then takes their position around the blackboard: Half to one side, the other half to the other side and one steps into the middle beginning the presentation.

FIGURE 73 | Milestone presentation centred around the blackboard.

CENTRE STAGE

Presentations are a reoccurring event at the D&I program. Most of the semester projects that the students will go through include at least one milestone presentation in addition to the final presentation and examination. At those occasions the studio room is adapted for this new situation: The tables are rearranged, some of the worst paper piles etc. are removed and sometimes external people, such as company representatives or an external censor is invited into the room.

Attention is pointed towards the blackboards at the front of the room. This large space enables all of the members of the large teams to participate – at least symbolically – during the entire presentation. This means that even though only one person is speaking at a time, then the rest of the team is still standing by the blackboard, looking at the presenter or the audience, listening to what is said – and at times jumping in to add something. Everybody presents their part of the presentation in this way – at this milestone they were typically each assigned one or two worksheets to present.

In the next episode we will here how this presentation proceeded for team 3.

EPISODE 8 | milestone presentation

While the supervisors take a small break in-between the two presentations, team 3 get up from their seats and start hanging the worksheets they have chosen to present on the blackboard. All ten of them are gathered in front of the blackboard as they make some last minute coordination before starting the presentation.

Once the three supervisors have returned to their seats on the front row and the other team behind them, team 3 take their positions to start the presentation: Half are standing to one side of the blackboard and the other half to the other side. Brian steps out into the centre as he starts bidding welcome: "Hi. We're team 3 and we are working on a redesign of a professional mixer. My name is Brian," he finishes and looks to Sarah indicating that they should take a round of introduction. Brian then finds a place next to the blackboard in order to be able to point to the first worksheet and start his introduction of the mixer they have been assigned. The other team members are standing quietly listening in a semi circle on either side of the blackboard.

FIGURE 74 | Using the worksheets to present insights from the fieldwork.

Once Brian has finished his walkthrough of the first two worksheets Emma is quick to jump in and continue with the next. Brian withdraws to the back as he skims through the notes he had prepared on a small note pad. Emma explains about the visual identity of the product, referring to both the company logo and some of the "lines" on the product, which they had been told about at their company visit. She points to the worksheet that Sarah has been preparing (showing a 3D marker drawing of the mixer with callouts indicating the names of the different parts of the machine) to explain how the machine has been designed to indicate "strength". She takes half a step back, turning to Oscar standing next to her, and he quickly takes over to present the next worksheet.

Meanwhile the three supervisors are sitting reclined in their chairs, listening to the student's presentation. Tom makes some notes now and again. For some of the more detailed worksheets they are flipping through the folders containing the students' report and all of their worksheets in order to see the worksheets up close.

Caroline presents some of the fieldwork they have been doing: "We have been to one of the supermarkets' baker's shops here in town, where we actually saw many of the issues the company had told us about." She point to the pictures on the worksheet and gestures with her hands to illustrate some of the problematic situations. "They believe that this thing about heavy lifting, that's just a problem we designers are creating: "They're strong men so that's no problem!"" She makes a slightly exaggerated caricature as she says

this to underline her point. When Sarah takes the floor she continues the talk of ergonomics with the help of official guidelines from the working environment authority: "If we look at the kettle for our machine – which can carry up to 20 kg – then you're actually only allowed to carry around 7 kg like this." She shows the posture of holding the kettle and puts on a serious expression before handing the floor over to Elliot. He recaps the problematics they have observed at another field visit, which seem to be symptomatic for all 10 places they have been: There were some difficulties around handling the kettle, difficulties cleaning the machine, and then problems filling ingredients into the machine during operation. "You can pour through the protective grate – which practically everyone does – but the small chute designed to facilitate this does not prevent flour and that sort of thing from falling over the sides and onto the floor."

Moving on, Leo presents the worksheet that Simon has been working on to illustrate how the tools are changed. From this point of view he also backs up Elliot's point: "It's simply no good if you have to stop the machine and lower the kettle every time you have to add more ingredients – it takes up way too much time!"

Towards the end of the presentation Elliot takes the floor again, looking at the paper pad he has brought, and starts to sum up the focus areas they have identified. He explains that they have grouped the problematic issues that they have observed in their fieldwork into four different focus areas, which could make up the focus for the remaining part of the project: *The mixer's problematics*, *Safety*, *Optimisation of accessories*, and *Hygiene*. Thus concluding the presentation the other team gives a short round of applause before the supervisors take turns asking questions. "Where is "the bear"?" Tom asks for example, "Where does the robustness reside?" In their answers the students continue to give reference to the things they have seen and heard in the fieldwork, supplementing each other in their arguments. Tom also remarks that especially the focus area called "the mixer's problematics" is a bit unspecific and does not offer them much help in guiding their onward process.

Finally it is time to split up the team into two smaller teams. One after one they draw a piece of paper, placing them either in a group to the right (from now on team 3a) or to the left (team 3b). Since this concludes the official program for the day they start packing up, but the new team 3a lingers a bit: They have already started discussing their personal preferences regarding which of the four focus areas they would like to work with. Within a week they will have to make a final decision and submit a problem statement to their supervisor for approval before the final stage of the project begins. They all seem eager to start this "design" part and are already think-

ing about possible solutions when they discuss the different problems once more amongst them.

A LEARNING PRESENTATION

The first 6 weeks of the semester, leading up to milestone 1, have been focussed on researching and analysing, that is, getting to know the assigned product in detail (taking it apart, finding out how it works, how it is made etc.) and how the product is used (visiting users, making observations and doing interviews). Leading up to the milestone presentation the teams have handed in a short 5-page report summing up their process and accompanied by 30 worksheets focussing on *manufacturing*, *use*, and *technical function* respectively. Each of the three supervisors has had a chance to look through these reports before the presentations taking place on this day. Instead of making a power point presentation as they would normally do, the students have been asked to select the most central worksheets from their report and do a 15 minute presentation based on these.

PRESENTATION CHOREOGRAPHY

Having observed the two teams during their presentations (and also with my own personal experience of presenting and listening to other teams present during my time at D&I) it seems clear to me that you might speak of a shared practice across the teams regarding how you do a presentation and how you act during the presentation itself and the following round of questions and feedback.

The milestone presentation is an interim culmination of the students' work. It is a chance to show the educators what they have achieved and discuss the difficulties they have encountered. But it is also a chance for the team as a group to take stock and show each other that something is beginning to emerge from their explorative work. Even though it is kept in an informal setting it is thus an important milestone for the students and they have invested a lot of collective time in preparing for it.

During their presentation we see something that can be described as a choreographed 'dance' of bodily doings including taking different positions on the 'stage' (in front of the blackboard) at different times. Everyone performs, even though they are not the ones performing their lines: Standing to the side, appearing attentive and interested in what is being

FIGURE 75 | Choreography in front of the blackboard.

said is also an important part of the choreography. For the lead character taking centre stage, the choreography becomes more elaborate, including pointing to the worksheet-props on the blackboard and making gestures to re-enact doings that have been observed during their fieldwork. The students also use visual cues when handing over the stage, such as forming eye contact with their fellow performer, nodding, and stepping towards the background of the stage.

PRACTISING A LANGUAGE

These doings are part of a practice of presenting that the students already seem relatively well-versed in on this, their second semester. But the doings are naturally linked to sayings. Though this presentation is not explicitly formal and the individual students still to a great extend bring their own way of talking into the presentation, then I believe it is possible to discern a semantic space in this episode, which is different from the one they occupy during their daily interaction in the team. In a presentation such as this an extra effort is put into using the language that has been introduced through lectures, exercises, and reading material (such as "visual identity"

and "problematics2), the arguments have been rehearsed in advance, and the number of sentences are generally economised (also to comply with the time limit). This 'design language' that the students are adapting gives them words to talk of the things they experience and notice in their work – but it also leads them to pay more attention to certain things.

The students hear and see each other present at several occasions similar to this during their education and they also interact and talk together in-between those episodes as we saw in Sketch 3. As a result, they collectively build experience and a repertoire of 'what works' or how it 'makes sense' to go about a presentation. In interaction with each other and the educators they also negotiate the *sets of rules* that govern these presentations and ways of adhering to them (such as giving everyone room to speak, keeping within the timeframe, and being ready on time).

EPISODE 9 | interacting with the machine

As I arrive this morning most of the students have already arrived and are taking their seats around the table clusters. 3 weeks have passed since milestone 1 and all of the teams have now had their revised problem statements approved at milestone 2. Sarah has placed herself by a cluster at the back of the room with her laptop in front of her. As Leo arrives he asks: "Am I way too early?" hinting at the empty seats around the table. Apparently he is not, but the other team-members will not be joining them today (two are on holiday and one is home sick). "That's just perfect when we're in the idea-generating stage!" Sarah remarks, "– but then it'll just be the two of us deciding."

Their plan for today had been to start brainstorming on solutions. "It's just ridiculous when you're only two people, right?" Sarah keeps complaining and looks to some of the neighbouring teams that are busy at work in front of a board with drawings and post-its. Instead Leo states: "I could do with taking another look at the machine." So they agree to go to the workshop instead.

In the workshop all of the different products for this project course are stored, but Sarah and Leo move straight to the worktable where the mixer is standing. Focusing on the kettle, Sarah grabs the handle on the side of the mixer to free it from the machine. As she stands with the kettle held in both hands she pauses and remarks: "Like that woman said, you have your fingers inside the bowl," looking at the placement of her thumbs over the rim of the kettle. "Right – you wouldn't just grab these," Leo replies and points to the square handles protruding on either side. Sarah continues to place the large

FIGURE 76 | Another team arranging their brainstorming ideas.

kettle on the workshop table, trying out different movements to simulate pouring its contents out on the table. "This is where some think it would be a good idea to have something on the side of the kettle to help you," Leo remembers and tries to illustrate it with his hands.

The kettle already has a small protruding knob at the 'back', which is used to fixate it to the machine, so Sarah and Leo discuss if you might somehow be able to combine these things: Fixating the kettle to the machine and providing a good grip when pouring from the kettle. Sarah grabs the post-it pad and pen she has brought and notes down a few key words to remember this idea. Meanwhile, Leo has already moved on: "I've been thinking," he says as he puts the kettle back in the machine, "that you could maybe have the screen extend a bit down into the kettle." He uses his hands to show what he means. "This way you could use the space in between to add ingredients." With his left hand mimicking the side of the kettle, his right hand shows how you could pour ingredients down the sloping screen (which is now a grate).

"Maybe it could be the side of the kettle that just extended up a bit at the front, and then you could also use that when pouring out of the kettle. I just don't know if it would be expensive to produce, because it's quite simple as it is now." Sarah nods her head: "I think it would be expensive to make." "Maybe Tom can help us figure out how much more expensive it might be. I just think it could be a way to solve the issue of adding ingredients." Sarah is already making another note with this idea.

FIGURE 77 | Interacting with the kettle while coming up with new ideas.

"My idea is actually to stick with the new plastic screen they have designed," Leo clarifies, "They seem pretty fond of that – they've just redesigned it, though I know perhaps we shouldn't focus too much on that." Sarah just stands by as Leo goes through his idea again: "I think their screen is placed like this grate, but then there's this indent that you can pour through," "It was just a really small indent," Sarah recalls. "Right – but if you made this extended rim on the kettle, then it would be easier to pour – we also have a lot from our fieldwork where there is flour all around the machine." Sarah agrees – that had been a reoccurring issue. "Alternatively you could make a new chute that is a lot better than the one they have," Sarah suggests. Leo points out that the spacing of the grate poses a limit to how much bigger you would be able to make such a chute or funnel. "But you could make the top of it much bigger," Sarah suggests and indicates how this would work with her hands. "But it should work with a plastic screen," Leo maintains and points out that at one of the field visits he has been on they had a machine with a funnel integrated in a plastic screen: "But they never used it because it was too hard to clean because it didn't fit in the dishwasher."

They continue going back and forth with different ideas to different issues while interacting with the machine and writing down a few post-it notes along the way. As they return to the studio Leo says: "I'm really happy we did this."

TO THE WORKSHOP

This episode turned out to be all I get to experience of the team's idea generating process. While it may not be symptomatic of the way this process would take place if the entire team had been present, then it may still show us some traces of the elements that come together in such creative practices.

It is about 3 weeks after the team was split up in two and a week after they have decided on a focus area and problem statement. The following week is the Easter holiday, so most of the teams seem to put in a sprint before letting the project rest (more or less) for a week. Leo and Sarah have inadvertently ended up alone on this day, which leaves them at a bit of a limbo at first: The creative techniques they have practiced during the lectures were all intended for a team effort (such as different brainstorming techniques). Instead they come up with a different approach, which involves going back to the mixer in the workshop – something that would have been harder to do in a large team.

MATERIAL INTERACTION

Given the special circumstances on this day Sarah and Leo are not able to comply with the maxims they have been given about how to generate ideas (for example using brainstorming techniques involving inspirational pictures). Instead they have a shared feeling that it makes sense to return to the physical object of their design efforts and let it help them proceed.

Confronted with the physical mixer and handling its parts themselves, they are reminded of issues that they have encountered during their fieldwork and heard from the professional users of the mixer. The physical machine thus accepts to take an active part in their idea generation, pushing them to ask questions and explore new options. Though it may not push them to great innovative leaps it instead helps them 'model' some of their ideas by using gestures and dialogue and thus 'test' how these ideas might relate to the rest of the machine.

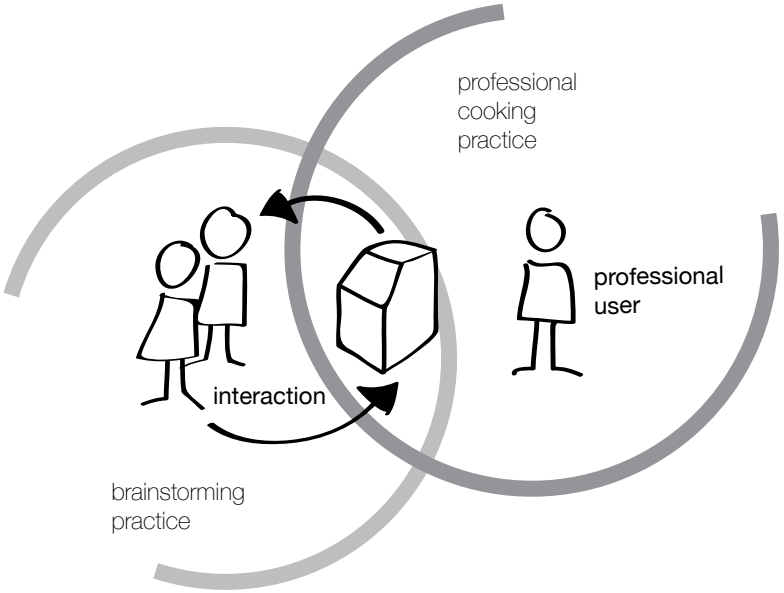


FIGURE 78 | Idea generating practice including the physical machine.

EPISODE 10 | discussing with drawings

This morning the students are already sitting around clusters of tables in groups of 5. Conversations are going on all around the room, but they are not about plans for the weekend, the football match last night or any such thing – everyone seem a bit more tuned in to the work at hand than usual. It is the day before the final project report is due and team 3a is sitting in the same corner of the room they have occupied most of the semester. All 5 of them are there, sitting with each their laptop open in front of them. They start out by distributing the work that needs to be done: They agree that they would like to try and complete and print all of the worksheets today.

Most of them seem to already have something on their computer screens craving their attention, but Emma states that she actually does not have anything to do right now. "We still have some technical drawings that need to be done," Sarah points out, "of the funnel for example." "That could be in scale 1:1," Thea confirms while she is opening an InDesign file of their worksheet template on her laptop. "I can do that," Emma says, " – but the funnel that's the part I haven't really worked with before, so I'll have to acquaint myself with it." None of the others seem to think this is much of a problem. Leo has put on his headphones and seems submerged into what takes place on his

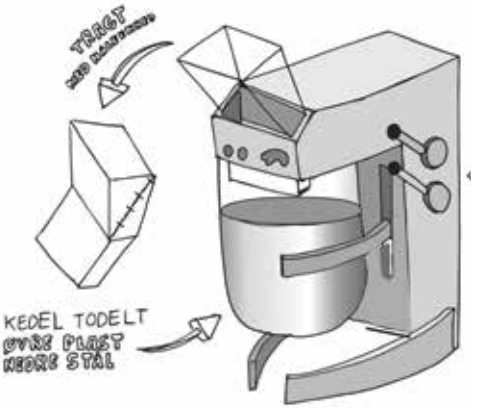


FIGURE 79 | Morning gathering in team 3a.

FIGURE 80 | Early concept drawing of the funnel placed through the top of the mixer (from the final report).

computer screen and Elliot is also pulling out a small set of headphones from his bag. "You can talk to Elliot about the measurements," Sarah suggests.

I have placed myself by the table propped against the wall section still displaying some of their worksheets. On the table you find a large, seemingly disorganized pile of worksheets. As I browse through a few of these, I learn that "the funnel" is part of their redesigned solution for the mixer. They have come up with a way to integrate this funnel in the machine in a completely new way from the original design.

After fiddling with her laptop for a short while, moving some files around on their Google Drive, Emma asks: "Isn't it just the outer measurements that need to go on that technical drawing?" "Sure," Elliot ensures her. Then she starts putting her laptop away and places a pile of A3 papers in front of her instead. She glances at Elliot's notebook lying in the middle of the table. It contains some simple sketches of the machine with indications of some of the measurements. Then she starts making her own rough sketch and indicating different measurements on this.

Apparently Elliot has used his notes when he created a SketchUp model of their concept. Emma now consults him to provide her with some measurements that she seems to be missing. He pulls up the SketchUp model on his laptop and they move to a vacant spot by another table. Thus sitting next to Elliot with his laptop Emma asks for different measurements as she continues working on her rough sketch. Elliot uses a measurement tool build in to the program to extract the numbers that Emma is requesting. It sounds

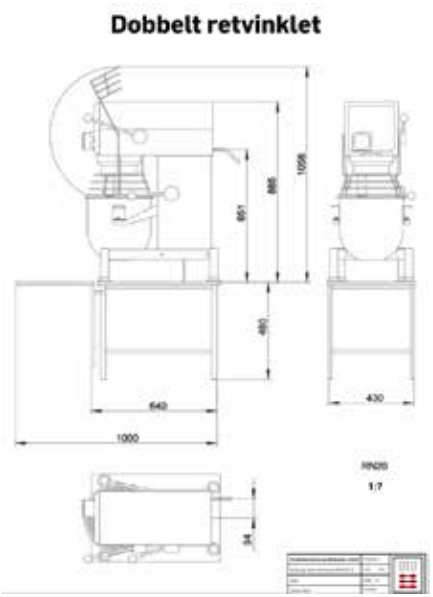


FIGURE 81 | Collecting measurement information from different sources.

FIGURE 82 | Previous workshet with drawing in orthographic view (from milestone 1).

like not all of these dimensions are the result of a conscious choice, but have emerged as Elliot was building the model.

As he measures the radius on top of the machine and the placement of the insert hole for the funnel, Elliot suggests: "We could move this closer to the edge of the machine – there is 2 cm now. Why is it that we haven't moved it closer to the edge?" "I don't know," Emma replies, "– but we are *not* changing it now!"

With her rough sketch complete with the measurements she wanted, Emma then returns to her seat by the table cluster. But she does not start drawing right away. Instead she gets her laptop out again and retrieves one of their previous worksheets: "Was this approved as a technical drawing??" she asks no one in particular. Elliot, who has also returned to his seat by the table, seems to know what she is referring to, so he answers: "Isn't it an orthographic view?" "Yes, but it's not a technical drawing – it's completely random which measurements are indicated!" Emma protests. Elliot hesitates for a moment and then argues that this is how they found the drawing on the company website. "Sure, but there are no hidden lines and that sort of thing, it's just a sketch with measurements," Emma insists. After musing about this for a while longer she pushes the laptop away and starts focusing on the blank sheet of paper in front of her.

Emma sits with her ruler and pencil and the rough sketch and then starts making the technical drawing of the cabinet for the mixer. She has a calculator open on her laptop, which she uses to plot in some of the measurements she has noted down and try out different scaling options. With her ruler she tests if the result will fit onto the paper, and then she tries a different scaling. Once satisfied the drawing will fit she starts making the first lines. As she is drawing, some questions start to arise: "Elliot, is that stick fitted to the middle of this part?" She points to her drawing of the side view, but Elliot seems to already know what she is asking: "Hmm well, you have to consider that it sort of goes into the machine," he explains, referring to the curved backside. "But did you measure the slot for the funnel like we discussed?" She did, but Elliot then muses: "If I had to make a serious worksheet about this, then it might have to move a bit closer to the edge," picking up on his thought earlier concerning the placement of the insert whole.

But this leads them into another discussion concerning the radius of the curved backside behind the kettle. "When the kettle is 31 in diameter then it must be 15,5 – right?" Emma asks, while Elliot gets up from his seat across the table to stand beside Emma instead. He mentions the thickness of the kettle sides, but then realises that it is an outer dimension they are discussing: "Then I have made the kettle too big, I made it 17," referring to the SketchUp model. In their discussion they use Emma's emerging technical drawings to point to and make quick sketches on another piece of paper to illustrate what they mean.

FIGURE 83 | Emma working on the technical drawing.

Elliot also refers to some decisions that were made yesterday concerning the bottom of the mixer, which he apparently did not agree with but just applied to his model. Now, as a result of the radius discussion, Emma and Elliot agree amongst themselves that the bottom of the cabinet should be slightly larger than the kettle radius. With this decision Emma continues her work on the drawing. Meanwhile the rest of the team is still sitting around the same cluster of tables working on each their laptop.

INDIVIDUALLY TOGETHER

In this episode we follow the making of an orthographic technical drawing, which is meant to document (part of) the final design in the project delivery that will be handed in to the supervisors the following day. The students have been introduced to this and other drawing techniques in a course on visual communication at the first semester. Emma is charged with this task simply because she is the one with idle hands at the beginning of the day. However, previously she has also proved to be one of those who are not hesitant to make a drawing.

Once again we see how much it means that the students are sitting together even though focussing on seemingly individual tasks. As was the case in Episode 7 the co-located individual work starts to melt together through the students' interaction. While we only hear from Emma and El-

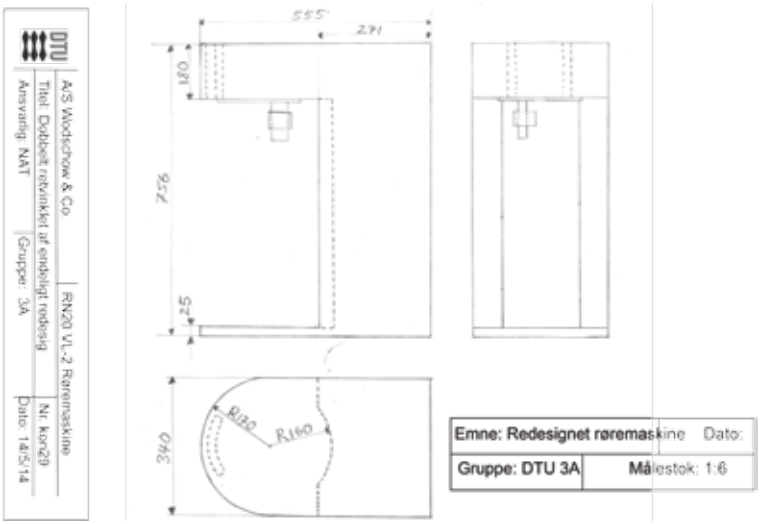


FIGURE 84 | The resulting technical drawing handed in with the final report.

liot then the other team members sitting around the table are also able to quietly keep abreast of the process. They have build a collective ownership around the project and they are doing it 'together' even though one might in practice have to execute the needed documentation on his/her own.

AN OLD TRADITION

The resulting drawing does not look of much per se: Some simple lines connected to each other with indications of measurements around the sides. But such an orthographic technical drawing plays off a long tradition of engineering drawings. In fact, to many people outside engineering or without technical interests, such a drawing makes little sense. Being able to read the details of such a drawing is linked closely to being able to make one: You need to know that it displays three side views of the same object, you need to be able to understand the connections between them by imagining the 3D version of the object, you need to know that the numbers indicate size measured in millimetres, etc. In other words a distinct *pool of understandings* govern this practice.

These types of technical drawings were originally developed to somehow package and carry information from one function to another, typically from the engineer who develops the design to the workman who will be executing the design. For such a process of translation to run as smoothly as possible it requires some fixed conventions used by the engineer to in-scribe information into the drawing and by the workman to de-scribe the information. Most of this work is performed by computer programs today, but earlier a profession of drafters were in charge of ensuring the strict conventions of technical drawings. Drawing by hand they would translate engineering sketches into meticulously accurate representations, which were then handed over to for example the workmen.

So why are these design students charged with making such drawings by hand today? In fact, they had already made a computer model of their design, so what could they possibly gain from such an antiquated tradition of drawing by hand?

A MEDIATING DRAWING

The thing is, that making such a drawing involves much more than the mechanic process of tracing lines after a ruler. The drawing in itself might

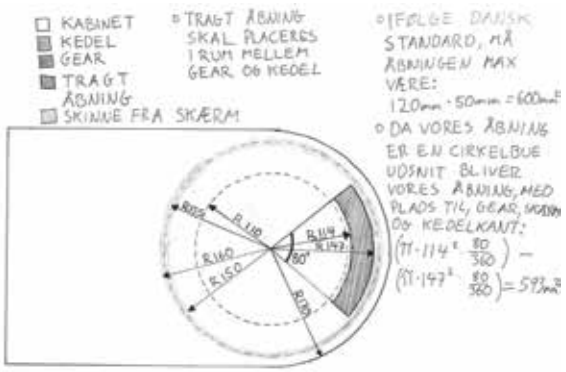


FIGURE 85 | The digital SketchUp model (from final report).

FIGURE 86 | Additional technical drawing of the insert whole (from final report).

just be a documentation of what has been made, but the *process* of making it is what is of real value here. This requires the kind of social interaction we witnessed in the episode above. The dialogue between Emma, Elliot, the SketchUp model, and the different pieces of paper comes to hold great significance for what appears on the resulting drawing.

Elliot draws on the work he has done on the SketchUp model and re-reads from this some of the decisions he has made regarding the dimensions and placements of different parts. It also appears, though, that not all of these choices have been conscious – and so only now, when he has to convey them to Emma, is he made aware of them (for example the placement of the insert whole for the funnel at the top of the machine, which is also depicted in Emma's drawing). In fact, later that same day Emma and Elliot decided that there needed to be another worksheet describing the placement of this insert whole more specifically, so Emma developed another drawing through a similar discussion.

The process of making these technical drawings, with all of the precision and explicitness they demand, thus appear to become part of the detailing process. Confronted with the emerging drawings Emma and Elliot are spurred to ask new questions of their design and unfold new dimensions (quite literally here).

Next, we shall see how the company representative received the results of this work.

EPISODE 11 | company presentation

As I walk down the familiar corridor I remember that I have to find a different room this morning: Today team 3a – along with the other three teams that have been working with the mixer – will do a kind of pre-exam presentation for the company representative that they met at the company visit at the beginning of the semester.

Deducting my way through the numbers on the doors I finally arrive at my destination. Compared to the large studios that the D&I students usually occupy, this room seems compact and dark, though it simply has the dimensions of a traditional classroom on campus. Rows of tables are filing through the room, with a wide gap in the middle. Each individual table is equipped with a computer screen, a keyboard and mouse. Apparently this room is normally used for one of the lessons requiring access to special software licensed by the university.

Five students are standing by the blackboard, looking at a laptop propped open at the front desk. One of them is speaking, though only the four team-members appear to be listening: It seems he is practicing the presentation. Some of the desks at the front of room are occupied by whom I recognise to be one of the other teams who went on the company visit at the beginning of the semester. As I find a seat a bit further down the room, another person enters the room; it is Kurt the company representative. A girl jumps up and bids him welcome, explains to him how they have planned the day and shows him a seat at the front row. The team that has been rehearsing now stops abruptly and quickly pack up their things and find a seat.

At this point team 3a files through the door. They have a portable table with them carrying the mixer that they received from the company, one of them is carrying a big foam model, and two others are carrying a wooden board with two posters attached. They position all of this in front of the blackboards as they greet Kurt, who has now retrieved a pad of paper from his backpack and seems ready to get started.

Team 3a will be the first ones to present, so they stay by the blackboard until they somehow figure out it is time to start. Emma then briefly introduces how they have been working with the project, doing field visits at 10 different types of professional kitchens and building an understanding of how the mixer is used. Then Sarah takes over to introduce some of the problematic areas they have identified during this work – all of which are related to the way the mixer is used. She has placed herself next to the mixer on the portable table and uses the machine to indicate precisely what she means when for example explaining the problems around adding ingredients during use. "You could use this chute to add small amounts, but if it's larger amounts,

then you need to stop the machine," she explains. Then she looks over to the poster to remind herself what the other problems were and continues her walkthrough. At the front row Kurt is nodding his head, seemingly agreeing with the things Sarah is pointing out.

Most of the other students in the room are sitting with their laptops open in front of them, browsing different websites, checking their Facebook, or some third thing. They do not seem too concerned that the first team should have uncovered something in their fieldwork, which they do not already know.

While Sarah steps back, Leo comes to the front in order to present the focus area that they have chosen to work with: "Originally we wanted to redesign the machine to reduce the operation time, because we had found out that time was quite important," he recounts. "But after another round of field visits we have discovered that it is actually quite effective the way it is," he then admits. "After timing it we could see that it is very little time that the user spends actually operating the machine right now." Instead the team reformulated their focus to be on simplifying the steps involved in operating the machine. Kurt grunts approvingly.

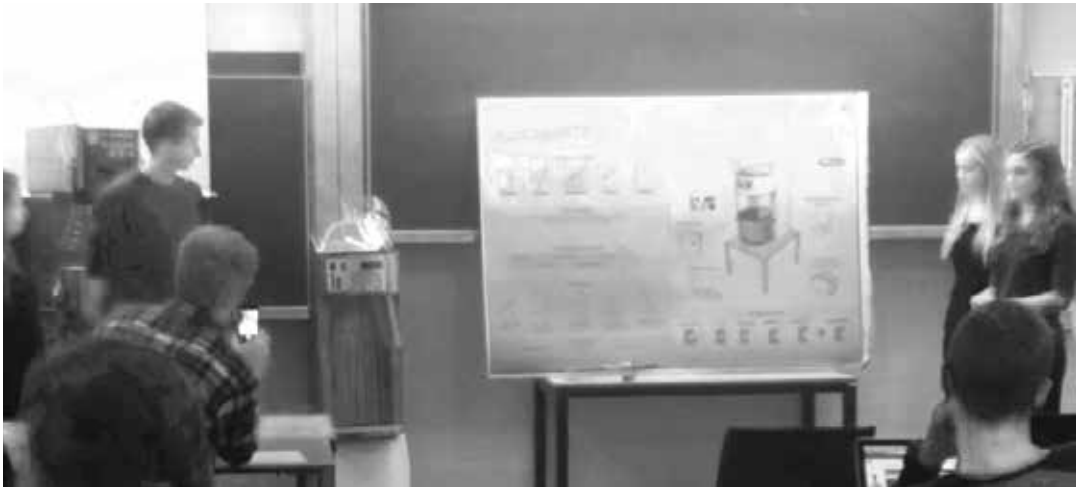
As an exemplification Leo moves to the machine and shows all the steps that are now involved in adding ingredients to the kettle: Stopping the machine, opening the grate, lowering the kettle, adding the ingredients, raising the kettle, returning the safety grate, and finally starting the mixer again. This spurs Kurt to ask in what types of situations people use this procedure, so Leo specifies that it is mostly when adding additional ingredients to the mix. Elliot adds to Leo's elaboration, that they had in fact observed places where the safety grate had been short-circuited making it possible to have the machine running with the grate up and thus enabling the addition of ingredients much more conveniently – even if illegally and at your own peril. Standing next to the machine Emma also inserts that even though the machine is turned off and the kettle lowered, then a bowl with the extra ingredients would collide with the mixer head, making it hard to pour in the last contents. "So you have to sort of throw in the last bits," she explains as she demonstrates with her hands, which brings out the humour in the situation and receives laughter from the other students in the audience.

Continuing the presentation Elliot quickly introduces the way they have been working with the creative part of the process: Using different techniques, brainstorming etc. "to explore the solution space – we had about 150 partial solutions" and then going through a process to sort through the generated ideas. "We arrived at 5 concepts, which were different ways of solving our problem." He moves from the machine and to the poster in order to direct Kurt's attention to the bottom row of sketches, which illustrate one

concept each. "The first one we called "The Simple One" because it consists of minor adjustments compared to the original one," Elliot explains. "It has a plastic screen with a build-in funnel, which is wider at the top than the current one," he forms a funnel with his hands protruding from the safety grate on the original machine. Then he turns to look at the poster again and explains that also the handles on the kettle were altered to facilitate a better grip. After briefly going through the key features and challenges for the other 4 concepts he arrives at their final concept. A 3D hand sketch/marker drawing of this takes up most of the second poster with different features blown up in detail around it. "And this should be a 1:1 mock-up model of it," Elliot says and points to the painted foam model placed in-between the mixer and the posters.

Then it is Thea's turn to take the floor and introduce the first feature of their final solution: The funnel. They have come up with a solution to avoid the trouble when adding ingredients through the grate by incorporating this new type of funnel directly in the head of the machine. "It has an insertion part, which goes into the machine so that the machine doesn't get dirty and you can put the funnel directly in the dishwasher afterwards," she explains while Elliot pulls up the funnel from their mock-up model. "That's quite smart," Kurt exclaims and pulls his phone from his pocket: "Can I take a picture of that?" "Of course," Thea answers a bit surprised while the other students in the room laugh a bit. Then she continues her explanations while Kurt starts taking pictures of the model.

FIGURE 87 | Kurt takes pictures while Thea explains about the new funnel.



Next part of the new design to be introduced is the screen they have designed to replace the safety grate. Sarah explains that they have ensured the view into the kettle from the front with a transparent screen, while the back of the cabinet screens off the rest of the kettle during operation.

When Elliot takes the floor again he starts by showing some of the problematic areas in relation to fixating the kettle to the mixer on the original machine. Their solution is to try and avoid all of the fixation mechanisms: "The idea is simply that you put the kettle here," he moves the original kettle to the mock-up, "and then when you start the machine it will have an induction magnet in the back, which holds the kettle in place as long as the machine is running." Again they receive a small grunt from Kurt. "Of course the trouble is," Elliot continues, "that the kettle is not magnetic as it is – but we have talked to a professor in materials, who has helped us find a suitable material, which is both stainless, magnetic, sensibly priced and facilitates deep drawing." Arguing for their choice of this solution, he points out that it eliminates the need for arms etc. for fixation (which reduces the need for cleaning) and that the kettle is only fixated when the machine is running (which is the only time it is really needed).

But the change in fixation of the kettle also means that the kettle is no longer raised up to the correct position in relation to the tools, meaning that the tools need to be fixated differently. Emma is in charge of explaining this part of the solution, which she does using a simple foam model of the mechanism involved. This makes Kurt take yet another picture with his camera phone. Leo then takes over once more to introduce the last parts of their

FIGURE 88 | Discussion using the mock-up as a reference.

solution, which includes some improved handles on the kettle and a build-in weight in the bottom of the machine.

To conclude on the new benefits their design offers, Emma quickly goes through what would occur during its use: "All in all we have saved a lot of steps: You can add ingredients directly to the kettle in the machine – using the weight in the base – when the machine is running you can easily add more ingredients using the funnel, or you can stop and remove the screen, and when you're done using the machine, then most of the parts are dish-washer proof and the cabinet itself is easy to wipe off."

With the presentation thus wrapped up, the other students give a short round of applause before Kurt starts his feedback: "I think you've come up with some very interesting solutions – I really like the funnel," he says as he gets up from his chair to take a closer look at the mock-up. Apparently the issues linked to adding ingredients are something that Kurt knows to be problematic in their current design. He asks the students to send him their material and drawings and also takes some more pictures of both the poster and mock-up.

Elliot is the one to ask if Kurt might offer them some critique on their ideas? Without going into detail on the individual ideas and concepts, Kurt emphasises his appreciation of the students' fieldwork and how they have been able to quite quickly get a sense of what is at stake. He also notes that they have mastered "the terminology" to talk about these things: "It's easy to hear that you know what goes on out there." They spend another couple

FIGURE 89 | The company representative documents the mock-up model.

of minutes talking about different elements of the students' design using the mock-up model as a physical reference before it is time to hand the floor over to the next team. As team 3a remove their things, Kurt helps himself to another couple of pictures of the mock-up.

COMMUNICATING RESULTS

This final episode takes place just 5 days before the final exam in the project course (which I did not attend) and thus marks the end of the student's efforts. At this point all of the teams have been given the opportunity to return to 'their client', so to speak, and present their suggestion for a redesigned version of the company's product. Tom has arranged the date and booked the room, but the students have been in charge of everything else themselves. This is not a task that the students seem to take lightly, even though it will have no impact on their final grades (none of the educators are attending). All of the teams seem to spend time preparing material for the presentation and rehearsing what to say and how to proceed through the presentation. In fact, we see much of the same choreographed 'dance' as we did for the milestone presentation in Episode 8, but a few other things also seem to stand out.

FIGURE 90 | The other team's presentation setup.

TESTING MEDIA

The students are still exploring and testing what it makes sense to do within this part of the design practice linked to presenting their work. Team 3a had chosen not to use any digital material in their presentation and instead rely on material objects in the form of the original machine, their mock-up of the redesigned machine and mechanism, and the two posters with both drawings and text. The team presenting right after them had made the opposite choice and only prepared a power point presentation – though because the original mixer was still standing by the blackboard they also ended up incorporating this into their presentation.

While the other team had some very nice illustrations in their presentation the projector made it hard to see them and the students struggled to 'interact' with them during their presentation. Team 3a's choice of posters, on the other hand, also had some difficulties relating to the size and distance to the audience – so even though these illustrations were easily visible on the paper they were still hard to see even at the front row. And again the 'interaction' with these drawings seemed somewhat restricted, causing the students to return to the two physical machines time after time.

Watching each other's presentations and thus experiencing the consequences of different kinds of choices the students collectively build experience with how to do a successful presentation for different occasions. At this occasion, for example, it proved very useful for the members of team 3a to have the material objects to interact with, physically showing different movements, and giving a spatial impression of the proposed solutions – and judging by Kurt's eagerness to document what he saw in pictures, this was also inspirational for him to witness (he did not take any pictures during or after the other team's presentation). They configure different material arrangements in their work, which clearly has different impacts on how successfully they are able to communicate their thoughts and ideas.

A PRESENTATION ROADMAP

As indicated there were no formal requirements set up for this particular presentation (as was the case for the milestone presentation and the final presentation), but nonetheless the students' presentations all seemed to follow an implicit roadmap in terms of what to include and in what order to present it. This way of presenting their work is structured by the actual

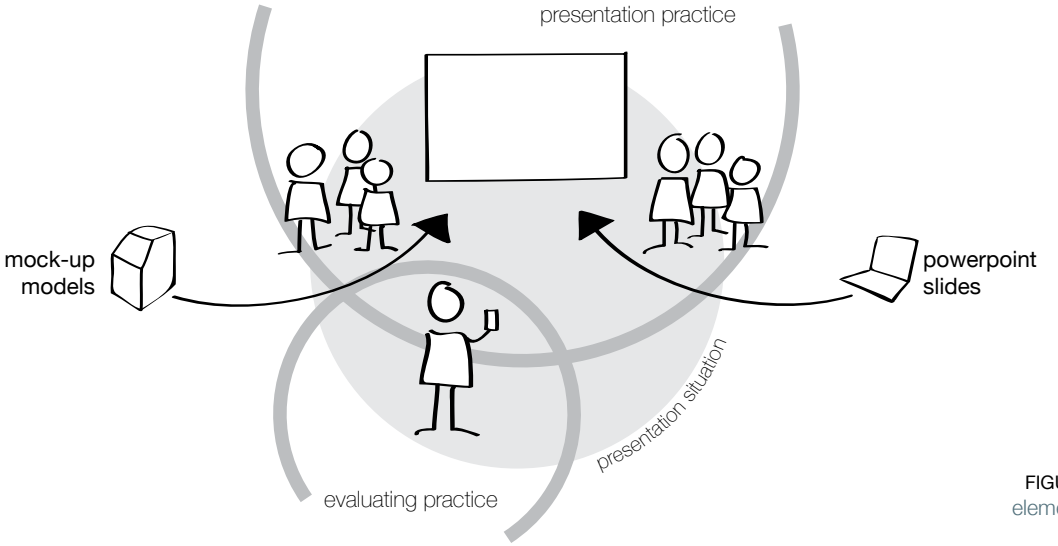


FIGURE 91 | Bringing different elements into the presentation causes differences in the interaction with the company representative.

process they have been through in the project. That is, it starts at 'the beginning' with the fieldwork, the problematics discovered, and the choice of a focus area, then it moves on to the exploration of the solution space, and then choosing and detailing the final concept.

I did not think much about this when I was sitting in the audience, for I have heard numerous presentations just like it before – and partaken in quite a few of them myself. But from the practice perspective this can be seen as an indication that there exist some common *way of presenting* at the D&I program and some shared understanding of how it *makes sense* to structure and focus a presentation. Following this roadmap means emphasising the design process and leaving the final solution to fade somewhat in the background.

Perhaps Kurt is not that interested in hearing about the students' 150 ideas or 4 discarded concepts. And perhaps a professional team of designers would have gone about such a presentation in a different way, focussing first and foremost on the proposed design and then following up with arguments for that design. But for the students this is not first and foremost a sales-pitch, but rather a kind of rehearsal for their final presentation. And they all know that at the exam they will be judged primarily on the way they have been working with the project and the way they are able to argue for their choices along the way.

PRESENTATION MODE

These types of communication episodes are actually quite central to the students' practices. Not only being able to prepare a presentation and execute 'a script', but just as importantly being able to act in the situation with all of the contingencies that this includes: Someone might forget to include a point in their part of the presentation, the audience might start asking questions (or taking pictures) before the presentation is over, the conditions in the room might be different from where you have rehearsed (lighting, distances, acoustics, projector etc.), or simply the words do not flow as you had imagined when preparing. After the presentation itself, there will also typically be a discussion of some sort, which is hard to prepare for. Here the students have to be able to think on their feet, but also figure out a 'code' for taking the floor (so that everyone does not speak at the same time or no one dares to say anything), and a strategy for answering critical questions and receiving feedback.

SUMMING UP

The ambition with this selection of episodes has been to show – even if just a fraction of – the many elements that enters into the doings and sayings occurring as part of students' project work in the educational sphere. The thick descriptions provide a situated perspective on the practices that these students are invited into during their education, which we may not recognise in the everyday.

The students we meet at this site are all first year students at the bachelor level and it therefore comes as no big surprise that they generally do not seem to have access to a particularly extended *pool of understandings*. Even though the individual may appear confident in his or her abilities within a specific field (for example drawing by hand or calculating dimensions) then, as a collective, they are unsure of how to 'go on' in different parts of the design practices they engage in. It is thus clear that their skills and expertise is not as developed as that of the professional designers (as we saw an example of at Site 1).

But the students do portray significant know-how, though this seems more linked to being a student and participating in educational activities than to the doing of design. For example the students know how to place

themselves in the studio for the different kinds of activities that the education incorporates (facing the front for lectures, facing each other for exercises, raising their hands when engaging actively etc.), they know how to follow the instructions that the educator gives them (for example in relation to the exercises), and they know how to engage during a lecture (for example asking clarifying questions or taking notes). The students we meet at this second semester are thus for the most part proficient students who know how to go in the learning practices they are participating in.

While being relatively accomplished students they appear to be seeking the *sets of rules* that permeate the design practices they are aiming to participate in. Through their contact with both Daniel and Tom they try to formulate some more explicit guidelines or rules of thumb to guide their doings in order to fulfil the expectations they meet. But many of these rules also seem to end up relating more to the educational activities and examination than the actual design work. For example they are met with definitions of certain terms they are expected to use and the formats they are working with are clearly defined (for example the worksheet layout and outline of the reports). In their work – especially the written part – the students thus need to relate to these rules and come to some agreement on how closely to follow them. In the very structure of the project course we do, however, also see the expression of some rules and practical understandings relating to how a design process should progress: Starting with an open, analytical part, moving on to an explorative idea-generating part, leading to a more focused conceptual (and eventually detailed) part.

The thing that the students thus seem to struggle the most with during this project work is to place themselves and their work in relation to a goal. Much of their internal dialogue revolves around agreeing on what is acceptable in a certain situation or what it makes sense to do. They are facing an ambiguous ambition: On the one hand a wish to do well in the course and achieve a good grade; on the other hand to do a good redesign of the product, which the company can find useful in their own redesign work. Even though this might on the surface seem compatible, then the students' frustrations also implies a certain divergence, which might imply that there is in fact two different kinds of *teleoaffective structures* at stake in the students' project work.

This leads us to take a closer look at how we might understand the practices we meet at this site in the following Discussion.

DISCUSSION

learning subtantive
practice

On the preceding tour through Site 2 we have experienced some of the episodes that occurred as a generation of engineering design students progressed on their learning trajectory from novices towards competent, and perhaps eventually expert, engineering designers. Though we only see a fraction of what takes place over the course of this educational program, it can nevertheless help us improve our understanding of the way engineering designers are 'made' through our educational system.

The Design & Innovation (D&I) program is still a relatively new program at the otherwise traditional technical university, which oversees the 'production' of the majority of Danish engineering graduates. While opinions still differ in respect to this program's relevance or adequacy of engineering expertise, then it remains one of the only programs to openly embrace the idea of *design* in engineering and experiment with the introduction of not only creativity but also a social understanding in addition to the more traditional technologic and analytic engineering curriculum.

The *Product analysis and Redesign* course is particularly exemplary for the bachelor's part of this education because of its structure and focus. First of all, as a so-called *semester project*, the course includes not only practice-inspired project work in teams but also theoretical lectures, examples and exercises. Apart from the kind of exercise we saw in Episode 2 the students also go through a series of workshop-exercises where they try out different kinds of production methods. Stretching over 2,5 days a week the focus of the course shifts during the semester from more lectures and exercises at the beginning to all project work towards the end. In this way the course structure reflects the overall understanding of learning found at D&I where theory is followed by hands-on exercises and reflections during longer stretches of project work, but also avoiding front-loading the curriculum.

Second of all, the course reflects the distinct interdisciplinary approach to engineering design work, which is the main feature of the D&I education. The course thus includes focus on production and materials (through the workshop-exercises), technical function analysis of components (through separation of the products), user and context understanding (through the ethnographically inspired fieldwork), as well as creative synthesis (through the idea generation and conceptualisation). In this respect the redesign project helps the students manoeuvre several different disciplinary domains and explicitly relate them to each other. At Site 1 we saw how people with different educational backgrounds or placed within different parts of the organisation carried different disciplines into the work of the UX team. Some sort of similar multi-disciplinary interaction is bound to face the D&I graduates once they leave the university, which is what projects like this is designed to help prepare them for.

Finally, I want to draw the attention to the strong emphasis on communication that this course also embodies. Across the episodes it should be clear that the visual worksheet technique is very central to the work that goes on and the communicative efforts both internally in the teams and with their supervisor. Furthermore, oral presentations were included at several points during the semester, forcing the students to select, structure, illustrate, and deliver their main insights to someone outside the team, which is no small communicative task. While the students are by no means experts in communication it also comes across that already here, at their second semester, they are not estranged to efforts of visualising and presenting their work and thoughts either on paper or through spoken words.

In this intermediate discussion I want to take a closer look at the *learning* that is involved in becoming an engineering designer and how the educational system suggests facilitating this. But before looking at the D&I program specifically, let us take a step back and look more generally at how we tend to understand education.

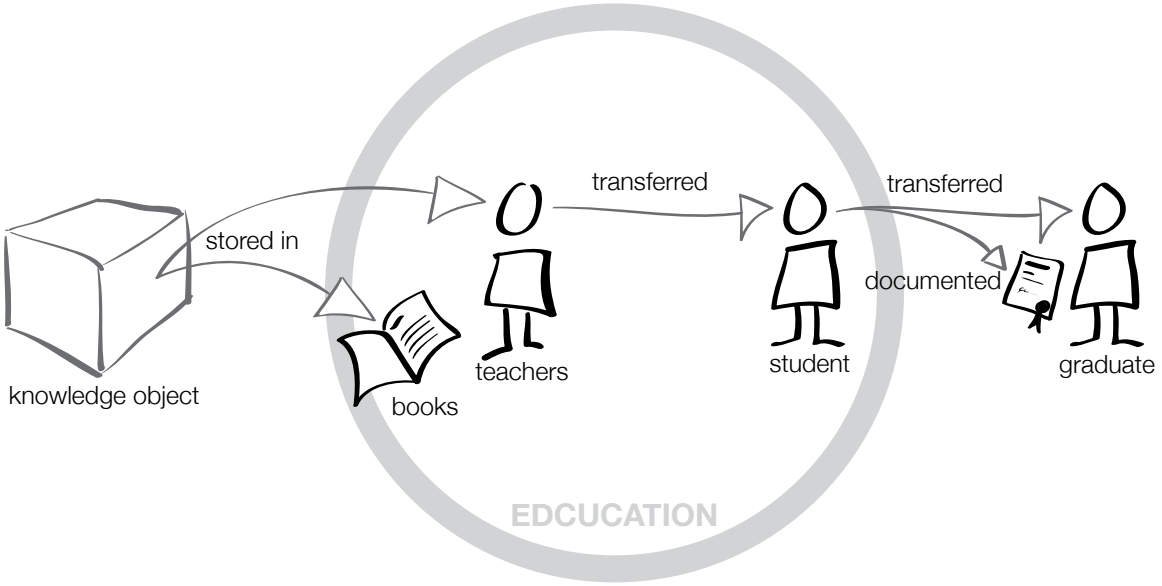
SCHOOLING TO LEARN

Part of humanity's success is our exceptional ability to learn. We are able to grasp and somehow 'store' input and impressions from our interaction with the world and thus improve our understanding of and doing in the

world. Not least are we able to specialise and develop specific skills within certain areas of doing. Our whole perception of professions fundamentally builds on this ability to adapt and learn. You are not born an accountant or an engineer: You learn to become one.

In the Introduction to this part we heard that you might perceive knowledge as pieces of information that are somehow stored in the individual's brain. From this perspective it makes sense to optimize the process of learning by assembling prospective learners in a room without distractions (such as a classroom) together with a person that already possesses this information (such as a teacher) along with other units of storage (such as books and computers) and then begin a process of information transfer from teacher to learner (typically through a lecture). As Kemmis *et al.* (2014) point out education in this sense closely resembles a *technical production process* engaged in the production of people with certain skills or expertise. Most parts of our western educational systems still build on this 'technical' understanding, which Wackerhausen calls a *scholastic paradigm* (see e.g. Wackerhausen 1999, Wackerhausen, Wackerhausen 1993).

FIGURE 92 | Learning production via transfer of knowledge.



We take for granted that receiving an education implies the *acquisition* of knowledge, skills, and eventually competence. Within the scholastic paradigm knowledge is traditionally perceived as a kind of 'object' or 'substance', which can be discovered, stored, and moved around as described above. When we acquire knowledge it is thus 'stored' mentally as an accumulation of knowledge-entities (and not bodily like the situative perspective suggests). Similarly, the notion of skills is understood to be based on explicit rules, principles or routines. Expertise is thus understood as something that can be described in explicit (although complex) rules (opposite the idea of expertise developed by Dreyfus). Finally, competence – which is perceived as the fundamental purpose of education – is achieved when a person possesses the relevant explicit knowledge and rule-based skills, which can then be applied in a professional manner. In other words, professionalism is removed from for example a person's experience, emotions, and ambitions; it is instead *contained* within the individual but not *dependent* on the individual nor the context; and it can be expressed explicitly in language (Wackerhausen, Wackerhausen 1993).

But from our visits to Site 1 and 2 it should be clear that describing the exact knowledge or the rules that the experts use or the students are learning to use is more than difficult. Instead it seems to be elusive and implicit in the episodes and embodied in the participants' (inter)actions. Hager & Hodkinson suggest that the "descriptions of performance outcomes (which can be specified accurately) are taken to be descriptions of the human skills, abilities and capacities that enable these outcomes. So the relative concreteness of the former is falsely attributed to the latter" (Hager, Hodkinson 2009, p625). When we draw up long lists of competences to describe educational outcomes we thus seem to be caught up in the idea of explicating and concretising something that might not be sufficiently described by words on a piece of paper.

In the Introduction we learned from Dreyfus that expertise is perhaps better understood to occur when rules are *not* explicitly followed, but rather when a strong experience-based intuition starts taking over. This also implies that we cannot separate the learner from the knowing nor the context of learning. Instead, seeing knowing as something that happens in practice implies that *knowing* becomes inseparable from its constituting practice. That is, it cannot simply be moved from one place to another or *transferred* for example between teacher and student or education and occupation. So it seems the metaphor of learning as *transfer* of knowl-

edge is problematic, which several researchers have also pointed out (e.g. Gherardi, Nicolini 2000, Hager, Hodkinson 2009, Tuomi-Gröhn, Engeström 2003).

Based on the situated actions we have witnessed at Site 2 it thus seems unsatisfactory to describe the learning that took place simply as a collection of knowledge objects being transferred from teacher to student, as ruled-based skills being acquired, and as professional competence emerging from this. An alternative metaphor is to see learning as a process of *transformation* of knowledge (Gherardi, Nicolini 2000). In this understanding it is not a question of moving the same 'substance' of knowledge from one place to another, instead the knowledge is interpreted and shaped through a transformative process. This leaves room for the individual differences in competence across for example a class of students. Differences in previous experiences, personal ambitions and interests can thus effect how the knowledge is transformed as the student is learning.

Continuing this thought Wenger suggests that: "in spite of curriculum, discipline, and exhortation, the learning that is most personally transformative [at school] turns out to be the learning that involves membership in […] communities of practice" (Wenger 1998, p6). Let us thus turn from the scholastic idea of acquisition to the idea of *participation* found within the theory of communities of practice to find an alternative way of understanding what we have seen.

COMMUNITY OF PRACTICE

Unlike the traditional scholastic perception where learning is an activity taking place within the classroom, Lave & Wenger see learning as an integral part of *any* practice and intrinsically linked to both its reproduction and continued development.

As discussed in Part 2, practices can be seen to be the basic meaning-making, identity-forming and ordering-producing activities that collectively constitute our lives as social creatures. Each of us engage in a multitude of different practices – different ones at different times, and with varying levels of engagement. But we do not participate in these practices alone, in fact a large part of any practice lies in the social relations that run through it and thus collectively upholds the sense of meaning and order within the practice. This collective is what Lave & Wenger

have named a *community of practice* (Lave, Wenger 1991). It is within such communities that our daily enterprises are defined as meaningful and our participation in the practice is recognised to be (more or less) competent (Wenger 1998).

Being knowledgeable, from this point of view, implies being competent at carrying out enterprises recognised as meaningful within the community of practice and pursuing these by actively engaging with others within the community (Wenger 1998). Meaning is thus placed as the ultimate goal of learning – that is, experiencing what we do, the way we do it, and the world we live in as meaningful; even relating meaningfully to what we do *not* do and what we do *not* know (in other words the contributions of others). Competence is thus not an individual property since it presupposes this negotiated understanding of what the community *recognises* to be competent. On the other hand, it is neither an abstract property of the community since it is only displayed through the mutual engagement of individuals in the practice.

At Site 2 we have seen different examples of the students' emerging competences, for example the competence involved in illustrating their newly acquired insights of the product and its use. If we were to move team 3 to a different community of practice – for example the one found at a design school or perhaps in a statics class at another part of the DTU campus – and have them draw up their worksheets there instead, then their efforts would most likely not be considered competent or meaningful to the local practices. Not because the students' abilities to draw and write text would change, but simply because their competence springs from a different kind of negotiated meaning than we would find at the design school or in the statics class. In the community of practice found at D&I the worksheets are not necessarily meant to display realistic renderings of shapes or surface materials, nor are they (in the contexts we have witnessed) meant to form the basis for setting up a formula for calculating deflections or stress-levels. When the students' illustrations – for example of how you add ingredients – to a certain degree display competence, then it is because they have emerged from a practice where it is meaningful to consider interaction between user and machine and where the very process of making these illustrations are meaningful in itself.

LEGITIMATE PERIPHERAL PARTICIPATION

A practice is only sustained through its continuous re-production, which naturally involves a more or less continuous introduction of new practitioners. The carriers of a practice at a certain point in time will thus include participants at different 'levels' of engagements, that is, more or less committed to the practice and more or less competent at carrying it out. Gaining access to such a community of practice and becoming a recognised participant in it thus implies a learning trajectory, which takes the novice from an initial peripheral position of participation towards a gradually more full and expertly position of participation (though not necessarily so and not following a straight line). The key to learning, according to Lave & Wenger, thus implies that the initial peripheral position is recognised and accepted within the community, thus granting the novice access. This is what they term *legitimate peripheral participation* (Lave, Wenger 1991).

But the community of practitioners is not only made up of learners traveling from the same positions as novices towards the same positions as experts as Dreyfus' 5 stages of skill acquisition might lead us to believe. Through their mutual engagement the participants of the community will surely develop similarities but also differences, specialisations or status. As Wenger puts it: "each participant in a community of practice finds a unique place and gains a unique identity, which is both further integrated and further defined in the course of engagement in practice" (Wenger 1998, p75). Their mutual engagements are thus not uniform but nevertheless amounts to a collective or joint enterprise accomplished by people in different roles.

I would argue that learning within a community of practice does not only take place in the direction from the more experienced (older peer or educator) to the less experienced (student). While this has not been the focus of the ethnographic enquiry, then I do believe it is safe to say that David for example also learned from his interaction with the 1st year students during the worksheet review. Facing the younger students' questions, their frustrations, and their interpretations of the worksheet format he not only faced issues that he had been dealing with himself at some previous point on his own learning trajectory, but also new issues. The new students might bring new ideas with them into the D&I community of practice and thus not only be influenced by existing participants but

also influence them in return. This is an important part in keeping the practice dynamic and always relevant to the present.

But does this social process of 'initiation' into a new practice sufficiently describe what we find within the educational sphere? Do the roles of 'students' and 'teachers' fit comfortably onto the learning trajectory from peripheral to more full participation? The educators at the D&I program are not necessarily engineering designers themselves nor in any way participating in design practices comparable to the ones we saw at Site 1. They are instead researchers knowing how to make sense of different kinds of disciplinary subjects, and they are pedagogically trained (to some extent) to facilitate learning. Perhaps our way of institutionalising academic education (as opposed to the apprenticeship structure in the craft tradition) thus fosters a different way of talking about what we have seen at Site 2.

LEARNING PRACTICES

In their analysis of teaching and learning in the school system, Kemmis *et al.* (2014) develop what I find a useful analytical distinction between *learning* practices and *substantive* practices. The *situative perspective* introduced in the Introduction to this part suggested that learning implies getting to know how to participate in a new (professional) practice. This kind of learning may often take place without any teacher present, but instead guided through the *legitimate peripheral participation* in a community of practice as we just heard above. Such a 'new' practice that the novice is being initiated into (for example an engineering design practice) is what Kemmis *et al.* call a *substantive practice*.

Looking at our formal education system, however, what we see is not students 'simply' practicing substantive practices through interaction with experts of varying seniority. We find instead a lot of examples of what Kemmis *et al.* call *learning practices* – that is, learning as a distinct kind of practice in itself. This term thus covers the kinds of practices by which people learn – or at least are perceived to learn within formal education. We all might recognise that when we put our minds to learn something new then we often take to engaging in certain kinds of doings and sayings and seek out certain kinds of material arrangements supposed to facilitate this endeavour. We might for example start by reading a book on the subject, maybe try out some online exercises or tests, or perhaps sign up for

an actual class on the subject. In other words, it makes sense to us to start participating in these distinct learning practices that differ from how we learn to engage in more everyday practices like oral hygiene or domestic gardening (where we simply practice the practice). With this term we are thus able to treat the kinds of practices we meet within the educational sphere as distinctive practices carried by people in the roles of both 'teachers' and 'students'– though not in the cognitivist sense of 'transmitter' and 'receiver' of knowledge. Instead both students and teachers are co-participants in a joint practice where they are negotiating and transforming what it makes sense to do and say.[12]

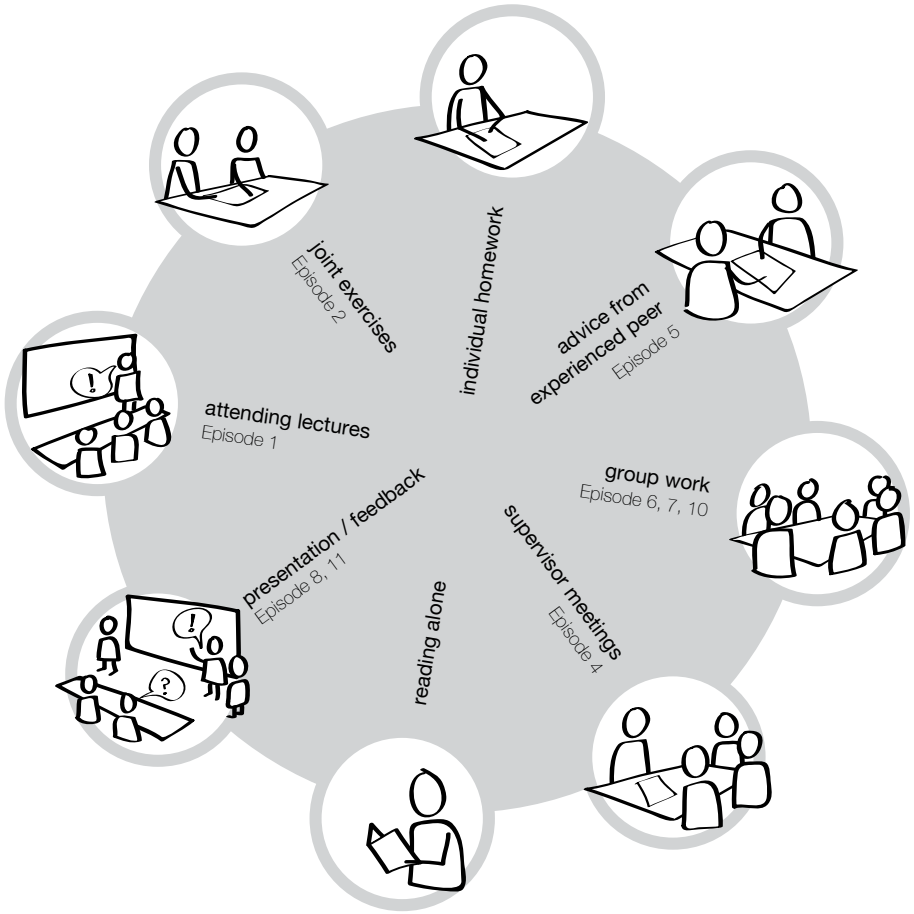


FIGURE 93 | Bundle of the most prominent learning practices at Site 2.

Here at Site 2 we see how the students participate in a mix of both substantive and learning practices. In relation to the learning practices employed in the project course, the students' engagement revolves around what Kemmis *et al.* (2014) term the *project* of coming to know *how to go on* in the practice of learning.[13] This involves recognising and employing the rhetoric used (for example knowing what 'working in pairs' means as compared to working 'individually' or in 'groups'), knowing how to participate in the activities (for example engaging in group work or presenting your outcomes), and being able to relate to the others engaged in the same learning practice (for example following the teacher's instructions, collaborating with fellow students, or taking advice from a more experienced student). Most of the students are already competent or even proficient participants in many of these learning practices. They are capable of using their know-how to engage in both individual work and collective group activities and take their cues from the educators in charge of the course. At the supervisor meeting in Episode 4, however, the students in team 3 appear less competent and unsure how to go on (for example what to bring in to the situation, who should take the floor, how to retain the feedback offered), suggesting that this is still a new kind of practice they are learning to engage in.

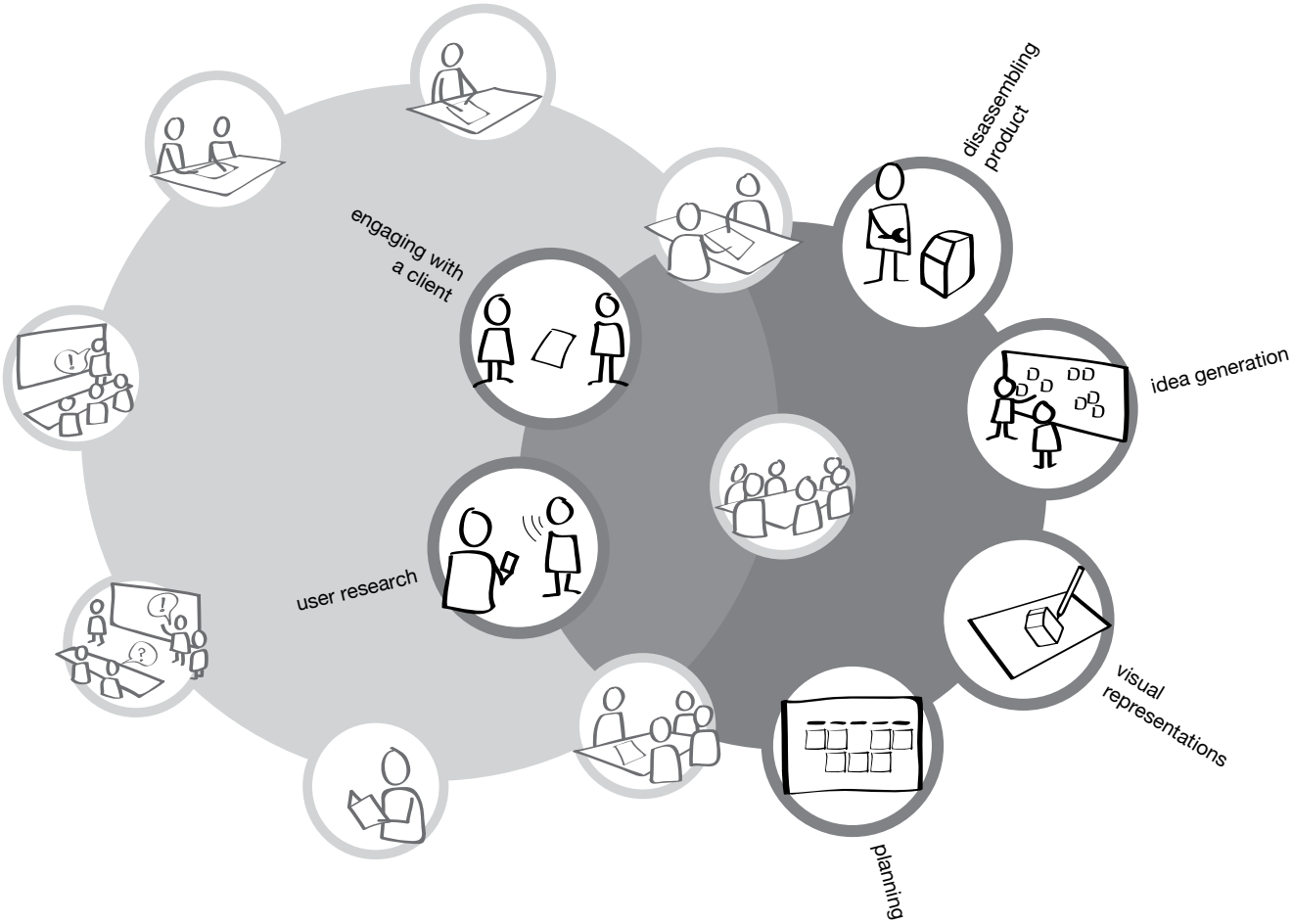
There is a strong community of practice upholding these learning practices, which also extends well beyond the walls of the studio and include the faculty, teaching material, furniture, curriculum etc. A classroom by any other name is still a classroom, and we recognise it straight away as such with its population of young(er) students and one or two older teachers, with its blackboards and uniform desks and chairs, and with its alternations between hosting more formal interaction at some dedicated times and more informal interaction at other times.

But we also come across indications that something beyond attending lectures or doing group work is going on in this studio. In fact the purpose of participating in these learning practices (beyond learning to learn) lies in another bundle of practices of a more substantive nature. The educators in charge of this project course want to facilitate an initiation into the *practice of doing engineering redesign* – a practice that they know to already exist within the occupational sphere. Let us take a closer look at this substantive redesign practice.

A SUBSTANTIVE DESIGN PRACTICE

Through this project course the students are being initiated into the practice of redesigning existing technical products (including analysing how a product is problematic in its current manifestation and coming up with a new and improved manifestation). Unlike the learning practices this *substantive practice* is new territory for the students. Coming into the field of engineering design the students might already have had ideas of how to improve on products from their everyday life (I know I had), but to actually go through the process of *doing* it they need to build a new *pool of understandings*, to recognise a new *set of rules*, and to navigate their efforts

FIGURE 94 | Substantive practice bundle mixed in with the learning bundle.



within a new *teleoaffective structure*. During this project the students come to know how to describe their object of re-design from different points of view (functional, production, and user), for example disassembling the product to identify different functional organs or 'reading' from the individual components how they have been produced. They come to know how to go on in the different kinds of activities they are involved in, such as completing a field visit or drawing up a worksheet. They also come to know how to relate to others in connection to the design process, for example the users they visit and the company representative that they present their work to. While the full bundle of professional engineering design practices is not represented in this course, elements from it have thus been imported into the educational sphere through the project-based approach.

VISUAL REPRESENTATIONS

In the episodes from Site 2 I have given a lot of attention to the worksheets that the students are working with because they seem to capture a lot of the complexity that is going on. Objectively speaking these worksheets are visual representations of different fractions of the students' work. From their study of visual representations as part of the knowledge work in an architectural design project Ewenstein & Whyte (2009) suggest that we might see such visual representations as partly captured and materialised *epistemic objects*. As designers engage with the drawings these unfold and open up new possibilities pushing the design process forward: "these objects reflect a knowledge development process that proceeds in an ongoing and dialogical way; embodying a lack, raising a question, begging an answer, unfolding, developing a lack elsewhere, raising new questions, and so on" (Ewenstein, Whyte 2009, p27).

In the architectural project that Ewenstein & Whyte studied these visual representations were mostly observed during interaction across different professions. Here at Site 2, however, they appear within a relatively homogeneous group of students with similar backgrounds. Juhl & Lindegaard have analysed the use of worksheets at the same redesign course 10 years earlier and found that: "the representations of the students can be understood to serve as a meeting ground for different kinds of recognitions that are derived through different disciplines" (Juhl, Lindegaard 2013, p15). In other words, the worksheets may not be a meeting ground for people with different backgrounds working on the same epistemic object, but rather a

way for the students to explore the epistemic object simultaneously from different points of view.

In Juhl & Lindegaard's (2013) analysis the worksheets actually displayed a distinct combination of both technical and user insights in the visual representations – for example showing an operator in interaction with a machine along with the functional components of that machine influencing the interaction. For some reason the students that I met at Site 2 did not exhibit the same ability to integrate different types of observations and understandings in their visual representations.

If we look back at the worksheets we have seen throughout the episodes, then it actually becomes quite striking that the human user has almost vanished (at least visually) and the machine is thus left to 'do' things on its own. Though we might see processes on the worksheets that we know intuitively include human interaction, then it is largely left implicit. So something happens in the translation from the students' dialogue, their field visits, and interviews and onto the pieces of paper that adorn their wall. The design object seems to become a *technical* object removed from its context that can be optimised through technical means rather than a *socio*technical object, which would require a more complex approach. Their object of design thus seemingly becomes manageable and comparable to the examples they have been through in the learning practices. In fact a quite typical engineering approach.

But this does not necessarily mean that the students at the D&I program 10 years later exhibit less understanding of the relations between different disciplinary domains. In fact, through the students' *interaction* with the worksheets – especially the dialogues that take place during the joint walkthroughs or interaction with Tom and Daniel – we can observe another dimension not inherent in the worksheets themselves. The students' own bodies and gestures actually come to stand-in for the human users omitted from the physical worksheets, thus bringing the sociotechnical dimensions back to life and re-represented in the complexity of the epistemic design object.

Simon is one of the students who put a lot of continued reflection into his work on the worksheets. In the collective walkthroughs in Episode 6 we see how his worksheets successfully spur questions and queries from the others: How big is the existing plastic chute actually? And how big does it need to be to enable adding ingredients? When is it actually used? How else might you add ingredients? The worksheet draws attention to

its own incompleteness and thus induces questions; it reveals some things while leaving out others. Similarly, at the company presentation in Episode 11, we can see that the students did not abandon the sociotechnical aspects of their design object. Through their choice of presentation material, especially using the original machine and mock-up models of the proposed design, the students are able to 'act' as the users of these machines while presenting their insights. Using their own bodies positioned next to the machine and their hands to grab different parts they are able to re-enact situations – though of course still leaving out the kitchen context and food ingredients.

While the visual representations thus hold a central place in the substantive practice bundle that the students are being introduced to, then it is just as important that they gain confidence in the communicative and enacting situations that accompany the use of such visualisations.

LEARNING DESIGN PRACTICE

From our visit at Site 2 we are now able to recognise that students engage in a different kind of practice bundle during their education than the one we saw in the occupational sphere at Site 1. Both educators and students are very invested in the project of *learning*, which is accomplished through a bundle of dedicated learning practices, such as attending lectures, doing exercises, or participating in project work. Throughout their education the students will move around in this bundle – some courses putting more emphasis on certain learning practices over others.

In this respect it does not help us to cling to the understanding of individual learning where defined blocks of knowledge are transferred and stored in the students' heads. While the members of team 3 are still individual learners, then it is in the collective interaction with each other and the faculty that their knowing starts to take shape. It is through testing their thoughts, ideas and understandings on each other and trying out different approaches that they start to build a *pool of practical understandings* of how to do things (such as making worksheets or structuring presentations) and piece together a *teleoaffective structure* that helps them determine what ends it makes sense to aim for (such as good grades and an extensive competence profile).

But the purpose of education is not only learning to learn. We expect that getting an education can help prepare you somehow and make you competent enough to take on a professional job. The students we meet here all aspire to one day participate in some version of the engineering design community that the UX team is already part of. So how does their education prepare them for this? What kinds of learning is it that graduates take with them from the educational sphere? How does engineering design educations like this one support the development of design competences?

Once again the answers are not straight forward, but let me attempt a brief recap of some of the things that seem to stand out from this site:

- The students' learning takes place as they are being initiated into a community of learning practices, which makes them competent learners.
- The community that the students form within a generation greatly influences the way they make sense of and are able to recognise 'engineering design work'.
- Working on actual products help introduce part of the real-life ambiguities into the students' work.
- And yet even in a project-oriented study model the substantive practices that students are introduced to are devoid of many of the elements of the full bundle of professional practices and material arrangements.

Let me expand a bit on these before moving on.

COMMUNITY OF LEARNING PRACTICES

Completing a formal education at the university – going through all of the different courses and surviving all of the exams – you have proven at least one thing: That you know how to learn. In fact, from what we have seen at Site 2 it seems fair to use the idea of a *community of practice* to describe the social collective of the 2nd semester D&I students and the D&I faculty. But it is a special kind of community since they are all invested in a common enterprise of *learning*. In this respect the educators can be viewed as expert learners. Not only do they have some pedagogical training on different kinds of learning practices and experience from teacher other students, but as scholars they are also used to having to acquaint themselves with new thoughts and ideas. The students are not exactly novices

either. In order to get to the university level they will already have been members of similar communities of learning practices throughout the schooling system.

Learning from the *situated perspective* reaches well beyond the individual and is influenced by the situated nature of engaging in a community of learning practices. The individual work in such a community depends on collective dialogue and interaction, which we have seen during both informal team meetings (working individually together around the table clusters) and more structured team efforts (like the collective worksheet walkthroughs). The students learn to participate in this joint enterprise of learning and making the life as a student liveable and interesting. They quickly become competent learners – though not all students are necessarily equally engaged or competent in all of the learning practices bundled together in the education.

The material arrangements at the studio classroom also seem to facilitate this community building. With all of the teams formed as part of the project course co-located in the same studio they are able to keep track of each other's progress and approaches. Especially the walls displaying the teams' worksheets through different stages enable their mutual engagement and interaction as a community. As they work in different team constellations on the different semesters their accumulating experiences are also shared and re-negotiated across the entire D&I generation, thus building a strong community.

But from our visit at Site 2 we also get an implicit idea of the limited engagement across the different generations of D&I students. Only traces of the older generations find their way into the studio – for example the worksheet examples shown at the beginning of the semester, and later the students are also provided with a few hard copies of previous reports. These are 'fossilisations' left for the new students' interpretations, but without offering any insights of how they have appeared through collective processes. Of course David also becomes an embodied representative of his, more experienced, generation of D&I students, but they never experience him 'at work'. This limited diversity in the local community of practice might inhibit the potential social learning across the generations of students.

ENGINEERING IDENTITY

Within the local community of practices that the students engage in during their education they collectively form and develop a sense of purpose of the kind of work they are doing. While one part of this is linked to the collective project of learning, then there is also a significant part related to making sense of the profession they are working their way into. These *teleoaffective structures* are thus closely linked to the identity work, which is a significant part of any education. Most students not only struggle with *how* to do the things they are attempting to learn but also *why* they make sense to do and what project they support.

The configuration of the practice bundles in the educational sphere thus greatly influences the understanding of doing engineering design work that the students are developing. At the D&I education for example, where great emphasis is put on fieldwork and user research, the students are forming an understanding that user-centred approaches hold a central part in doing design, whereas more traditional programs might promote the understanding that programming or maybe calculations of material stresses are the central parts. While this helps them build a certain professional profile, then it is also problematic that the students do not meet these other ways of understanding engineering design work before they step into the occupational sphere. They are thus not prepared to *negotiate* their understanding of design or *translate* it into a common project.

A FEEL FOR DESIGN

In the project the students are assigned an actual product (in this case one that will in fact be redesigned by the company shortly) and thus a version of a 'client' to convince with their design efforts. This is an important way for elements of complexity and ambiguity to enter the students' design work after all. They have to relate their efforts to what they were given and translate and negotiate their knowing in interaction with the design object well aware that there is no one 'right' answer or solution. Meeting the world outside the university (through real products, company representatives, production workers, professional users etc.) the students' learning-oriented understandings are thus being challenged and more substantive elements introduced.

In Episode 7 we hear how some of the students have a conception that there are other rules governing the work within the university than outside

in companies – for example Caroline believes that they will be rewarded at the exam for challenging the common perceptions of what is possible. At 'school' there is thus room to be wrong – as long as you learn from it. But meeting 'clients', such as Kim, and their priorities of for example economically competitive solutions throughout their education the students are regularly reminded of the kind of material-economic arrangements and *teleoaffective structures* governing their potential future workplaces.

But the students do not have any access to experience how a professional engineer would engage with for example a technical drawing and use it in a development process or how economic considerations might enter the professional's design process. The lack of access to *substantive* practice communities thus limits the legitimate peripheral learning that the students are able to experience during their education.

SUBSTANTIAL REFLECTION

Even in a project-oriented study model (like the D&I program) the substantive practices that the students are introduced to are not able to fully reflect those intricate practice bundles that we find in the occupational sphere. While there are clearly some elements we might recognise across Site 1 and 2 then there are also many distinct differences. First of all the students at Site 2 all work in teams composed of people with very similar backgrounds and experience where teams in the occupational sphere will typically include people with different backgrounds (education or experience-wise) and of different seniority. While there are good reasons for this setup in the educational sphere then it naturally robs the practice bundle of some of its complexity and potency. Second of all the students are completing their work in a relatively isolated and protected context: There are no externally imposed budgets to comply with, no management representatives to satisfy or other departments to coordinate with. There is not even a requirement to come up with a functional and sellable product in the end because it is the *learning* that is important; that the students are able to display their acquired *practical understandings* and reflect on their process and results.

In other words, the students are never exposed to the same level of complexity and ambiguity that the UX team had to spend much time and effort to navigate in order to do their jobs well. In fact the students appear quite uncomfortable with the ambiguity they do meet. They are looking

for rules and 'rights' and 'wrongs' to guide their doings. As Dreyfus reminds us it is important, though, as the students move along their learning trajectories that such rules do not become the only means for them to engage in the engineering design practices. In order to become proficient or even expert designers they need to develop a professional *intuition* about their work.

The students are actually using quite a bit of intuition in their work already – for example when deciding how to visually represent certain insights on their worksheets. We do not see them deliberate whether to use one drawing technique or the other, instead they seem to dive right in, already having formed an idea of the visualisation they want to make when discussing the worksheets to be made at the team meetings. It does not always prove completely successful, though, which reminds us of their lack of an extensive experience repertoire to help them react successfully. Reflecting on their choices and letting the resulting outcomes 'sink in' will, according to Dreyfus, be important for them if they are to build such a repertoire.

Building on the situated perspective then framing the kinds of practices that the students engage in during their education as *learning* and *substantive* practices respectively helps illustrate the twofold educational project. Engineering education facilitates the students' learning through a bundle of dedicated learning practices, which are more or less recognisable across the educational system. At the same time the project work offers the students the possibility of starting to build experience with some of the elements of substantive practices, though without exposing them to the full complexity and ambiguity of the epistemic design practices that we find in the occupational sphere.

In the next chapter I will attempt to sum up and position what the visits to these two sites have shown us with regards to practicing engineering design work.

3 TO SUM UP | 4 another perspective

If we want to overcome the perceived gap between engineering education and occupation, then we need to form a better understanding of how engineers conduct their work and how they learn to participate in professional practices (Johri 2014, Stevens, Johri & O'Connor 2014). So far, however, there are only a limited number of studies on professional engineering work practices.

In this part I set out to offer my contribution to improving our understanding of how engineering design is *practiced* – that is, how bundles of design practices are being re-produced in local, occupational situations and how engineering design students become able to participate in such practices. To wrap up this part I will now briefly position what we might take from this endeavour. That is, how we might understand engineering design work; how we can understand the role of knowledge and expertise in this work; and how engineering education can be understood to prepare students for this work.

ENGINEERING DESIGN

In a report on how to prepare the next generation of engineering graduates for life as professional engineers in 2020 the American National Academy of Engineers (NAE) suggests amongst other things that: "students should be introduced to the "essence" of engineering early in their undergraduate careers" (National Academy of Engineering 2005, p2). Not a bad idea but – you might ask – what *is* the 'essence' of engineering?[14]

It is actually not surprising that there is such a demand for an essence. In fact, when asked many engineers perceive themselves as 'atypical' and believe that what they do is not 'real engineering work' (see e.g. Downey

2014, Parker 2004, Trevelyan 2010). Trevelyan (2010) points out that much of the social work that fills an engineer's every day is largely marginalised and relegated to a peripheral position in the professional repertoire, thus not perceived as part of this 'essence'. So is our current understanding of engineering work useful at all? Do the prevailing ideas of the rational engineering problem-solver really tell us anything about what engineers actually do?

Reaching back to the 1980ies the dominant understanding of engineering design (especially in the German tradition) has been on a methodical search for solutions, typically treated as successive series of ordered activities leading from problem to solution (e.g. Ulrich, Eppinger 1995). From the realms of artificial intelligence Simon (1996) interpreted this is a rational, logic process – even if a complex one at that. The situated perspective I have adopted in this thesis allows us to look more closely at the situated doings of engineers in their every day work. While this may not provide us with a straight answer in regards to engineering 'essence', then it does help us recognise what plays a role in the situated doings of engineering design work beyond the rational plans.

Based on the occupational and educational sites that we have now visited I thus propose that we acknowledge the unfolding nature of engineering design practices by adopting the idea of *epistemic practices* (Knorr Cetina 2001). This allows us to move beyond the metaphor of well-defined problem solving and instead recognise the open-ended and explorative nature of the work that goes on.

Based on Dewey's philosophy of human experience and inquiry (see e.g. Dewey [1938] 2009) Stark (2009) criticises the perception of well-defined problem solution for, as he points out, in innovative processes you most often do not know what the 'problem' you are trying to solve really is. The ambiguities of the constantly unfolding epistemic practices we have witnessed here seem to echo this observation. "Whereas problem solving involves the precise exchange of information," Stark explains, "the interpretive model fosters open-ended, unpredictable conversation. Where the former seeks clarity, the latter seeks spaces of ambiguity since the challenge is to integrate knowledge across heterogeneous domains" (Stark 2009, p3) These perplexing situations where there are multiple understandings of what counts or how to see the world is where innovation finds room to unfold – not locked up in well-defined boxes with a single end in sight.

In order to be able to work in innovative (knowledge) organisations it is thus imperative that new engineering graduates are not discouraged by this ambiguity and seemingly chaotic process of navigating on the edge of, and possibly beyond, what is known.

KNOWLEDGE AND EXPERTISE

Understanding engineering design as *epistemic practices* is thus linked to how we perceive knowledge and define expertise. Within the engineering community we often find an instrumental and rational perception of knowledge. Cook & Brown (1999) have called this dominant position 'the epistemology of possession', that is, knowledge as something individuals either possess or lack. There is thus a tendency to overlook the importance of the on-going and situated actions taking place in the every day (Orlikowski 2002).

As we have seen, epistemic objects are constantly evolving and inspiring new inquiries and so the traditional cognitive perception of knowledge as some well-defined, codifiable 'possession' falls short of the dynamic interactions taking place in open-ended epistemic practices. Instead I propose that we adapt the metaphor of *knowing in practice* to emphasis the social and situated accomplishment of this interaction. As Gherardi puts it: "To work is […] to use a set of knowledges as resources for action, and working produces further knowledges. Working is knowing, therefore, and not simply applying acquired knowledge" (Gherardi 2012, p20). This does not mean that there is no theoretical knowledge but rather that knowledge only lives and develops through practice and doing.

The individual's trajectory moves through diverse practices and situations where learning always plays a central part, and where knowing is achieved as a consequence of doing (not the other way around). Knowing how to go on in a situation is thus grounded in the local practices and the communities that carry them. When we consider experience it therefore makes sense to look beyond the ideas of stocking knowledge or impressions in the individual's mind and instead recognise the collective, sociomaterial processes that it is produced by (Gherardi 2014).

Our continued display of knowing in practice is what leads to experience. In Dreyfus' (1986) terms it is based on an extensive and growing repertoire of previously encountered situations that an *intuitive expertise*

is developed. Becoming an expert in engineering design thus relies more on extensive activities of knowing in practice than on elaborate rules and methods.

ENGINEERING DESIGN EDUCATION

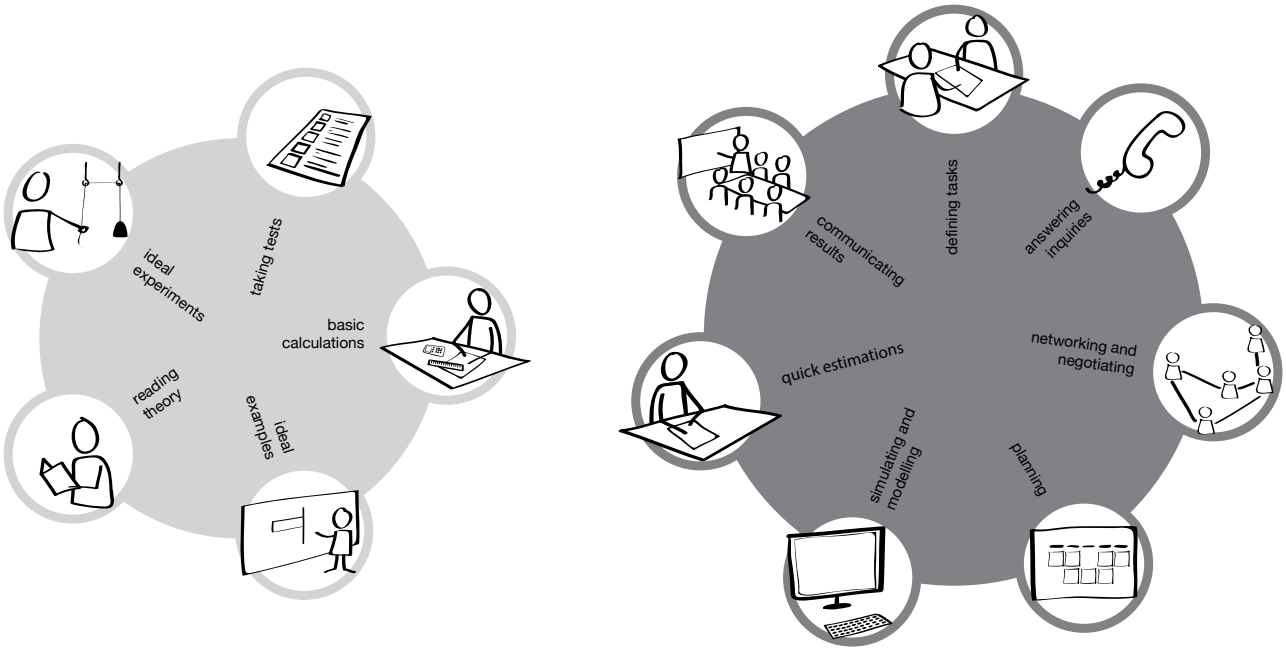
Preparing graduates to engage in engineering design work thus depends on students learning how to go on in epistemic practices and begin to form a repertoire on which to build an intuitive expertise.

Within formal education learning is assumed to be the core business. The students are learning to learn, or rather gaining access to the university's bundle of practices linked to various forms of learning activities (informed by various pedagogical practices). Viewed from the situative perspective the academic system can be seen to offer an atypical form of learning, which is removed from the context of daily life (Johri, Olds & O'Connor 2014) . The distinct practices supporting this learning can be usefully referred to as *learning practices* (Kemmis *et al.* 2014). If we stick to this analytical distinction, then we might be able to pin down some of the challenges that engineering education is facing in relation to supporting students' proficiency in professional engineering design practice.

Within the educational sphere, if we look at a (broadly speaking) traditional engineering education, then a large part of the program will be spent reproducing certain learning practices that are deemed characteristically engineering, such as doing delimited calculations, performing traditional experiments, and reading through exemplary science-based texts, followed by attending written exams with well-defined and single-answer assignments. When attending engineering education students thus build an understanding that this is what 'real engineering' is about: Their ambition becomes to slice the world into manageable and well-defined pieces that can then be treated just as the ideal intra-disciplinary equations they have practiced over and over. "The (over)emphasis on solving well-posed, single-answer problems with its reductionist, deterministic ideology works against taking the social and constitutive features of engineering seriously" Buch & Bucciarelli (forthcoming, p3) point out. The way the bundle of learning practices are configured thus holds a significant influence on how the substantive practices they are aimed at are perceived.

But learning does not stop once we move on to the occupational sphere. *Knowing in practice* also holds a strong component of continuing to learn and building an increasing repertoire of experiences informing your professional intuition. The thing is, however, that the practice-bundles look very differently within the occupational sphere. Elements of working professionally may very well include elements of calculation and experiments, but the bundle also brings together many other kinds of practices, which have no (explicit) parallels in the educational sphere: For example planning, negotiating, and communicating. Furthermore, learning is most of the time an integral element of the substantive professional practices and not facilitated through explicit learning practices. Instead, Gherardi (2014) speaks of activities at the *core* of the practice – oriented towards the epistemic object – and activities at the *margins* of the practice – oriented towards the reproduction and development of the practice itself – as she puts it: "At the margins of the practice the production and circulation of knowledge take place in the form of a reciprocal and interwoven process

FIGURE 95 | Different configurations of the practice bundles leads to different conceptions of 'real engineering'.



EDUCATIONAL
bundle of learning practices

OCCUPATIONAL
bundle of substantive practices

of learning/teaching" (Gherardi 2014, p20). Learning and working are thus always entangled, leaving a different way of perceiving engineering design.

Faced with such a constellation of interrelated practices it is no wonder that the image of 'real engineering' build through education (and general societal projections) seems to be unfulfilled in the occupational setting. Fact is – as an increasing number of studies are now showing – that engineering is much more than calculations and that problem solving requires much more than a proficiency in the rational natural sciences and mathematics. Hopefully the thick descriptions offered in this part have also helped to illustrate this.

For the multi-disciplinary team at Site 1 it was crucial to their work that they knew not only how to recognise for example social factors, but also how to bring these into their epistemic work and interaction with other parts of the organisation. This required an alternative (in this case more visual) language than numbers and equations, but also a collective *pool of understandings* where working in this way makes sense.

At Site 2 we have seen how the introduction of project work and visual representations to the bundle of learning practices helps integrate elements of the substantive practice bundles found in the occupational sphere – though still without much of the characteristic ambiguity and restraints.

Moving forward it is important to keep in mind that how engineering education is structured and practiced influences how engineering as a profession is viewed.

MEETING THE CHALLENGES

If we want to start bridging the experienced gap between engineering education and occupation, then we need to confront our fundamental understandings of knowing and learning and look for ways to rethink our bundles of learning practices in engineering educations so that they can better accommodate the introduction of epistemic practices and the inert ambiguities they hold.

The D&I education can be seen as an attempt to create such a new type of creative engineering education that embraces the more heterogeneous elements of engineering work. Looking at the graduates that have

emerged from this program it is clear that the approach has resulted in a very flexible profile that fits within many different occupational settings.[15] But what expertise does a heterogeneous and holistic engineer have? That can be hard for both the students and their potential employers to formulate and to translate into existing institutional infrastructures. At DTU the D&I program is commonly referred to as 'Pictionary' (the game, in Danish called 'Draw and Guess') by the other engineering students on campus. This illustrates the innate distrust in creative and explorative approaches over the rational logic of science, which is lodged in and promoted by the engineering educational sphere.

Even though programs like D&I, which are trying to embrace and propagate the heterogeneous aspects of engineering work that we see in design departments like Volvo's UX centre, have emerged then there are still some problematic 'displacements' between education and occupation.

It is not enough to reflect the existing reality of working like an engineer in educations because that alone will not guarantee that the resulting graduates get the opportunity to display their heterogeneous expertise. In a study of how two D&I engineers were embraced in a traditionally informed engineering consultancy, Buch (forthcoming) found that their 'holistic' approaches faded in favour of a more instrumental approach, which was prefigured in the structuration of the work within the organisation. So in order to have any real impact workplaces also need to be open to receive such non-traditional engineers and the organisational structures must provide the necessary room for their agile practices. At Site 1 we saw how something as simple as a stage-gate-model created challenges for the UX experts and barriers for their practices.

In the next part it is exactly these organisational structures and infrastructures we will be taking a closer look at. What kinds of challenges do they really pose and how do they affect the evolvement of practices?

4

Action is the foundational key
to all success.
Picasso

CHANGING

Our visits at the two sites within the occupational and educational spheres in Part 3 enabled us to build a situated understanding of how engineering design is practiced locally – both in respect to how such work is carried out and in respect to how it is rehearsed by students. While the individual practices are ordered by some *pools of understandings*, *sets of rules*, and *teleoaffective structures* it is also clear that they relate to each other in strong or more loosely defined bundles: Engineering design is not one thing but rather locally defined bundles of practices. It has, however, also become clear that the local doings are affected by phenomena outside the practices. Material arrangements such as physical locations, wall space, projectors etc. have an impact on how the practices can be carried out. But more than that, we have seen indications of relations extending beyond the local practices of engineering design into for example practices related to management and strategy work.

Zooming out from the local practicing I will in this part make a second move that can bring us closer to the organisational phenomena, which has grand impacts on the emerging efforts to change how engineering design is done and understood.

4 INTRODUCTION | 1

infrastructures
transcending boundaries

Both the UX centre and the Design & Innovation program started out as new additions to some otherwise very traditional engineering organisations. But what is important to remember is that none of them – no practice bundles – are static or stable. Instead there is an inherent dynamic in the idea of practices, which takes shape from the conditions at each site to each time. This results in constant (though often small) shifts of the doings and meanings through the re-production. At the same time it is not hard to find ambitions of further or greater changes within or across practices.

Change is a notoriously tricky process to tackle or even control – sometimes it happens seemingly out of the blue, wrecking the established ways of doing, at other times, when change appears to be badly needed, nothing happens despite targeted attempts to induce it. Organisational and management literature is perhaps especially interested in what to do in order to manage such change processes because the development and success of organisations depends on it.

The empirical basis in this part will draw on two efforts to create change, which have emerged in a continuation of the practices we witnessed at Site 1 and 2. Without going into quite the same level of thick descriptions I will use these efforts to explore where the obstacles of change seem to arise in an organisational perspective. First, however, I will expand on the conceptual framework to help us shift the focus beyond the individual practices.

HANGING TOGETHER

Practice theory has been criticised for overlooking or underplaying issues of change. Focussing on routines and continuation of historic practices there is a tendency for practice studies to bring out processes of stabilisation and persistence rather than change and dissolution of practice bundles.

But through the focus on performance of doings and sayings we might not only see actions converting into a stabile ordering. Through situated re-productions of the practice the practitioner not only keeps the practice alive, but also evolves it. Participating in practices transforms us, but it also transforms the world in which the practice is carried out (Kemmis *et al.* 2014). Over time this inevitably brings change and dynamics into the practice (or bundle) – sometimes quite abruptly.

While traditions and the history of the engineering profession continues to influence the way engineering design is practiced today it is also clear that great changes have occurred both within the educational and occupational spheres. Not surprising for a profession born out of the technological and scientific revolutions that our civilisation have experienced over a relatively short timespan and the major impacts this have had on the ways we are able to live our lives. Even so, what we witness today is a certain dis-harmony between the engineering design that new students practice doing and the engineering design that professionals do. A range of national educational reforms and more local initiatives at universities (new programs, new pedagogical strategies etc.) has and continue to attempt to bridge this gap. And yet the effective change remains insignificant.

In Part 3 we saw how bundles of practices order the activities at workplaces as well as in the educational system. In the same way the practice perspective allows us to see organisations as both the site and result of a myriad of work activities (Nicolini 2013). From a typical institutional perspective organisations tend to refer to a body or unit structured and managed for the purpose of pursuing a common goal. Within organisation studies Gherardi (2006) uses the concept of *texture* to break with this idea of 'an organisation' as a distinctive structure produced by rationality. Instead she uses the practice perspective to emphasise the idea of much more dynamic processes of organis*ing*, that is, achieving and reproducing connectedness in action among practitioners, material arrangements, understandings etc.

When the engineering designers perform their *knowing in practice* it is thus done following structures embedded in the organisation: "knowing in practice rests on an interactional infrastructure which, if it holds together, is invisible, taken for granted and unproblematic. [The texture] enables the reproduction of practices as they were previously, or with minor adjustments which do not significantly alter the pattern of activity" (Gherardi 2006, p230). In other words, these *infrastructures* are a significant part of what holds the individual practices together within an organisation.

Infrastructures thus become relevant when looking to understand the dynamics of engineering design practices and efforts of changing these. These structures have to be made visible, opened up and restructured in order for new ideas and initiatives to gain foothold. But how can infrastructures be understood in relation to local practices? What are they made of? What kinds of effects do they have on the local doings? And how does this impact the efforts of changing how engineering is practiced?

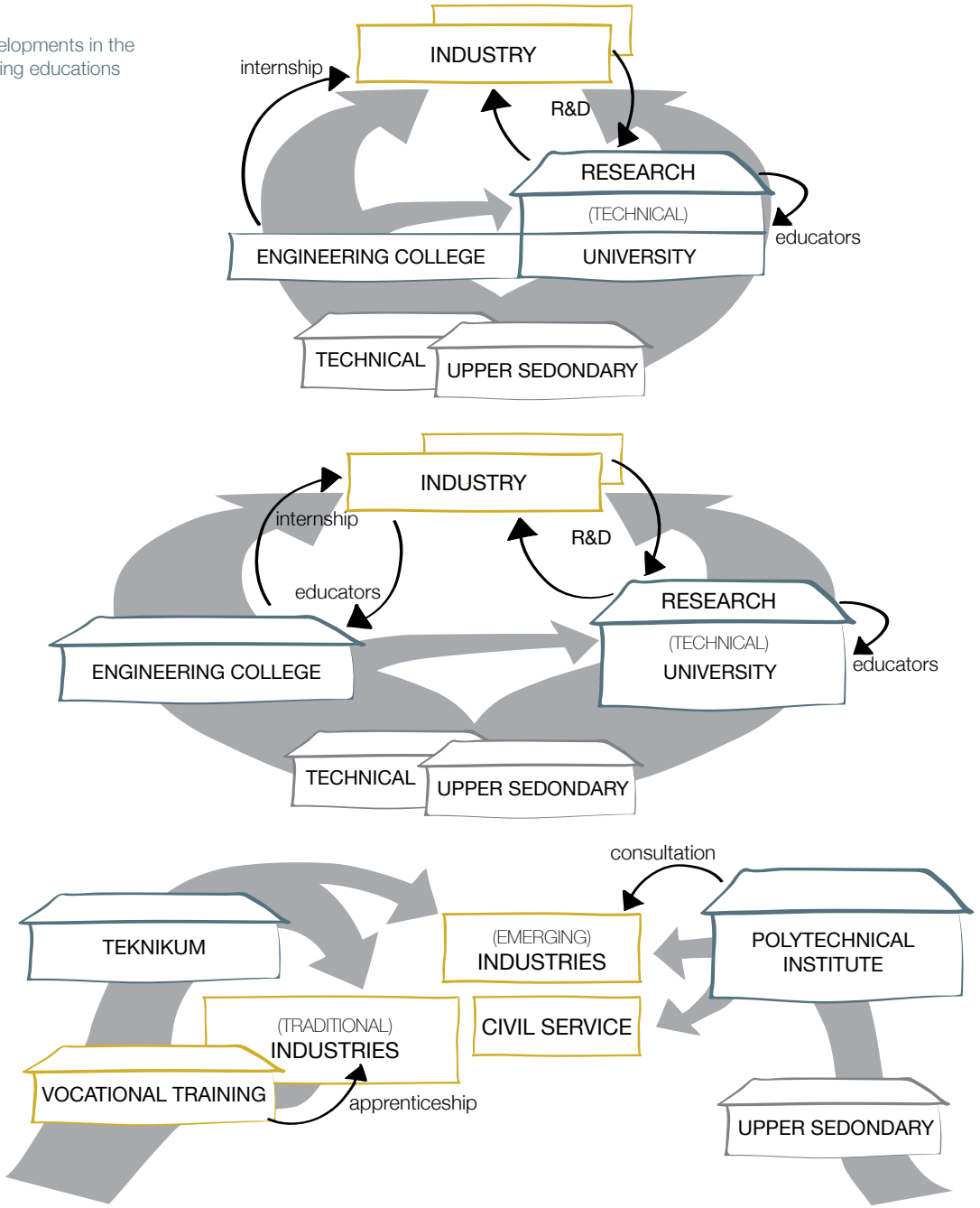
First, however, it is important to recognise that practices are ongoing, and thus also historical constructions. Anything we might recognise as a practice today also comes from somewhere; it has gone through a development making it into what it is today and also indicating what it might be tomorrow. In other words, looking back helps us look forward. So let us first take a brief look at some of the historic changes within the educational sphere that have already affected the way we practice engineering design education today.

DANISH DEVELOPMENTS

While the engineers of today are probably best included under the broad label of 'knowledge workers' then the educational developments reflect the continued tensions between the (scholastic) knowledge and practical skills that continue to characterise the professional engineering practices.

In Denmark our modern engineering educations have roots in two main educational tracks. The first drew on the craft tradition and offered a supplementary degree that could be added to a traditional vocational education (from local apprenticeship or a technical school) such as building constructor or mechanic. In the early to mid 20th century this type of supplementary education was offered at the Danish *Teknika* (comparable to the German *Fachhochschulen*). At these local institutions the educational

FIGURE 96 | Developments in the Danish engineering educations over a decade.



orientation was towards the needs of the local community and (especially mechanical) industries (Christensen, Erno-Kjolhede 2011).

The second track instead drew on the university tradition but also the scholastic developments of polytechnique institutions. In Denmark this initially manifested as the *Polytekniske Læreanstalt* (translates roughly to *Polytechnical Institute*) located in the capital, which recruited directly from the academic upper secondary educations (popular among the middle-class). In an attempt to form a stronger connection between theory and practice the education offered in theoretical natural science was here combined with practical laboratory-based instruction.

Up until the early-mid 20th century it was especially the highly skilled and practically oriented 'teknikum' engineers that contributed to the regional industrialisation, while the moderate number of theoretically trained 'civil' engineers[16] ended up both as civil servants (designing infrastructures) and in emerging new industries (for example electrical and chemical).

By the mid-late 20th century, however, the new industrial landscape and rapidly evolving technologies required much more research collaboration and a firmer scientific base and specialisation in their engineers. At the same time vocational training was no longer as popular among the youth and the number of academic upper secondary schools and programs started growing (now including a special technically oriented version (HTX)). Eventually this led to replacing the Teknika with new engineering colleges awarding non-academic vocationally oriented degrees in 'diplom' engineering. Enrolment at these colleges now also required a degree from an upper secondary school (thus converging the basis of recruitment), however the ambition was to maintain the practical orientation through internships in industry and use of instructors with industrial experience.

In the same period new research laboratories had emerged in connection with the polytechnic college and the civil engineering degrees were turned even more towards the university and research tradition. Research in engineering science and engineering educations were now joined at engineering faculties and dedicated engineering scholars headed the educations. Overall this meant that engineering was now to live up to more *scientific* ideals and *scholastic* approaches.

At the beginning of the 21st century the European initiative to ensure comparability across European degrees (the so-called Bologna process) also resulted in changes in the Danish engineering educations. The engineering colleges now awarded professional bachelor's degrees in engi-

neering (BEng), while the universities offered both distinct bachelor and master of science degrees in engineering (BSc and MSc) as well as research educations for PhDs.

At the same time Danish reform initiatives meant that the remaining engineering colleges were now to merge with other educational institutions. The intention was for these professional colleges to merge with other non-academic professional colleges (educating for example nurses, teachers, and social workers), however the result has been an overwhelming migration into universities around the country. This can be seen as a symptom of what Christensen & Erno-Kjolhede describe as *academic drift* to: "seek what they [the engineering colleges] perceive as better opportunities and higher status for themselves in terms of prestige, institutional progress and development of staff and students to be able to compete in a highly competitive market for engineering labour and higher education" (Christensen, Erno-Kjolhede 2011, p286). University degrees and scientific research, it seems, is thus placed at the top of an implicit hierarchy. One manifestation of this drift has been the engineering *faculty*. Earlier people with practical experience from the industry dominated, whereas research achievements today signify the most sought-after educators. This also implies a change in the teaching practices. While the end remains the same – educating competent engineers – then the *practical understandings* of how to achieve this were previously dominated by 'what works in practice' but is today more dominated by 'what constitutes real engineering science'.

Also internationally engineering education is today largely the domain of universities (technical as well as more traditional) and ambitions are high within engineering sciences. The apparent trade-off has been that learning engineering is now less about *doing* engineering and more about *knowing* engineering (Downey 2006). Natural science dominates the curriculum and more hands-on subjects such as drawing or machining has been excluded to make room for the new science subjects. There are many good reasons for this. Technology has been evolving drastically ever since the industrial revolution, requiring more and more elaborate specialisations and new subject fields. In order to avoid a 'crowded curriculum', sacrifices have been made. And keeping with the academic ideals and scholastic paradigm theoretical knowledge was prioritised over practical skills.

TWO DOMINATING INSTITUTIONS

The two largest Danish engineering education institutions today are the Technical University of Denmark (DTU) and Aalborg University (AAU). As their name implies these are both academic universities, however with different institutional structures and origins.

DTU is considered the oldest engineering education institution in Denmark, dating back to its starts as the Polytechnical Institute (Polyteknisk Læreanstalt) in 1829. At that time it only housed 22 students and 7 educators and was a part of Copenhagen University's Faculty of Philosophy (which was common for the emerging natural and engineering sciences) (Technical University of Denmark 2015). Only later, after expanding as an independent institution, do we hear of different departments devoted to specific fields such as chemistry or product development. In 1957 the Danish Engineering Academy (DIA) was founded as a shorter alternative to the programs offered at the Polytechnical Insitute but under the same management. In 1994 these two institutions merged with one of the Teknika and was upgraded to the status of a technical *university* with a single-faculty structure. Today, after merging with an engineering college, the university houses around 9.000 students distributed amongst more than 30 engineering programs undertaken by 19 departments (Technical University of Denmark 2015).

Compared to this AAU has a much shorter history. In fact it is one of Denmark's youngest universities formed in 1974 by merging several existing educational institutions. The institutional structure resembles the 'classic' university with multiple faculties – The Faculty of Engineering and Science being the largest of four. In 1995 this university also merged with an engineering college and today houses around 8.000 engineering students (Aalborg University 2013). Despite the traditional university model, AAU has distinguished itself through an explicit cross-disciplinary focus in research as well as educational programs, and a problem-based didactic approach has also been an important part of the university's profile from the beginning. Many of AAU's engineering graduates also receive credit from industry for being overall more adapt to entering the occupational sphere.

No doubt that the institutionalisation of Danish engineering education within the academic universities has shifted the profession further towards the academic pole of the area of tension laid out in the Problematisation.

This development, I might add, is not unique for the Danish context but largely paralleled in other western countries. But why is it so hard to (re) introduce other aspects of engineering doing in our modern educations? At AAU a pedagogic premise of PBL (problem-based learning) permeates the curriculum structure and at DTU the professional bachelor's programs have adopted the design-based CDIO (conceive – design – implement – operate) initiative. And yet despite the focus on more practically oriented projects and teamwork there still appears to be this gap between education and occupation. So what is it in these educational structures that restrain our abilities to reflect engineering practices as we find them in the occupational sphere?

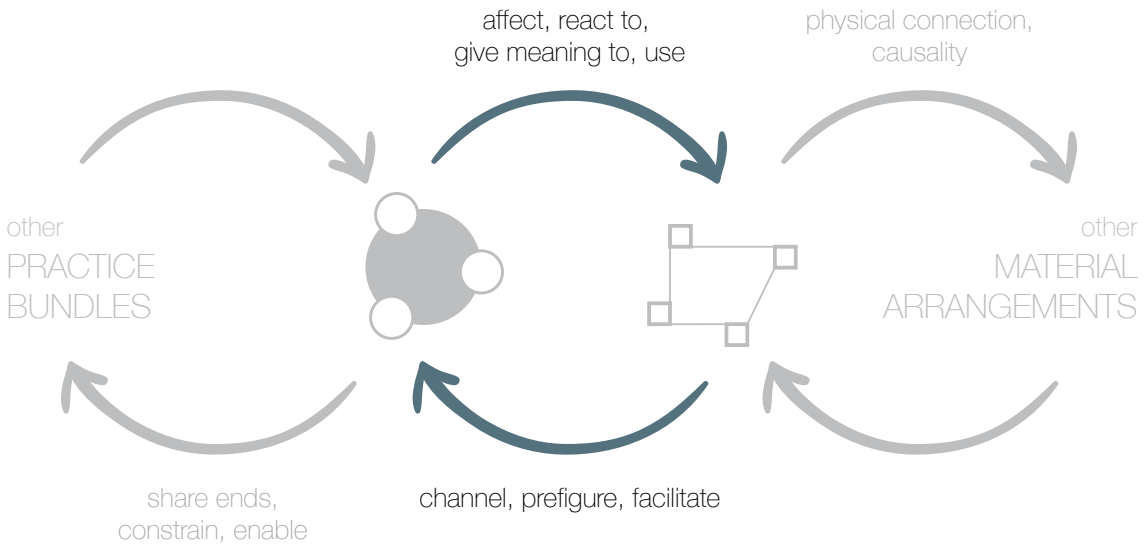
Before trying to answer these questions I will introduce some theoretical concepts that can help us put words to what is at play here.

BUNDLES AND CONSTELLATIONS

In Part 3 I introduced *bundles of practices* and *material arrangements* to help us talk about the material elements that are linked to the unfolding of interconnected practices. Here, I would like to stress how there are also strong relations *across* practices and their arrangements. Not only do practices affect, alter, use, and give meaning to material arrangements, they are also inseparable from these arrangements that in turn channel, prefigure, facilitate, and are essential to practices (Schatzki 2012). Because of this intimate relationship Schatzki suggests the notion of *practice-arrangement bundles* (Schatzki 2011).

One example of a practice-arrangement bundle is the bundle of professional practices we saw at Site 1 related to material arrangements that included meeting rooms, post-its, video equipment, teleconferences, emails, coffee machines, excel sheets etc. Another is the bundle of learning practices at Site 2, which was linked to material arrangements of markers, cameras, drawings, workshops, tools, products, post-its etc.

The totality of practice-material bundles is *the site of the social* (Schatzki 2002). That is, the hanging together of human lives – the way we co-exist and interact – takes place as part of such bundles spread out across the globe and through time. From a practice perspective nothing we do can be seen outside these bundles. But at the same time no individual human is 'trapped' within a single bundle but rather, through his/her existence,



engages in and re-produces a number of these bundles (through participation in practices).

FIGURE 97 | A maze of interconnected practices and arrangements are formed through thickets of relations.

CONSTELLATIONS

Because this part aims to zoom out from the local practices and look at broader relations I will take one step further and also introduce Schatzki's notion of *constellations*. Constellations are in many respects the same as practice-arrangement bundles: They are made up of the same elements and linked by many of the same kinds of relations. This is a consequence of the *flat ontology* that characterises Schatzki's practice perspective (nothing being above other things). The difference thus mainly lies in their size and possibly (though not necessarily) in their complexity (Schatzki 2011).

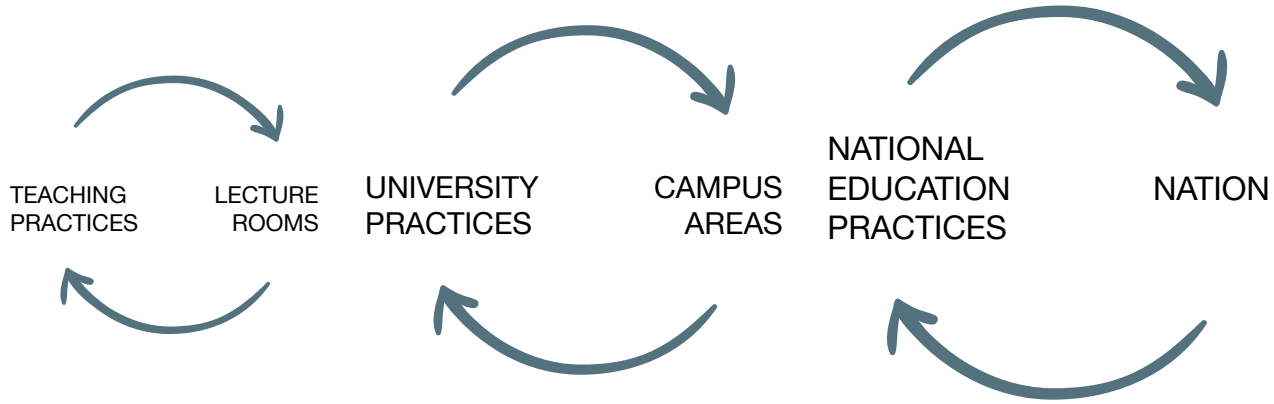
The way I have described first *bundles of practices*, then *material arrangements,* and just now *practice-arrangement bundles* it is hopefully clear that the idea of *relations* permeates all of these. These relations, of varying kind, strength, and density, criss-cross the site of the social. Locating practice-arrangement bundles we have been looking for strong and concentrated thickets of relations with a certain level of continuity. At the same time, though, these bundles will also have thinner and looser relations to other

practices and arrangements (perhaps belonging to other bundles). The same material arrangement may also support several bundles of practices.

Constellations in this sense are just spatially larger bundles growing out of a more spread out network of relations across practice-arrangement bundles, for example when one practice-arrangement bundle is dependent on another – "In the end, all bundles and constellations form one immense plenum of practices and arrangements" (Schatzki 2014, p20). When the UX team is dependent on the work done by other groups of designers in the company such relations form a larger constellation of bundles. Or when the learning practices of engineering students are dependent on the teaching practices of their professors.

A company or a university can thus be seen as a *constellation* of different practice-arrangement bundles related either trough the practices carried out or the material arrangements supporting them. This also means that no practice is 'above' other practices – management for example is not a superior practice but simply another practice more or less directly related to the different practice bundles within an organisation. Zooming out even further, we could also find a constellation in the national educational system including different universities, ministries, book publishers, accreditation systems, prospective students, catalogues, educational fairs and so.

FIGURE 98 | Bundles and constellations are fundamentally the same, just different in size.



CHANGING CONSTELLATIONS

Because constellations are large practice-arrangement bundles these also emerge, persist and dissolve in similar ways to smaller bundles.

EMERGENCE

Emergence is the appearance of new practice bundles amid material arrangements, for example by new *pools of understanding*, *sets of rules*, and *teleoaffective structures* starting to form one or more new practices; by new relations between previously unconnected practices and/or arrangements forming; or by existing practices either splitting up into new ones or merging together (Schatzki 2013, Schatzki 2011). In other words, the emergence of a constellation is the emergence of new combinations of the orderings of practices, material arrangements, and the relations between bundles of practices and these arrangements.

PERSISTENCE

Just as individual practices are dynamically re-produced over time, so are constellations of practices and arrangements. Therefore the persistence of such constellations does not involve a static unchanging state, but rather a state where the changes occurring are limited, cumulative, and occur amid general continuity in the components of the constellation (Schatzki 2013). It is thus a state of stable re-production – not excluding evolution – relating to the same or similar material arrangements.

DISSOLUTION

Contrary to this, constellations will dissolve when large or frequent changes occur to the components, either suddenly or in a more evolutionary manner. For example, if a company moves to a new building then the existing constellation may break apart and a new has to be formed to keep the different parts of the company's activities together.

The notion of bundles and constellations of interlinked practices and arrangements also implies that there are overlapping spaces of collaboration – or at least confrontation – between the different practices. These spaces are particularly interesting when looking to understand changes in practices, for it will often be here – around the edges of practices or tightly knit bundles – that frictions occur and interruptions in the usual ways of doing emerge.

Now Schatzki does not offer too much expansion of what goes on at these sites of intersections, so I shall turn to science and technology studies (STS) for some useful concepts when focussing attention on these.

BOUNDARIES AND INFRASTRUCTURES

If we focus on constellations at the scale of an organisation, then it seems quite clear that these contain groups of people working closely together (participating in closely knit practice-arrangement bundles) while also interacting more or less directly with other such groups of people (engaged in different bundles). But what actually holds it all together?

In Bucciarelli's analysis of engineering design work he points out that:

> *"Turning inward, within the firm a more immediate infrastructure sustains participants' efforts. Organization, informal as well as formal, structures relationships among participants in design. It provides modes of communication and facilitates participants' negotiations; it provides physical resources (tools, work stations, fax machines) and legitimate charge numbers (procedures for accounting and keeping track); and it governs access to the infrastructure outside the firm's four walls and sets the stage for the culmination of design – the "launching" of a new product. Organization is people situated in a formal hierarchy, but it is also grapevines, taboos, and unwritten rules and norms." (Bucciarelli 1994, p140)*

While pointing to these infrastructures Bucciarelli does not offer much reflection on how we might identify them, understand them, and relate them to the practices that they sustain. This 'something' that links together activities of many kinds, that facilitates cooperation, but also organises and puts into place can perhaps best be explored through the notions of *boundaries* and *infrastructures* developed by Star, inspired by a motivation to analyse the nature of cooperative work despite the absence of consensus (Star 2010).[17]

A *boundary* in this context should not be understood as a place demarcating one thing on one side and another on the other side, such as a sharp edge or an official border. Instead it is a shared space where the distinction between here and there is confounded (Star 2010). In the original work of Star the social entities overlapping in this way were framed within the

social worlds/arenas theory (Star 1988, Star, Griesemer 1989) but has since found a strong conceptual ally in the practice theoretical approaches to learning and especially Lave & Wenger's notion of *communities of practice* (see e.g. Star, Ruhleder 1996). Here, however, I frame these social entities as the social orderings made up by practices, material arrangements and bundles of these.

Social worlds, communities of practice and practice-arrangement bundles essentially each in their way grapple to describe organised human activities. Schatzki himself has made this parallel when he compared social art worlds (as laid out by Becker 1982) to constellations of artistic practice-arrangement bundles: "an art world consists of practice-arrangement bundles and constellations thereof," (Schatzki 2014, p22) he posits. While social worlds easily become a collection of individual practitioners then focussing on practice-arrangement bundles instead helps capture how practices and bundles to some extent prefigure the doings of their participants and can induce what they do: "networks of cooperating people subsist within or across particular bundles whose components and organization bear on the actions and interactions these people carry out," (Schatzki 2014, p22) he continues. These networks of cooperating people will be what I refer to as practice-arrangement bundles in the following. This view, however, also points to the boundaries between these bundles as interesting spaces where some sort of mitigation needs to take place in order for the larger constellations to hang together.

In order to account for the way tension between divergent viewpoints may be managed across individual social worlds (practices or bundles) Star & Griesemer (1989) framed the concept of *boundary objects*, which will be introduced next.

BOUNDARY OBJECTS

It is arrangements of *boundary objects* that form the boundary spaces between different practices or bundles. But because of its confounded nature this space also requires a special architecture of flexibility and shared structure (Star 2010).

The same boundary object inhabits several intersecting social entities and 'works' within all of them. It is thus flexible in the sense that it can be interpreted and used differently by different groups of people. This is true

for any kind of object, which is why this alone does not make a boundary object (just because an empty water bottle is a piece of waste to dispose of for some, a source of income to others, and a resource to be reused by yet others does not mean that it necessarily acts as a boundary object between those groups of people). A boundary object can only be developed and maintained as a boundary object through interactions between a range of social entities as they negotiate and co-construct its meaning (Thomas, Hardy & Sargent 2007).

Within each social entity there will be local representations build on the common understandings and meanings connecting the respective bundle of practices. These are typically relatively well-structured and explicit but also difficult to 'read' for people outside the practice bundle, which can obstruct cooperation. In order for several such social entities to cooperate they therefore need to reconcile their representations in some common way that can be related to by all and bridge or overcome perceptual or practical differences. This is what the boundary object does, either as abstract or physical artefacts.

The boundary object thus works across the social entities. In such common and shared use the boundary object is weakly structured, whereas in

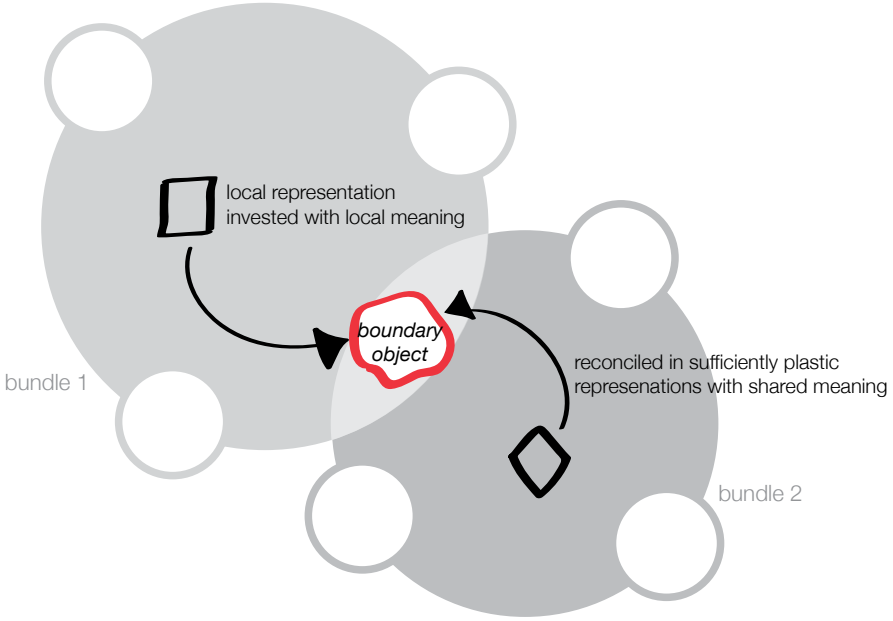


FIGURE 99 | Strongly structured local representations inside individual practices or practice-arrangement bundles are co-constructed into a shared but weakly structured boundary object.

the local use within the individual entities it remains strongly structured and tailored to the local meanings. There is thus a continual dynamic between the ill- and well-structured uses of the boundary object. While the meaning differs in this way the structure of the boundary object (or arrangement) is held common enough across the different social entities to make it recognisable by all participants.

What makes boundary objects a special kind of (conceptual) objects is thus their ability to allow diverse groups of people to work together without an established consensus across the local doings. This helps create coherence across constellations of practice-arrangement bundles and helps maintain the relations holding them together – but it also means that the boundary objects are constantly riven with tension and ambiguity (Thomas, Hardy & Sargent 2007).

Some of these objects are naturalised in more than one social entity over time. They are not then boundary objects, but rather they become *standards* within and across the multiple entities in which they are naturalised (Star, Bowker 1999). "When the movement between the two forms [weakly structured and strongly structured] either scales up or becomes standardized, then boundary objects begin to move and change into infrastructure, into standards (particularly methodological standards)" (Star 2010, p605). Standards are, in other words, an attempt to make the weakly structured boundary object equivalent to the strongly structured local representation.

INFRASTRUCTURES

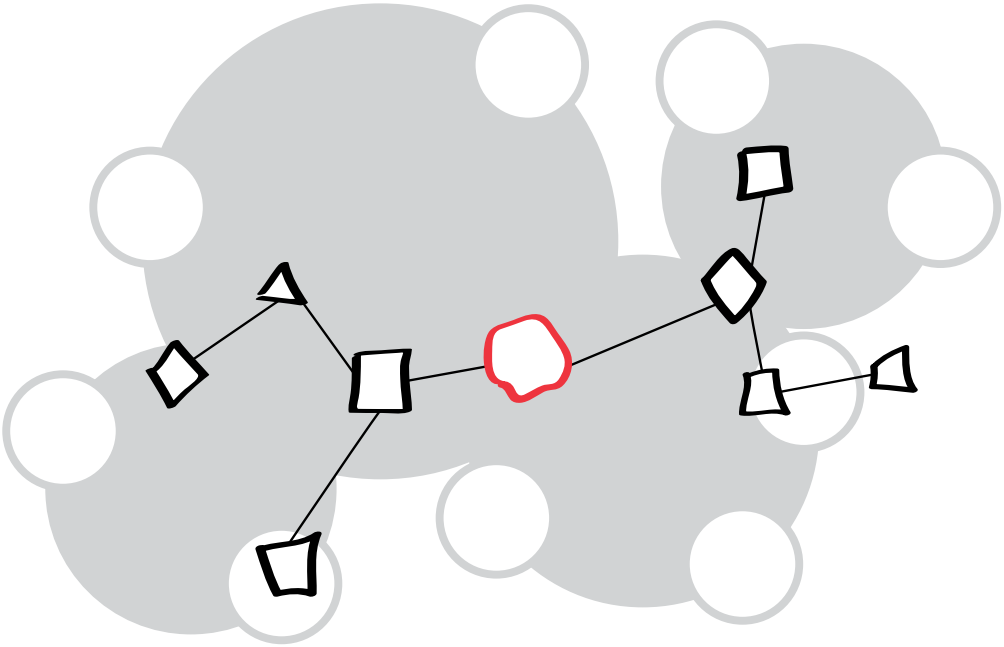
When a whole system or regime of boundary objects starts to stabilise in this way you can begin to talk of an *infrastructure* (though necessarily in an organic sense). Typically, when several groups of people have to work together or cooperate somehow, there is a need for the flexibility of their interaction to stabilise and become less plastic in order for it to work in longer timespans. The arrangements of boundary objects thus tend to solidify to some extend: A common language emerges (for example a corporate language shared among departments working with otherwise completely different things – that is, not sharing practices) and common structures (for example intranet platforms or organisational hierarchies) are formed. These infrastructures thus facilitate doing things together

across diverse groups of people, be these within a single organisation or distributed across multiple organisations.

"Infrastructures can be understood, in a sense, as frozen discourses that form avenues between social worlds and into arenas and larger structures" (Clarke, Star 2008, p115). Or in other words infrastructures connect and stabilise practice-arrangement bundles into larger constellations. Under normal circumstances these infrastructures will fade into the background or sink into the practice-arrangement bundles, more or less frozen in place – but nevertheless implicitly governing the actions that take place through them. Star & Bowker put it this way:

> *"Boundary infrastructures by and large do the work that is required to keep things moving along. Because they deal in regimes and networks of boundary objects (and not of unitary, well-defined objects), boundary infrastructures have sufficient play to allow for local variation together with sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics, and so forth) to be applied. Even the most regimented infrastructure is ineluctably also local: if work-arounds are needed, they will be put into place." (Star, Bowker 1999)*

FIGURE 100 | Infrastructure build of networks of boundary objects across many practice-arrangement bundles.



Boundary objects are thus an essential part of a dynamic process in which changes in social infrastructures and identities in one group of people cascade into bordering groups through the use of these mutual objects (Gal, Yoo & Boland 2004, p196).

Infrastructures are necessarily built over time, but also endure over long stretches of time. Cascades of interdependencies thus add up across bundles, making them hard to change. Infrastructures can in this respect act as hindrances that constrain the array of possible (new) doings and preserve the existing. Regimes of standards are an obvious example of this. While they are translated into the local doings of different communities they also keep these doings locked-in to a certain extend. As Star puts it: "Because infrastructure is big, layered, and complex, and because it means different things locally, it is never changed from above. Changes take time and negotiation and adjustment with other aspects of the systems involved" (Star 2010, p611). Infrastructural changes, then, are not something that can happen independently of the larger constellation.

Even so, change does happen: "The installed base of a particular infrastructure carries huge inertia. And yet infrastructures do change over time, sometimes transforming remarkably rapidly, sometimes apparently discontinuously" (Star, Bowker 2006, p18). When change does occur in one part of the infrastructure this will carry over to the rest, thus spreading across the constellation of practice-arrangement bundles.

CHANGING PRACTICE

No doubt the engineering profession and associated educations have changed significantly over the years. Vast technological developments and an increasing pressure to develop engineering sciences have led to not only an explosion in engineering fields but also an increasing specialisation and separation between these fields. We now have bio-engineers and nano-engineers for example with little in common with the more traditional civil engineers and mechanical engineers. Some would even challenge the meaningfulness of the engineering label to unite all of these fields (e.g. Williams 2002).

This part of the thesis is devoted to develop a better understanding of what is involved in the developments of working with engineering design and educating new engineering designers. Doing engineering today is a

far cry from the doings of craftsmen, and learning engineering has also significantly changed from apprenticeship to academic graduate. But these changes have not occurred solely as an effort to improve and perfect how engineering is done, they are also reactions to developments in the surrounding society and emerging discourses.

With the concepts of *constellations* of practice-arrangement bundles and *infrastructures* we can now move on to take a closer look at the relations that reach beyond the local practices and impact how these are able to evolve. This helps us better understand how the educational and occupational spheres relate to each other and what it is that the efforts of change are up against and shaped by.

4 | 2 ORGANISATIONAL RESTRUCTURING

strategic meddling

In this chapter I will take my point of departure in what I will be referring to as *Site 3* and the efforts related to initiate a more user-centred focus in Volvo's R&D work. Using excerpts from my empirical material and drawing links back to Site 1 I will discuss how the idea of *experience design* is translated into the workings of a traditional organisation.

INTRODUCTION OF SITE 3

In Part 3 we already visited Volvo's UX centre at Site 1. We might see this centre as the home of a closely-knit *practice-arrangement bundle* revolving around experience design. In other words, the people we find here all in some way work towards a common end of improving the user experience of Volvo's cars, which distinguishes them from the rest of the R&D organisation (where the focus is more technically and functionally aimed, although – as we shall see – 'the user' also has a role to play in other parts of the organisation).

The majority of Volvo's R&D work takes place at the main office in Gothenburg. Here we also find the Design department working with the overall shape and expression of the cars, while the different engineering departments in R&D work with each their sub-system of the cars, and the Marketing department works with selling points and customer segments for the individual cars and clusters. With the UX centre there has been a new addition to this organisational setup. However, the UX centre is not a department at the same level as the others mentioned above. There were some initial issues regarding where to place such a group of people in the organisation given that experience design was such a new territory for the otherwise technology-driven car company. Organisationally the centre has

thus for now been placed as part of the *Digital User Experience Attribute Centre*, which deals with the software related interaction and HMI (human-machine-interfaces) inside the car. More specifically, the management has defined the UX centre's work to focus on the digital interfaces of the cars. However, the head of the UX centre clearly indicates that they would like to work with the car as a *whole* in time. Actually, when I first started my field visits the attribute centre was called the *HMI & Infotainment Attribute Centre*. The change in name thus hints at the effect the inclusion of the UX centre has already had on the way the work performed here is perceived.

The UX experts thus appear to also share an ambition reaching beyond the work they are currently invested in concerned with the digital interfaces. Within the UX centre there can be traced a commitment to work towards a broader implementation of their design approaches in the rest of the organisation. This idea of changing (or at least influencing) the design practices in Volvo is what the following discussion will revolve around.

Though obviously strongly overlapping Site 1 and 3 are thus distinguished by their span and composition. At Site 1 I was interested in the internal practices of the UX designers, though these were connected in bundles reaching beyond the physical UX office. Planning the workshop in Episode 6 we thus heard how the UX team were interacting with several other departments and attempting to navigate the practice-bundles represented there. They worked to translate their local understandings depicted on the journey wall into a more common and shareable reference, which is part of their more long-term ambition of influencing the way the design work is done or prioritised at Volvo. However both here and in Episode 7, where they were trying to find funding for those of their activities which fell outside the dominating stage-gate structure, they encounter some structures that appear to lie outside or in-between the local practice-bundles. Here at Site 3 I am thus interested in the organisational navigation across the Volvo organisation. I have only had access to this work through the UX centre's activities, however with the change of focus in this part it is nevertheless possible to start unwinding some of the issues at stake at the more organisational level.

THE PRACTICE CARRIERS

The second designer I shadowed during my visits at the UX centre is Sebastian[18]. He holds a MA in film and media studies from Copenhagen

University and used to work at Nokia just like Jonathan. When I started my visits he was just finishing a project, which he had been project leader on and was starting working on another project. Ella is heading this project and has been doing the initial legwork. She is closely linked to the many organisational initiatives that take place in Gothenburg and thus travels back and forth a lot. Her educational background is a degree from the business school, which adds to the multi-disciplinarity of the centre.

Apart from Sebastian and Ella the team also includes Tristan and Lucas; an interaction designer from the IT university and a design engineer from the Architecture and Design program at AAU.

A STRATEGIC PROJECT

The current project is internally referred to as *the umbrella project*, seemingly because it is made up of several components – for example one part concerns developing a kind of toolbox with UX inspired methods that other parts of the R&D organisation can use, while Sebastian is in charge of coming up with a process for picking up so-called *seed* ideas and initiate new projects based on these. In-between contributing to other parts of the umbrella project Sebastian thus works primarily alone on the seed sub-project.

EMPIRICAL APPROACHES

In parallel to the fieldwork presented as Site 1 I also followed the work of Sebastian and all of his activities through participant observations for half a day at a time during 5 visits. Because most of Sebastian's work took place by himself in front of his computer he himself took steps to start explaining to me what he was doing, also at times making small drawings to illustrate what he was working on. When possible I included these informal conversations and sketches in my field notes (some of these are re-presented in the following). My field note technique developed in parallel with what was explained at Site 1, but while I still focussed on the local interactions my interest here was also try to find traces of the underlying understandings and structures that was influencing the local doings that I could observe directly. Because of this difference in focus I did not take as many photos at this site though I have included a few in the following

episodes – if nothing else then to illustrate the difference of these more strategic activities from the design activities we saw at Site 1.

Before starting the observations I conducted a semi-structured with Sebastian to get a sense of his professional background and view of the UX centre's role in Volvo. I had also planned to do a follow-up interview later on, but because of the ongoing informal talks we had during my field visits I was able to build a sufficient understanding of the meanings and ideas guiding the work along the way.

The following episodes have been selected to illustrate some of the different ways that ideas of changing the bundle of design practices manifests themselves in the local doings and understandings.

EPISODE 1 | modelling alignment

Returning to his desk Sebastian allows himself some time to look at the material Ella has sent out to the team in order to prepare for the meeting they will have later that day. The first attachment is a power point full of process models: One illustrates an interaction design process; another is a model of a user-centred design process adapted from an ISO standard. Sebastian's first step is to do a quick search on the web for this ISO standard, which he does not know off-hand. He quickly finds a webpage where a similar model is shown and notes that it is a standard from 1999.

One of the slides also contains a model of a more traditional linear stage-gate process overlaid with the steps in a user-centred approach. He continues going through the slides, trying to form an understanding of the material. After a while he decides to look for a presentation from an introduction course, which he attended when starting at Volvo – he explains that he remembers seeing a model in these slides, but does not recall the exact phases represented in it. Quickly scanning through this new power point he finds the model that he is looking for: He remembers its distinct V-shape. Looking at this model again there are a few things he did not realise at the time, which now seems to help him understand the new models. He returns to the user-centred model where four primary boxes are connected in a circular movement. The model is represented on three different slides, each with a different heading and minor changes in the different boxes. He switches back and forth between these three slides for a while before moving on to the second power point attached to the mail.

After lunch the entire team meets up in one of the meeting rooms. Since Ella has called for this meeting she is the one to introduce the topic: She just

wants to keep the others in the loop on the processes she is involved in in Gothenburg. She explains that at the meetings she has been attending these past weeks they are mainly discussing processes and what she calls "hot topics". Sebastian asks who "we" are, and she explains that she takes part in a series of meetings with representatives from several departments (Ella being the only one to participate from the UX centre). These meetings have arisen after something she refers to as "the crisis workshop" that HR facilitated for the Infotainment department earlier in the year. Apparently many of the employees had expressed a lack of motivation in their work and so the process they are all now engaged in is part of making a better work environment throughout the organisation by making it more clear who does what.

Ella now turns to the first power point that she sent out. The starting point is a description of the interaction design process. She also shows the more formal "back end process" displaying the many gates that Volvo typically operates with. But there are differences in the way the different departments work. Ella explains that in her experience the Design department works with much iteration in their work, whereas the Software department works more according to "the waterfall model". All the slides contain an abundance of abbreviations, which decouples me from most of the conversation, but Sebastian, Lucas and Tristan seem to be following most of it. When in doubt, they simply interrupt Ella to ask.

Then Ella skips forward to show the ISO standard model of user-centred design. She openly wonders why "the Gothenburg group" has chosen this

FIGURE 101 | The UX team discussing the emerging new model from the meetings in Gothenburg.

as their starting point for developing a new model, but "it is supposed to be iterative". Sebastian is now able to provide a bit of information about the ISO standard based on his preparations before lunch. He explains to the others that it is a standard from 1999 and that its stages match pretty well with what is represented on the slide: There are four overall boxes with "understand", "define", "design", and then finally some "evaluation".

The three different versions of the model that had confused Sebastian earlier are supposed to illustrate one iterative cycle each, Ella explains, starting with "pre-concepting", "concepting" and then "implementation". What they have been working on at the meetings is to agree on the different aspects listed under each of the boxes (such as who provides what kind of input when) in the different iterations. But that has been – and still is – a long process.

Staying with these three slides for a while, Lucas inquires about the terminology – he has noticed that "UX" is mentioned quite a few times on the slides, "but do we all agree what UX is?" he wonders. Apparently the rest of the Volvo organisation has adopted the UX concept perhaps a bit too eagerly, Ella agrees, and now people tend to put it on "everything". She has been aware of this in her dialogue with the rest of the group in Gothenburg and so a bit of it has been cleaned up now and returned back to the original "UI" (user interaction) concept.

Other things that are indicated in the models are a type of hand-overs labelled "FDR" and "SDR". The team briefly discuss what these actually are, how they are used, and what they know about how the other departments operate. The first type of hand-over seemingly describes *functional* requirements, which are at a high level and mostly used internally in departments by the function owner.[19] The second describes *system level* requirements, which are more detailed and the ones that are actually passed on between departments. Lucas believes that the designers use these SDRs to know what to work on.

Overall, Ella seems a bit sceptical of the models that are appearing from the process – "where is the agile?" she asks. According to her, the person who is effectively leading their process does not think in terms of agile processes and "sprints" like they do at the UX centre. Sebastian then asks if there is anything in the models preventing an agile approach? Tristan also wonders about the temporal aspects in the models – the labels given to the three cycles of iteration seem to him to indicate a gate-to-gate focus (which can span several months), "but the agile elements are more at a biweekly interval," he points out. This again leads them back to the requirements used in the design work: Sebastian points out that these should be stabile and not change

every week, but at the same time the departments must be able to handle if/when they do change.

Finally they return to their own role in the process as laid out in the diagrams. They are a bit worried that the UX centre might come off as wanting to take over the design process from the other departmetns. But in Sebastian's mind it is the different types of designer's job to prioritize within the specific functions they are in charge of – part of their competences are based on their professional judgement (faglige dømmekraft), as he puts it. Tristan exemplifies this with the designers in charge of the user interfaces (UI): In his mind they have an artistic understanding of how things are connected and they should use this to be "design-critical" when evaluating why certain functionalities of the interfaces are not used. So at this meeting they all agree that the UX teams should not be in charge of *making* the design decisions, but rather *facilitate* the process of making these decisions. As Lucas puts it: The design process should not be democratised, but rather the designers should be empowered and their professionalism (faglighed) not "washed out".

The team's discussions have brought them to the end of the allocated time this afternoon and the meeting breaks up. It is now time to work individually for a while.

HOW THE ORGANISATION WORKS

This episode depicts just one of the meetings that made up the activities involved in the umbrella project. But from this condensed excerpt we get a sense of the complex infrastructures within the organisation, which the UX experts (and all of the other Volvo employees) have to navigate as part of their work.

The central process, which the umbrella project is linked to, basically has to do with the work environment within the R&D organisation, but also extending to the Design department. Some time before this episode there has apparently been what Gherardi (2006) would call a *breakdown* in the organisational texture (or *infrastructure*) when a group of employees in the Infotainment department had expressed a lack of motivation in their work to the HR department. Motivation is closely linked to the *teleoaffective structures* that bring purpose to the doings and sayings you are engaged in. When this fades the ordering of the practices are disturbed and the relations between the different practice-arrangement bundles starts to be

challenged. When such breakdowns occur the otherwise largely invisible and unproblematic infrastructures linking an organisation together (both internally and externally) becomes visible and problematic in a new way.

The ambition at the series of meetings in Gothenburg is to make the organisational roles and responsibilities more clear-cut and transparent by providing the employees with a better understanding of what other departments are doing and how their work relates to that. Ella is participating in these meetings along with representatives from the other departments. The power point slides that she is showing to the rest of the team in this episode represent the work that is being done at these meetings.

At this point still being relatively new to the Volvo organisation it is clear that the UX experts are struggling to piece together an understanding of the workings, priorities, and frustrations of the other departments. What they do seem to agree on (having been confronted with its 'shadow' on several occasions) is that stage-gate understandings runs through the organisation. At the same time they also recognise that the local doings within the different departments (including the UX centre) are guided by different *practical understandings* of how to best organise the work (more or less explicitly related to the stage-gate structure). In their dialogue they inadvertently start to express certain 'categories' of different designers in the organisation in order to talk of the roles and responsibilities that are embedded in the process model.

At Site 1 we heard Jonathan's frustrations related to figuring out the timing of their work in relation the other departments. He pointed out that: "I think the problem is that we don't have the daily contact with these people and talk by the coffee machine. And I suppose most have a tendency to focus on what is urgent here and now instead of what might be important in the long run. So I think we often come up with things that are not here-and-now and then there's not really any energy to respond to it." Jonathan also explained that they were unsure how the 'gates' actually worked in practice – when and how they take place and how to prepare for them in order to ensure a successful response (see Episode 6 at Site 1).

TRANSLATIONS ACROSS BUNDLES

It seems reasonable to frame the UX centre as a tightly connected bundle of practice-arrangements distinct from the doings taking place in other parts of Volvo - partly because of their geographical isolation but also

because of their specific professional orientation towards user experience and close local interaction. We might assume that the other departments or sub-departments can be similarly framed as practice-arrangement bundles oriented towards common ends and engaged in common doings and sayings. Not saying that we would not find people participating peripherally across such bundles or people organisationally placed within one department but actually relating more to the doings of another. That, however, is not the point of interest here.

Framing the different departments as practice-arrangement bundles we are now able to see how the stage-gate model, in all of its interpretive flexibility, acts as a boundary object between these bundles. Where their doings overlap they all have to relate to the official gates that coordinate their work and relate to the deliverables that are exchanged between the departments. When a shared meaning of what these gates and deliverables entail (however loosely and fragile) is performed in the parallel processes across the organisation the infrastructure persists unchallenged. At the

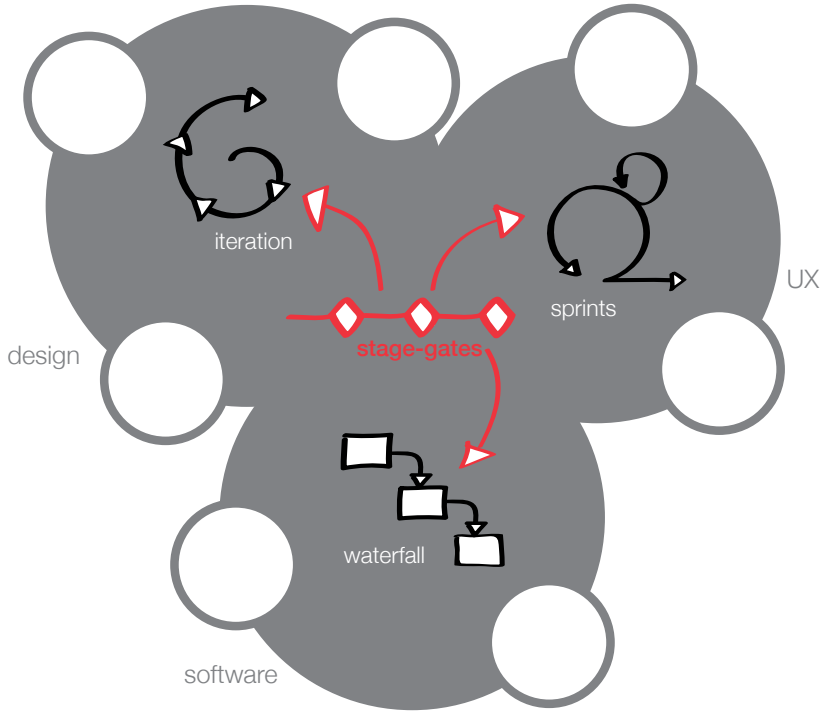


FIGURE 102 | Though the stage-gate model is the official spine of the organisation it is tailored to the local bundles found around the organisation.

same time they are able to tailor their own representations locally, within the individual departments, in ways that better support the local *pools of understandings*, that is, what and how they are used to do and say. For the UX experts, for example, working in an agile manner through sprints is how they usually organise their work, while Ella's impression is that the designers in the Design department work with great iteration and the software developers are used to a more sequential approach like the waterfall model. Based on the *pools of understanding* that are embedded in the local bundles of practices the UX experts are in this way able to recognise activities that fall outside their own practices.

Now, the stage-gate model is neither new to the organisation nor independent of other boundary objects holding the organisation together. It necessarily links to for example budg*et all*ocations, project selection criteria, supplier contracts, job descriptions, and industry standards. A cascade of interdependencies is thus build through time, which forms an infrastructure of these stabilised boundary objects and keeping the organisation in place.

At the same time infrastructures are also always being challenged. Adjustments and work-arounds have to be put into place in order to translate the structures into the local conditions, just like the individual boundary objects are tailored to suit the local doings and sayings. There is thus a continued tension between the local doings and the more global (or in this case simply organisational) structures. Most of the time these tensions are resolved or overcome, but at times a more dedicated effort is needed. The "crisis workshop" mentioned in this episode indicates that this is such a time within the R&D organisation.

Re-negotiating and changing the established stage-gate model structure disrupts the established ways of cooperating in the absence of local consensus that has hitherto existed between the different groups in the R&D organisation. It thus opens new debates about the models acting as boundary objects across the organisation. Since the group of UX experts has never been part of negotiating that consensus in the first place this appears as an interesting opportunity for the UX centre to push the general understanding towards a more user-centred focus. In the opening interview Sebastian commented: "It is a big old colossus we are trying to develop – But on the other hand we get to be a bit special and position ourselves as distinctive, which is also quite fun." Apparently they share the ambition of changing the organisation with other groups. The existing

infrastructures have already been made plastic (to some extend) and the UX team is seizing that opportunity to put their mark on the emerging new structures.

ADAPTING A STANDARD

The point of departure for the new model that is being developed is an ISO standard on human-centred design. An ISO standard is a part of another vast infrastructure extending far beyond individual organisations. Standards such as this provide common points of reference, but in order for the ISO standard to provide any kind of value to the R&D work at Volvo it has to be tailored to the local meanings and structures found here. This is what Ella and the other representatives are trying to do at the meetings.

The ISO standard defines 5 'steps' placed in a circular connection. The first step, entering the circle is to plan the process; the second step is to specify the context of use; then the third step is to specify requirements from both organisation and user; in the fourth step design solutions are produced; and in the fifth step these are evaluated against the requirements. Steps 2-5 can then be iterated until a final result is achieved.

The preliminary result of translating this iterative model into a Volvo version presented by Ella in this episode suggests, however, that they are not completely free of the stage-gate model. Like Tristan points out, the new emerging model still bears resemblance to the known stages that are structuring the R&D work today: Pre-concepting, concepting, and im-

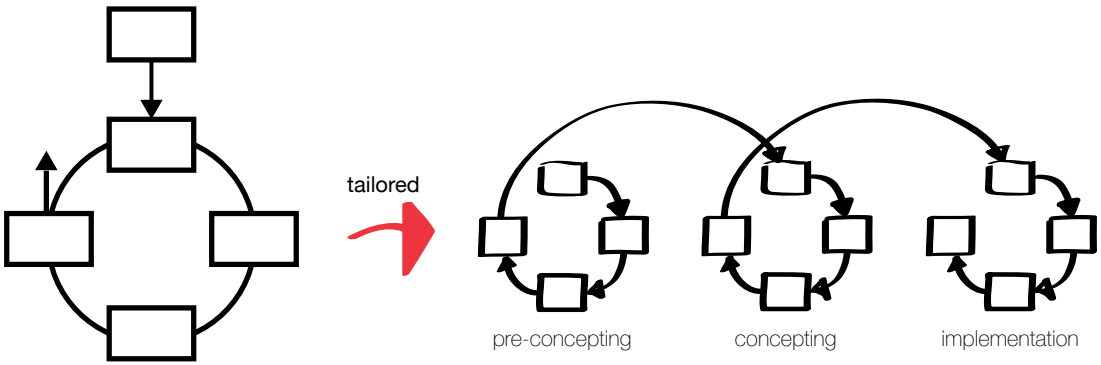


FIGURE 103 | The ISO standard is being tailored to the Volvo organisation through the meeting series.

plementation. This, however, is not surprising if you consider the vast infrastructure linked to these ideas of structuring and dividing the work. Truly abandoning the sequential structure for an agile approach would require vast changes in the ways department budgets are managed, projects are initiated or closed down, how and when suppliers are included in the work, how the management structure is organised, how and when industry standards are handled in the work and so on. In other words, not something a couple of meetings between a selection of department representatives can begin to change.

Despite the UX team's apparent reservations about the emerging new model it is also worth noting Sebastian's interjection that there is nothing in the model *preventing* them from continuing to work in an agile manner. In other words, it is still plastic enough for them to form a local representation suiting their practice-arrangement bundle. As Sapsed & Salter put it boundary objects are in this sense "empty vessels to be filled with whatever is the preferred local beverage" (Sapsed, Salter 2004, p1519).

FIGURE 104 | Mapping and discussing elements in the toolbox.

EPISODE 2 | assembling a box of tools

Last week the team facilitated a workshop in Gothenburg. About 15-20 stakeholders from two other departments in R&D participated. The UX team had been quite taken aback by the fact that they had been met by an open interest to more or less start implementing user-focused tools straight away. Now the team is therefore faced with the challenge of making these things concrete quite quickly in order to proceed.

To continue their work on the workshop input Sebastian, Tristan and Lucas agree to meet in the big meeting room. A big mobile whiteboard has been divided into columns with headings deduced from the team's notes. Each denotes a specific aspect of user-involvement. The first columns ("Journey -> User stories" and "UI guidelines") have been filled with post-it notes during Sebastian and Tristan's work yesterday. Joined by Lucas they now move on to attack the two last columns ("UX/UB going agile" and "Design spikes").

Their discussion starts out quite broadly, diving into some of the aspects mentioned by the participants at the workshop. There are quite a few indications that the different departments have already tried some user-inspired approaches, but also that for some reason it has not been very successful.

Sebastian believes it is a problem that their colleagues in Volvo seem to perceive the various forms of user testing as "valid research methods" – meaning that they expect a grand setup and more quantitative results. Whereas the UX team's view is that even small, more informal interactions with the users can aid the designers in their work. Lucas agrees that the prevailing understanding of "user tests" in Volvo seems to be different than the one he would like them to promote: That these tests can be used not only for validation (towards the end of the design process) but also as actual design tools (guiding the process from the beginning) that will strengthen you as a designer. Since there seems to be a clash of understanding regarding this topic he wonders if they should try and call it something differently in their toolbox?

A recurring theme of the conversation is their discussions on how the other departments or teams at Volvo actually work. Being new to the organisation they have still only had limited interactions with the other departments. They each contribute with pieces of information on what they have experienced or heard from different places in the organisation, trying to slowly form a more cohesive picture. Their challenge is how the UX centre's input actually fits into the other work that goes on. They are constantly wary at stepping on toes around the organisation. Their organisational location may not comply 100% with their own ambitions, but at the same time they are aware that other departments are also allocated their share of the design

process, which could lead to frictions that they are not interested in. And so the meeting participants agree that it is quite crucial for them to recruit people – "ambassadors" – from especially the Design department and the Interaction Design department: They should want the UX team's input via the UX toolbox, but also be willing to allocate time and resources for its use.

On the whiteboard several of the post-its refer directly or indirectly to prototypes. But now Tristan raises the question: Do the different departments even make prototypes that can be tested on users? None of them are sure, but Lucas points out that even "low-fi" prototypes can be used to a large extend. In Tristan's opinion, though, all the things that the Design department produce are very "picture perfect" – every last pixel should look right before they start testing. To avoid this clash of interests he suggests that they separate the user experience tests and the usability tests. Sebastian on the other hand points out that when you already have users doing the usability test you may as well also ask about the user experience. While going back and forth, Tristan is noting down new ideas on post-its, handing them over to Lucas who is closer to the whiteboard and can place them in the relevant column without stopping the on-going discussion.

At the end of their meeting they move on to the column labelled "Design spikes". Tristan starts by reading a bit from his notes from the workshop. The spikes have something to do with handling the unforeseen in the design process. But the three team members are quickly slowed down by their lack of insight into how the other units actually organise their work: "Do they work in sprints?" Sebastian asks and Tristan continues, "are there time-outs in their process to pick up on problematic points, look at the larger picture, adjust the direction of the design?"

In their view, the design spikes are supposed to be a way to become more proactive rather than reactive when it comes to unforeseen issues – and therefore it is very much linked to planning. Sebastian points out that it would make sense to link such planning activities with the other tools they are discussing – such as a so-called "journey review" across departments, which would most likely spur some unforeseen issues. Planning a design spike in relation to such a review would thus make the process more proactive. But Sebastian also points out that it might be a challenge to introduce if the units are understaffed, therefore it needs to be introduced at a high management level – it is too easy for middle management to say no. The design spikes thus touch on a slightly different level than the other tools, which the team is not quite ready to attack at this point. Instead they agree to wrap up this meeting.

USER FOCUSSED

In this episode the UX designers are working on one of the tasks included in the umbrella project: Developing a collection of UX inspired tools or methods to use in the design work that goes on across the R&D organisation and into the Design department. In compliance with how they would approach any other design task the team has included the future users of these tools in the development process by first of all inviting them to participate in a workshop. Later on they will also be involved when moving forward with some more specific tools.

I have not had the opportunity to observe how the UX team arrived at the different categories of tools that are represented on the whiteboard when I join the process. Clearly these have been discussed an agreed on at a previous point, which now leaves the process of synthesising them into something more concrete.

The team had not beforehand expected to be met by a positive interest from their colleagues. But maybe that is not so surprising after all. In Episode 1 we already heard that 'the user' is not new to the other designers working in R&D. Within the field of HMI, for example, there is already a user *interacting* with machines. So what is it that the UX designers want to change? Most notably it is how the user is understood and brought into the design process. They have experienced that even though words or terms are recurring across the bundles of practices they do not necessarily imply a shared meaning and use. For example the idea of doing 'user tests' implies at least one other interpretation than the one the UX designers use.

SHARING A USER

The notion of *user experience* is very central to the shared *teleoaffective structures* and *pools of understandings* found across the bundles of practice-arrangements at the UX centre. All of the UX designers essentially share an ambition of making this emotional interaction with a product (in this case a car) the common design object across the R&D organisation (with room for local translations into more technical objects, but maintaining the user's positive emotional experience as the ultimate goal of the design work). At Site 1 we saw this reflected in how natural it is for the UX designers to

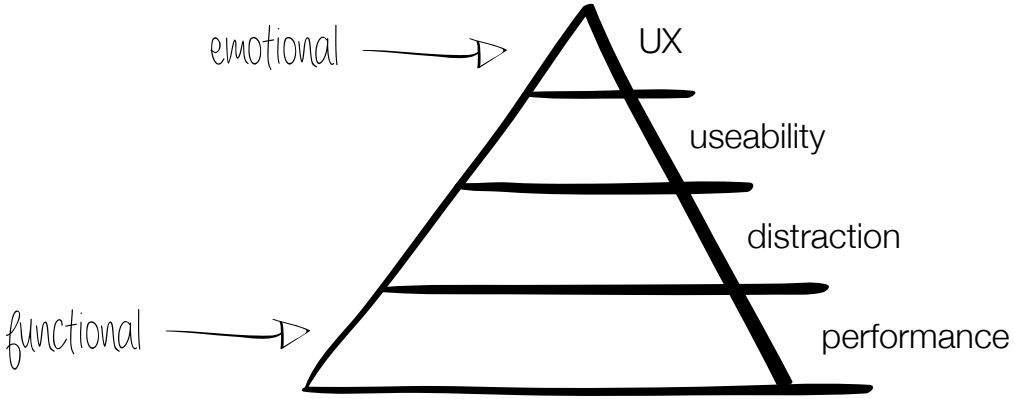


FIGURE 105 | The pyramid model placing the emotional user experience at the top of a foundation based on functional performance, elimination of unnecessary distraction, and basic usability.

focus not on the car itself but on the different situations occurring during an otherwise trivial journey such as commuting to and from work.

So while the UX team appreciates that the other departments apparently share their interest in the user they are also concerned that their UX perspective will be diluted by a quick uptake of the term across the organisation. To explain to me how they position their work Sebastian draws a triangle with assigned labels. This is a reference to 'the pyramid model' that the UX centre has introduced in order to communicate their work within the organisation.

At the base of this pyramid we find a *performance* layer, which everything else is resting on. This is where technical aspects are defined and tested for basic functionality. The next layer deals with *distraction*. Sebastian stresses how important this is in car-design as opposed to mobile-design: None of the things they design for the digital interfaces are in fact meant to be in the centre of attention for the driver, who instead must keep his/her attention on the traffic. When these two aspects are satisfactory one can look at the next layer of *usability*, which quite traditionally deals with the ease of use (so this is where *user interaction* comes into the picture). Then at the very top of the pyramid we find the *user experience* layer, which clearly is where this centre's focus is directed. Here it is the *emotional* experience of driving that is key – but, as Sebastian stresses, this can only be manipulated and enhanced if the below layers are performing well.

The user thus has a role to play from top to bottom in this pyramid, but in fact in quite different interpretations. In this respect the notion of the user also acts as a kind of boundary object giving a sense of unity to

different practice-arrangement bundles (a joined project of satisfying the user), however also translated into the local *pools of understandings* of how to go about achieving this. At the UX centre, for example, the user is a source of inspiration, insights into user practices, and even to some extend ideas for new designs. This kind of information is collected through qualitative approaches like we saw a glimpse of at Site 1. Contrary to this, there are communities of designers within R&D framing the user more like a source of validation, a test-person who either approves or disapproves of a certain design solution. This kind of information is typically collected through more large-scale quantitative setups. In both cases, however, the user will typically be delimited to the driver of the car.

You also get the sense that there are yet other practice bundles translating the user into an abstract body removed from social orders and other material arrangements. This translation leaves standards and tables defining normalised bodily measurements and ergonomic positions to be applied in the functional design. Finally, we might also mention how the marketing department translates the user into a *customer*. Any relevant information is thus collected through qualitative marketing surveys of various kinds.

While this is a pretty crude characterisation due to the limited access of my field visits, it nevertheless gives us a glimpse of yet another infrastructure running through the organisation. This one related to survey protocols, sales projections, scoring charts, test drivers, industry standards and so on. But it also links up to the organisational models and distribution of roles that was discussed in Episode 1. Validation and tests, for example, are typically associated with the end of a sequential model (though it could be otherwise) while participation at a small informal scale is more comfortably linked with an early iteration cycle.

Creating a new collection of user-focussed tools thus might not be as unproblematic a task as the first workshop could lead you to think. While the workshop is a way to invite the other practice carriers into the negotiations about what the toolbox as a boundary object should consist of and how it should be understood, then it takes more for it to have an impact. The team is also conscious that designing the toolbox is only part of their job – they also have to involve people around the organisation to act as ambassadors and ensure commitment to actually *use* these tools. Introducing a new tool (or set of tools) will not change any practices on its own. They might be incorporated into some of the *sets of rules* ordering

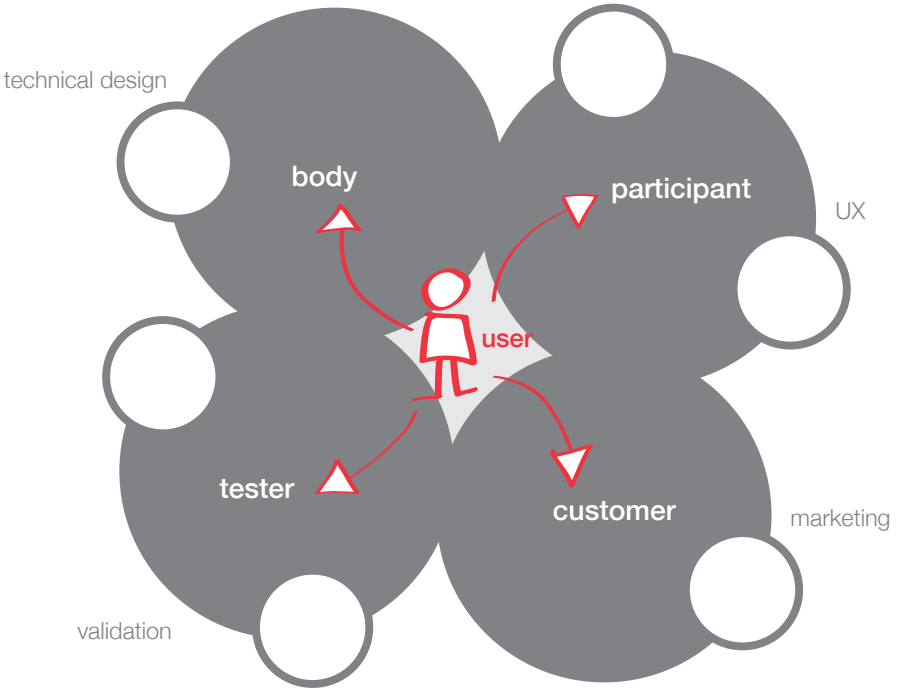


FIGURE 106 | The notion of 'the user' is tailored to suit different ways of working around the organisation.

different local practices – but only if participants are willing to 'carry' them into the practice bundles. It thus requires collaboration from within the other practice bundles, but if there are incongruences between the tools and the affiliated *pools of understandings* and *teleoaffective structures* this seems unlikely to happen.

UNDERSTANDING EACH OTHER

As mentioned a couple of times already the UX designers are a new addition to the Volvo organisation. However, creating relations to the other practice-arrangement bundles does not happen solely based on being appointed a space in the organisational diagram. Instead is mainly through *interacting* with the other parts of the organisation on the various projects that such relations and mutual understandings can be established.

When I first met Sebastian explained to me how their work had been related to the more technical designers at Nokia: "At Nokia we were phys-

ically located with the people who developed the software – sometimes this work was outsourced but for the most part it was people sitting right around the corner at the same office who developed the actual solutions. And you see that interaction is really important when things have to be implemented." Here at Volvo they do not have the same kind of daily interaction with the people working with the rest of the 'pyramid', which leaves them a bit out of touch with how the work goes on the other departments.

When discussing options for the 'design spike' the UX team is thus quickly hampered by their lack of understanding. Their own reference is the SCRUM framework for organising a design process in an agile way (which is where the idea of a 'design spike' also originates from), and while they have a feeling that the other departments are not referring to this framework (as discussed above), then they do not have an understanding of what reference they are using instead. Contrary to this Sebastian also explained how good their understanding had been at Nokia: "you have to be able to understand the logic and also the psychology among the people who sit and develop, that is, when someone says 'no, that can't be done,' then there are many different reasons why they might say that. Either it can't be done, or they don't want to be bothered with it, or they can't do it themselves, or it could actually be done but they just can't accommodate it right now. That was something you learn over time and it is a very satisfactory work environment to have that close interaction with people."

EPISODE 3 | nursing seeds

3.1 Preparing for management

Tomorrow Sebastian has a one-hour meeting with two representatives from the middle management in the R&D organisation (including the director of their department). At this meeting he needs to ensure buy-in from the rest of the department cluster by presenting the condensed recommendations of the proposal he has been working on. He is positively surprised that he has succeed in setting up this meeting the week before Christmas, which to him indicates that their project holds a priority to those higher in the organisational hierarchy.

Slightly removed from the rest of the team Sebastian has been charged with developing a proposal for a new way to tackle so-called *seed projects* in the future. The aim is to come up with a procedure for capturing good ideas (the "seeds") in the organisation and help bring them into actual projects.

The team's hope is that this procedure can be introduced throughout the R&D organisation and not just in their department cluster.

At this point Sebastian has developed both an extended power point of the proposed seed process with descriptions of all the elements involved and an executive summary. Talking to the managers tomorrow he will use the executive summary and make sure that it is as crisp as possible, enabling them to make their decisions. Having worked on the content for so long he is quite confident that he will be able to answer all the questions they might have at the meeting.

The first slide outlines the purpose of the seed projects – this, Sebastian explains, is important for him to be very explicit about right from the beginning in order to ensure collective agreement amongst the participants at the meeting and before moving on to discuss the details. Then there is a slide visualising the seed process as he imagines it and finally a slide with examples of problem statements – or, as Sebastian has more strategically named them in this presentation, *innovation opportunities* – that could be possible seeds to nurture. He has found these examples from the other projects that the UX centre has already been involved in.

One of the first points on the first slides states that the new seed projects will *not* be focused on technology development. Sebastian is a bit concerned that this might be one of the things that the managers will question, since he knows that at least one of them would like the technology development projects to also be part of the initiative. He explains to me that at Volvo they

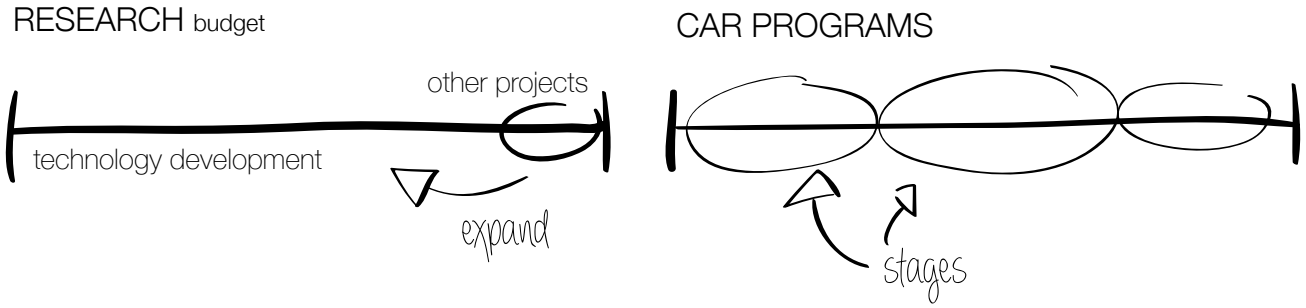


FIGURE 107 | Reproduction of Sebastian's sketch of the types of development projects.

are currently employed in two overall types of development projects: There are the *car programs* where the new generations of cars are being developed and then there are the *research projects* where new opportunities are being explored and developed.

The car programs themselves consist of many different stages and typically span several years, however they operate with a fairly locked development trajectory (framed by the stage-gate model) that does not leave room for much new innovation to enter along the way – as Sebastian puts it: "the readiness to accept 'new solutions' are greatly reduced for each gate that is passed." So each year a pool of money is also allocated to research projects. In the current setup these are primarily focused on maturation of new technology, which may take years to make functional and involves a lot of risk (the technologies may after several years prove unfeasible or be overtaken by new developments on the market). These projects are also managed through stage-gates. Only a small part of the research funds are today allocated to other types of projects – but this is what the UX team wishes to change with their seed proposal.

In order to explain to me how new research projects are typically initiated Sebastian draws three circles on a piece of paper. The first one he labels "customer", then "technology" and "business". In Sebastian's understanding the UX designers are working within the customer domain, but he mentions that the marketing people and the test drivers at Volvo also see themselves as representing the customer. In the business domain he places for example the

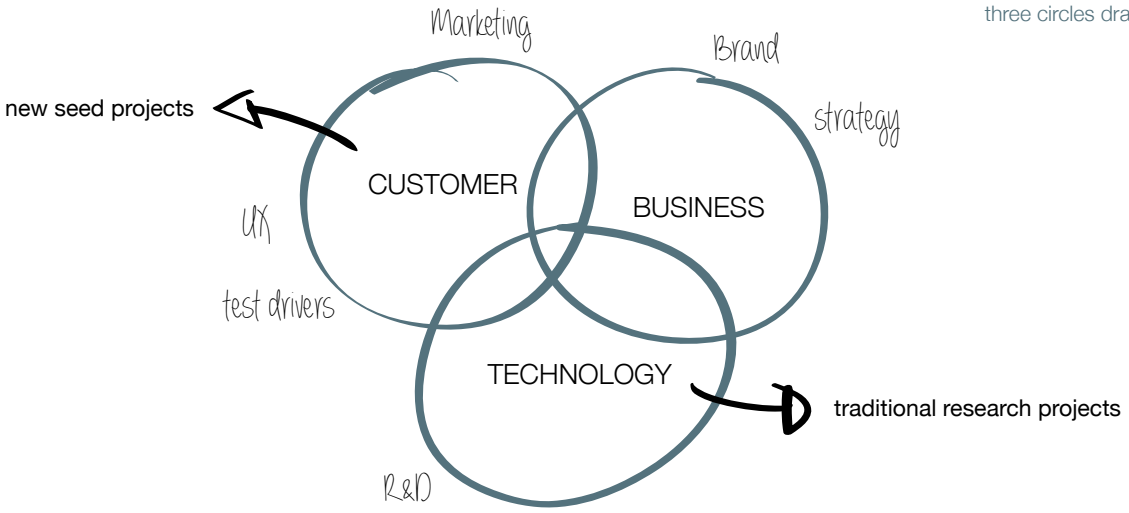


FIGURE 108 | Reproduction of the three circles drawn by Sebastian.

Brand department and talks of strategies. New research projects, however, typically come from the technology domain as things are now, whereas what the UX team wants to achieve with the seed project is for more to come out of the customer domain.

In his executive power point slides Sebastian has refined the process model that he started developing a couple of weeks ago. This is now a visual representation of the stages involved and the relevant roles at each step. When he started drawing the model at my last visit he became aware that he had not previously thought about the last step in the process and the accompanying roles, that is, how the seed projects would be implemented and actually carried through.

While Sebastian has been working on this task he has also been building an elaborate mind map by collecting different information and ideas, giving him a collective overview of the many elements that feed into the process. He now checks the mind map to make sure that all is in place for his presentation, which he is confident it is. Then he moves on to give Lucas a hand with an excel sheet they are developing as a template for mapping the competences available within the different departments.

3.2 Proposing a pilot phase

When I return about a month later Sebastian's focus has shifted somewhat. He is now looking more concretely at what can be done in order to get this new process started as a kind of piloting phase. To do this Sebastian has had

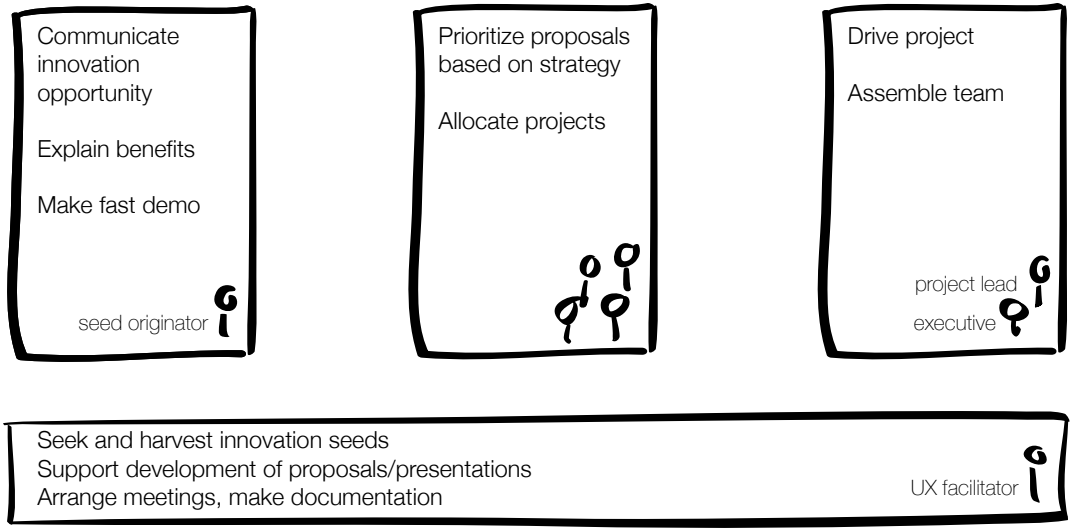


FIGURE 109 | Reproduction of the process model in Sebastian's executive presentation.

to go into the details of the funding structures for research in the organisation. He knows that the typical research/development projects last for 2-3 years and are focussed on developing new technologies. But the UX team is used to significantly shorter development cycles of maybe 3-6 months from the software industry and they do not necessarily focus on making new technology but rather finding new ways of using or combining existing technologies. With this new seed initiative they want to bring such a way of working into the organisation. The ambition is to take over half of the research budget, but the process and structure around it needs to link to the existing structures.

So Sebastian has contacted a person from the management team to learn when the budget negotiations take place. In reply he has received a graphic outline of what is called the "Annual Factory". Steffen has pored over this document yesterday and is thus now able to identify "we are the blue ones" and "here and here are where we must deliver something" in order for the management team to include their efforts in the yearly resource allocations. He explains that this process is governed by some cross-organisational councils that decide which projects should be allocated a budget.

Yesterday Sebastian also started drawing up a plan for how the piloting process – quite literally, for he pulls out a large piece of paper from the piles on his desk to show me the bars he has sketched and labelled with different abbreviations. He needs to consider how to treat and place the daily commute project (which Jonathan is a part of) in this process. On his paper he has

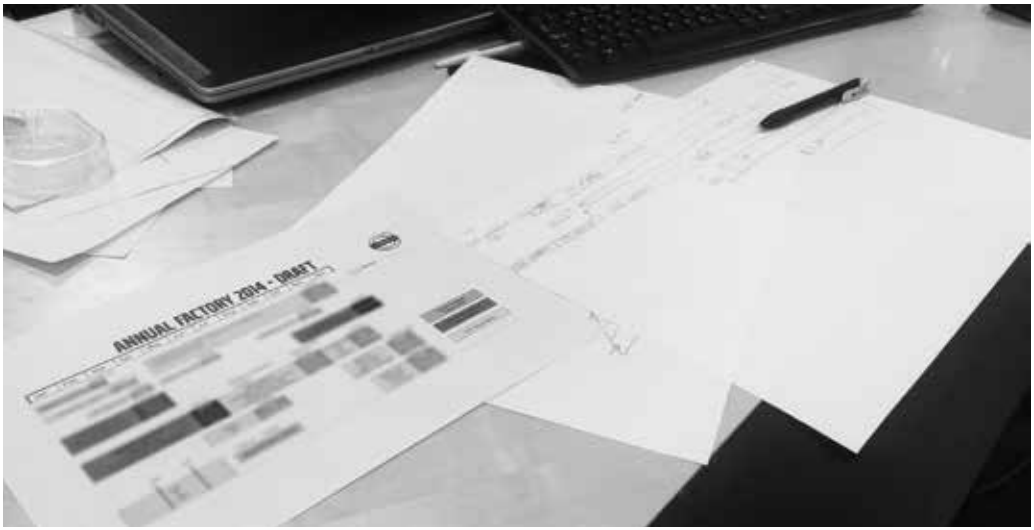


FIGURE 110 | The "Annual Factory" document and Sebastian's first attempt at planning the piloting phase in accordance with this.

placed this project as the topmost bar, the length indicating its duration and overall stages on the imagined timeline stretched out by the width of the paper. This project is to date the one coming closest to how they would like to work in the future, so the UX team is quite keen on bringing it in as part of the pilot process. But on the other hand they also want to avoid disturbing the dynamic process that Jonathan's team is in the middle of by imposing new types of deliveries on them. So Sebastian is trying to figure out an approach where they can protect the project but at the same time learn from it and use it as an example in other parts of the organisation. The journey mapping process, for example, which the Jonathan's team has focussed on so far, has resulted in several potential ideas that will not all be taken forward in that project. These could turn into the 'seeds' of other pilot projects.

FINDING ROOM FOR CHANGE

This episode introduces another part that is included in the umbrella project: Setting up a proposal for a new seed project procedure in order to catch and use more of the ideas that emerge from the traditional development work. It is thus another front being explored in the attempt to influence the design work in a more user-oriented direction than presently.

We learn a bit more about the way the work is structured across (and beyond) the R&D organisation. There are, for example, two overall 'categories' of projects: Those linked to research (that is technology development) and then those linked to the car programs. New car programs typically start up every second year and end up with the release of a new car cluster. Through this process many different groups of people work in parallel on different parts of the cars within their areas of specialty. Much of this work is interdependent to some level, which is why the requirement documents were also given so much attention in the new model being developed in Episode 1 (working as boundary objects between the different design teams). At the same time there is a tight time frame to keep within in order to stay in step with the general car market (which is managed through the stage-gate model). As a result there is very limited space for any new innovations to find their way into the car design after the car program has been initiated.

Contrary to this, the research projects have an explicit focus on exploring innovation potentials. They often start as a pre-project within the

different departments and focus on developing new technological possibilities that could be used in the next car generation. At the end of the project it is assessed whether the new technology is now mature enough to form a part of one of the coming car programs or if it will have to wait another 2 years (or be shut down).

The UX designer's concern is that developing new technologies more or less from scratch takes a significant amount of time, money and effort – without the guarantee of a useful result in the end. Committing to certain technologies from the beginning of a car program also creates a lock-in, which hinders the innovation potentials along the way.

AGILITY MEETS ECONOMY

In both Episodes 1 and 2 we heard how the UX designers are used to agility in their way of working. A central component of their *pool of understandings* is thus how short iterations and rapid reactions to changes is a sensible way to go on in design work. From their reactions throughout these three episodes we also get a sense that they recognise their way of working as different to the way the other designers in the organisation works. An agile development approach is generally dominant within software development, which is also the field that the UX experts have previously been working within at Nokia. Since the software market develops notoriously fast the agile approach is a way to not only reduce time to market but also ensure relevance of the products released. Working with incremental development in short iterations the direction can continuously be assessed and adapted to changing requirements. The risk of developing obsolete or irrelevant solutions is thus greatly reduced compared to the sequential development approaches that appear to dominate Volvo's development work.

The new seed projects are intended to bridge these two development paradigms. Moving the focus from technology towards user needs their hope is that new innovations can be achieved in significantly shorter timespans using already existing technologies (but in new ways or combinations to support the user's experience). In Sebastian's own word: "We emphasise being able to act on new insights, opportunities and development directions quickly in order to achieve a faster way from 'seed' to sellable product. Not least a faster development cycle for the car's digital solutions where the user's point of reference is 'consumer electronics', which devel-

op far quicker than the car industry's more traditional technologies." So to Sebastian the new seed projects are to be a way in which the organisation can more quickly adapt and pursue new design ideas through a kind of front-end innovation. But in order to make it possible to work with such quick adaptations and flexibility in the organisation there are significant infrastructures that need to be modified – perhaps most significantly the economic structures, which hold the organisation's activities in place by allocating budgets and managing expenses.

Right now a yearly sum of money is allocated to the research projects based on the planned stages of the work and expected timeframe among other things. But with roots in an agile development understanding the seed projects require a different structure. They will have to be financed from the same pool of money used for the research projects, but they will be much more difficult to lay out a plan for once a year at the budg*et all*ocations because they are likely to emerge from many different sources and ideas (such as user studies, new trends, new technological experience opportunities, and strategic wishes). They might even potentially feed into on-going car programs provided the structure of these are also made more agile and open to changes.

ATTACKING INFRASTRUCTURE FROM THE TOP

While my fieldwork has not allowed me to see the full picture of the seed project possibilities and implementations, the doings around its proposal nevertheless point to some of the challenges that such efforts of change are met with. Again we see how the UX team has to manoeuvre around and engage with the infrastructures holding the organisation together. Many different elements and their historic manifestations take part in forming these infrastructures, such as the business models directing the company, the way budgets are structured, how decision paths run through the company, the physical distribution of departments, and also external elements such as industry standards.

Many of these elements are closely linked to the bundles of management practice-arrangements. In this sense there is also an uneven distribution of power in relation to the infrastructures, where the management levels are closer to and thus better able to make changes in the infrastructures.

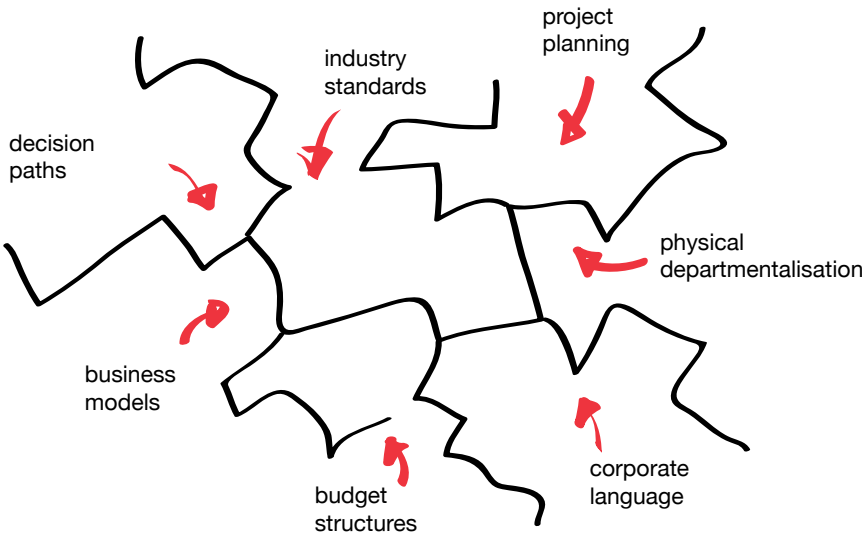


FIGURE 111 | Examples of elements that are forming the organisational infrastructures.

Before starting my visits Sebastian told me: "Basically there are some roles in the organisation – both at top and bottom level – that actually believes that a change is quite good, while people who are responsible for things being delivered on time as usual are typically less willing to change – or at any rate need to have it spelled out. […] So processes of change they need to be deeply rooted high up in the organisation before anything happens. After all that's one of the things we will be working on – we can't just do it on a one-on-one basis with all 2000 colleagues up there [in Gothenburg]. But that's part of the game."

While the work on the new UX toolbox was aimed more at collaboration with the 'bottom level' or the designers themselves, then this seed project is an attempt to enter into dialogue with the management layers of Volvo and through that draw closer to making changes in the budget structures and project planning.

DISCUSSION

With the UX centre Volvo has in a sense added a new practice-arrangement bundle to the existing constellation of the organisation, which necessarily creates some new tensions. Altering relations among practices and the connections between material arrangements through reorganisations within a corporation helps evolve the complex bundle that is the corporation (Schatzki 2013, p42). The UX designers are now working on adjusting to their new setting at Volvo but at the same time they have an ambition to also influence this setting – not by taking over all of the design work but by helping to facilitate how it is structured and linked together.

So what might we learn from the visit at this site? How do openings for change emerge and how do you take advantage of such openings? Let me try to summarise some of the most important learnings and expand a bit on them below:

- Established infrastructures hold the organisation together and stabilises relations across the constellation of practice-arrangement bundles.
- Openings for change can occur in connection with breakdowns in the constellation, which affect more than the individual bundle.
- A repertoire of boundary objects is necessary to negotiate across the different practice-arrangement bundles.
- Inertia in the infrastructures makes it hard to achieve any fundamental change.

A FOUNDATION OF INFRASTRUCTURES

At Site 1 we saw how individual design practices are linked to other practices in *bundles* and to different *material arrangements*. From the events presented at this site we can extend that view to larger *constellations* of such practice-arrangement bundles, which stretch across the entire organisation and essentially also beyond. "The normalcy of organizational life arises from relations of connecting in action, and this connective texture is taken for granted when the alignment of ideas, persons, materials and technologies holds together" (Gherardi 2006, p165)These constellations are thus not only held together by the dynamic relations that link together the indi-

vidual practices and bundles (which are only just starting to take form for the UX centre), but also by an infrastructure of *boundary objects*.

At Volvo it appears that a stage-gate understanding has over time manifested itself as a central component of such an organisational infrastructure. Being translated into a number of documents, procedures, and underlying agreements it has thus come to be a common foundation framing the doings within the individual departments in relation to each other. The infrastructure is thus *embedded* in other structures, social arrangements and technologies found in the organisation but also reaching beyond this site. Though the infrastructures are normally *transparent* (Star, Ruhleder 1996) the UX designers are gradually getting to know the structures by being confronted with their different manifestations while becoming more fully-fledged members of the Volvo organisation.

BREAKDOWNS CREATE OPENINGS

While the *infrastructures* are normally taken for granted and fading into the background of the everyday doings, then they also contain a certain level of tension – especially in the boundary spaces between different practice bundles. At times such tension might result in more or less extensive breakdowns in the infrastructures, thus making them more visible (Star, Ruhleder 1996). At this site such a breakdown has occurred elsewhere in the organisation and while I have had no access to unfold what initiated this breakdown then the effects are clear all the way into the UX centre. By revealing some problematics in the organisation's existing infrastructures there is now a possibility to open up the taken-for-granted and make the infrastructures more plastic and thus changeable.

While the UX designers do not necessarily share the same frustrations that the Infotainment department had expressed at the "crisis workshop" then this opening provides an opportunity for them to further their own agenda by getting a say in the negotiations surrounding the new structures. The big question is how much room for change has actually been created and how much the stage-gate thinking will continue to restrain the plasticity.

A REPERTOIRE OF BOUNDARY OBJECTS

The concept of *boundary objects* can help us understand how physical or abstract devices can help mitigate the cooperation across different bundles. To challenge the existing infrastructures there is an abundance of possible strategies and such devices that can be put in motion (far from all equally successful, though). Some of these might prove useful in some contexts and others in other quite different contexts. The ambiguities embedded in a situation thus speaks for having a repertoire of representations enabling you to chose what appears to 'sell' your proposals in the best way under the given circumstances or makes more sense collectively across the bundles.

The UX designers are used to working with such open and fluid objects, which is a large part of their *epistemic practices* that we witnessed at Site 1. Here at Site 3 they also appear to be pursuing several such strategies in their ambition to make a change. Sebastian, for example, has made two different representations of the seed proposal (a short and extended power point presentation), which he intends to use in different situations: Meeting with the management level he needs a presentation that is short, clear, and to the point, while meeting with other layers of the organisation requires more elaboration and exemplification.

But it is not only different representations of the same proposals that the UX team is working with; they are also working to promote their ambitions on several fronts. In these three episodes we thus hear how they have engaged in the process of producing a new model of their common work, how they are developing a shared toolbox, how they want to engage 'ambassadors' in other departments, and how they try to influence the research strategy and budg*et all*ocations, but they are also working on yet other fronts within the umbrella project. All of this work includes the production of boundary objects and co-construction of meanings with other bundles in the organisational constellation.

INFRASTRUCTURAL INERTIA

Just as the relations across practice bundles are usually plastic enough to support dynamics and reactions within constellations they also make the constellations 'tough' in the sense that a lot of effort is required in order to make any lasting changes (that is, keeping it from 'snapping back' to its original shape). Changes do happen all the time – with every re-produc-

tion of practice you will see displacements of the doings and sayings that are considered to be within or outside the practice, however these local displacements can rarely account for changes across the entire constellation.

Negotiating room for such changes requires agency, that is, it is the practice *carriers* rather than the practices themselves who manage these processes. In the everyday the practice carriers act within and through the existing infrastructural framework, but through intervention they may also create new additions to or changes in the infrastructures. While this may sound simple it is far from a straightforward endeavour. Star points out that:

> *"Because infrastructure is big, layered, and complex, and because it means different things locally, it is never changed from above. Changes take time and negotiation, and adjustment with other aspects of the systems are involved. Nobody is really in charge of infrastructure." (Star 1999, p382)*

Attempting changes in one part of the organisational constellation thus interlinks through infrastructures with the social orderings found in other parts. So while Star points out that infrastructure is never changed from above then it is also worth pointing out that it will not change from the bottom up either. In fact, 'top' and 'bottom' becomes irrelevant when viewing the organisation as a constellation of practice-arrangement bundles (cf. Schatzki's 'flat ontology'). Instead you might say that change needs to happen across the entire constellation, which includes management practices as well as the everyday design practices (and much more).

Because of the complex relations running through a large organisation like Volvo the institutional infrastructures thus create a significant inertia that is hard to overcome when wanting to change engineering design practices in the occupational sphere.

4 | 3 EDUCATIONAL DEVELOPMENT

negotiating new practices

In a time where educational reforms are really gaining speed, it is also interesting to ask where do new educations come from? How are they developed? And what does it take to bring them into existence?

Though the descriptions presented in educational catalogues might suggest a clear-cut purpose and direction, reality is that every new educational program is the result of both social and institutional processes. With my practice perspective I will look into the making of a particular new engineering program that was conceived, planned, and initiated in parallel to my PhD project by the research group I am placed in. This has presented me with a unique chance to observe 'in the making' what elements actually play into such development practices. Several of the people involved in this process had 10 years earlier been involved in the similar process of developing D&I at DTU, which we visited at Site 2. This site will thus provide input for discussing and illustrating the complex bundle of practices and concerns involved in educational development.

INTRODUCTION OF SITE 4

Soon after starting the project a possibility arose for me to follow the development of a brand new engineering design program focussed on sustainable design and thus get a sense of how new ideas of practicing engineering design can find their way into our educational system. While this site in this way was the first one that I visited in my multi-sited study I will use it here to round off our tour across and in-between education and occupation.

The site is linked to the research group that I am associated with at Aalborg University (AAU) but also has links back to Site 2 and DTU. The faculty group in question had been researching and teaching alongside each other for about 10 years (for some even longer) at DTU. Much of their work here had been linked to the development and continuation of the Design & Innovation program (D&I). However in 2012 this group moved their research to AAU where they formed a new section, *Sustainable Design and Transition* (BDO) and started a new research centre (*Centre for Design, Innovation and Sustainable Transitions*, DIST) in collaboration with a few other newcomers as well as some of the existing AAU faculty. The ambition with this cross-faculty centre was to effectively bring together scholars from the humanities, the technical, and the social sciences in order to work with the complexities and challenges of sustainable transitions in our modern societies (Jørgensen 2013). However, being located at a university the ambition was also to link this line of research to educational initiatives at AAU. As the scholars span a wide field of disciplines their educational interests also range from anthropology to city planning and from innovation management to design engineering. While they today contribute to several such programs at AAU, it is only the engineering program in *Sustainable Design* (SD), which is initiated and 'owned' by the BDO section.

As we heard at Site 2 the D&I program at DTU brings together organisation and socially responsible interaction with technology on one side and product development and construction on the other side to create a new cross-disciplinary engineering design education. Here at AAU the ambition is very similar, though with the added interest of integrating sustainable transition of society to the mix.

A SITE OF EDUCATIONAL AMBITION

Developing the Sustainable Design program thus emerged as an ambition to create a common project for the scholars joined in the new centre. Most of these scholars are invested in science and technology studies (STS), sustainable transition theories, innovation management, and/or design work. The ambition is to create a program that combines the more classical engineering competences with design competences and analytical sociotechnical competences, all of which is aimed towards a broad sustainability agenda. Referring back to the area of tension in engineering design

(Figure 4 in the Problematisation) there is thus a wish among the initiators of the program to strike a new balance between the different poles.

THE PRACTICE CARRIERS

The process of developing and implementing the new program was necessarily carried by a diverse group of people. A small group – what you might call the core group – consisted of 4-5 scholars that had previously been involved in running the D&I program. Of these Mark, Ann, and Phillip[20] will be the most central figures in the following. Phillip had also been part of the original educational development group at DTU while Mark and Ann had both been central educators before the move.

EMPIRICAL APPROACH

Being myself one of the scholars that moved from DTU to AAU (as a PhD fellow), I have been placed at the edge of this process. This has given me the opportunity to observe and participate in some of the events and discussions that have taken place up until the launch of the new program in the fall of 2013 and continued well into its first year of implementation in 2013/14.

With my self-ethnographic approach to this site my main empirical data comes from the various types of meetings that I have attended internally in the core group of developers and with other parts of the faculty. The episodes presented in the following are thus based on transcripts from two internal meetings in the core group, one exploratory meeting within the centre, and a one-day seminar between the core group and faculty from the mechanical department (translated from Danish). From these I have extracted and described short episodes to illustrate some of the elements that have fed into the process of developing the Sustainable Design program. In the following these are presented in chronological order to give the reader a sense of the unfolding process.

However, sharing an open office space with many of these people I have also been able to keep up to pace with the process through more informal observations parallel to my normal doings at the office. This has helped me piece together the developments that have also taken place in-between these meetings. On the second semester I have furthermore been supervising a group from the first batch of students attending the

new program. While this will not feed directly into my empirical material it has nevertheless giving me access to observe the meeting between the curriculum and intentions on the one hand and the actual students on the other.

Finally, I have also had access to various documents developed along the way – most importantly the official documents used in the accreditation process (including the curriculum).

ENGINEERING EDUCATION IN SUSTAINABLE DESIGN

The new SD program is actually part of several change processes. At the local level it is part of the relocation to AAU by a number of scholars and establishment of the DIST centre. At university level it is part of a strategy to strengthen the regional activities in the capital (the main AAU campus is found at the other end of the country) and establish a position to better compete with for example DTU. At the professional level it is part of an effort to bring the creative and social back in engineering design. At the societal level it is part of a change in discourse towards sustainability and transition to a greener economy. While these are all interesting and interconnected I shall focus on the more local levels here.

From the educators' point of view the intention with the new program is to create an engineering education where creativity, technical knowledge, and sociomaterial understanding go hand in hand (in continuation of the D&I program at DTU). The hope is to enable the students to understand and stage innovative processes leading to the design and realisation of sustainable products, services, and sociomaterial systems (curriculum draft, 2012). That is, not just environmentally sound solutions, but also solutions touching on the social and economic aspects of sustainability. The educators thus hope to educate creative engineers with social responsibility.

Even at the local level the vision behind the SD program thus has many components. There is a wish to offer a strong and popular new engineering education. There is a wish to attract a diverse group of students to the engineering profession. There is a wish to unite an interdisciplinary group of scholars (from i.a. DTU and AAU). There is a wish to reform the way

engineering designers work (creatively and inclusive). There is a wish to influence a more sustainable development in society.

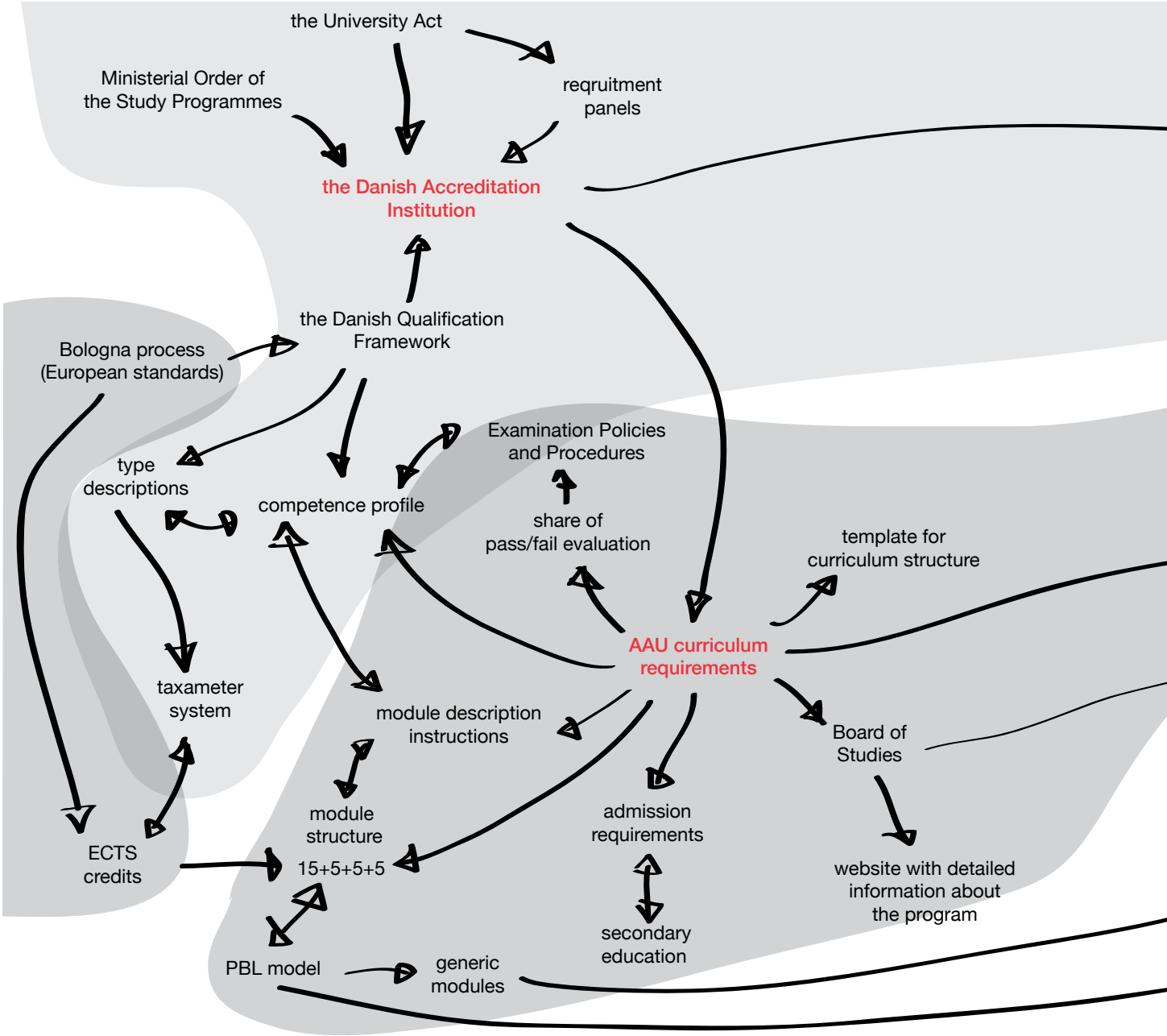
But how do all of these hopes and intentions translate into an actual and functioning educational program? What kinds of infrastructures are the educators forced to navigate in order to materialise their ambitions?

PREPARING ACCREDITATION

When the whole process started Tina (a former graduate from the D&I program) was put in charge of the practicalities of writing up the necessary documents and getting it all ready in time for the quickly approaching accreditation deadline. An important part of the accreditation application is the *curriculum*, which provides a relatively detailed sketch of the overall program and individual modules. While the core group of educators might have had some more or less firm ideas about what the curriculum should contain there were also several other elements that shaped it. In an interview a couple of months later Tina explains it this way:

> *"We had a deadline for when the curricula [for the bachelor's and master's programs respectively] had to be done, we sent them to AAU where they went through different parts of the hierarchy and was finally approved – they had a lot of corrections though, primarily at an overall level, such as 'you need to have this module on the 1st semester' and 'there needs to be more emphasis on this and this,' and also things like 'are you sure you want to have this many modules with grades? Wouldn't you rather have some with pass/fail – you only need this and this share.' So they tried to acquaint us with all those government regulations that you don't really have track of, but they did not get into the content of the individual modules. It was very much at a framework level." (translated from Danish)*

The accreditation process is the first official step that the vision of a new education has to survive – but it also feeds into the process of shaping the program. Tina hints at two of the major infrastructures present at AAU: *The Danish Accreditation Institution* and *AAU's curriculum requirements*. The first is shaped by both national and European standards and requirements for higher education at large. The accreditation infrastructure thus links to the government level (or governmental practice-arrangement bundles), for example through the University Act and the Ministerial Order of


the University Act
Ministerial Order of the Study Programmes
reqruitment panels
the Danish Accreditation Institution
the Danish Qualification Framework
Bologna process (European standards)
type descriptions
competence profile
Examination Policies and Procedures
share of pass/fail evaluation
template for curriculum structure
AAU curriculum requirements
taxameter system
module description instructions
Board of Studies
module structure
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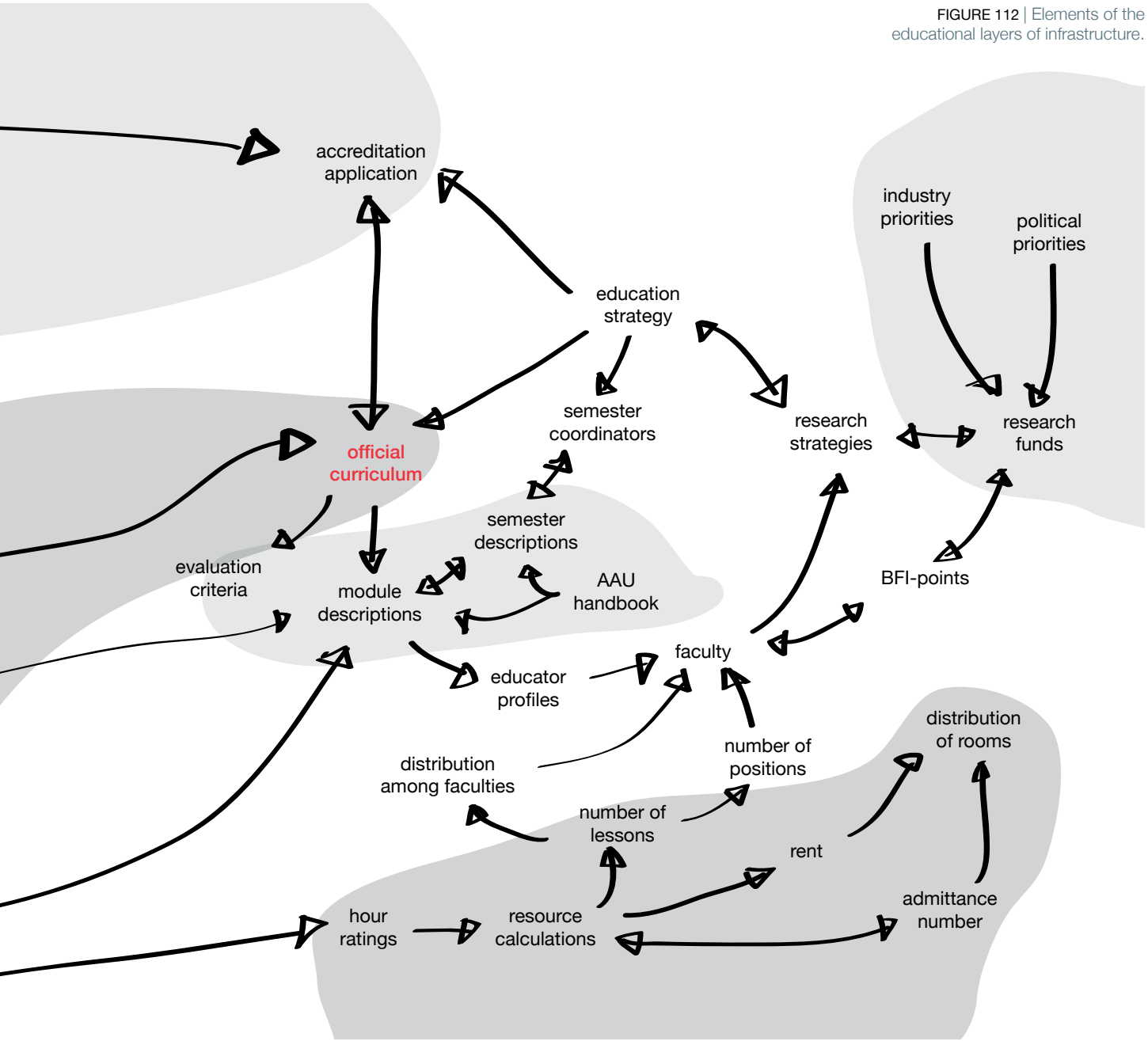
admission requirements
website with detailed information about the program
ECTS credits
secondary education
PBL model
generic modules

FIGURE 112 | Elements of the educational layers of infrastructure.



Study Programmes. It also includes what is know as the *Danish Qualification Framework*, which specifies the expected level of knowledge, skills, and competences to be attained at different levels of education – requirements that have been set up to match the European standards negotiated through the so-called Bologna process.

AAU's curriculum requirements instead prescribes the local framework for describing an educational program – naturally closely linked to the national and European standards but also reflecting local ambitions related to educational design. For example the required module on the 1st semester that Tina mentions is related to the pedagogical *PBL model*, which plays a large part in differentiating the university and its programs. The local curriculum requirements thus translates the national requirement that a bachelor's program should consist of 180 ECTS credits to a model where each semester on a bachelor's program as a rule should consist of three 5 ECTS credit modules and one 15 credit project module. Writing up the curriculum according to the provided template and these standards and requirements thus influences how the original ambition is more officially manifested.

But the curriculum is not the only part of the accreditation application. It also contains a so-called *competence profile* for the entire program. This is actually a very important part of what is assessed by the accreditation institution. Again we hear Tina's take on this:

> *"And then there's the competence description where you describe what knowledge they [the students] should have, what skills they should develop, and what competences they should gain when they are done with this education. And it was actually that one, which a lot of emphasis was put on and it was also that one, which AAU made some corrections to, for example saying 'it should be more engineering-based, it is too vague, you need to put more emphasis on engineering competences.'" (translated from Danish)*

These competence profiles are strongly linked to *type descriptions* made in relation to the qualification framework and the Danish *taxameter system* (assigning a certain amount of money to the university per student). In the taxameter system the rate for engineering educations are higher than for example for humanistic studies due to the importance of technical equipment and laboratories, which are expensive facilities. In order to get this higher rate the competence profile must ensure that the students will

in fact build *engineering* competence during their studies. Already through these descriptions of competences deeply rooted understandings of what 'real engineering' is and contains is thus inscribed into the new education. If we go back to Figure 2 and Figure 4 in the Problematisation it is especially the *academic* and *systematic* poles of the engineering profession that tends to be maintained in this way and the functional *analysis* and *technology* components of engineering design.

Even before the official approval of the accreditation application was received the core group of educators started translating the official curricula into something even more concrete and implementable. Around this time Ann and Tina made a mobile installation to be used in this process. It consisted of a mobile whiteboard where each module from the curricula was represented by a folded piece of paper. The title of the respective module and a few keywords regarding the content was printed on the front of the paper and inside was the details as specified in the curriculum.

FIGURE 113 | The whiteboard overview of modules on the bachelor program (left) and the master program (right).

All of this was arranged in relation to the individual semesters (rows) on both the bachelor's (to the left) and master's program (to the right).
This whiteboard subsequently 'participated' in all of the planning meetings leading up to the launch of the program. I joined two of these meetings at a point in time where the program had been in the making for about 10 months and the first batch of students were expected to start in another 10 months. The following two episodes will provide an idea of what took place at these meetings.

EPISODE 1 | translating visualisation

"But do we have such a visualisation and form-giving [Danish term] module in this plan?" Mark interrupts the discussion. He looks to the mobile whiteboard that has been transported into the small meeting room at the university. A number of coloured sheets of paper are fastened to the board by magnets. At the top of the board you see the titles of the bachelor's and master's program respectively.

"I don't know – that was why I asked about it," Ann replies, "I think it is over there in the yellow now – if you look at 'Actor-oriented' up on the first semester." She points to the top row of papers on the board and Mark, who is standing next to it, turns to zoom in on the indicated yellow sheet of paper at the top: "'Simple visualisation techniques', 'presentation techniques'," he reads from the short sentences written beneath a heading called 'Actor-oriented design'.

"Yes – that's because there had to be room for that one called 'Project work - and something' on the first semester, because Aalborg requires this – right?" Ann turns to look at Phillip who is sitting reclined by the meeting table. Meanwhile Mark starts reading from a different paper: "'Project work and scientific method'..."

"Oh, it's that Aalborg module, okay," John (another former D&I graduate turned STS scholar) nods his head and Mark continues "...'Problem-Based-Learning'. Yes that's it."

"So there's something there that I think..." Ann begins but Phillip cuts her off: "Yes that's one that has to be axed. The other one is 'Linear algebra'," he states bluntly. "So write a note on those two, Mark. Just – you don't need to write they should be 'axed', but just write a note on them," Ann suggests.

"What do you mean 'axed'?" Mark inquires, "Should we try to get them out?" "They shouldn't look like that," Phillip replies, "It's just the two things that Aalborg forced us to put in contrary to the plan we had made."

After going through Phillips experience of the process and negotiations with the university management regarding the curriculum some months earlier they return again to the visualisation dimension. "Surely the point here is that if we want to do research-based education then we don't just want a person who can jump in from the sideline and teach the students how to make sketches, which they can use for communication," Mark points out, "Then we want a person who actually has a *practice* concerning how you mediate." "Exactly," Phillip agrees, "We need a person who can teach drawing and illustration and that kind of thing and who also enters into the broader research agenda."

FLESHING IT OUT

We find ourselves at a meeting with the core group of educators who have taken on the job of developing the new program. This is not the first of these hour-long meetings, and it certainly will not be the last during the process of developing all the elements of the program. While much of this process necessarily takes place in-between these planning meetings the dialogue presented in this episode can help us catch some glimpses of the issues and infrastructures that the core group is dealing with.

From an earlier version of the curriculum you can see that a full module was originally devoted to the visualisation and communication techniques discussed in the episode. However, because of AAU's requirements Tina had to put these elements into some of the other modules on the 1st semester in order to make room for "the Aalborg module". This is a generic module that is being taught on all of AAU's programs by the dedicated PBL scholars and introduces the new students to the project-based learning model and basic theory of science. Similarly the "Linear algebra module" is a generic mathematics course found on all of the engineering programs. Apart from these two modules AAU's curriculum requirements also prescribe a special pre-project designed to give the students a feel for the type of project work they will be doing on each of the coming semesters.

In order to get the curriculum approved by the Dean of the faculty the group had to incorporate these elements into the curriculum – this was also what Tina referred to above. But while these elements have grown to be taken for granted by the AAU faculty and administrators it does not sit as well with the newcomers who have their own ideas of how to best

structure and what to include on the 1st semester. So while Phillip has an agenda of challenging these standards the rest of the group are also concerned with how to fit their ambitions into the dictated module structure.

Part of the core group's ambitions are linked to what we might call a response to the seemingly diminishing capabilities of thinking and working visually in engineering. A challenge, which in their understanding is closely linked to the doing of design. This is why time dedicated to practicing and developing visualisation competences are a priority to them, however, how to do this more concretely remains a challenge for the group at this point.

From this episode we get a sense of how strongly linked the practice bundles of teaching, researching, and educational development are. Determining the need for new faculty positions relating to the new program is thus not only concerned with fulfilling the teaching requirements but also creating alignment with and contribution to the on-going and future research activities. In this way infrastructures relating to research funding and strategic planning also have an impact on how the program takes shape.

EPISODE 2 | beyond modules

A week later the core group meet up once more in one of the small meeting rooms at the campus. An agenda has been prepared for the meeting, but Phillip – who is heading the negotiations with the AAU rectorate and other collaborating faculties – wants to add a discussion regarding the new faculty positions that the program requires.

"So what are the demands regarding professional competence that we would like to pose for those that should be hired in other places of the organisation than here with us – that is, especially the mechanical and manufacturing part. And other places than us could also be those design-oriented positions because maybe we're suddenly met with 'well, they shouldn't be with you but with Architecture and Design'," Phillip muses, "So we need to start a process where we determine as far as possible what competences, what kinds of profiles we want to supplement ours. I think we need to try that."

While the other people in the room appear to agree with this Phillip continues: "I need to make two prospects or two small folders – one concerning the qualitative and visual exposition for why our workshops and studios should look as they do. We have the prospectus and that sort of thing han-

dled and we also have some descriptions but we need to put it all together in one, which also contains considerations regarding square meter and cost more clearly. And the other one is about hour ratings and positions – how many students and which positions does that prompt, and what do we have and what does it take."

While it is not Phillips intention they draw up the two prospects now, he would like the core group to discuss the content and start the process. "Giving us something to convey and negotiate?" John asks. "Yes basically to convey and relate," Phillip confirms, "And like I said at the last meeting there's a positive attitude towards this. At M-tech they are very prepared to include us in the definition of these positions – so it's just a question of doing the actual work."

Mark, who is again positioned next to the whiteboard overview of the program modules, picks up the thread: "If we look at this list of modules, then I think there are places where you could imagine the same person involved in several modules, so we could link people more closely." Several of the other meeting participants nod their heads.

"And I took that list and added M-tech in the left-hand side to see how large a share they have – and that's actually pretty much," Phillip points out. "And that has been negotiated?" Mark wonders. "No, nothing is negotiated yet," Phillip makes clear, "but it corresponds quite well to what Kim himself had arrived at. So we have read it somewhat similarly."

ADMINISTRATION INFRASTRUCTURES

In this episode another layer of infrastructure appears. This one is found within the university and relates to the more administrative aspects of offering and running education. Where Episode 1 hinted at the research dimension of faculty positions this episode tell us how official hour ratings and resource calculations play a part, also in the cross-faculty collaboration. Financing a position in the Danish university system is dependent on funding from both research grants and teaching obligations. Having the same person involved in several modules thus implies a stronger funding platform for that person's position (bringing continuity and coherence to the program is not a part of this discussion, though it is certainly also related). In cross-faculty collaboration it can, however, also result in a fight to get larger shares of the available teaching hours, which has little to do with the learning content of the individual modules. Entering into constructive negotiations with the other social entities at the university is thus

important if content and form is to take precedence over the financial and administrative layers.

The M-tech group mentioned here is another department at the university working with mechanical and manufacturing engineering and thus an important partner in succeeding with the developing the SD program as an engineering education.

But the people who will be running the new program is one thing, another thing is the physical facilities that will be housing the program. Based on their experiences at DTU and inspiration from other design-oriented programs (for example at TU Delft and Stanford) the educators have an ambition of using so-called studios and dedicated workshop facilities to house the new engineering design students and their activities on campus. Despite the project orientation of AAU's existing programs this is not a model that has previously been implemented at the university. However, because the buildings that will accommodate the new and expanded Copenhagen campus was at this point in time being transformed from corporate offices to university facilities there are some openings for trying out new ways of arranging learning environments.

While an alternative learning environment sounds like a job mostly related to decorating, this part of the ambition is also faced with significant infrastructural challenges. In the episode Phillip mentions square meters and cost. This is related to the utilisation of the spaces available in the buildings related to the cost of rent and the expected income per student occupying the space. Without going into the details it is thus clear that this is yet another part of the administrative infrastructure concerned with assuring a reasonable distribution of the available space to the different programs housed on campus while also insuring economic profitability.

Next we will get a snapshot from an information meeting at the BDO section, where the core group more broadly informed the potential future educators on the program about its status and current design.

EPISODE 3 | informing the rest

"I just want to point out," Ann says well into the meeting, " that when we sent off the accreditation applications 'Sustainable Design' was the working title and these," she points to the power point slide with a list of modules on

the bachelor's program, "these are also working titles. But the thing is that we found out once we had received the accreditation then that was sort of it – then that was the name of the programs. I guess we're able to change the titles of the modules though, but I dare not say for sure – but I think we can, right?"

"Sure, that's not too hard," Phillip assures her. "It's a shame Ben just left," Doris interrupts, "because I believe he has been dealing with something like this on the Sustainable Cities program." Mai also believes that it is different how such things are handled at Aalborg compared to what they have been used to at DTU.

"Well that's not right," Phillip protests, "it has nothing to do with the accreditation. It has to do with how the Board of Studies works at Aalborg, but this program has not been through the Board of Studies yet." Ann and Mai both seem relieved to hear this. "But it's true that there's a different kind of red tape at Aalborg because of those Board of Studies and Heads of Studies," Phillip agrees, "So if you don't have them sworn in you're a bit screwed. But then you should just see to it that you do."

"Well, there's some work to be done there too, then" Ann sums up, "We don't know that much about the Board of Studies – in that way were haven't reached that far."

"We need to find a way to move on with this gross list, we need to find some people that are responsible and make some small groups of people responsible for the individual modules," Mark takes over, "We imagine a model where some people are responsible for ensuring coordination and cohesion between the individual semesters – and those are the names listed to the left," he points to the power point slide. "And then I think we should have a discussion regarding what kind of process we should get going to move on from here. Do you think it's a good idea to work with these people in charge of the semesters so we can get a more de-central structure than just 'Ann and Mark sprinkling names'?"

Gina has not been part of the development process so far; she has instead been invested in the program on Sustainable Cities that was started at AAU about a year before the new group arrived. "I think we have some clear experiences from Sustainable Cities, which can be improved a lot," Gina now adds to the discussion, "People in charge of the semesters would be a really great idea! Well because some of the challenges we face are to make those modules connect with those projects. A huge challenge. Right now, as I see it, those modules just end up as some trivial add-ons that you are completely indifferent of how is taught," she complains. "And *we* believe it is really important that these modules on the first semester are brought into the first semester project," Mark emphasises.

Meanwhile Ann gets up from her chair and moves to the mobile whiteboard. "If you look up here on the board, then this is a semester," Ann points to a row of the colourful papers on the whiteboard, "and a semester, and a semester, each consisting of some more technical modules," she points to the blue papers, "and then there are these 5-credit modules," she points to the pink papers, "and then a semester project," she points to the yellow papers. "As things are now then there are elements that could resemble a 5-credit module, which are actually part of the project and the other way around. So we envisage this subject integration on all the semesters where it is really important that that is the way it is carried out," Ann points out. "So, someone needs to be in control of the individual semesters and someone needs to be in control of the whole, making sure we know what should come out in the other end, making sure it does not become some fragmented bits and bobs," Ann makes clear.

Having held his tongue for a while Phillip now joins back in: "Well this is being presented at a module level, I mean we are going forward with some principles that we've used earlier – that is, some principles called there's semester *coordination* – subject integration is something else, that is a way to handle the consolidation of sub-disciplines, which have otherwise been separate, into more cohesive subject configurations – that is relevant in relation to science and technical subjects amongst other things. And the third one is thinking about progression in the learning processes," he clarifies, "And I believe those principles have been fundamental for the structuring of the program. That's just to say that it hasn't suddenly disappeared. It's true that Aalborg hasn't had these principles because the project-based model has never been considered in relation to coordination – because they've just viewed the projects as these big things that automatically took care of the rest." "Exactly," Gina concurs.

"So I believe we should try to move forward in this discussion in relation to what the intentions are – otherwise we'll end up putting too much emphasis on this having become a list of modules instead of seeing it as semester themes," Phillip suggests but Gina maintains "It *is* a list of modules." "But it is a list of modules because there is no semester theme description. We do not see the semester theme behind it."

"But isn't it the projects that are the theme?" Mai inquires. "There's a bit more to it than that," Phillip explains, "The themes have been part of the way we have structured the program in connection with the accreditation." "We'll try and find the theme description for you," Ann says, "I don't have it with me."

PRINCIPLES OF TRANSLATION

At the meeting in this episode the core group are met with wonderments and experiences from other educators in the section. Because of the Copenhagen expansion much of the faculty is currently involved in relatively new programs. It is quite clear that most of the people at the meeting have come into contact with elements of the university's underlying infrastructures; however how these are interpreted also differ among the different participants.

What I would like to bring out from this episode is the reference to three principles that have been used to translate the original education strategy into the official curriculum structure and now needs to be carried on in the more practical implementation of the program. These are overall *progression*, *semester coordination*, and *subject integration*. These principles are a great part of what the educators have brought with them from DTU and their experiences with developing coherence at the D&I program. Each principle works on a different level in the curriculum with overall progression focusing on the learning progression throughout the program, each semester raising the bar a bit higher, semester coordination is instead an idea of creating linkages and mutual support between the individual elements on a semester, and finally – as Phillip explains – subject integration is about forming new cross-disciplinary modules by integrating different yet closely related subjects. In a memorandum from the development of the D&I education it thus reads: "we work with a combination of the mathematical, natural science and technological subjects organised around cross-disciplinary themes instead of leaving these subjects separately" (Jørgensen 2002, p1 (translated from Danish)). The general idea is thus to teach the more theoretical subjects (such as mathematics and the array of natural science disciplines needed in engineering) through a more exemplary and applied approach than such subjects are traditionally taught.

In the first two episodes we heard of the generic mathematics module that is required on all of AAU's engineering programs. Such a generic module is a relatively simple way of ensuring that one of the fundamental requirements for achieving an engineering status in the type descriptions are being met. There are also more practical reasons, however, such as the advantages of duplicating the same module across several programs, which saves resources.

FIGURE 114 | Development and population of the new design studio (both pages).

With the principle of *subject integration* in mind, however, we can now more clearly see why the educational developers behind SD are unsatisfied with such an external requirement – it goes against a fundamental aspiration of making the abstract and idealised world of mathematics useful when for example the principles of differential equations are needed to describe and model a particular problem.

STARTING UP

In September 2013 the first generation of students started at the SD program. Leading up to that a lot of practical tasks had to be completed: The modules and lecture plans for the 1st semester had to be completed, marketing material had to be designed and distributed, applications had to be assed, the Virtual Learning Environment had to be prepared, and the studio and workshop facilities had to be reconditioned. While all of this gave rise to new challenges for the educational development I will now fast forward a bit.

You might think that once students are accepted into the program it is 'done'; it has been translated from idea to reality. And while this appears to be the ideal that is embedded in the educational infrastructures fact is that educational programs are dynamic and evolving constructs. One generation of students will never go through the exact same program as the generation before or after them – partly because the execution of the

program shifts but also because the students themselves are a crucial component of bringing it to life. And the first generations of students appear to have an even greater role in giving the program a form. Having been part of the second generation at the D&I program I have experienced for myself the power of student feedback and discontentment and the flexibility present in a new program even after running for a year. Through my engagement as supervisor on the SD program I have been able to catch a glimpse of this student influence here as well.

The students are at this point well into their 2nd semester. They are working in teams on a redesign project similar to the one we observed at Site 2, though here the objects of redesign are different domestic appliances (such as refrigerators, ovens, and coffee machines) and the objective is to reduce the environmental impacts.

But doubts are starting to surface: Several students are considering dropping out or changing to a different program, some have stopped committing to the collective work, leaving the other team members frustrated. In the middle of the semester the core group thus calls for a 'crisis meeting' with the students in an attempt to get some clarification and give the students a possibility to vent their frustrations.

Several issues emerge at this meeting. For one, many of the students are discontented with the execution of a module combining the subjects of dynamics and regulation (one of the modules developed according to the principle of *subject integration*). A matter that is already being attended to

through dialogue with the responsible educator and the Board of Studies. But for some of the students this semester does also not represent what they expected to be working with in this program. They express that they were expecting more design, more creativity. They have not been engulfed by the STS-informed focus on sociomaterial relations, but rather want to play around with "crazy ideas" and see what they can make of them. They want more focus on aesthetics and training in visual techniques. And in the midst of all of this they are starting to question their identity or rather the identity they are working towards: What does it mean to be an engineering designer? As an example of this I noted the following exchange right after the meeting:

"We are also not going to become *real* engineers, so what exactly will we be?" a student asks Mark. "Arhg yes – I could just strangle those guys from M-tech who said that to you! Of all the many things they've been talking about in their lectures, this small ill-considered comment is what you remember!" Mark says while shaking his head: "*Of course* you will become engineers – you will just be a different *kind* of engineer than what you might call a 'traditional' engineer," he starts to explain. However the students around the table still seem puzzled as to what that might mean.

The students and educators give the educational strategies and plans concrete life by carrying out the constellation of practices that have been introduced here and are more or less supported by the material arrangements present. But there are obviously some tensions where students, educators, and the educational developers do not interact smoothly across the boundary spaces. Like Mark says at a meeting the next day:

> *"So the compiled feedback the students offer, if we should try and report their critique of what is going on with this semester, is that we have a semester that – despite the fact that we [the educational developers] believe it to come together very well, actually better than the first semester I think – then they experience it as diffuse." (translated from Danish)*

Going back to Site 2 again we see no such similar frustrations amongst the D&I students, also on their 2nd semester and also working on a redesign project. But the situation at DTU is also different in many respects. One thing is the type of students attracted to the two different university

profiles (elite technical university versus PBL multi-faculty university). Another thing is the 'age' of the program in question. At D&I the semester and related modules are running for the 10th time and has thus settled in a relatively solid form, which is not challenged (at least not openly) by the students. At SD everything is still in a much more experimental and thus more fluid stage. Recognising the students' frustrations and listening to their experiences of *doing* the semester modules the educators gain new inputs to feed into the further development of the program – first of all the next semester, which at this point in time remains a description in the official curriculum.

With such a 'crisis' some of the diverging conceptions of doing higher education and ideas of where engineering professionalism is anchored also start to emerge. While the configuration and performance of the individual subjects are what inspires these discussions they are also symptoms of the different normativities that are brought into the local situation as part of different practice-arrangement bundles.

EPISODE 4 | cross-department negotiations

Representatives from two research groups are assembled in a meeting room at the AAU Copenhagen campus this morning. The M-tech group has just flown in from the main campus in Aalborg to be at the meeting, which is scheduled to last for most of the day. As we arrive in the meeting room everyone kindly shake hands and introduce their first names. The room is equipped with an oval table surrounded by chairs. When sitting down we automatically place ourselves with the two groups opposite each other at the table. The M-tech people all arrange themselves with black laptop PCs in front of them, while the BDO people either have Macbooks, an iPad, or simply a paper pad in front of them. Somehow this seems like a discrete physical manifestation of the different perspectives gathered around the table this morning.

During the initial presentation of the BDO group Edward explains what the overall ambition with the new program is: "Renewal should to a great extend be about looking at practice, that is, how is it engineers and design-oriented engineers work in real life – and not just a question of what sort of theories and models they should learn, but the connection between models and the way work is done in practice. That is the crucial contribution we want to make."

When the floor is later handed over to Kim, who is heading the M-tech group, he also introduces how they look at the process from their side of the table and their role in it. "First of all I just want to – this thing about 'real' and 'less real' engineers, we have to kill that completely," he starts off, "We have engineers with different profiles. We have to pursue and respect this. And that is simply necessary for this to succeed." Looking around the table no one openly disagrees.

"One of the reasons why I'm glad to see what you write Phillip, is that we can see that you have collaborated with the mechanical department [at DTU], because we can see that there's a better integration – not that it will be easy to provide the modules we have designed. That is, we were met with – and excuse me for getting into the professional domain – but for example 'linear theory in this and this way, could you provide that?' Well no we can't because linear theory requires this and this and this, so perhaps that's not the right domain. So there have been some issues where our group has not been integrated in the planning – but I believe that has changed now," Kim makes clear.

"So where does that leave us?" Kim asks, "I think we need to be careful about expecting the same equality you have had with the mechanical department at DTU – it's hard for us to enter into that collaboration because we don't have the same history that our colleagues at DTU do. We should be able to do it, because professionally they are not superior. We have PBL with us, which means that we are used to think in the structure you are proposing. But you have to understand that it requires an effort to incorporate new modules – you have to get a take on the students."

"We have talked before," Kim looks at Phillip at the other end of the oval table, "Of course we have. But meeting directly like this where we also have specialists directly in front of each other at this level is really important." All seven participants around the table quietly nod their heads. "And what is on the agenda for today is really good, I think," He points to the printed paper in front of him, "because I really believe that if we don't have this common understanding of what this education is, then how are we to convey it to the students? In my world that's the crux. We," he gestures to his mechanical colleagues sitting next to him, "we must be able to explain what an engineer in sustainable design is. Otherwise we cannot deliver to this type of engineering education." Phillip mumbles approvingly while Kim continues: "And we have to stop calling him less than a real engineer, because he *is* an engineer – or she is, sorry – an engineer in sustainable design."

"And that has been very hard," Mark jumps in, "But it is crucial for our own development project in this group, knowing what we are coming together to work on and developing modules for. But," he points out, "it is also important

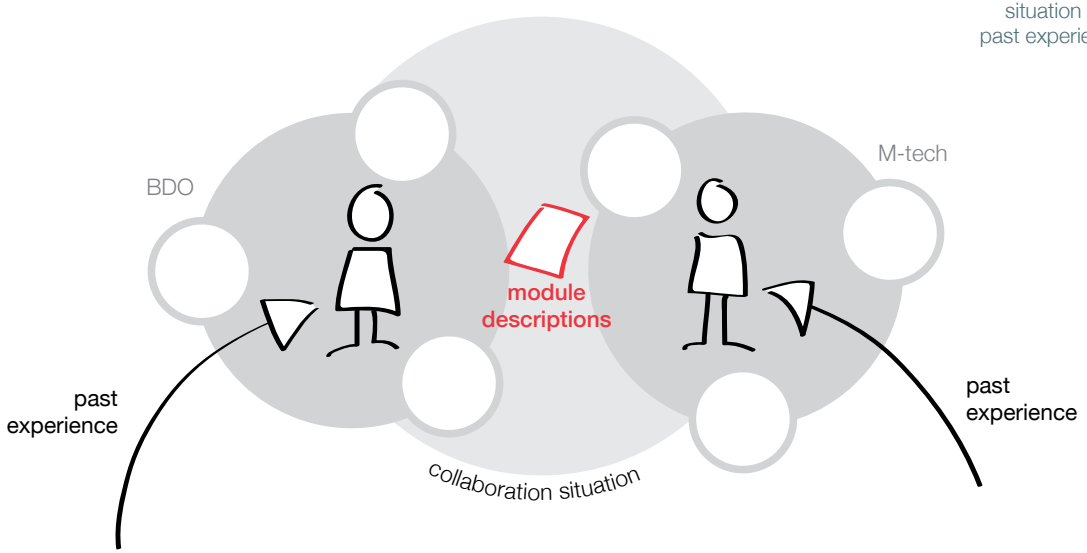
for the students. They are young people in a really searching phase of their lives, and they really want to be able to identify themselves – and be able to present for their roommates at the dorm what they are good for, so to speak."

BUILDING COLLABORATION

At this meeting we find representatives from two of the central research groups involved in the planning of the new SD education: The core group of educators from the newly formed BDI section, headed by Phillip, and the engineers from the M-tech department, headed by Kim. The meeting takes place the day after the 'crisis meeting with the 2nd semester students. As indicated, this is not the first time the two groups interact, but negotiations are still on-going relating to how exactly to translate the ideas of subject integration that have now been inscribed in the curriculum to the actual execution of the technical modules.

The descriptions of the relevant technical modules from the curriculum act as boundary objects between these two faculty groups. While they may not be physically placed on the table between them at this meeting it is what forms the basis for the meeting and where their interests in collaborating are founded. From Kim we get the sense that the process of

FIGURE 115 | The two practice bundles represented in the situation bring different kinds of past experiences into the present.



constructing these boundary objects has not been straight forward leading up to this point and there has been some misalignments between the two groups. However, getting the opportunity to sit down face to face and communicate around a table appears to make up for some of the elements that have hampered the process so far.

But they do not arrive as blank slates to this table. They each bring past experience related to the situation at hand – at this site it is made even clearer because one group comes from an entirely different institution. History and previous experiences always feed into the present and thus influence the future in-the-making.

It is one thing agreeing at an overall level (for example that subject integration makes sense, that engineering designers are also engineers, that theory and practice should be connected), but it is another thing entirely to translate that into actual doings and sayings in the learning situation. This is where the *pools of understandings* and *teleoaffective structures* ordering the different practices that meet (also indirectly) in a situation start to push in different directions and promote different agendas and practical understandings. It is thus not only representatives for certain teaching and researching practice bundles that are present at the meeting, but the administrative and management practice bundles at the university and the governmental practices related to education are also represented through their infrastructural sedimentations (such as the module description format).

While the core group of educators has at this point succeeded in engaging educators from different disciplines and faculties of the university there is thus still a significant distance to cover before such engagement results in teaching practices at the new program that differs from what these educators contribute to other existing programs.

EPISODE 5 | integrating in practice

"I was actually thinking," Mark says cautiously towards the end of the meeting, "would you consider talking to Jacob about whether there could be advantages in one of you doing the whole module one semester, to give some continuity in the person carrying it through?" He looks to Lucas at the opposite side of the table who has been in charge of the material component on the 1st semester module on mechanics, materials and mathematical models.

"I don't think we would like that very much," Lucas replies a bit hesitantly, "Then we would have to rebuild the module from scratch because it's not everything that's on my slides – but *I* know exactly what to say," Lucas points out. "And really, right now it's structured so that Jakob goes through his part before I take over so it's not like I'm there one week and then the next week it's Jakob – that's the problem with the mathematics part," he says more firmly, "the mathematics is completely decoupled from the rest, he just pops in whenever he feels like. And I think that might be confusing them more," he says referring to the students. "I build on what Jakob has taught them in my part, for example in the assignments they have to use some of the things he has taught them. I think the problem is worse with the mathematics because they show up for class and suddenly they are looking at differential equations and then the next day they are dealing with aluminium."

Mark nods understandingly, "But what can we do to link it – we wanted to integrate these things, that's been the whole idea behind requesting something from mathematics, something from materials, and something from mechanics."

"Well, completely politically incorrect, I would prefer that the mathematical part was excluded and those 5-8 lectures we used for something completely different!" Lucas says bluntly, "They don't use that mathematics for anything and we don't use it for anything, and the mathematical basis they are accepted into the program with is actually enough for them to have the prerequisites for doing what we do."

While Mark appears to understand Lucas' frustrations he also points out: "But we cannot maintain it as an engineering education without that mathematics component – well, so let's be frank and say it's a fig leaf..."

EXECUTING INTEGRATION

We are still at the meeting between the two groups of educators. Obviously the students' discontentedness has made Mark think about possible ways to accommodate their frustrations. As a way to alleviate the experience of diffusion in the so-called integrated modules he suggests reducing the number of different educators that the students are subjected to on a semester.

Jakob and Lucas, who are two of three educators engaged with the module in question, participate in practice bundles with shared *teleoaffective structures* making it easier for them to collaborate around the planning and execution of the specific module. However, the person in charge of the

mathematics part of the module does not appear to share the same project. Though integrated in the same module the mathematics thus remains a separate part of the engineering curriculum, just like the case is with the generic mathematics course. Succeeding in changing the *structure* has thus not (yet at least) resulted in any changes in *practice*.

This episode thus shows us that the idea of integrating subjects are not only about co-representing them in the same module but about changing the way the educators collaborate and coordinate their teaching and structure their lectures – that is, changes in the practices. This sort of cross-section collaboration, however, is something that the official hour ratings tend to work against because collaboration uses time in a different and less clear-cut way. Time that the educators themselves have to 'sponsor' in the current system (using either research time or spare time) – something that will only happen if they are truly invested in the project.

In the longer run it is also part of the ambition behind the new program to build a new research group dedicated to a more design-oriented and cross-disciplinary approach to engineering sciences (mainly mechanical and material sciences). Such a group would be more naturally invested in the envisioned integration of subjects through shared practices and material arrangements. But new faculty positions require new funding, which can be hard to come by when starting up something new. Next we shall look a bit more at the relationship between research and teaching.

EPISODE 6 | cross-department planning

The BDO group has just introduced the types of research projects they have been involved with during their time at DTU, and Mark now invites the M-tech group to make a similar introduction of their research interests.

A bit hesitantly Brian starts to explain why he is sceptic about basing new educations on research interests: "One of the reasons why I think you sometimes fail when building it on a research group is that what is in focus in research is seldom static, it almost always moves in waves," he indicates a large wave with his hand, "Sometimes something pops up and then fades out over maybe 10-15 years – and then it's of no interest in real life. And it's quite dangerous if you hit such a wave when planning a new education."

Mark muses at this objection for a moment and then answers: "Okay, when I bring this up it's not to be understood as if the education should be based on the most hyped research profiles here and now. But at the same

time I think – and this is just my personal experience," he points out, "that with the pressure we're under today then it's important that there can be synergies between our research activities and the teaching we deliver. And sometimes I also find that what the students think is interesting is actually what you yourself is really enthusiastic about, where you are professionally well-grounded." Brian nods his head: "It's where you have the best stories to tell."

RESEARCH AND EDUCATION

Considerations of the link between the faculty's practices of researching and teaching come to the surface in this exchange, though at most times during the development process it is more implicit in the debates. Most members of faculty at universities switch between the role of educator and scholar several times a day. From a practice perspective it is thus in the individual faculty member that the practice bundles of teaching and research meet – in fact two completely different kinds of practice bundles with quite different *pools of understandings*, *sets of rules*, and *teleoaffective structures*. Many also tend to favour and identify more with the one than the other.

But it is not only through the individual that these bundles influence each other – it is also through the infrastructures that run through them.

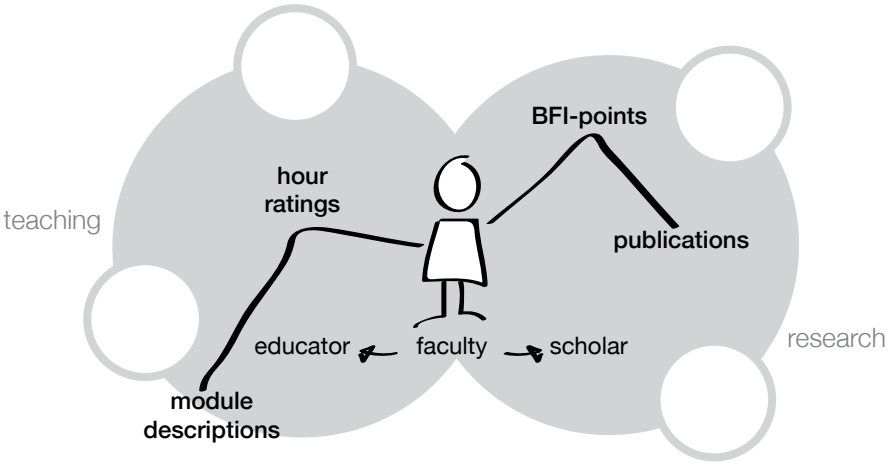


FIGURE 116 | The bundles of teaching and research meet in the individual, who is in turn held in place by overlapping infrastructural layers.

What Mark is referring to in this episode is the way research is being evaluated and rewarded today. In Denmark we have a performance-based research funding system based on the 'Danish Bibliometric Research Indicator', commonly referred to as *BFI-points*, which measures the output of research – as manifested in scientific publications – as a means of distributing more funding to institutions performing better (that is, producing more publications) (PhD on Track). These points are thus part of an infrastructure that emphasises the writing and communication part of the research bundles and rewards effectiveness in this endeavour – much the same as the hour ratings tends to reward individual work over collaboration among educators.

Because educator and scholar is the same person, however, how the scholar prioritises his/her time also has influence on the educator and vice versa. Or as Mark puts it, finding ways to make the tasks of researching and teaching overlap to a greater extent helps the university constellation function more smoothly.

The challenge of negotiating a balance between research and education is not made easier by the fact that this program builds on a multidisciplinary approach to engineering. This means that different types of research practices, but also different types of educational practices are to be coordinated and even integrated.

The short exchange in this episode also opens up a central and more normative question: Where *should* new educations come from? From new research areas? From industrial needs? From political agendas? From pedagogical ideals? From traditions? Or perhaps from other academic fields? Education is a long-term project, so what (and who) decides what will be a sound educational foundation in the future?

DISCUSSION

This site has offered me a unique opportunity to follow a new educational program in the making. It is perhaps especially interesting because of the concrete situation with a group of newcomers to the university, which made the infrastructures stand out even more clearly.

With the conclusion of this final site how are we now able to understand the challenges faced by educational development? What are the obstacles of change in the educational sphere? With what we learned from Site 3 in mind I shall in this discussion focus on the infrastructural implications:

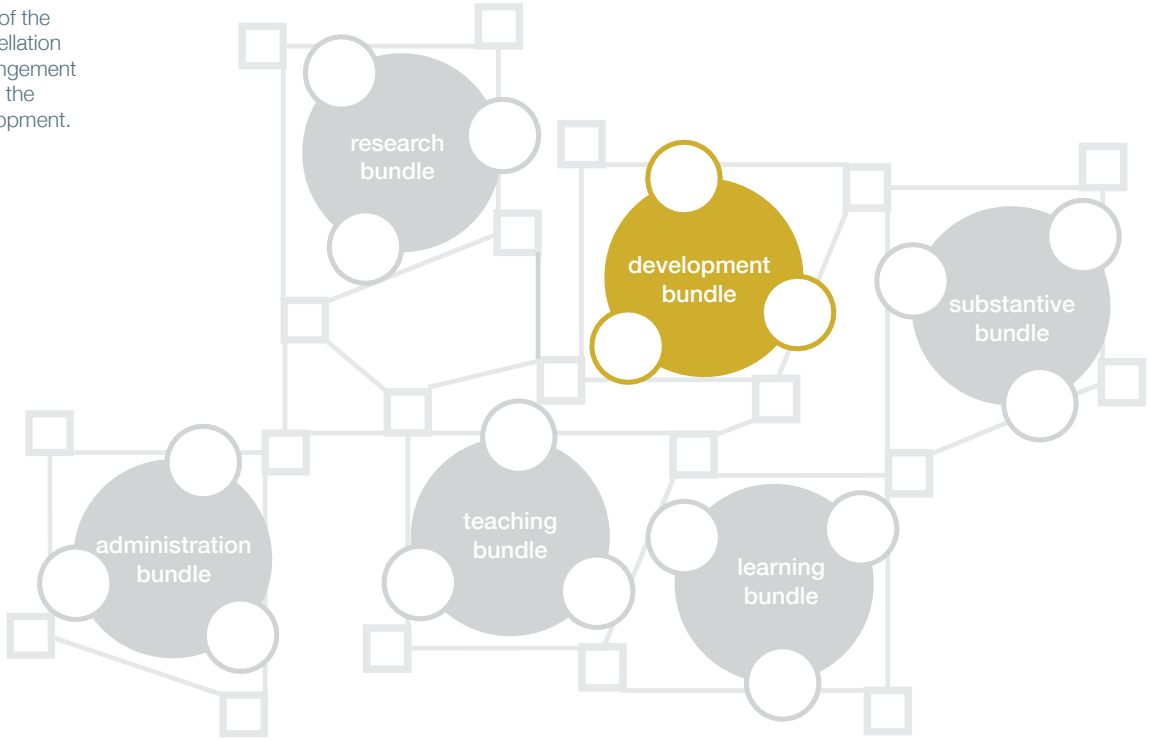
- The academic university can be understood as a complex constellation of multiple practice-arrangement bundles.
- Educational ideals can in time end up as infrastructures that are taken for granted and stay largely unchallenged.
- New ideas that do not fit comfortably into the existing infrastructures have to find openings and negotiate new structures.

AN EDUCATIONAL CONSTELLATION

Taking what we learned from Site 2 we can now begin to piece together an even more elaborate understanding of the educational constellation – or what Kemmis *et al.* refer to as the *education complex* (Kemmis *et al.* 2014). That is, the constellation of diverse practice-arrangement bundles that all contribute to the project of higher education. From the students' perspective the most central bundles are concerned with learning and substantive practices, but naturally the teaching bundle also has much to say. From Site 4 we can now add the research and administrative practices that are closely linked to the development of new educational programs.

The material arrangements including the physical buildings and rooms, the work stations, printers, blackboards, projectors, office chairs and so on not only supports a single bundle but actually a large part of the entire constellation. But there is also another layer of objects that act in-between the bundles – the boundary objects that we also saw at Site 3. These often come in the shape of forms or documents being exchanged across the constellation as an important part of creating coherence and re-producing the local doing of education.

FIGURE 117 | Part of the educational constellation with practice-arrangement bundles related to the educational development.



PBL BECOMES INFRASTRUCTURE

The persistence of the educational constellation found at AAU related to the stable re-production of engineering education in this way strongly relates to what we might call the infrastructure of PBL. The PBL model is a central part of AAU's identity, it is (or has been) what sets this university apart from other Danish universities and has earned AAU an international reputation (for 'the Aalborg PBL model'). PBL is a pedagogically based regime concerned with *how* students learn and how they are given an active and engaged role in the acquisition and creation of knowledge. Here problems/wonderings appropriate to the study program serve as the basis for the learning process (Aalborg University 2010). Since the university was established in 1974 this problem based learning approach has been the common ground across all programs offered and thus strongly engrained in the very way elements of each semester is structured.

The originally pedagogical concept has thus grown to be such a fundamental part of the university that it has begun to stabilise in a regime of boundary objects, which are taken for granted by both faculty and administrators. Though there are still strong ideological ideas present these have over time been anchored in a structure full of coordinated procedures, obligatory courses, standards for semester structures, expectations in the corps of censors, hour ratings etc., and the established teaching practices naturally also bear clear marks in their *pools of understandings* and *sets of rules*.

The core group behind SD comes from a different context. DTU is more 'traditional' in its approach to facilitate learning: The backbone is still lectures and given, well-structured assignments (that is, not problem-based). Part of the mission behind the D&I program was thus to renew this approach and give project work and subject integration a more prominent role. Thus the D&I program turned out as a problem- and project-based education, though it was developed without the embedded institutional framework found at AAU (instead there was a whole other web of infrastructures to navigate, which I shall not get into here). At DTU the challenge was instead to dedicate modules to the specific program (to ensure the relevant subject integration) and to dedicate a third of each semester to project work. At AAU it is already inscribed in the formal structures that half of each semester is dedicated to project work and that modules are meant to feed into this central project.

As newcomers to AAU, even though they share the general understanding of learning approaches, it thus became a challenge to navigate the structures that had been build through 40 years. Especially the issue of subject integration turned out to be the cause of conflicts. At the same time the expansion of the Copenhagen campus and subsequent attraction of a new kind of student profiles caused some breakdowns in the existing infrastructures, which opened at least parts of it up for negotiation (for example the principle of free intake of all students that fulfil the admission requirements).

The PBL infrastructure helps achieve and reproduce the connectedness in action across the different organisational units at the university, but it also makes it hard to challenge the established settlement of ideas into standards.

MAKING ROOM FOR CHANGE

In Part 4 we heard how the ideas of what 'real engineering' is start taking hold in students already from their early years of study, greatly influenced by the way learning practices are structured and facilitated. Changing the perception of engineering design within the fields of tension thus rests on making room for change in the educational constellation. The SD program has ambitions of making more room for the creative and social parts of the area of tension in engineering design (cf. Figure 4), but also ambitions of creating more integration among the academic and systematic areas of engineering (cf. Figure 2). The latter is where the concept of 'subject integration' comes in.

Subject integration is not an existing part of the PBL infrastructure – though it builds on the same kind of learning philosophy. Working with the new education the core group (and especially Phillip) has brought this concept into both descriptions and discussions. You could thus view this concept as a new boundary object introduced into the boundaries between the different kinds of practice bundles linked to the SD program (especially between the different mathematical and engineering science subjects).

The idea is quite simple. By integrating different disciplinary fields or subjects into the same course new connections are made clearer for the students, which helps link for example more abstract theoretical subjects (such as mathematics) with more technical subjects (such as mechanics). All in all a concept that most of the faculty involved can support and make sense of. However, when it comes to the detailed planning of the individual modules – managed by educators in different departments and participating in different practice-arrangement bundles – the common idea of integration is translated into the local conditions and opportunities afforded by the specific subjects. These local and more well-structured manifestations of the concept are thus invested with local meaning, but from the perspective of the core group of educational planners that may not be a particularly successful translation.

So while negotiations of a more political nature within one part of the constellation eventually results in the adoption of the subject integration concept in the new program's official curriculum structure (avoiding otherwise mandatory generic modules through dispensation) this alone does not mean a change in projections of 'real engineering' that the students

are subjected to. In fact mathematics appear to remain as some add-on that you 'have to have' in order to become a 'real engineering' (as dictated by the official type descriptions) but without being put to any practical use.

Real change, it seems, does not manifest until the practices within the constellation start to include and mutually adapt to the infrastructural changes. Not until the doings and sayings are changed has anything new really been achieved.

4 TO SUM UP

4 pushing change

One could claim that the challenges that the world – and the engineering profession with it – is facing demands that we change our practices and start *doing* in new, more sustainable, ways. But practices are hard to change. They have strong historical roots through which rules, understandings, know how, and projects are shaped and developed. They do not only live on through rational and logical actions but through bodily and inter-human relations through emotions and mutual recognition. It is thus not enough to *decide* to act differently as individuals because an individual's actions are always understood and responded to within social practices, which helps us determine what is 'normal' and acceptable, what can be considered 'competent', and what rules to follow.

If we want to start making a change in the way engineering design work is done and competence is build and unfolded, then we need to form a better understanding of the things that are holding such changes back.

In this part I set out to offer my contribution to improving our understanding of how engineering design is attempted *changed* – that is, how infrastructures and boundary objects frame the way engineering design unfolds at an organisational level and how different efforts are trying to challenge these. To wrap up this part I will now position what we might take from this endeavour. That is, how ideas of change manifest themselves in the local situations; how we can understand the role of infrastructures in relation to change; and finally how educational reform initiatives can be understood in this light.

CHANGE

There is a sense of continuity embedded in the idea of practices. What we do today is a continuation of what we did yesterday, and also a precursor to what we will be doing tomorrow. Returning to work tomorrow we are most likely to find everything in the same place as we leave it when going home today. And yet change is happening all the time. With every cycle of re-production a practice is not only sustained and maintained but also potentially transformed and displaced. The fluidity of the future means that each new day also brings new beginnings, new opportunities, new ideas, new relations etc. Kemmis *et al.* (2014) refer to this as a *dance* between re-production and transformation. While the notion of practices is typically associated with stability and continuation it thus also holds a transformational component.

Schatzki (2012) also points to this indeterminacy of practices. In fact, there is no *guarantee* that the future will extend from the past. This has the implication that our past experience and the judgements we base on them can be thwarted – or, in Dreyfus' terms, that our *intuitive expertise* only holds value as long as the practice bundle within which it has been build follows the same trajectory of development. This might help explain why change is also resisted in many instances.

In this part I have used the notion of *infrastructure* to focus on the frameworks that both shape and are shaped by the conventions of practice (Star, Bowker 2006). These structures are particularly interesting when looking into change. While physical infrastructures are usually thought of as static (such as railway tracks and sewer systems) we should keep in mind that they are also formed by changes in use and needs (junctions can be activated, tracks can be added or closed down etc.). While the overall infrastructure appears to stay the same it is also responding locally to changes from within and without. Organisational infrastructures work in much the same way. Infrastructures should therefore be recognised as dynamic and flexible – at least to a certain extend.

> *"Small changes always occur within bundles, what components change shifts around, whether big changes arise from and include smaller ones, and whether big changes occur depends on how the world reacts to small ones, and, as a result, bundles and constellations exhibit uneven, shifting development of a highly contingent and unpredictable sort."(Schatzki 2014, p31)*

Change is thus a natural part of the persistence of our doings and sayings (which should come as no surprise if you look at the changes in ways and customs that occur over a single lifetime). However, most of the changes that we see are not intentionally induced by one or more actors. They are, as Schatzki points out, contingent and unpredictable but also multiple and conflictual – there is no one direction for change. So what happens when you want to induce change and control the direction it takes?

MOVING ENGINEERING DESIGN

The efforts of change that we have witnessed at Site 3 and 4 respectively are not unrelated, though the specific doings and participants at the sites have little to do with each other due to the different settings and infrastructures. There are, in fact, quite many similarities between the two sites and what the participants are hoping to achieve in their current situations. In this way we may see them as different parts of the same constellation of practice-arrangement bundles revolving around engineering design. The same, of course, could be said of many of the other practice bundles that has been represented in the previous chapters, so let me here frame the constellation in question as one directed specifically towards the social and creative poles of engineering design (where some of the others are more distinctly directed towards the technological, cf. Figure 4).

In the UX case the designers are working to make room for their user-oriented design approaches where qualitative knowledge of the users and early user tests are central components, and they do this within an organisation otherwise dominated by a technology-driven approach. In the SD case the educational developers are working to make a 'socially responsible' engineering profile similarly oriented towards user-involvement and prototyping, and they do this within an engineering education environment dominated by technical disciplines and historical developments of the engineering profession. In other words, there appears to be a similar *teleoaffectivity* concerning the direction in which these actors are working with regards to their efforts of change and how that matters emotionally to them. In this way there is a strong normative component to the efforts of change. There is also a similarity across the two sites in the *pools of understandings* of how to go on with design work, which the 'change agents' are pushing to introduce via their efforts; overall you could say that

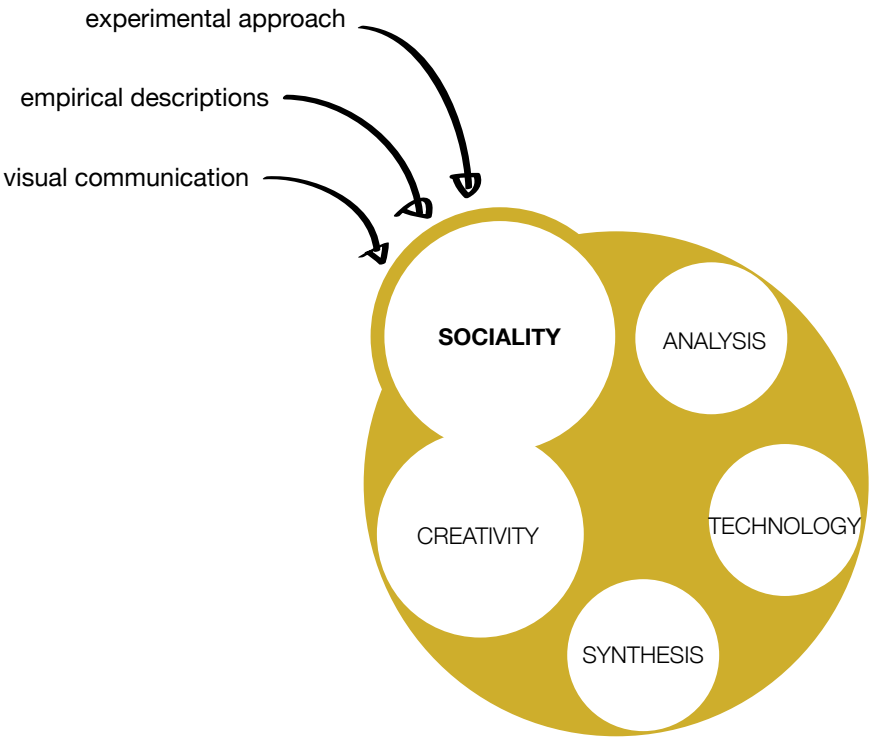


FIGURE 118 Pushing the engineering design field of tension with alternative pools of understandings.

these were focussed on an experimental approach (with early user tests, prototypes, and multiple iterations), empirical descriptions (using qualitative enquiries in contact with user and context), and visual communication (using pictures, videos, and drawings to communicate findings and ideas).

I would venture that this transition is not limited to the two specific sites we have visited here, but can actually be recognised in processes taking place in many places within and on the verge of the engineering community. It is thus interesting to take a closer look at the local challenges that such an overall move is confronted with.

STRUGGLING WITH INFRASTRUCTURES

At Site 3 and 4 respectively the specific activities of the overall transition run into different challenges. The ambitions of a new and more perform-

ative and communicative doing of engineering design challenge the local infrastructures that have sedimented over time in relation to different practice constellations. Layers of infrastructures, which favour certain relations and thus also contribute to the power distribution, hold these constellations together. To use a term from STS a new *staging* (e.g. Clausen, Yoshinaka 2007) of the design processes are thus needed in order to achieve the overall transition of engineering design.

The UX designers are in this way struggling with local infrastructures related to the traditional mass-production of cars and clear organisational separation of (technical) product development, interaction design, surface design, and the production itself. As we have seen at both Site 1 and 3 the stage-gate-model has manifested itself as a crucial backbone for the coordination of time allocation, requirements, specifications, presentations, and assessments. While these layers of infrastructure do not determine the division of labour and mutual relationships between departments they do hold a very strong influence on how the everyday proceeds – setting the stage, so to speak – and thus influence how it might be changed.

The educational developers at Site 4 are struggling with some similar yet different manifestations of infrastructural layers within the educational sphere. In Part 3 we saw how we might perceive engineering educations as bundles of practice-arrangements related on one hand to learning and doing education (learning practices) and on the other to reflections on the kind of professional practices that engineering students should learn to be a part of (substantive practices). In this part it should now be more clear that there are also many other practices involved in the educational constellations: Faculty is also involved in teaching and researching practices, the university also includes a significant administrative practice-bundle, and then there are the educational development practices we have encountered at Site 4. These are all related to and through dominating models for organising and structuring engineering education and perceiving competences, which manifest themselves in the weighing of different disciplines within the programs, the distribution of responsibilities across the university, and who and how educators are hired, amongst other things.
Intervention and negotiation within the constellations thus occurs through the frameworks of existing infrastructures that are found in the local situation – but it also forms new infrastructures in the process, which may conflict with the old structures. Such negotiations require a lot of time and effort (as the episodes of both Site 3 and 4 have hinted at) and dialogue

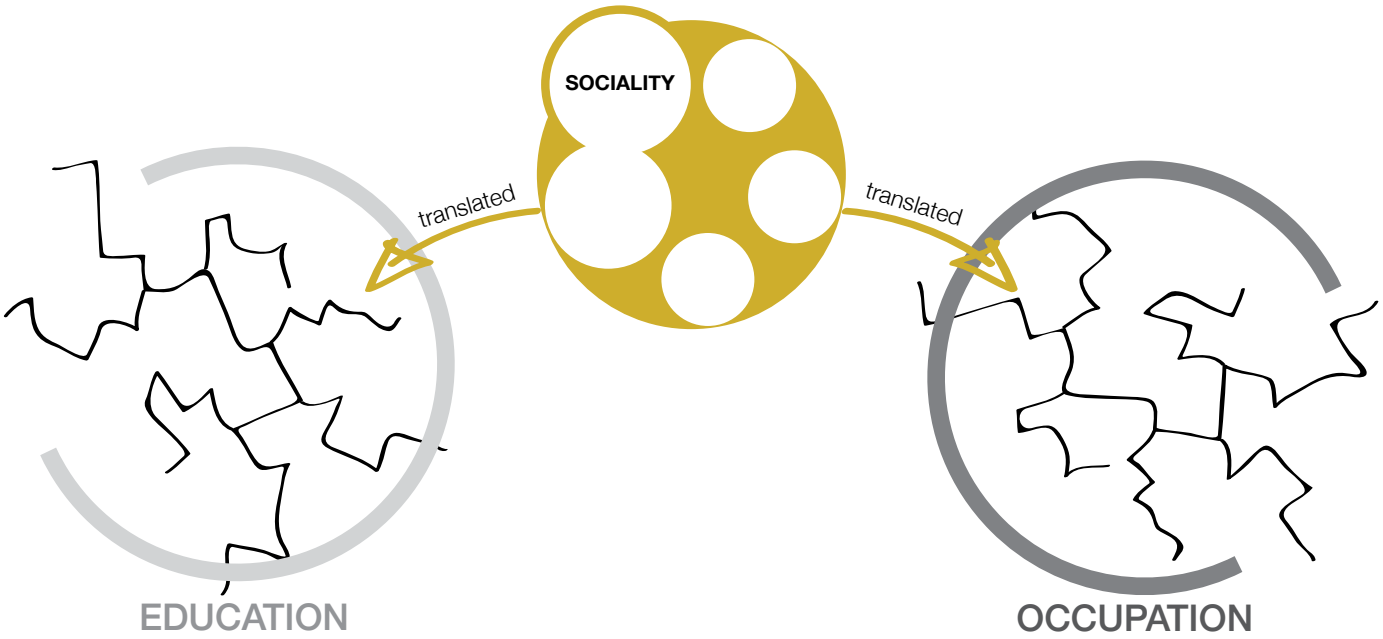


FIGURE 119 The overall transition towards a more socially informed engineering design profession is translated into the local layers of infrastructure.

between carriers of the different practice-arrangement bundles. Making the different parts of the constellation prioritise participation in such dialogue can be difficult, but when *breakdowns* in the different layers of infrastructures occur this can make room for a dedicated effort (like the process following the crisis workshop at Site 3). Breakdowns can be caused by any number of things, but we often find them in relation to significant changes in surrounding constellations, technological development, or an infrastructure that has grown too rigid and complex over time.

But changing the infrastructures will not in itself result in changes in practice. Actual change comprises changes in practice-arrangement bundles and their relations in constellations as a whole: Changes in the *projects* that practitioners should and do carry out and the related bodily doings and sayings, changes in the *material arrangements* linked to the practices, changes in the *ideas* and *knowledge* that circulates in the bundles, and to some extend changes in the prescribed or accepted *ends* and pertinent *rules* (Schatzki 2014). It all interweaves and thus changing one element may not result in any lasting changes within the larger practice bundle or constella-

tion. Whether it is a beginning of change depends on how the rest of the bundle – and perhaps especially the practices – reacts.

RESISTING CHANGE

The thing is that while infrastructures are not static they are *tough*, meaning they are hard to change even when breakdowns occur due to their intricately connected reproduction. In everyday life multiple infrastructural arrangements overlap and plug into each other, for example through standards (Star, Bowker 2006). In this way they also contribute to sustain each other. The different layers of infrastructures present within a constellation of practice-arrangement bundles thus co-produce each other – but also respond to changes within the other layers.

Even though 'organisational change' is a popular terminology and occupation in most organisations' management layers there is a limit to how great a change they actually accomplish when looking at the everyday doings. Putting a new name on a unit, moving individuals to other positions, or dictating new work assignments may signal a transition but not necessarily any actual local changes – and not necessarily the intended changes.

Kemmis *et al.* similarly point to the difficulties of changing education:

> *"Despite these transformational aspirations, however, classrooms and schools have remained strikingly stable as social forms, still clearly recognisable as the progeny of the late nineteenth century multi-classroom, multi-teacher schools created in the industrial era and transported around the globe in the late nineteenth century spate of nation building." (Kemmis et al. 2014, p1)*

The persistence of constellations and the related practice-arrangement bundles are closely linked to the layers of infrastructures that have been established in the course of their continued re-production, but it is the constellations in their interdependencies that must be transformed to make any significant change.

EDUCATIONAL REFORMS

Based on the findings from this part let us now return to the issue of engineering education and the ongoing efforts of changing or reforming these.

You could say that political reforms are a way to force through change, however countless examples show us that the results do not always match the intentions – thus supporting Star's observation that change is not achieved from the top (Star 1999, p382). While such reforms can effectively influence parts of the educational infrastructures (primarily on the left-hand side of Figure 112 in the last chapter) they typically omit entering into negotiations with the associated practice-arrangement bundles (related amongst others to teaching, learning, researching and not least the substantive practices) and the doing of education thus largely remains the same.

> *"As social forms, schools and schooling are obstinately stuck in the nineteenth century. They remain stuck there because people doggedly remake them as 'school' – that peculiar form of life familiar to almost everyone in the developed world, remote though it may be from the ways life is lived in other parts of contemporary societies, and in other parts of the days of schoolchildren, their teachers, their parents, their communities and the organisations in which the children will one day work." (Kemmis et al. 2014, p1)*

Though universities spring from a different tradition than the primary schooling system, the same frozen or stubborn understanding seems to be embedded in the organisations and reproduced in the practices by educators and students alike as the one Kemmis *et al.* lay out above.

At Site 4 the problem that remains and prevents a truly successful implementation of the program is that there has been little room to create the necessary shared practices across the involved faculty groups, which could create a shared understanding and a shared purpose among educators and students alike – something which the educational developers are indeed aware of. Instead discussions, meetings, mail-correspondences, and phone calls have circulated through the infrastructures and given cause to conflicts and disagreements. Instead of building and developing a shared experience regarding teaching and learning practices (including the physical facilities, pedagogical practices, and student learning trajectories)

the discussions ended up revolving around hour ratings, distribution of square meters, module structures, job adverts, budgeting models and so on. Instead of building a common understanding of what a 'sustainable engineering designer's' substantive practices consist of and how they unfold (including how design work is understood in an engineering context and how the notion of sustainability is used with a problem-solving focus) discussions ended up revolving around ownership, semester coordination, project themes, and how 'engineering' ECTS credits are distributed in the curriculum.

So why are practices so hard to change when they are so dynamic at the same time? The quick answer is: Because of the complexities. Because changing one thing in one place is not enough to cause the dissolution of existing practices and emergence of new ones. In their analysis of educational practices Kemmis *et al.* make the following summation of their contributions:

> *"We think that our analyses show, through the exploration of specific instances of changed practices, how practices are transformed not just by changing the sayings, doings and relatings of those involved, but also by changing the practice architectures that enable and constrain their practice. Moreover, we think our analyses show how transformations of practice are secured not just by working on teaching, student learning, professional learning, leading or researching practices alone, but by transforming each of these practices in relation to the others – in ecologies of practices. Understanding how practices are embedded in practice architectures and in ecologies of practices, we think, provides new resources for transforming education." (Kemmis et al. 2014, p22)*

The struggles and activities that have made up (and continue to make up) the efforts to develop and introduce a new engineering design education at Site 4 seems to point to some similar conclusions. Perhaps first of all, that making an education involves a whole range of different activities – and also an ongoing and evolving effort. The efforts, so to speak, thus never fully come to an end. So while a practice could be changed from one specific reproduction to the next (however challenging the established understandings of 'normal' and 'sensible'), the 'sediments' that such reproductions leave behind in the form of infrastructures, reaching across

and linking together individual practice-arrangement bundles, necessarily create a certain amount of resistance to rapid and/or significant changes.

The struggles that the UX designers at Site 3 and the educational developers at Site 4 have been through in this part are thus not only related to changing the sayings and doings of the practices but just as importantly they have been an ongoing effort to also rearrange or renew parts of the established organisational infrastructures. Actually doing educational reforms thus requires continued attention to not only the content and scope of education, and the directly related teaching and learning practices, but also the more bureaucratic practices and organisational infrastructures that govern the educational institutions. Making room for exchange and renewal across educational constellations is not a natural part of such practices and infrastructures. But if the educational constellations are to stay relevant such efforts need to be carried into the practice-arrangement bundles somewhere – and the educational development efforts seem a natural place to consciously do so.

The ideas of ecologies of practices that Kemmis *et al.* introduce above provide an interesting perspective on the relation between the elements of practice bundles and the larger infrastructural layers in relation to how constellations are then able to evolve. In the concluding part I shall introduce this more in full in order to round off the discussion and take status of where this thesis leaves us in relation to practicing and changing engineering design.

Others have seen what is
and asked why.
I have seen what could be
and asked why not.

Picasso

CONCLUDING

We have now been on a journey through the intricate landscape of engineering design practices in Denmark – even if only a fraction of it. I would venture that this journey can help us improve the understanding of what engineering design involves, the relationship between the spheres of education and occupation and its role in preparing students for such design work, and the challenges we are facing when attempting to move the engineering design field forward.

In this final part I will recapitulate the main points that have emerged from the two moves through the empirical material and analytical discussions. From this I will point to some interesting areas that could warrant further research in order to identify where and how we might make room for changes after all. Finally, I will move on to reflect on my approach and the contributions that this has yielded.

5 DISCUSSION | 1

the point being

Over the years engineering has grown to be an important profession for societal development in an era of complex technological challenges. Engineering designers have built a reputation as society's problem solvers holding the key to the future. Young students are drawn into engineering educations with promises of cool technological gadgets, mind-blowing science and hopes of 'making a difference'. Notwithstanding a tarnished image of engineers being either the guy in a hard-hat and tie at the building site or the geek in front of a computer, the Danish universities have successfully increased the uptake of engineering students over the past 10 years (Uddannelses- og Forskningsministeriet 2014).

But despite a growing number of engineering profiles, a growing diversity among the students drawn to the engineering profession, and a continued cry for more engineers in industry there appears to be a persistent challenge in the transformation from student to professional. Something appears to be out of sync between education and occupation.

PRACTICING AND CHANGING

In this thesis I set out to take a closer look at this problematic space in-between and across engineering education and engineering occupation. The fundamental problem that I have been curious to unfold is how our contemporary and academically informed educational system appears challenged when it comes to prepare engineering graduates for the actual design work done in industry. I have been interested in the dynamic relations, the mutual reflections, and the continued tensions between education and occupation.

I thus asked:

> **How can we understand our academic educational system when it comes to resonating professional engineering design practices?**

I will here provide a brief summation of the main points that I have developed in Part 3 and 4 of this thesis relating to my wish to explore how engineering design is *practiced* on one hand and *changed* on the other.

PRACTICING ENGINEERING DESIGN

Part 3 showed us how design practices bundle together with other practices at the local sites and how material arrangements support and manifest the doings and sayings of practice carriers. Engineering design is a special kind of practices, which thrive and unfold through ambiguities and dynamics. As such I proposed they best be understood as *epistemic* practices that revolve around that which one does not yet know or fully understand. While professional engineering designers engage in these epistemic practices at work they also participate in practice bundles including more administrative, strategic, and network-oriented practices, which appear to be crucial in order to find room for the exploration of design as an epistemic object. The practice bundles that engineering design students are engaged in instead show a distinct twofold quality. One (the substantive practices) bears resemblance to the professional practice bundles, while notably missing the administrative, strategic, and network-oriented components. The other is dedicated to the project of *learning* (the learning practices) and relates to the doing of higher education. The dilemma of engineering education is thus that you can be a competent student without necessarily becoming a competent engineer.

Seeing engineering design as *practice-arrangement bundles* with many and divergent elements we are thus able to recognise the complexities that feed into the everyday doing of engineering design in education and occupation alike. Hopefully this can help us move past the simplistic and rational perceptions of problem-solving processes and help educators and students realise the many facets that feed into the accomplishment of design solutions – facets beyond the technological, scientific, and methodical elements that are currently prioritised in the 'core curriculum'.

CHANGING ENGINEERING DESIGN

Part 4 showed us how recognising both strong and weak relations that link different practice-arrangement bundles together in larger *constellations* help remind us of the complex interdependencies that exist with other practices beyond the one(s) at the centre of attention. Efforts of change are challenged by these interdependencies because making a change in one component of the constellation will far from ensure (the desired) change overall. Nevertheless practices are dynamic and constantly evolving, which have the potential to change with every new re-production. But there are other things at stake, which hold back efforts of changing the room for and scope of engineering design. These are layers of *infrastructures* settled in their current forms over long stretches of time and relating to previous re-productions of the practice constellations. Making room for a more socially and creatively informed engineering design practice within the educational and occupational sphere alike was thus met with strong organisational infrastructures that had to be navigated, opened up, and rearranged through various strategies. The notion of infrastructures can thus help us understand why the results of change initiatives are often so modest when they are translated from idea to practice.

RESONATING OCCUPATION IN EDUCATION

So how *can* we understand our academic educational system when it comes to resonating professional engineering design practices? Well, I hope to have shown that education and occupation unfolds within two spheres made up of similar components (practices and material arrangements) but with different structures (layers of infrastructure), which relate to their distinct historic developments and continued re-productions. Each sphere can be seen as a collection of constellations revolving around either the project of educating for certain profiles (such as engineering designer) or professionally achieving certain results (such as user-friendly cars). The ability of education to resonate occupation is thus challenged by the respective infrastructures, which enable and give shape to the practices and constellations. Academic education can never become a mirror of professional practices though much reform work appears to have this as the ideal. Similarly it is also naïve to hope that occupation can or will reflect the ideals that are governed in education.

But do we really want to bring education and occupation as close to each other as possible? Does that really provide us with the innovation and development that we crave so much?

Though posing many challenges I would propose that the so-called 'gap' between education and occupation could actually be a source of *productive* tension. We might all agree that academic education and professional occupation should be able to relate to each other in some way – if the two spheres are too far removed they start to become irrelevant for each other. Practices found within the one will not share anything with practices within the other and there will be a lack of understanding across the two spheres. This is clearly a situation we are trying to avoid by continuing to develop the educational sphere and attempt to re-produce it as relevant for the occupational sphere.

But what if we imagine a situation where the educational sphere fits the occupational sphere like a glove? What if new graduates are being educated to do *exactly* what they will be doing in their future job? While such an ideal situation is unlikely to ever occur I would also question just how ideal that would be. If education and occupation start to fit perfectly together then they will simply be reproducing each other as status quo. There will be nothing to push a change on either side – and though the push could still come from other spheres it is not too hard to imagine the immense infrastructural layers that would have to be challenged if these two spheres more or less merged together.

Instead, what we might aim for is to find that balance between education and occupation where each keeps its unique configurations but remains close enough to mutually push each other's development. Such a productive field of tension would ensure the dynamic necessary to keep the educational practices alive and useful also in relation to the future job market – and it would help us move past the much more mechanistic 'gap' discussion, which tends to lead to conservatism rather than development.

Reforming engineering education should thus not only be seen as a way to keep up with the current demands from the occupational sphere, but perhaps even more so as a way to *push* how engineering design can be done. Doing this, however, you have to acknowledge and deal with the inertia and conservatism that educational and occupational constellations alike accommodate in their infrastructural layers. This fosters thinking about the complex relations in an ecological perspective.

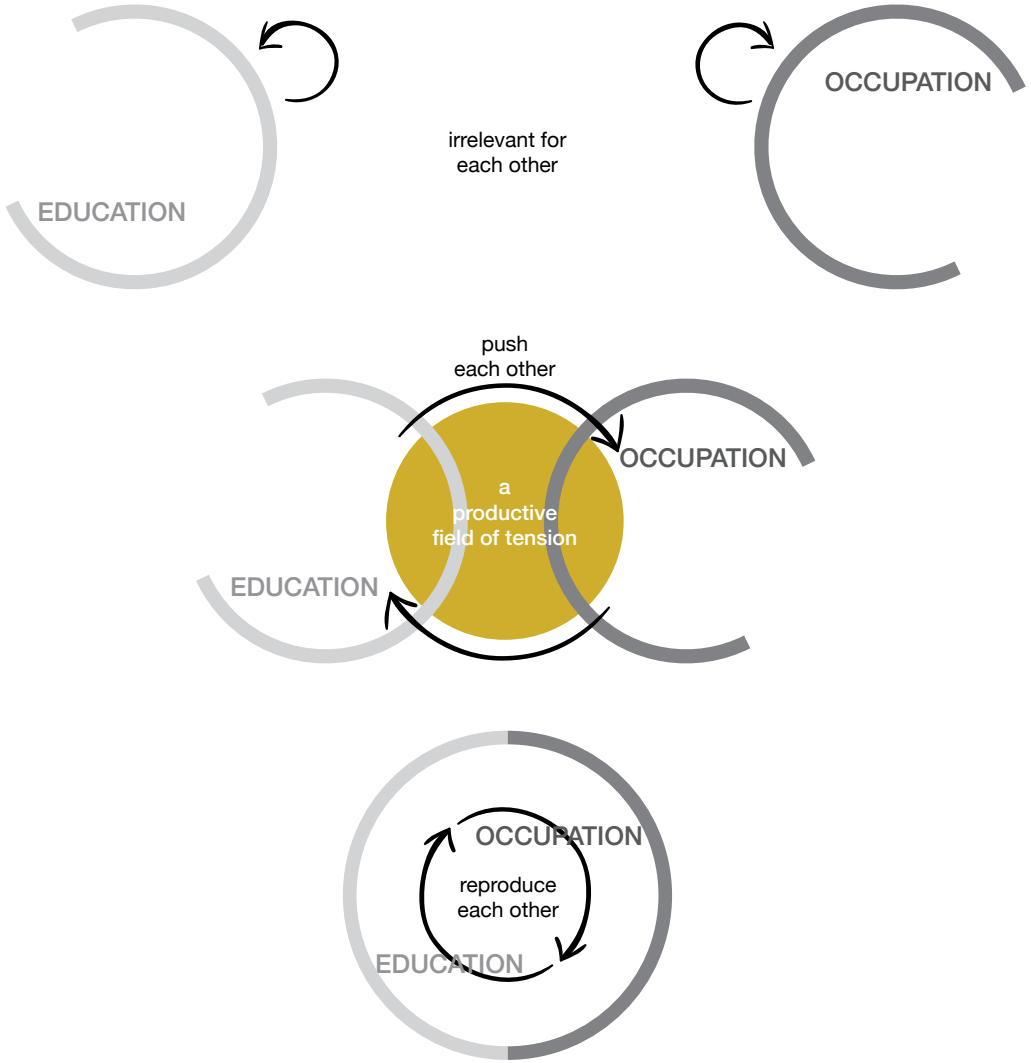


FIGURE 120 | Finding the 'right' balance between education and occupation creates a productive field of tension.

RECOGNISING ECOLOGIES

My juxtaposition of the educational and occupational spheres in this thesis is interesting because it points towards what we might call the broader *ecology* surrounding engineering design practices. Allow me to pause here

for a minute to put my observations into perspective before moving on to discuss how this research could be taken forward.

In their book on educational practices Kemmis *et al.* suggest that practices exist in ecological arrangements characterised by interdependence among the practice-arrangement bundles and infrastructures[21] and develop this to a theory of *ecologies of practices* (Kemmis *et al.* 2014). The way this thesis has moved from focusing on the components of individual practices, their related material arrangements, on to how these elements bundle together and are connected in larger constellations it now seems appropriate to end with such an ecological perspective.

Looking at ecologies of practices means recognising the networks of interrelationships between practices, which mean that the unfolding of one practice bundle can leave residues or create affordances (sedimenting in infrastructures) enabling and constraining how another practice bundle can unfold – just like different parts of living ecosystems relate to one another interdependently. As an example, teaching and learning practices depend on each other to persist or be re-produced and they shape and take shape from each other (that is, it is not only the practice *carriers* that relate to each other but the practices in themselves). This perspective also supports the natural evolution and dynamic which is a natural part of practices' persistence.

As I pointed out above, changing engineering design is not only about changing the way engineering design is taught or what is placed at the core of the engineering curriculum, but also about changing the educational constellations as a whole as well as the organisational constellations that engineering design is a part of. In other words, it is about changing the *ecology of practices* that engineering design exists in. Schatzki similarly argues: "Because social phenomena transpire in a plenum of linked practices and arrangements, social change consists of changes in bundles - in the practices, arrangements and relations that compose bundles" (Schatzki 2015, p17).

Engineering design in the form best known today, with its focus on technical synthesis and functional analysis, persists because of the interdependent relations across the ecologies of practices that have evolved with it and supports it. It is therefore not enough to set new targets for education, to introduce new pedagogical methods, to make new curricula requirements, or to adjust what is assessed at exams. Such measures only target a fraction of what goes on in-between and across education and

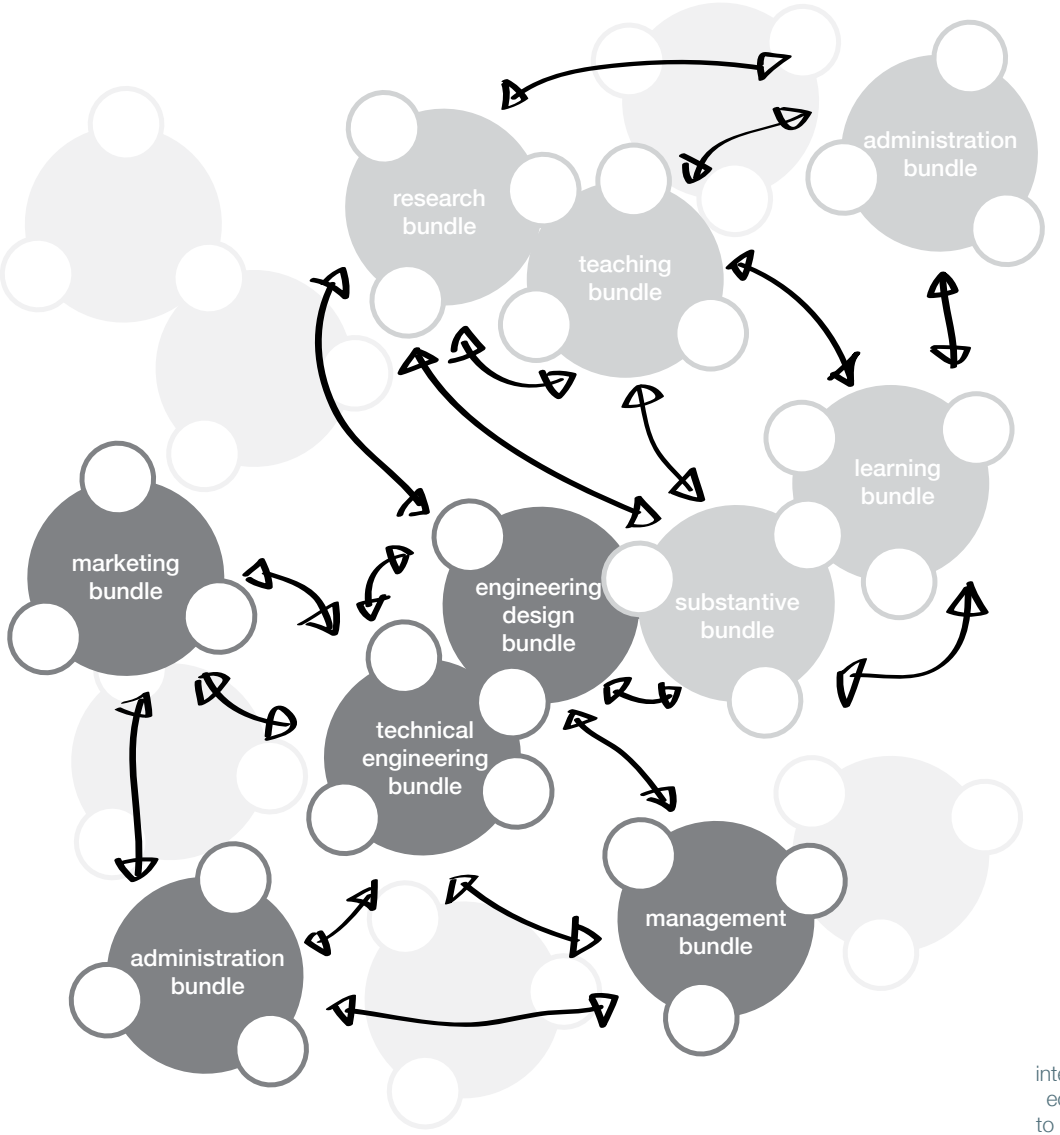


FIGURE 121 | Examples of interdependencies across the ecologies of practices linked to education and occupation.

occupation. Instead you have to take the ecologies as a whole into consideration.

Kemmis *et al.* conclude their observations of primary education this way:

> *"Thus, it seems to us, the connections between these practices [student learning, teaching, professional learning, leading, and researching] arose rapidly and simultaneously with the advent of mass schooling. From this moment, they were designed to be interdependent. And they still are: if change in education is to be wrought, then all five of these practices need to be changed in relation to one another […] We contend that if educational change is to be realised, then the transformation agenda needs to address these practices not just one at a time; it seems to us that transformation of each requires the transformation of all five, in all their ecological interdependence." (Kemmis et al. 2014, p 51)*

Based on my study I would add to this that the ecologies of practices found within the occupational sphere are also interrelated with the educational complex. Changing how engineering design is practiced is thus not only a question of composing new study programs or transforming the educational complex, but it also entails making changes in the professional practice bundles that are ecologically interlinked with engineering design.

GOVERNING CHANGE

In her introduction to the anthology *Ecologies of Knowledge* Star (1995) refers to Hooks (1990) in the field of (American) feminism to make the following point:

> *"the notion of "institutionalized racism" has been crucial in understanding that racism is not simply a matter of people not being nice to each other, nor necessarily to be found in a single set of micro-interactions – rather, it is a web of racist discourse and practices that extends through and informs all human practice – and cannot be simply transcended." (Star 1995, p10)*

Such 'webs of discourses and practices' is exactly what we have been engaging with in this thesis – though not related to racism but instead engineering design. The racism example, however (in my opinion), helps recognise why change does not come easy. It is not simply a matter of going about design in different ways, nor is there necessarily always conflicts of interests in every interaction. But there is a significant resilience to be reckoned with.

The durability of these webs of discourses and layers of infrastructures running through constellations of practices tend to increase with the complexity of the constellation and thus start to loose some of the original plasticity that characterises the initial boundary objects. From the ecological perspective you could say that the more complex the network of interdependencies, the more resilient it is, and thus the harder it is to change (or the better it is at countering changes).

This durability, however, should not be confused with definity – from the situated perspective it is still 'created' anew in each situation. Practices are realised in everyday interaction between people and objects at local sites. They occur at particular times and under particular circumstances that relate to the particular situation and the particular people and the practices that they carry with them (Kemmis *et al.* 2014).

The STS tradition also reminds us that things could always have been otherwise. It is not set in stone (or in practices) that things unfold as they do; there is not some rational necessity behind the way things are constructed or inscribed. And therefore it can also be changed – in fact it will always keep changing: "What I am saying is that small or local change always occur, that which bits change shifts, that big changes include and arise from small ones, that whether small changes lead to bigger ones partly depends on how people and practices respond, and that every activity is thus potentially a beginning" (Schatzki 2015, p17). The question, then, is can we do anything to actively govern or steer this development in certain directions rather than others?

Governance is an interesting concept when discussing educational development and strategies. It is the intentional intervention in the form of directing, shaping, or influencing some target (such as future engineering designers), aiming for some goal (such as a more socially oriented way of doing design) (Schatzki 2015). In this way governance links to specific ends, to decision-making, and to power relations.

Schatzki also considers governance in the practice perspective in one of his latest texts: "Would-be governors (and policy makers) should think about shaping the organisations and trajectories of practices, creating new practices and bundles, eliminating others, and altering key bundles and constellations," – in other words thinking in the ecologies of practices. "Doing this requires focusing on, among other things, the teleological organisation of practices, interwoven timespaces, the ideas and knowledges alive in practices, the interactions and power relations that characterise

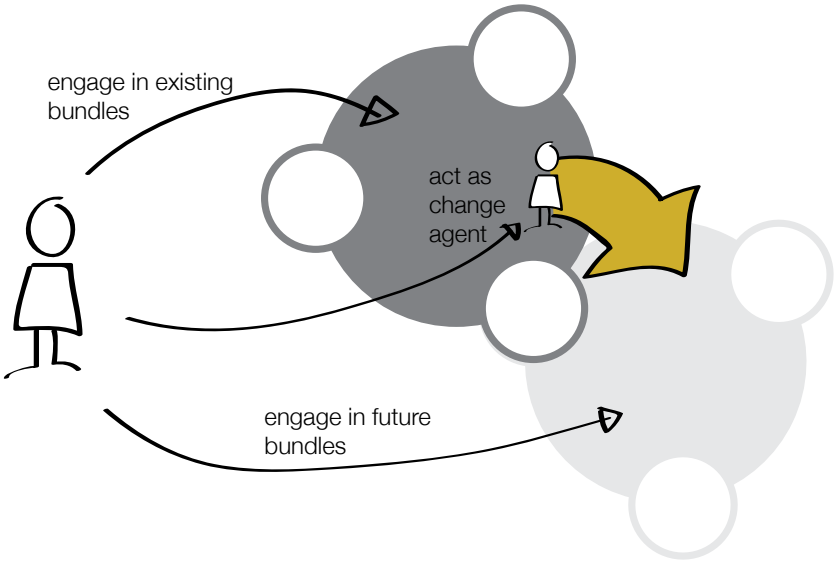


FIGURE 122 Potential role of future engineering designers.

them, and their materialities and objective spaces," – that is, not only the practice-arrangement bundles but the full web of discourses and infrastructural arrangements. "It also requires attention to relations among practices, among arrangements, and between practices and arrangements, as well as to the bundles and constellations that form the contexts in which specific practices and bundles emerge, disseminate and dissolve" (Schatzki 2015, p22). Taking all of this into account also requires a diversity in the governors instigating and directing the changes.

At Volvo the engineering designers were fortunate to be part of a unit with shared practices, which made them a stronger participant in the negotiations of change. When new design graduates enter the occupational sphere they most likely do not have this collective support for instigating change and making room for alternative ways of doing design. It is thus important for educators to consider not only how new engineering design profiles may look (such as the sustainable design engineer) but also how these should be prepared to negotiate the room necessary to unfold the new practices they bring with them within existing organisational infrastructures.

This leaves me with a new curiosity: Is it possible to educate for change? Can we educate engineers to be more capable of navigating existing con-

stellations and infrastructures in order to change them into new ones that leave more room to unfold certain alternative practices? And could this become a component necessary in future engineering work?

CONTINUING

The future might seem far away, diffuse, and hard to do anything about. But the future is actually being made right now, all around us and through our current actions, aspirations, and projections. With the educations we develop right now, with the changes we are trying to push through in different situations, we have an impact on the future. Just as the past is in the present, so the future is also in what we are doing right now. The foundation of future of engineering design is being made with the young students and their project work at the design programs. It is made with their reactions to our ideas of what engineering design education should be. It is made when new ways of doing either find room in industry or withers away.

Allow me to point towards a few areas that appears to be interesting to unfold further or at least keep in mind in future research related to 'future-proofing' engineering (design) education from a practice perspective.

THE NORMATIVE COMPONENT OF DOING

What makes a 'good' or 'sufficient' or 'successful' engineering program appears to be far from an unequivocal and neutral project. Like so much else it depends on the eyes of the beholder and is influenced by a myriad of agendas, ambitions, convictions, and interests. Improving engineering education is thus not simply a matter of 'optimising' the teaching, improving the identification of occupational 'competence needs', or more clearly specifying 'engineering professionalism'. Engineering education is necessarily always also a *normative* project, which is carried out in local situations and by embodied people, who participate in a number of practices.

Within engineering studies Downey (2014) speak of a *normative holism*, which appears to dominate engineering education across the world, in which a strong equivalence is drawn between the technical components of engineering and the engineering profession's contribution to the general advancement of humanity as a whole. At the same time, however, there

appears to be many different understandings of what 'human advancement' actually entails – in other words, reality is a normative *multiplicity* rather than the holism that continues to govern our engineering educations (Downey 2014) and have sedimented in the infrastructural layers.

As a continuation of the present study it could thus be interesting to take a more discourse-oriented approach in order go deeper into the rationalities embedded in the different practice-arrangement bundles that are involved in the doing of engineering education and the local conflicts related to the doing of such education. This thesis shows that not only educational developers influence and give shape to engineering programs, but we should also remember to look to university administrators, research groups, the students, politicians and public servants, industry leaders, HR departments, professional societies and so on. There are many discourses related to the doing of engineering work both now and in the future, and yet there seems to be a tendency for the same discourses to be re-produced or re-translated into new engineering programs over and over again. Combining the present analysis of organisational infrastructures with a focus on discourses and power relations could be a productive way to further improve the understanding of the delicate tension between education and occupation and the production of engineering profiles.

THE POLITICS OF PRACTICES

In this thesis processes of negotiation, convincing, even lobbying have come out at several points. It is thus not a far stretch to call attention to the *political* work that is often involved in the doing of engineering education and engineering work.

Change (or resistance to change) is a central element of politics and governance – but in such connection it is also always oriented towards some goal or ambition, perhaps even part of a larger program. Different challenge perceptions and response strategies are in this way closely tied to different practice-arrangement bundles, and tensions between these perceptions and strategies are important in order to understand the controversies that arise.

A way forward could thus be to draw on governmentality studies in order to get a better hold on the way the engineering challenges are perceived within different bundles (and not only the engineering bundles) through the more concrete response strategies. Buch (2012) has in this

way identified three different strategies related to the reformation of engineering education: The business strategy (responding to market challenges by introducing more business and management), the professional strategy (responding to challenges of social responsibility by pursuing alternative professional ideals), and the hybrid strategy (responding to knowledge challenges by reconceptualising engineers into new hybrid academics).

Another way forward could be to draw on a political process perspective and the ideas of staging socio-technical spaces in connection with boundary objects. Clausen & Yoshinaka (2007) have in this way explored the challenges faced in the staging of design processes across organisational spaces populated with practices well-anchored in departmental structures, established disciplines, cultures, and ways of thinking and how multiple perspectives and types of knowledge are brought into especially the early (fuzzy) phases of product development. Their findings that "The concept of socio-technical spaces points at the negotiated frames of interpretation and the selective mechanisms by which innovative projects are launched through organisational 'filters' which affect the identification, evaluation and selection of ideas," (Clausen, Yoshinaka 2007, p76) are well aligned with my findings regarding the negotiated infrastructures between and across multiple practice-arrangement bundles that influence the efforts of change. The concept of staging could, however, be useful in further sensitising the political dimensions of the various meanings and interests that come to shape the doings of design and the role of the engineer as a 'change agent' or 'stager'.

Looking closer at the politics of practices will thus be interesting in relation to better understand what gives rise to efforts of change, what enters into the ongoing negotiations and marks the different positions, who's goals and ambitions 'win' the negotiations, what these goals are, and who stands to gain from these ambitions – in other words what normativities drive the political negotiations and ambitions to govern the engineering professions in certain directions rather than others. Keeping the sociomaterial infrastructures in mind we might be better equipped to understand where certain goals and ambitions get blindsided or marginalised in the process and how power relations are maintained in the broader ecologies of practices.

As we are facing severe sustainability challenges both now and in the future it is very relevant to not only look at what is 'wrong' with how we do

things but also to look to our past and present doings and improve our understandings of these. Change is constantly in our doings and they could always be otherwise – and yet our actions are not completely random or without reason. If we want to make changes we need to recognise the delicate complexities and interrelatedness that makes up our sociomaterial world and govern our actions.

REFLECTION 5.2

doing it my way

From the beginning of this project I have been quite humble of the task I have set before myself and aware that I would only be able to engage in a fraction of the multiple relations that make up the problem area in-between and across engineering education and occupation. Also I did not set out to pinpoint 'culprits' or wrongdoings. Instead I set out with a great respect for the complexities that makes up the problem area. As such, I have also not had any ambitions of coming up with the solutions to 'fix' the gap between education and occupation. So what has my research contributed with instead?

CONTRIBUTING

First and foremost I hope to have contributed to the *understanding* of how and why design practices are carried out as they are in the everyday life of students and professionals alike.

EMPIRICALLY

The empirical material presented in this thesis offers a rare juxtaposition of education and occupation and analytical linkages across these two grand spheres. By framing my problem area in-between and across education and occupation my work points to the correlations across and the many layers of complexities that need to be taken into account when trying to understand what unfolds in this area of tension.

With the thick descriptions I have offered my humble contribution to our growing understanding of the situated doings of engineering design practices as they unfold in the mundane everyday life – an understanding

that springs from and continues to grow within engineering studies. With the explicit practice perspective my empirical material brings new insights of the heterogeneous elements that enter into and shape engineering design work and also holds it in place. It helps recognise the normativities that are always embedded in the re-production of professional practices.

By recognising the interrelatedness and complexities that govern the space between education and occupation my hope is that this can lead to the identification of possible openings for change and opportunities for improving our engineering (design) educations.

THEORETICALLY

With this thesis I have also made a contribution to the field of engineering studies by strengthening the practice theoretical vocabulary for understanding engineering doings and sayings. Employing Schatzki's framework, in my opinion, offers useful concepts to describe and analyse empirical material from ethnographically inspired research, which prevails in engineering studies. With this conceptual approach I have thus shown how complexities that are otherwise likely to be marginalised can be captured and rendered comprehensible through a generic vocabulary sensitive to such nuances.

I also hope to have made a modest contribution to the development of engineering educational research from a practice perspective by building on Kemmis *et al.*'s work in "Changing Practices, Changing Education" (2014). Especially the notions of *learning* and *substantive* practices and *ecologies of practices* respectively provide a vocabulary, which is more than relevant to also introduce in discussions of higher education in general and engineering education in particular. This vocabulary also helps facilitate discussions of the relations between education and occupation and thus strengthens this part of the educational research agenda.

REFLECTING

To wrap up this thesis I want to indulge in a bit of self-reflection in relation to the overall approach that has guided the work behind this thesis, which was introduced in Part 2. A lot of choices have been made along

the way in this project and I want to offer a short discussion of some of the consequences of these.

PERSPECTIVE

In Part 2 I pointed out that where you start from and what you look for holds great influence on what you might see – let me therefore start by reflecting on the consequences of my fundamental perspective in this thesis. My choice of focusing on the sociomaterial interactions that are practices necessarily has strong bearings on what has been presented on the preceding pages.

The situated perspective has helped unfold the complexities of even apparently mundane doings, such as making a drawing or performing an interview, by paying attention to the *situations* of these actions as physically located occasions that are inseparable from what takes place.

My relational epistemology has enabled me to see the multiple normative dimensions that are negotiated through a continual and processual dynamic. But my focus on these relations has also effectively given privilege to the processual elements of the everyday over the nature of the specific objects that are brought into these processes.

With my choice of perspective it is not surprising that my findings all circle the issue of *complexity* – for complexity is exactly what the situated practice perspective allows me to see. In my opinion it is important to recognise the interlinked nature of our doings and sayings and the ways we perceive and understand these doings and sayings in relation to our surroundings.

METHODOLOGY

My research design bears strong marks of my ontological and epistemological stance and close-up, locally situated, ethnographic enquires have thus dominated my methodology.

Venturing into an ethnographically inspired study with no background in anthropology, cultural studies, or sociology might seem a daring choice – and perhaps it has been. But nevertheless it was a choice that made sense to me in the light of my ambitions for interests in the project. With my own background in engineering design with a sociotechnical profile I am also not a complete novice in the doing of observing and listening in the

field. This being said, the relatively short timeframe for my ethnographic enquires compared to the more 'traditional' ethnographies does necessarily hold some limitations for my findings. With roughly a handful of visits to each site I have been able to follow the processes at work in the various settings, though I have necessarily had somewhat limited opportunities to get 'under the skin' of the local doings and learning to understand the local 'languages.'

Based on my initial experiences with a more interview-based approach at the subsequently discarded sites of architectural engineering education and occupation I choose early on to devote my attention to the ethnographic observations in the middle of the everyday life at the individual sites. These observations have enabled me to experience engineering design in the making, that is, the *concrete* re-production and manifestation of engineering design practices at the local sites rather than the *perceived* reflection of doing engineering design that an interview-based research design would provide.

Looking back, however, I recognise that a greater methodological multiplicity in the empirical enquiries could strengthen my conclusions further. The practice perspective has helped me see the multiple forms of elements that feed into our everyday doings and sayings. While many of these can be observed – at least in their consequence – many are also more tacit in nature and only appear as indirect shadows in the local situations. With a stronger interview component in the research design I might have had better access to the discourses and multiple normativities that contribute to these shadows and are drawn into the local situations by participants from different parts of the constellations. However, given my somewhat limited access to the participants engaging with my primary observation subjects it has not been possible to invite a reasonable share of these multiple perspectives into the empirical material through interviews.

Nevertheless, the multi-sited ethnographic approach and the methodological flexibility it calls for has proven its merits to me over the course of this project. Visiting different yet interlinked sites of engineering design practices has reduced the risk of 'blind spots' and ensured a wide representation of understandings despite the limitations of access at the individual sites. What I might not have noticed at first at one site has then later stood out at a different site. There is also a certain opportunistic character of a multi-sited study, which is interesting to work with. Links may emerge

and opportunities may arise as the study proceeds. In practice, however, it is far from all of these you have the opportunity to pursue.

Circumstances would have it that my field visits at the different sites would take place in largely overlapping periods of time. While this has helped me see similarities and differences across the sites it has also meant that learnings from engaging with one site has not easily been transferred to the field approach at the next site.

CLOSENESS

I have had both the advantage and challenge of being very close to the empirical field that I have studied. The advantage has been my already established insight in and knowledge of – at least part of – the workings in design work and education. The challenge, then, has been the obvious peril of forming blind spots and failing to see what a more 'outside' ethnographer might have noticed and questioned. I will not claim to have balanced this delicate line perfectly. But I do believe that my unique situation has given me an advantage in taking on such a research design.

As a PhD fellow I have in fact neither been a 'true' insider nor outsider, but rather 'on the verge' of the practices that I have been observing. Though I have myself been a student at D&I and participated in the very project course we came to know at Site 2, then it is 10 years ago and I no longer think of myself as a 'D&I student' (though I do find myself missing it at times). I thus embody the recollection of being a student there and doing the kind of design work I have now observed, but the passing of time have inadvertently helped me create sufficient distance to now treat it as an object of study and reflection. As for the sites of professional practice my closeness has not been as pronounced – merely through my own education and professional interests resembling those occupying these sites. Finally, there is Site 4, which has probably been the most challenging one for me to deal with. This site emerged in my research design as a true construct of chance; simply unexpectedly finding myself in the middle of the kind of consequences that attempting to change how engineering design is done educationally can induce. Too good an opportunity to miss – but also very close to home (in fact even a change of 'home'). Suddenly I found myself studying not only many of my new colleagues but also my main supervisor.

Experiencing the messiness of 'the other side' (education from the perspective of the educators rather than the students) was a lot to take on in the middle of also adapting to the new life that comes with doing a PhD. And then the fact that I was (and to some extent still is) a newcomer to this 'other side' has also been what has helped me deal with the closeness. What happened in these in-house episodes was not self-evident or easily understandable to me – they simply happened very close-by, which gave me the unique opportunity of keeping up with the developments.

Engineering work and education is a complex, multifaceted, challenged, and very fascinating field. Research in engineering studies and STS offer an important counterbalance to the traditionally more positivist and substantialist ways of understanding and working with engineering. Instead of trying to set up models and methods that can help make engineering work more effective and efficient and more objective and true, these studies of the everyday, situated, and socially informed doings of engineers helps add a different perspective and offer important nuances to the debates of the future of the engineering profession. With this thesis I hope to have made my, however small, contribution to these debates.

Concepts

BOUNDARY OBJECT

Either an abstract or physical artefact that inhabits several intersecting social entities, which negotiate and co-construct it's meaning. With its inherent interpretive flexibility the boundary object can bridge or overcome perceptual or practical differences between the social entities.

COMPETENCE

There are many ways to define competence, which also relates to the diverse context of use. In relation to the educational qualification frameworks competence is typically used to describe a student's ability to combine and use the relevant knowledge and skills in concrete situations. To expand a bit on this from the situated perspective you could point out that what the individual is able to do in a concrete situation not only hinges on him/herself but also on other people and elements in the situation. While competence is thus often discussed as an individual ability it has in fact a strong sociomaterial component.

CONSTELLATION

Corresponds to a practice-arrangement bundle only spatially larger and often more loosely connected. Relations between practice-arrangement bundles thus form these larger constellations, which are made up of the same elements of practice bundles and material arrangements.

ECOLOGY OF PRACTICES

Just like different living organisms are co-dependent and links together in complex systems with other organisms and their environment, so the theory of ecologies of practices suggest that some practices exist in ecological arrangements where they relate to one another interdependently. The shape and content of one practice thus holds consequences for the shape and content of another.

EPISTEMIC OBJECT

A physical or abstract object embodying that which one does not yet know, thus lacking object-ivity. The epistemic object is fluent, unfolding, and constantly insisting on further exploration.

EPISTEMIC PRACTICES

A knowledge-centred, creative and constructive practice revolving around that which one does not yet know (an epistemic object). Epistemic practices thus include ambiguity and uncertainty and are always dynamic and potentially filled with conflict.

INFRASTRUCTURE	Helps connect and stabilise practice-arrangement bundles into larger constellations through a regime of stabilised boundary objects. Infrastructures normally fade into the background or sink into the practice-arrangement bundles, but nevertheless implicitly governing the actions that take place through them.
INTUITIVE EXPERTISE	An intuitive 'feel' for what is the appropriate response in a concrete situation, which the expert builds on an extensive and growing repertoire of previously encountered similar situations.
KNOWING IN PRACTICE	A way of seeing knowledge as an ongoing collective and situated accomplishment and thus makes practice and knowledge equal because practicing is knowing and vice versa.
LEARNING PRACTICES	Learning as a distinct practice in itself, especially within formal education, that is the practices by which people learn. It thus includes preparing for class, attending lectures, working in groups, preparing assignments and so on.
MATERIAL ARRANGEMENTS	Material components linked to the doings and sayings of a practice. These can include human bodies, artefacts, organisms, and things that can be linked by physical connections or causality.
POOL OF UNDERSTANDINGS	The practical understandings of how to go on in a sensible way in a situation, which is build on the history and traditions embedded in a practice.
PRACTICE-ARRANGEMENT BUNDLE	Practice bundles and material arrangements are inseparable from each other, but also link together through thickets of relations in bundles of multiple interconnected practices and material arrangements.
SET OF RULES	Rules with explicit formulations of how things should count or how they should proceed within the practice.

SITUATED

The idea of situatedness acknowledges *situations* as more than mere containers of actions but as part of the doings and sayings that take place. A situation is thus seen as a physically located occasion where actors (and their interests) and environment (with its objects and opportunities) meet and are reciprocally defined.

SUBSTANTIVE PRACTICE

The professional practices, which new practitioners (students) are being initiated into, that is the 'target' of learning practices. It could for example be engineering design practice.

TELEOAFFECTIVE STRUCTURE

The overall project and ends of the practice, governing what it makes sense or is acceptable to do looking towards the future.

NOTES

1. The term 'civil engineering' emerged to distinguish the new branches of non-military engineering. In Denmark we have held on to this broad understanding of the term whereas in other countries civil engineering is dedicated to engineers working with the built environment.
2. In Denmark the *Polytekniske Læreanstalt*, see also the Introduction to Part 4.
3. The Project on Research of Opportunities and Challenges in Engineering Education in Denmark.
4. In Denmark there is a strong focus on the concept of 'competences' where you might talk more about 'skills' or 'skill-sets' in other contexts. While there are many similarities there is also a difference. Under Concepts you can find a short definition of 'competences', which will be the concept that I primarily refer to throughout the text.
5. He has also suggested adding general understandings (including e.g. religious, ethical and aesthetic understandings), though I will not be going into those here (see e.g. Schatzki 2002, Schatzki 2012).
6. Wittgenstein labelled this 'family resemblances' to capture how we can group entities together that only share some similarities and not actual common properties, much like members of a family can have similar features though are not exactly the same (see e.g. Wittgenstein 2010).
7. In other practice theoretical frameworks this is emphasised by including the materials in the practice itself, Shove *et al.* (2012) for example suggest that practices are composed of *competences*, *materials*, and *meanings*.
8. All names are pseudonyms.
9. There are also details from the observations, which I have not included in the episodes represented here because they seem of little relevance to my focus in this study. This includes for example the nationality of the team members and their general appearance.
10. I have had no chance to interview her in order to get her own view on the matter, so this is strictly deducted from the reactions I have observed.

11. All names are pseudonyms.
12. There are also clear power dynamics at play in the teacher-student interaction, but that lies outside the scope of the current analysis.
13. They draw philosophical inspiration from Wittgenstein's notion of *knowing how to go on* (see e.g. Wittgenstein 2010).
14. In the NAE report it is suggested that this 'essence of engineering' includes "the iterative process of designing, predicting performance, building, and testing" (p53).
15. An evaluation conducted in 2010 showed employment of D&I graduates within large international corporations, small private companies, as well as public institutions in positions spanning product development, consultancy, research, programming, and management (Brodersen, Lindegaard 2010).
16. In Denmark 'civil engineering' is used to denote all academically trained engineers, and not just those working with building construction.
17. In Star's original research this was aimed at analysis of the scientific community but has since been widely adopted because cooperative work between entities with different goals are found in many – if not most – professional work settings.
18. All names are pseudonyms.
19. As the team's understanding of the FDRs later on improves it turns out these are also quite important in the cross-department collaboration when a function involves input from several domains.
20. All names are pseudonyms.
21. Instead of practice-arrangement bundles and infrastructures Kemmis *et al.* speak of *practices* and *practice architectures* (Kemmis *et al.* 2014).

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Engineering design is essential in our contemporary societies. But does our ways of understanding and educating engineering designers sufficiently prepare them for the complex challenges we all face?

This thesis offers a novel practice theoretical perspective on the intricate relations in-between and across education and occupation on a journey through four Danish sites of engineering design. The journey offers to nuance the understanding of what engineering design involves and the challenges faced when attempting to move the engineering design field forward.

Recognising the complex sociomaterial elements of practicing and changing engineering design does not provide answers but rather *understanding* of how and why design practices are carried out as they are in the everyday life of students and professionals alike.

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