REELER Working Paper Series

Responsible Ethical Learning with Robotics

If we had a specific idea of the product 12 months ago, it would never be what we have today!

A study in situational pragmatic actions and strategies in everyday technological development.

Stephan Hansen

Aarhus University

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Cathrine Hasse, Stine Trentemøller, and Jessica Sorenson (Eds.)

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Foreword

Responsible Ethical Learning with Robotics – REELER – is an interdisciplinary H2020 project funded by the European Commission with 1,998,265 EUR from the 1st of January, 2017 – 31st of December, 2019. Its main objective is to develop the REELER Roadmap for responsible and ethical learning in robotics. The project involves four European partners from the fields of anthropology, learning, robotics, philosophy, and economics, who work closely together in a research-driven collaboration between SSH-RRI and Robotic-ICT communities. Together, they aim to raise awareness of the human potential in robotics development, with special attention to distributed responsibility, ethical and societal issues, collaborative learning, as well as economic and societal impacts. The REELER Roadmap aims at aligning roboticists' visions of a future with robots with empirically-based knowledge of human needs and societal concerns, through a new proximity-based human-machine ethics that takes into account how individuals and communities connect with robot technologies. REELER's comprehensive research methodology includes a design-anthropological approach to onsite studies of roboticists' laboratories and daily work, as well as onsite ethnographic studies and impact studies of present and potential affected stakeholders. The project also includes quantitative research in geographical distribution of patents and an AMB (agent-based model) research approach. Furthermore, the project makes use of novel methodologies to give both robot-designers and affected stakeholders a space for mutual exchange about a robotic future, built around a number of REELER's ethnographic case studies of robots being developed in Europe. These novel methods include experiments with mini-publics, role play, social drama, and also explorations of the established sociodrama approach with professional sociodramatists. REELER aims to include all relevant aspects of this research in the roadmap, which will present ethical guidelines for Human Proximity Levels (HPL) in design work, as well as prescriptions for policy makers and robot-designers for how to include the voices of new types of users and affected stakeholders. The project aims to present an agent-based simulation of the REELER research to be used by roboticists and policymakers. The working papers presented in this series present ongoing research results, literature reviews, and position papers.

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The REELER consortium includes Aarhus University, Ab.Acus Srl, De Montfort University, & University of Hohenheim.

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Summary

This thesis uses the concepts Phronesis, Ethos, Episteme, Techne, and intuition to analyze everyday life and work in a local context of technological development, in a Danish startup company. The author went out to study the relationship between plans and actions in innovation but found few plans. Therefore a study in pragmatic navigation in a social setting began.

After introducing methods and theoretical background, the thesis breaks down Aristotle's notion of Phronesis into 3 tenants; Episteme, Techne, and Ethos. It then defines both Ethos and Techne within the context. It argues that though Aristotle sees these as purely intellectual virtues, actions must be included in an analysis. Therefore the work of Dreyfus and Dreyfus is introduced, to discuss as well experience, expertise and intuition, in connection to the intellectual virtues. A brief discussion of clashes between episteme and expertise concludes that epitome, after all, weighs in the most.

The next chapter focuses on Ethos. After a brief discussion of recognized actions and characteristics as enacted values, it commences the search of such values. It concludes that the local virtues are pragmatic improvisation, humor, tenacity, and nonchalance. It defines the vices of over control, conventional thinking and sloth. After this, it discuss how stable such values might be, and concludes that they are highly contextualized in both time and place. Therefore, they are more guiding than ruling.

In the concluding chapter, the research question is answered. Succeeded by with an outline of what Phronesis is in the context of technological development. It also discusses the implications of the findings, arguing that development is development is more about processes and understanding than plans, but that this is a matter of perspective. Lastly, it suggests areas for future research.

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Also my parents, who taught me work ethics, and to never accept what could have been better. A special thanks go out to two of my former English teachers, AC Sund and Sandie Pedersen, who have granted me support in editing my dyslexia out of this thesis. Also important for this work has been my friend and business partner Rolf Østberg, who has provided as well distractions as competent sparring. Last and most importantly, I would like to thank my Fiancé Zoé Jørgensen, for not only enduring my physical absence for three months, as well as my mental the next five. Also for supporting my struggle, and making even the darkest of days brighter.

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Chapter 1: Introduction

In the autumn of 2017, I conducted three months of fieldwork in a minor start-up company, developing and manufacturing new technological products. Due to our confidential agreement, I cannot say much about the company. However, I can say a lot about what they did. Yet, before going there, I would like to introduce a very special pile of metal, plastic, and computer parts. During my time in the field, few objects grabbed my attention as much as The Monster. Therefore, before introducing anything else, I would like to introduce just that.

High-Tech Take-Do Solutions – the Story of The Monster

The Monster is a prototype of the products built and developed by the company. It is roughly the same size but does not look finished. The Monster got its name from the way it looks, and one quickly gets the name. You see when I say “Monster”, it is not in the “King Kong” way of it being unnaturally big, or a freak of nature. It is more in a Frankenstein way: Different parts put together in order to make functional imperfection. It is not built to be elegant, and it is not. Just like Frankenstein’s monster, it is, however, “alive” and fully functional; at least enough to test on.

There is a certain beauty to the beast of development. It is not the massive amounts of paint, the different colors of the parts, or the fact that everything seems to be attached with zip ties. It is not even that the waterproofing is duct tape, or the wooden board attached at some point to keep it together. It is more the combination of all this. The Monster has a certain look, nay, quality to it. A combination of high-tech and an art project from kindergarten.

All software and hardware changes are tested and built on The Monster long before anyone else sees it. Therefore, this monstrosity of quick solutions is the cutting edge of development at this place. The curious combination of expensive, well-made, customized parts and whatever strip of wood within reach at the time of attachment provides a good metaphor for the company. While many of the things happening are top-of-the-line, it is brought together by a certain pragmatism and tinkering. End solutions are the culmination of countless makeshift attempts.

Relevance and Research Question

When discussing technology and technology development, the technology itself will often be the center of attention. Just like my tale of The Monster above. In the social sciences, a lot of work has been done studying how technologies affect human life and society (Star 1990; Morley 2012; Hasse and Brok 2015; Hasse and Skov 2017; Selwyn 2017; Keulartz et al. 2004). Though it is changing (Darsø 2009; Wallace 2015), the making of technology is less visible in research and in public debate.

This does not change the fact that technologies are always man-made. Design is done with some sort of goal in mind. I would argue that there is a widespread idea that engineering is a development process with a clear goal, and a plan defining the exact actions needed to achieve the goal. This view of both engineering and "innovation", as something linear, planned, and plannable is shared in different areas of research as well (Cooper 1990; Edquist 1997; Paulsen and Klausen 2012; Jacob 1977).

When conducting my fieldwork, it was so apparent that this idea of development as something linear, or planned out, was so far from what I observed, that writing against the idea was not enough. I aim to contribute to an understanding of what happens when it is not a carefully made plan, people follow. It seemed more like a constant learning process, of simultaneously developing equipment, and learning about the equipment being developed. This raised a new question for me; how do these engineers navigate in a project with seemingly no plans at all?

Looking through my empirical materials repeatedly, a pattern, or maybe patterns of patterns started to emerge. It seemed that there were some unspoken, yet authoritative, *right* ways of doing the many different tasks that the engineers performed. It seemed like there were some sort of overruling guiding principles or ideas that somehow constituted both the how's and the why's of doing. And yet, I was unable to put my finger on it.

Then I encountered Aristotle and his use of Phronesis. Phronesis is a term that to Aristotle is both a combination of intellectual skills, and a sense of right and wrong, as well as being the ultimate skill (Aristotle 2000, 107). At other places, Phronesis is described as a certain state of mind where skills are combined with experience, ethics, and a set goal that all forms around, in order to achieve (Aristotle 2000, 107,109,120). Not too different from what Mihaly Csikszentmihalyi in more recent years have described as flow, the psychological state different experts are in when doing what they do best (Csikszentmihalyi 1996, 2014).

I do not use Phronesis in the way of a temporary state of mind, but rather as a bricolage of knowledge, skills, experience, intuition, and an intimate understanding of local ethics and goals. I argue that this Phronesis is bound to context, and therefore ought to be different in different contexts. Though a comparative study of different Phronesises could have been interesting, it is far beyond the possibility of a thesis.

I use Phronesis as the proper combination of Episteme (knowledge), and Techne (skill) applied through Ethos (the societal values) to reach a goal. I take this abstract and wide-ranging understanding into the context of technological development in a minor startup placed on the outskirts of Denmark, and while applying Aristotle to better understand the processes, I too challenge Aristotle on his view of human ability to be solely intellectual. Therefore my research question:

Within a local context of technological development, what constitutes the everyday work and learning practice, and how can this be analyzed as virtues of Episteme, Techne, and Ethos?

Overview of the Thesis

To answer this question, I go through six chapters.

Chapter two explain the various methods used before, during, and after the fieldwork. It explains how I initially got the idea, made contact with the field, and the preparations. The methods used in the field are discussed in detail, explaining the various applications of ethnography I made over the course of my fieldwork. Lastly, this chapter explains the process and strategies in the analysis.

Chapter three explains my theoretical background. Here I introduce some of the greater theoretical influences on the project, as well as explain what contributions I hope to make.

Chapter four inquire to what constitutes Ethos and Techne in the context of my fieldwork. After this, I show how neither are sufficient on their own but must be combined. I demonstrate how this combination requires both experience, and intuition, as well as a discussion of how this intuition is acquired. I then go on to study the local production of epistemic facts, as a learning process. Lastly, I study the relationship between Episteme and intuition, concluding that Episteme is above.

Chapter five examines Ethos within the context. I argue that values are acted out through actions and characteristics. I demonstrate, through a study of acknowledged behavior, that the virtues of technological development are a sense of pragmatic improvisation, humor, tenacity, and nonchalance. I also demonstrate that these virtues interplay, and to some extent must be learned, and taught. I then define the vices of overly control, conventional thinking, and sloth. I argue that as the values I observed were highly ambivalent, so is my analysis. Though the virtues and vices are the dominating ones, they are not uncontested.

Chapter six entails a summary of my conclusions and the answer to my research question. After this, I briefly discuss the implications of my results and suggest further work within the field of technological development.

But now, I would like to finish my introduction to both my fieldwork, the people there, as well as the project.

The Company

My fieldwork was conducted with and in connection to the same company. This company is located in a small town in Denmark, roughly 15 kilometers from a larger city. They develop and deliver automatization solutions to different industries. Though the industries vary, the products are somewhat alike and have many elements in common, both software and hardware. Due to the nature of their business, I cannot give too many details, as this would threaten the organization and the people within.

Especially one of the industries in which they fight to get a foothold is competitive. It is a rather large industry, with millions of people working worldwide. At this time, the industry is generally not automatized. This means a lot of potential money and just as much competition.

As far as I know, only two companies attempt to get into this market. Both have products ready and are competing for different markets worldwide. Industrial espionage is consequently both a potential and genuine problem. Insights into the organization, as well as insights into the technical details, would potentially benefit competitors. Therefore, technical details are left out or altered. Names of people and parts have gotten pseudonyms or just removed.

What I can tell is that it is a startup, a few years old. At the time of my fieldwork, there were between nine and 25 people who in different ways were employed by, or connected to this company. This means that the company structure itself is somewhat complex; there are people assigned to do marketing and build up sales networks; people to assemble products already sold; student interns given tasks that fit their study, as well as the company; and the CEO who does finances, aids development, administration, prioritization, and whatever needs to be done. More than that, there were quite a few consultants, either employed on their own or because they are part of an organization in which there was a partnership. Though I have come to know these people, and rely heavily on some of the information they shared with me, none of them were my focus of the fieldwork. My focus was on the three or four engineers working in the workshop. The workshop is, therefore, the primary stage of my ethnographic tale. Let me give you a tour.

The Workshop

Wood boards cover the original floor, to protect it from the immense amounts of oil, tar, mud, paint and whatever. The same substances that, combined with daily activities, creates a distinct smell of the room. The combination of oil and drilled metal is still clear in my memory as the feeling of the workshop.

Even when there are not people in the room, there are always sounds and once employees show up at work, silence is completely ruled out. There is always a fume extractor or vacuum cleaner running. A power drill making its way through something. Constant clicking from three keyboards. Different sorts of electronics buzzing, as well as the occasional sigh from one of the engineers running into another bug or problem.

In one corner of the room, you find a workbench. Tools on the walls, and multiple toolboxes. A soldering station with the fume extractor placed over it. You will find big tools made to bend and cut heavy pieces of metal. Next, to small tools; screwdrivers, wire cutters, and the like made for electronics. Apart from this, you often find the guy assembling the products for customers, as well as being an all-around handyman.

Other than tools, you will find the many things built and developed here. You will find parts of products modified to fit the current standards or piles of parts soon to be assembled. All along this is the remedies needed from time to time: duct tape, glue, grease, as well as the essential pink nylon wire which has multiple purposes.

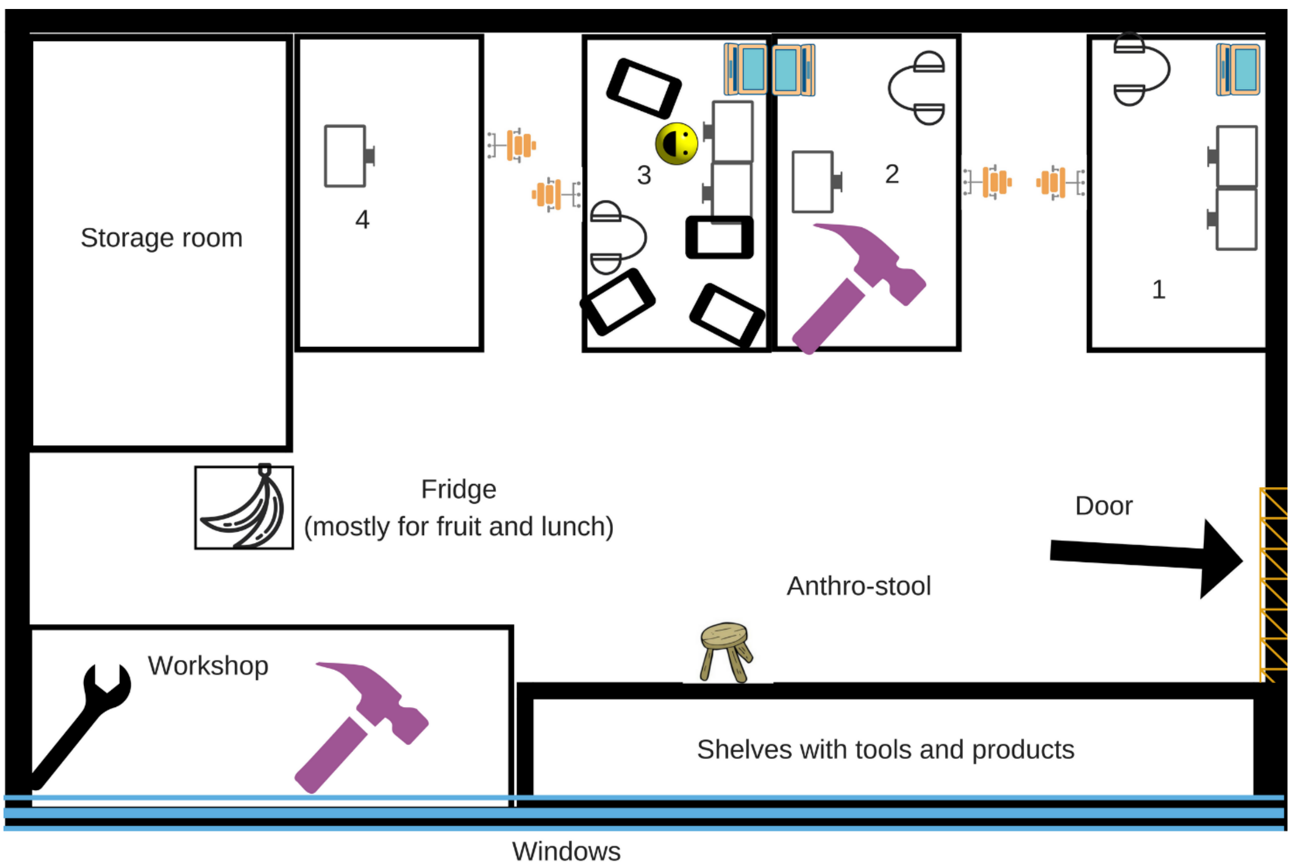
Right next to the workbench, you find a storage room. Again, with the big locknuts, as well as miniature screws. Next to all sorts of computer parts. There are sorting's of screws, locknuts, LED's, wires, jumpers, and plastic pieces in all different sizes and making.

Along the windows are shelves which contain an array of different tools, too big to fit in the workshop or too frequently used to move somewhere remote. You will also always find a mountain of empty boxes here. The company has many deliveries, and boxes can be reused later to send something else away. Therefore, you will find empty boxes most places in the company rooms. Except on Mondays because most Fridays, someone will get annoyed with the boxes and drive them to the trash facilities. Without telling of course. This is also where the products – either the ones not shipped off to a customer yet or the ones held "home" for testing or maintenance purposes are stored when not in use or worked on. And of course The Monster, this is where it spends most of it's time.

Another important object you will find in this area is an IKEA wooden stool, with four legs and no back. This stool does not seem important, but for my three months of fieldwork, it was an "anthro-stool". This was my usual position in the room and the physical place from where most of my notes are generated. This is discussed in detail in the methods chapter.

Desks and People

The rest of the room is occupied by four desks. I will briefly introduce these, as well as the people using them. The purpose of this is to give an insight into what, and who I am talking about when explaining life in the shop.



At desk one (1), we find Rick. This desk has two large screens. Having more than one screen, and especially in the quality found on this desk, is useful when programming. Rick usually had multiple terminals, the program showing the code(s) worked on, open at once. Sometimes I counted eight consoles open at a time, as well as a smart switch system so that he could shuffle over to another virtual desktop with eight other. Other than the screens and the computer, this desk is usually empty, and tidy. Rick spends most of his time programming. I am not entirely sure what he did as I do not "speak code", but I know that he was working with the deeper controls of the systems. The parts that tell the components how to behave given different inputs. His main task is to optimize the code already in function, as well as add the bits of code for new abilities the products must be able to perform. He is also the one who oversees keeping the versions of the software in check, and the one who controls updates.

The second table (2), seems like another world indeed. There is only one screen found here, and this screen does not stand alone on a tidy table. This is the desk and screen of Charles. Here you find a muddle of different tools, parts of all sorts next to testing equipment used in his daily work. Charles focuses mostly on hardware. Tinkering with a board, some sort of relay, or stress testing some component is what he does the most. All levels of hardware changes must go through him. More than that, he is also in charge of assembling and repairing equipment from time to time.

The third table (3), has two screens again. Here you find Percy, a programmer, who, like Rick, always has a constellation of consoles open next to web pages, trying to figure out how to do this or that. Percy works on another part of the system, the user interface. He spends his time making the program look good and intuitive, while parameters must meet up to demands, as well as fit into the deeper control software created on table one. He is also the one who makes most new features. This desk is not empty and tidy, like table one. You will find computers, tablets, phones, tools, a bubblehead smiley, Post-its, wooden sticks, some and wires from an old project lying around.

One thing these three tables has in common is a big headset plugged into the computer. Not because they work with audio, but because music can remove distractions. This strategy is widely used by all the engineers in this office.

The last table (4) has the only stationary computer found in the company. This computer is their datacenter. A machine with more calculating power mostly used for video editing. This table is not claimed by anyone. However, Kent a student helper, studying to become an engineer, is the only one I ever saw sitting there in my three months. The fact that he was sitting in here, and not in one of the other offices (where other student helpers, part-time employees, interns, and everyone else were located), seemed like a strategy to become a part of the development team.

Other than this, you will find a refrigerator with a microwave on top of it. No one uses the microwave, and the refrigerator I mostly used to store some fruit the company buys for its employees.

Chapter 2: Theoretical Background

During my fieldwork, as well as in the aftermath, my analytical focus has changed. One of the consequences of this is that many of my observations became useless, while some of the observations I did not think would matter, is now the foundation of my analysis. Here, I introduce some of the research that has informed my work. As any section on theory, it will be in many ways incomplete, as it is limited in length, and the study is limited in time. I have organized not by authors, but by field.

Innovation

My offset for the fieldwork was innovation studies. I have long been widely fascinated with the theories and accounts of innovation, and my initial project was to discover what innovation looks like on a daily basis. During my fieldwork, and especially in the aftermath, it became clear that this was not the most interesting thing to look at.

It became clear as I started going through my data, that I had more data concerning how people did the day-to-day work than anything else. However, my focus on innovation was so influential that I shall give a short account, though it is not widely used in my thesis. The most visible influence innovation as a term and subject have in my thesis is seen in quotes from interviews, as I still focused on innovation, at the time of interviews.

There are many theories on how innovation happens. An important influence on my thinking has been Robert Coopers stage-gate model (Cooper 1990). This model has been so influential for me because it is made from an organizational point-of-view and therefore differs from how I, as an anthropologist, understand the world. The Stage-gate model is linear and assumes that different stages of an innovation process are following a strict logic, and can be managed from this perspective. I see the world more like group dynamic theories like that of Lotte Darsø which has also been important in my understanding of innovation (Darsø 2009; Darsø and Høyrup 2012; Ibbotson and Darsø 2008). Lastly, I want to mention the work of Mihaly Csikszentmihalyi (1996) studying common traits of creative and innovative people as something happening in the stage of "flow", where the body and external world seems to become one while being immersed in an activity (Csikszentmihalyi 1996, 2014).

As informative as these studies are, I find that they have a common flaw; a disjunction in time. The innovation they study is far removed in time from when it happened to when it was studied. This means that innovation is only talked about in retrospect and that the innovative actions thus become abstract, instead of tangible. This also means that the errors and mistakes that could have been innovative are left out. The entire process of innovation is studied from examples of it going right. This is why I argue that anthropology can contribute to this field of study because our primary method is to get into the daily, almost mundane, life of people (Winther 2017, 28–29).

My last issue ultimately and the reason for me moving away from studies of innovation is that there seems to be little discussion of *why* people innovate. There seem to be few values, and people are described based on their doing, rather on why they are doing so.

My contribution to the studies of innovation will be examples of situations where people are innovative or at least developing and some descriptions of this development as it happens. Adding to this, I also elaborate more on the ideas that turned out to be less useful, and what these mean for the further work. More than that, I provide an analysis of some of the *why's* in doing what they are doing, and some of the social *how's*, in discussion values and chartists.

Lab Study / STS

My focus on lab studies and STS, in general, came in somewhat late in the process. When I was still focusing on innovation, it seemed redundant to focus on the fact that my informants made technology. It was not before, I read Andreas Roepstorff chapter in "ind I verden" (Roepstorff 2010) that I started understanding my field site as a laboratory.

Lucy Suchman, whom my thesis supervisor consistently argues I ought to use, has made impressive contributions to ethnography, ethnomethodology and otherwise in the studies of engineering practices (Suchman 2007, 2000a, 2000b). Yet, my primary use of her work has been her work on plans as both a prescription on how to conduct a practice, as well as a practice in itself.

Another big name in STS is Bruno Latour, who together with Steve Woolgar made impressive analyses of scientific conduct and “laboratory life”, and here found that it was surprisingly every day like work that constructed scientific facts (Latour and Woolgar 2013).

What seems to lack in STS, or maybe just slip my literature review, is values. The question of how one ought to conduct oneself in these planned or not planned everyday-like situations. My contribution to STS is an empirically founded analysis of the methods, values, and ideas of the people designing and producing the technology that in many ways form our world.

Aristotle and Technological Development

When analyzing my materials, I use the theoretical framework of Aristotle, a philosopher who lived some 2300 years ago, in Greece (Crisp 2000), very far from the fieldwork location in Denmark. Aristotle was one of the earliest philosophers in the modern euro-philosophical canon (Crisp 2000), and his influence on later thinking is not possible to do justice here. Choosing a philosopher who is so distant from my field in numerous ways has constituted some challenges. For one thing, I do not speak ancient Greek, and have used translations of his works; or, rather, translations of translations. This also meant that certain conflicts arose in phrasing. Some of the terms I use: Techne, Episteme, and Phronesis are translated to “art, science, and wisdom”. I had to translate some of it “back” to apply the terms analytically. Another challenge is that the work of Aristotle is so remote in time, location, technological development, politics, and in virtually any other way from the context as possible (Crisp 2000).

So why use Aristotle, despite these hindrances? My inspiration came from Bent Flyvbjerg (Flyvbjerg 2001, 2009). “Phronesis” demands both Episteme (knowledge), Techne (skill), and Ethos (understanding of right and wrong). This must be applied through experience which then provides an intuition of what to do next, as well as a demand for accepted characteristics. All of this has to be put to use to achieve a certain goal (Aristotle 2000, 103,59,107,199; Flyvbjerg 2009, 9–21). This holism intrigued me. Having a term that demanded and described the use of so many different aspects at once seemed, in Kirsten Hastrups words: “*provide the proper questions for the many answers I had found*” (Hastrup 2010a, 9)

Interactions / pragmatic anthropology

I have been strongly inspired by Gregory Bateson (2000) and Erving Goffman (2005, 1986, 2012), and their ideas about breaking "what happens" in a given, or constructed, interaction, or situation, into different "frames" with their own rules of conduct, as well as the social keys and keying which separate these. Consequently, my notes on as well conversations as other interactions are descriptive and focused on detail. Though I am not explicitly using frame theory during my thesis, I still mention it here, because of their influence on both my thinking, as well as my note-technique. In the work of Handelman and Kapferer, they put down detailed accounts of interactions with as many descriptions as possible, so that to choose the most important for analysis (Handelman and Kapferer 1972). I have attempted to do the same, at least in my notes. Thus, I have quite a few pages, where every "line" and gesture of my informants are described. Though I may not use the level of detail I have, it has been a privilege to be able to choose only the best. In addition, this means that I have had to rely little on memory, in order to construct the narratives I put forth in this thesis.

Another, more recent, use of pragmatic anthropology is that of Hervé Varenne and Jill Koyama who argues that context, history, and knowledge of any person will always inform him or her of the only question that according to Koyoma and Varenne matter: What's next (Varenne and Koyama 2011; Varenne 2008). To Varenne and Koyoma the enterprise of anthropology becomes to study these critical moments when a choice has to be made, and afterward analyze on what basis, what understanding of context, it was made from.

My focus on interactions means that I have a good access to *what* people were doing, saying and in what order. By that, it also allows me to look at the development of development and gives detailed accounts on even what sort of tools were used to cut a wire the first, second and fifth time an informant tried. What interactions lack, in my search for Phronesis, is the entire question of why anyone did what they did, as interactions is an account of what people do, not why, or what they feel while doing it. Therefore, I have used interactions as a method and inspiration in fieldwork, but not in analysis.

My contribution to interactions study is demonstrating how it can be applied to look at more than just what people do.

Local Values and Study of Character

When looking for looking for values, I choose to let me inspire by Stuart Dreyfus who explains that ethics is what is seen as good in the social context (Flyvbjerg 1991, 103). I have been going to Axel Honneth's work on recognition in looking for values, or Ethos, as acted out in practice. Honneth explains that society is created through communication and that values are a product of acknowledgment (van den Brink and Owen 2007a, 3). In his work, positive recognition is seen as praise and this is ought to determine what is seen as good or right within the context. This is contrasted by either lack of recognition, or some sort of negative recognition or reprimanded which then defines what is negative or bad (Honneth 2007a, 105). I have therefore been looking for actions that were either explicitly recognized as good or bad.

There is a tremendous power in defining what is recognized. While Honneth had hoped for his theory to be more critical, he himself argues that is has become more of a strategy of government in different social settings, where most everyday acts of recognition just confirm the already existing normative values (Honneth 2007b, 323). While this critique of the original theory might be true, it only strengths the argument for applying ideas of social recognition, when trying to define the already existing normative values. Though there is much more to Honneths work than a method, this is the only part I have used.

Interestingly, I realized later, Annemarie Mol and some colleagues arrived at the almost exact same method, looking at what people speak of as good or bad, without reference to the same work (Mol, Moser, and Pols 2010).

Learning Theory

One of the important, though somewhat obvious, points Aristotle makes about Phronesis and the different virtues in it, is that none of these are born or instinctive – they are all learned and habituated (Aristotle 2000, 99,107,109). Learning part has become a big part of the thesis.

There are many learning theories, and I cannot begin to do justice by them all. I have relied heavily on Hubert and Stuart Dreyfus phenomenological model of learning and skill acquisition (Dreyfus and Dreyfus 2005; Flyvbjerg 1991, 2009, 2001; Honken 2013). I have chosen this perspective on learning, not because it is the only one, not necessarily the most developed, but because it is based on observable action, while still taking narratives and the body of the learner into account (Honken 2013). More than that, as Flyvbjerg explains, this specific model includes both the human as a learner and a body while considering context as essential for both learning, as well as what can be learned (Flyvbjerg 2009, 19).

My Contributions

I am not affiliated with only one field and draw from many others than the ones listed above. My contribution to anthropology, in general, is empirical data and analysis concerning engineering practices and development as an everyday practice. My theoretical contributions are detailed and empirically founded analysis elaborating who the people creating technologies are, and how they work. In doing this, I demonstrate how interaction-focused anthropological work can unveil social values. Lastly, I give an empirically informed application of philosophy, both Aristotle, and learning theory, applying abstract notions, into real-world messy human interaction, and demonstrates how the work of philosophers can help understand these.

Chapter 3: Methods

The methods used for any study will always be an important factor in understanding the results, as Bourdieu argues, any method will have its own ethics, and different ideas of how to produce "data", and what counts as valid (Wilken 2011, 89). In this chapter, I have chosen to make three different sections describing my methods. They are divided into before the fieldwork; explaining my way to the field and my preliminary work. The next will discuss my fieldwork, and the primary methods used. Lastly, I explain how the process of analyzing data, writing up findings, and constructing the thesis has been done.

The Way to the Field

My search for the field site began 8 months before the fieldwork. I had decided to study *something* with innovation, and preferably a place with technological development. That is a broad spectrum. I, therefore, started contacting firms around the world. Everything from the largest I could find, like Google and Vestas, to some minor ones, with only three employees. I got few answers, and those were "no". I then contacted one of the automatization networks in Odense, I cannot specify which one, and asked for contacts. They were interested in my project and put me in touch with two different companies. Having an external contact truly helped. I visited both, and while both were interesting, and seemed interested in me, one had a board saying no, and thus it was decided.

Secrets

The company I found is a startup, trying to get into a market not yet automatized. While this has many effects on their work, the first one I was confronted with was secrets. There is a fear of industrial espionage, as there are close competitors. This meant that I spent quite some time negotiating with the company on an NDA (Virk.dk 2014) disallowing me to give away any secrets while protecting my right to publish. It is enclosed in Appendix 1.

However, once in the field, this meant relatively little. I was allowed access to pretty much anything. This was partly because of what the CEO referred to as a "humanist filter."

Humanist Filter

People from outside the company would come to visit for various reasons. One interesting difference was how this was prepared in the shop. Anyone who has not signed an NDA is a potential threat, but not equal from all people. When an engineer came to visit, every piece of hardware was covered up. When more "softly" educated people came along, this was not necessary. As the CEO explained, you have to know a lot about this kind of equipment to be able to pick up anything important. He referred to this as a humanist filter.

This humanist filter was also the reason I could take notes, but not record conversations. In his understanding, nothing technical would get into my notes because I understood tech too little. This was not entirely true.

Though I am not an engineer, I understand basic programming and know at least how coding works. I also know a bit about computer hardware. Given this, I already understood more than he expected. More than that, I asked many questions and did quite a bit of research on all the terms they used to describe their work. Not because my intent was to understand the different components and codes per se, but because understanding what people are talking about, makes it easier to understand how they work together. At one point, the manager, somewhat jokingly, said that if he had known how much I would understand about their tech, he would never have considered allowing me access.

Do not Disturb

Another concern was that I would disturb the work. I had to promise to do my best not to disturb and respect a “no” if I got one. I was also told that, without warning, I might be asked to leave. This was also a part of the contract and became the foundation for my very quiet and passive methods, described in “the anthrostool”. It was also the reason for my somewhat creative approach to “places” where I was allowed to talk with people, like by the coffee machine. I seem as if I succeeded not disturbing, as I at least got no comments on it.

Methods in the Field

Methods describe *how* the work was conducted(Davies 2008, 28,31; Hastrup 2010c, 400; Madden 2010, 15) and thus, hopefully, answer the questions of why the analysis is to be seen as valid. Because anthropology varies it is hard to describe. This is no excuse to not do so, but rather a reason for devoting more energy to it (Hastrup 2010b, 29). As discussed in above, methods were chosen to study innovation *as it happens*. This means that my primary aim throughout the entire fieldwork was to be as close to the processes and the people as possible.

I have chosen to focus my discussion of methods explaining not ”just” participant observation, but rather the specific form I used, and to some extent developed to fit my fieldwork best (Larsen 2017). I also show some of the mistakes or accidents which ended up providing a window into untold rules and normative relations. I have tried to be honest about my methods, and especially writing out some of the mistakes and downsides of these. The proportions of the mistakes are not one-to-one with reality; the majority of my fieldwork went well. However, as Madden says, being open about what went wrong is the only way to make any analysis credible (Madden 2010, 26). I commence this section with a brief discussion of why ethnography has merits when discussing technological development.

Being There

Madden explains that the very essence of ethnographic research is being there (Madden 2010, 16). Exactly what you do or do not do differs from study to study, and from day to day, but being there is the alpha and omega of ethnography. By why is that so important? Could one not obtain the same understanding by reading about the experience? Or ask people? Is it necessary to spend so much time obtaining data?

When in anthropology or ethnography circles, and reading mostly anthropologists work, it sometimes seems self-evident that ethnographic methods are preferable without questioning why. I will for a brief moment go to psychologist Kevin Dunbar to explain why “being there” is so immensely important when studying everyday life.

Dunbar has studied processes in laboratories, focusing on the language and analogies scientists use. Here he used two different approaches. First an approach used in experimental psychology, he calls “*in vitro”* studies. This means that the method includes a setup, where Dunbar build a “cognitive laboratory”, a simulated molecular genetics laboratory, where they place different subjects, asking them to do carry out mock research. The psychologist could then change different parameters as the experiment was repeated with new “researchers” (Dunbar 1995, 2).

This method is in many ways used as it is an efficient way to test selected parameters of behavior, but it does have some serious shortcomings. First, research is a social process, and most in vitro studies only have one subject at a time (Dunbar 1995, 3) (See also: Suchman 2007; Latour 2011, 1998; Latour and Woolgar 2013). Secondly, tasks that are not actual scientific problems, but parts of an experiment, are approached drastically different from those who are. Thirdly, the subjects used and available are usually not researchers. Fourth, and for my purpose most important, experiments will always be limited in time and resources, and thus may last only ten minutes, whereas actual research and development may go on for decades, including thinking outside the workplace, hundreds of failed hypotheses, and several changes in staff (Dunbar 1995, 3–5).

The other approach that Dunbar suggests is what he calls *“In Vivo”*. This is where the researcher goes to the field, and observes *real* scientists, in a *real* physical and social context, carrying out *real* research in *real* time (Dunbar 1995, 3–6). Though Dunbar admits that it is time-consuming and that the data usually is less consistent, he also argues that the data presents a more honest picture of the real and lived life (Dunbar 1995, 8). This is the foundation of ethnographic study (Madden 2010, 16) and my offspring on methods.

Participant Observation

As explained above, I shall not go into detail on what participant observation is and is not, but rather into a discussion on the specifics of my fieldwork.

I understand “participant observation” as a spectrum. Stretching from the extreme participation, what Madden calls “immersive anthropology” where the researcher is so absorbed in the field, that the researcher forgets the purpose of his or her presence (Madden 2010, 77,80) all the way to the other extreme, which is merely an observation. The natural scientist making an observation, trying to get as far away from the data as possible while striving to be "objective" – see Andreas Roepstorff explanation of laboratory work (Roepstorff 2010, 366). Ethnography is always moving back and forth on this spectrum, mine was no different.

The Anthrostool - Observation

My primary physical position in the field was, especially in the beginning, my stool. It was arbitrary that I ended up there but, quickly, it became "my" place in the room. From there I could observe. Therefore, I did. This method meant that a lot of my research was conducted more as an observer than a participant. When I was on the stool, I did not participate but observe. I was as quiet as possible and almost succeeded not commenting on their work and processes. One afternoon, I had moved my stool closer to a hardware project and was writing down field notes on actions and conversations. I wrote the words: "Stephan, could you flip the switch", without realizing that he was talking to me. It was not before everybody involved stopped working and looked at me, I noticed that right now I was asked to participate, and not just observe.

This is, of course, a simplification of reality; I was not ignored or treated as a camera when on my stool. Still, the time I spent there almost constitutes a contrast to anything with active participation.

In any case, this method was necessary; I was not able to participate at any level with the engineers in most of their work, and given that I was not allowed to cause any disturbance (See "do not disturb"), observing was the obvious method. This position in the room gave me access to a lot of situations. I could see everything, and hear almost everything. I quickly got an understanding of the distribution of roles and the patterns of communication between people.

The downside of observing was that I became quite detached in my observations. I had many disconnections to the practices, some because I simply did not understand what the engineers talked about and because many things were not introduced to me, due to my not being a part of the team. Where In contrast Helle Bundgaard explains, how she became an apprentice and was shown how things worked from an insider's perspective in order to "become one" (Bundgaard 2010, 55), I was an outsider on my stool, observing.

Too Involved - Participation

As described above I was more of an observer than a participant, when sitting on my wooden stool trying to stay quiet. As time went by, I was invited to participate in more and more activities. More so, I also found myself so immersed in the field from time to time that I forgot to write down, or even take notice of what happened.

One of these occasions was an evening of problem-solving. There had been a problem with a product out with a customer. After sending it back and forth a few times, and doing countless repairs, tests and developing theories on why it behaved the way it did, something finally began to make a bit sense. The engineers improvised a test, involving a stick and a man pushing it into the equipment. The energy was high in the room, as test after test got us a bit closer to a solution. Standing in the smell and fumes of burned rubber, we were jumping wires around, cutting some up, trying others together, and testing repeatedly, until quite sometime after office hours, we finally found to a solution.

I used “we” here, for the first time. This is not a coincidence because, for a short period, I was part of the action. At least, I felt like that. My practical knowledge from my years of farming gave us an edge in the process. Moreover, given that the entire company spent weeks trying to solve this, any idea was welcome near the end. It was a strong experience, and while it unfolded, it seemed like the only thing of interest. This event is discussed further in chapter four.

As Madden explains, anthropologists can be too immersed in a field. Meaning, we do whatever happens so much that we forget our purpose of doing it (Madden 2010, 78). I have done ethnography for years and never experienced this problem. Therefore I was shocked when, during the evening at home, I went over my notes and found little from this intense event. I grabbed my voice recorder and got as much down from memory as possible. This was more than I expected, and it has proven sufficient to be included in my thesis several places, but it still stands as an indicator that I needed to keep my focus on data generation, and not on trying to “become” an engineer. I had to get myself close by not too close (Madden 2010, 81).

The Coffee Machine

While I was under strict orders not to disturb people in their work, I quickly discovered the coffee machine as a potential field site. After a development meeting, I met one of the engineers, Charles, waiting at the coffee machine. He asked if I understood anything from the meeting, and I admitted having a lot of unanswered questions. “*Well*”, he said; “*you have until the machine finishes to ask*.” After that, I started to get coffee myself, whenever somebody else was getting. This worked out well, as it meant I could get two-to-five minutes of conversation about details I did not get during a meeting, ask what people were doing today, or casual chitchat.

One of the reasons this place was so effective was that people going here were almost on a break. They, obviously, neither coded nor built on their way to and from the coffee machine 20 meters away in another room. Therefore, I could ask my questions and build rapport, the mutual feeling of acceptance and trust (Spradley 1979), without the risk of disturbing them. While these conversations were pleasant and great for building rapport, I was always aware, and sometimes reminded my informants that this was instrumental. The way I behaved myself had the purpose of generating data (Madden 2010, 65). The only real downside to using the coffee machine as a field site was that my caffeine intake during my fieldwork was rather high. Only pouring half cups, and oftentimes water easily corrected this.

Following

When I was negotiating access and tried to explain what an anthropologist would be doing in a tech company, I gave the example of following people when they were in transits. This was taken literal and I was invited to pretty much anything involving a car. Though I started out a bit overwhelmed by how much I was asked to follow people when they were going somewhere, it became one of my best ways to gather data and do semi and unstructured interviews. Like with the coffee machine, people are not explicitly working when driving a car from A to B. Therefore, I had many opportunities to conduct unstructured interviews. This also meant that I ended up planning a few days ahead when possible, so I had time to prepare myself for road trips.

More than a place to conduct interviews, road trips are also a good place to have a casual conversation which I was not able to do from my stool. Therefore road trips became a place to build rapport, and as Madden points out, just have conversations with people (Madden 2010, 64–65).

Furthermore, we were always going somewhere; hence accompanying people gave me access to encounters with customers, suppliers, partners etc. Also, tagging along gave me access to the many tests conducted with the equipment.

The downside of this is that it is harder to write down field notes while having a conversation. In order to keep conversations casual, I could not sit and openly take notes all the time. I tried it, and it quickly became not just uncomfortable but stopped people from talking.

I also tried carrying a dictaphone with me for a whole day while driving. This caused several other problems. For one thing, I fear I have overstepped some boundaries in my data collection. As the dictaphone was just lying there, my informant seemed to forget about it. This means I have recordings of many things that were clearly between the two of us. Another problem is the transcribing time. I have chosen not to transcribe that day, as ten hours of audio would take weeks to get through. In addition, due to vibrations from the engine, many of the conversations are impossible to comprehend, above the sound of plastic grinding against plastic.

Meetings

In the company meetings were a common activity, and I was invited to the majority of them. These meetings constituted a welcomed situation with everyone together, and where the majority of the work was speaking aloud, rather than programming or tinkering. This meant that I had a better chance of following processes, observe problem-solving as it was happening and study the dynamics of this group. Inspired by Gary Olsen's work on meetings in tech (Olson et al. 1992), I wished to record some of them, to try to decipher the different sorts of conversation going on. Regrettably, I was not allowed to due to confidentiality.

Not recording presented a problem; due to the content of these meetings, including many technical details, I did not understand the conversations fully enough to cover them loyally. Therefore, I focused on collaboration, without understanding what they were collaborating on. The majority of this data has in analysis proven to be less rich than I had hoped, and hard to extrapolate from.

Conferences and Projects

Due to different political and economic relations, which I will not elaborate on, a company like the one I worked in is part of multiple projects with other companies, universities, the European Union, and various NGOs.

I was invited along for some of these projects as an observer. I have attended workshops where I understood little about what "we" were working on as well as a 1-day-seminar at which I googled my way into what we were being lectured on. And yet I got some interesting data from these events. For one, being a white male, I stood out extraordinarily little. At one conference, we were total 80 people; 79 white, and two women, whose function was to get coffee and sandwiches in the breaks.

I also attended a workshop, again without really understanding the subject, but perfectly able to perceive the non-cooperation. In this particular project, there were many different companies. One of them works closely with the primary competitor of "my" company. This being the case both parties were very interested in each other's equipment, while neither would like to share any insight. However, the workshop was about developing their equipment.

The lack of cooperation was striking, to the extent that I did not understand it. In my field notes from that day, it is clear that, for a long while, I thought we simply had not started yet. I wrote down how everybody was sitting with their own computer, not talking. I assumed that this was because we had not started the program yet. I was wrong. I have field notes on two entire days, where some 20 people working "together" in a room carried out next to no communication. There were a few jokes shared and some funny YouTube clips NOT concerning work. Other than that, a professor was assisting some students building a prototype of some sort.

Saying Too Much

As described initially, I was strictly prohibited from speaking to anyone about the location as well as contents of my field study; which I sadly transgressed. I cannot stress enough that this was not intentionally. However, this mistake of mine became an opportunity to study the reasons these restrictions were incorporated in the first place.

At the above-mentioned workshop, I, accidentally, gave a technical specification, while talking to one of my informants, one that was apparently secret. I also mentioned one of the larger problems they were facing with their equipment. Both times in unfortunately little distance from one of the engineers working with the rival company. At the moment, my informant just sought to avoid developing on the subject, and I did not think of it. It did not even get into my fieldnotes that we had the conversation. On the car trip back, however, he explained that this was very much a thing "we" do not do. Not only did I de facto break the agreement in the contract, I also trespassed the anthropological ambition of doing no harm (Davies 2008, 53)

Back at the company the next week, I had to tell the CEO. Though annoyed by this, he said that those were not the biggest of secrets. Subsequently, the entire company had a meeting establishing what information we *do* and *do not* share about the company in which we work. There was no measurable reprimand for me, but it was made clear that this is endangering everyone, as well as the company. The meeting started with the words "*Thank you, to Stephan, for making sure that we get to talk about this*".

Though, as I said earlier, this was by no means done intentionally, it became a window into the secrecy of the company. In everyday work, this was not something anyone talked or, it seemed, thought about.

This fear is not paranoia which became evident at another event only a few weeks later, when, during a talk one of my informants was giving, people from the competing company were observed inspecting “our” equipment. Without permission. This episode was the cause of quite some discussions later, on whether or not this could be understood as industrial espionage. There was not found a solution by my time of departure.

Working with Secrets

Though secrets did not explicitly change nor affect my position in the field, I was still under the NDA after all; it serves the purpose of exemplifying how much access I obtained. I, an outsider, was allowed not only to look right into the hardware. I was allowed to see the potential hardware upgrades and prototypes, I know of new features that are not yet released. I am fully aware of many weaknesses and limitations of products. All this, and more, I was invited into.

My way around this was that my field notes did not contain too technical data. I used my knowledge of the subjects to understand more on the social behavior of informants, but I left out the technical details. In this way, even if someone else accidentally got hold of my field notes, they are heavily encrypted, but, still, they will only know that the informants talked about this or that.

Helping

A concern before my fieldwork started, was how to be a part of the company. During earlier fieldworks, I had the good fortune of getting some sort of role, which helped people recognize me as part of the field. In this field, there seemed to be nothing I could offer.

My primary strategy to counteract this was offering help. In whatever way needed. I helped a lot moving empty boxes around. I cleaned floors when visitors came and was used as a lending hand when something heavy had to be held. The craft skills from my youth also came in handy.

I also started to get minor jobs closer to the core of the company. One of these was the fitting plastic parts. From the factory, they came with a lot of excess plastic, which had to be cut away and sanded down. This was not a particularly hard task, however, one that needed to be done. It gave me a position in the room as more than just the guy in the corner, as well as building a bit of reciprocity. I had many such minor tasks.

This meant that, gradually, I became a part of not just the company, but also of many of the functions and processes that underwent. Though I was by no means irreplaceable, I was a part of the rhythm in many things. When something needed to get from A to B, I was a natural part of it, when something had to be cleaned, I usually helped.

The skills from farming in my youth proved more than helpful. I know how to handle most basic tools, and have been trained to build and maintain a variety of equipment. Thus, I was the one who was asked to modify The Monster with a power grinder. No one else knew how to use it. In addition, on the evening of problem-solving mentioned above, I lost my patience with one of the engineer's attempts at removing the insulation from a wire and took over (see chapter 5). I helped out in multiple minor projects, which also means that I have more data on situations involving hardware than I do software. This is also because hardware development is more observable, while most software was either code or visible only through “behavior” of the equipment. Consequently, Charles, responsible for hardware, appears more often in the thesis.

Hence, I began to develop a more natural role in the company. It was not a courtesy that I was invited along to different functions, it was also because I added value to some of the processes happening around me.

The impact of my basic knowledge of different crafts cannot be held solely accountable for my position in the company. Especially in the beginning, I was often teased with questions of math or physics that I was not expected to be able to answer, due to my academic background. And though never explicated, it did give me a bit of status that I was (usually) able to answer.

Saying ‘No’

As time went by, I got more and more tasks. The CEO at one point said that he had to hire someone after I left because I freed time for everyone else. He was joking, but he had a point. I did spend a lot of time doing stuff, other than fieldwork. Therefore, I had to start cutting back and saying no. Though this meant a few minor confrontations, it worked out. I explained that I was happy to help, as long as it was with or around the people, I was there to study. Cutting plastic was fine, whereas driving errands to the store did not get me anywhere. This was accepted. After this, I still helped with many things, getting my hands dirty, but always with chores that also enabled me to do better fieldwork.

The Phone and Field Notes

An important part of ethnography is writing down field notes (Davies 2008, 233; Spradley 1980). As field notes are a more authentic representation of past events than memory.

These notes have to be written down on something. A usual anthropologist's tool is a notebook (Madden 2010, 119). I attempted this, as I have done in earlier fieldworks, but it has shortcomings. It is slow, takes up room, the size of each page is limited, and so it is hard to add extra reflections to a note. The solution was my phone. Not only do I write a lot quicker on the phone, but also due to note-taking software, Evernote, the phone has strong amplifiers. Without any hassle for me, notes got timestamps, so I know at what point of the day something happened. Evernote also adds pictures, effortlessly, into the notes. Therefore, my notes are rather chronological and well organized. I simply have a file for each day, my notes have timestamps, and my pictures and videos are right next to the text or explanation of why the picture was taken, I thus had almost no problems with arbitrary pictures.

Other than that, the phone had another advantage: Google. As this was a tech company, filled with engineers specialized in their field of work, many technical terms and abbreviations were used in their everyday language. It quickly became apparent that it was impossible to study their process when I had no idea what they were talking about. I, therefore, began writing down phonetically what they were talking about, and at some quiet moment googling it. My field notes, therefore, have another dimension as well; links to web pages, explaining what something is. Understanding what the engineers were talking about, though not always understanding what they were saying, helped me a great deal in deciphering how they worked together.

Downsides of the Phone as a Note-Taking Tool

While the phone as a note tool has numerous advantages, it also comes with drawbacks. Sometimes, the phone "froze" leaving me unable to take notes for minutes; this always happened when something interesting was going on, and I failed to have a piece of paper ready for these situations. Another aspect is that while a phone, via the internet, is capable of performing many things, it is oftentimes hard not to get distracted by them. While on my phone, it was hard not to focus on texts from my girlfriend, messages from Facebook, reading my E-mail, and so forth. These distractions took up a lot of time. Once this occurred to me, which was later than I like to admit, I uninstalled every sort of communication the phone had which greatly improved the quantity and quality of my field notes.

Another downside to a phone is that, as sophisticated as the software is, it is still software working by rules. I could not jot down a quick drawing of something, and it was impossible for me to ask my informants to draw what they were thinking or explaining. In addition, notes to myself, explaining what something I wrote earlier meant, were a bit harder to distinguish. Had it been paper, I would be able to change my writing or something, but Evernote is "only" a text editor.

The Desk

On my first day in the field, I was assigned a computer desk in an office. This seemed redundant; I was wrong. I put up my laptop in there, and though somewhat remote from the shop, it became an important part of my fieldwork. While a phone is good for quick notes, it quickly became apparent that it was too slow, and I managed to overwork my thumb. I, therefore, used the phone for quick notes, synchronizing these with Evernote, and then proceeded to my desk 10 meters away, in the other room, to write them "out"; somewhat in the style of what Madden refers to as consolidated field notes (Madden 2010, 124). This means that my notes are rather detailed and that I did not have to leave the field for long periods.

The downside of "leaving" the field several times a day is obvious: I was unable to make new observations while standing in another room. Yet, if I had not been able to walk into the neighboring room, I would have had to take off time to make consolidated field notes (Madden 2010, 124–25). Thus, I would have had to make do with shorter days in the field. Consequently, I cannot perceive any better way of taking notes in my specific fieldwork.

On Field Notes and Memory

The insight that memories or narratives and actual action may not be the same is true for me as well. At least to some extent, we as ethnographers must trust our field notes in that they do indeed represent an acceptably accurate representation of the events covered. The notes will remain both a narrative and a representation of reality but brought into existence in a manner where credibility at least ought to suffice.

Memory, on the other hand, is far less reliable. I remember, even now, how one of the informants, was incredibly hard to get talking in the beginning. I remember spending a vast amount of time and recourses – weeks – to get to know him. I therefore also remember how happy I was when he started to accept not only my presence, but also started talking to me, and sharing. I remember being so happy about getting a real conversation going with him, after all this hard work, that I made a note that I finally got through to him. This is my memory. Which is why I was so immensely surprised, to find the "I talked to him!" note, as early as my first Friday. Four days into the fieldwork. Therefore, clearly, I did not spend weeks getting to talk to him. However, even after knowing my memory or narrative is factually wrong, it still *feels* like it took forever.

I have numerous of these examples; Interviewees I recall as rude, who did absolutely nothing during the interview, pictures I remember taking in the evening, with a timestamp saying 13.30 and quotes I ascribed to someone, but which were said by someone else. This insight provides numerous revelations. For one thing, it presents yet another argument for doing filed notes metrically and for jotting down as much and as honestly as possible.

In terms of method, this has implied that I have had to rely more on what was written. Though I would never willfully lie, it seems that the sole usage of recollection, simply, is not consistent enough to use for data. The consequence being that, considering my shifting focus during the fieldwork, there will be many situations that I cannot discuss in a trustworthy manner, as these for various reasons did not make it into my field notes. I found that everything not written down must be regarded inadequate as data.

Interviewing

Interviewing is a cornerstone of anthropology (Spradley 1979; Wallace 2017; Madden 2010, 67; Davies 2008, 105). I had the interesting problem of strict limits as to how much I could "disturb" people, and par agreement only had 30 minutes with each employee for interviews.

This became a stress factor. Knowing that I only had 30 minutes made me overwork, and overthink how to use them best. Consequently, all my interviews were at the end of the fieldwork. I spent too much time trying to make it perfect. It would have been better if I had carried them out along the course of the fieldwork to a higher degree, but scheduling them close to each other timewise provided interesting options as well.

I structured my interviews in two sections. The first one was experimental and invented for the purpose. I had a hunch, based on the way people talked about each other's work, that there was not a clear consensus of who did what. To best explore this, I made a paper with the eight people I worked with the most. Under each name were five lines, and I asked people to write down, as well as describe who did what in the company. See appendix 2. This is a rich source of data on how the employees work together. My theory was, by the way, wrong. Analyzing these worksheets indicated that they are agreeing about each other's positions.

The other part of the interview consisted of more classical anthropology. I included questions designed to describe some of the "native" terms (Spradley 1979). The purpose was to take words I knew and connoted certain meanings to, like "innovation" or "problem-solving" and ask the interviewees to give their understanding of the words.

I also asked them to give me a quick tour (Spradley 1979) of a concrete problem I had seen them work with earlier. I tried to do different levels of abstract questions. Some answered these reflectively with ease, others did not fully understand the point in asking a question directed at something unspecific. This also means that I had to navigate and interact differently with my informants in interviews. Though it is inconvenient, it is imperative to ethnography that people are different. See full interview guide in appendix 3.

Performing Interviews

As Madden says, one will always build a specific social situation when doing an interview, so one might as well think about it (Madden 2010, 68–72). And I did. Therefore, apart from my questions and the role sheet, I went to quite some lengths in making the interviews appear as informal, casual, and maybe even as *hyggelige* as possible. This was by design. One of the ways to do this was that I provided cake at every interview (snøfler), as this makes the session more casual.

Another method was doing what was possible about building report. In this regard, I spent some time explaining that the interviews were about each interviewees' individual perspective on the given questions and that there were no correct or wrong answers. The physical position in the rooms was not random either, I made sure that we were always sitting next to each other by a table, to ensure there was no power relation between us, which often tends to be the case when sitting at different sides of a table asking questions from a paper. I also went to some length in making jokes, and no less in laughing at *their* jokes. Furthermore, I did my very best to take on the technical language the engineers use, to come across as an internal part of the company to the highest degree possible.

Other than that, I focused on giving my informants time to think before answering and hold my tongue with whatever comment I might have had (Spradley 1979). I cannot say that I was solely successful; from my transcripts, I realize that on occasion, I even interrupted my informants, but overall, I will maintain that the interviews went well.

DATA:

Fieldwork and interviewing produced a vast amount of data. In this section, I initially present the quantity of my data, and then I discuss its strengths and weaknesses.

Counting the Data.

Type	Quantity	Pages
Participant observation	77 days	1350
Interviews	8	40 pages (rough transcribes)
Other sound files (notes, recordings and the like)	12	Not transcribed
Other documents (flyers, handwritten notes, drawings)	~60	~100
Pictures and videos (cannot be published due to confidentiality)	~100	~50

Strengths and Weaknesses

Previous to my fieldwork, I have been strongly inspired by frame theory and the detail-oriented descriptions of social life. The strength of this approach is that my descriptions are close in time and space to the interactions I encountered. I can, therefore, be specific about what I will use. As an ethnographer and human being, I can only focus on so many things at a time (Spradley 1980). Therefore, there are some lacks from time to time. Sometimes I have described five or six pages on a conversation but forgot to put in exactly why it was taking place, as well as who was present, but not participating. At another point, I focused so much on describing some detail that I missed the fact that everyone had left for lunch. Luckily, most of the time little interaction happened because the engineers were focused on their own work on their respective computers, so I had the possibility to fill out my notes.

I had a focus before I came into the field. This is needed not to get overworked and try to focus on everything at once (Spradley 1980; Madden 2010, 101), however, it also means that there are things I did not pay attention to. I came in with a focus on the acts of innovation, and a sub-focus on playfulness and flow. This means that I only gradually started coming to an understanding of the entire economic and political structure of projects: funding, investors, and the like rather late. I do not regret this choice, as my focus was on what happens among people in an interaction. Yet, had I initially dedicated more resources to structures, maybe even preceding the fieldwork, I would have had a broader picture of the motivation behind many of the actions observed.

Another astonishing aspect of my data is its magnitude. With roughly 1500 pages of consolidated field notes, interview transcripts, as well as my filled out role forms, and other documents I found myself having more data than time. Going through it all several times during my analysis is simply too time-consuming. Consequently, I have been coding it instead. This is discussed more in “coding”.

Finding Exactly What I Was Looking for

Before entering the field, I did my best to research what to expect. Based on these findings, as well as my initial visit to the company, I had an informed idea about what I was going to experience, and what to focus on. Prepared and expecting to be surprised by the reality of the field site, and having to adapt my questions to fit the fieldwork, I was ready to leave all ideas, and choose the research problem for which the site was ideal (Hammersley and Atkinson 2007, 29, 34).

This is why I was so utterly surprised to find almost exactly, what I was expecting. People mostly working with their computers and talking about the problems they were not able to solve themselves. I expected them to work on the offset of the “scientific method”; hypotheses, test, and evaluate hypotheses (‘Khan Academy’ 2014). I expected people to be iterative, deploy a solution, and try to improve it until it was satisfactory. And this is precisely what I found.

This is potentially problematic as I never heard of an anthropologist, finding what he or she expected. There might be different reasons for this. One is that I was lucky; one is that I did my background research really well, and the last one, is more problematic, I might have been so biased in looking for something specific that I would have been unable to find anything else.

Finding what I expected meant that the methods I had planned from home were, for the largest part, well suited for the fieldwork. I did not have to experiment in the field to implement my methods, thereby freeing time to experiment in perfecting my methods.

Unavailable Data

During any fieldwork, there will be things that the ethnographer had hoped to understand better and get more data on. One of the things I had hoped to get was the company's own log file. In this file, employees write what they have done, and why, as well as share important findings. This would have been a goldmine of data. Regrettably, it was seen as too big a risk to let me copy it. It contains not only a lot of technical information but also descriptions of their products problems and weaknesses. I was allowed to read it but failed to get enough information to use.

Anonymity and Secrets

My largest ethical issue is that of anonymity. This has two aspects.

One is that of secrecy; people outside the organization are not supposed to be able to recognize the company targeted in my work. This was a great concern of mine but turned out to be a minor problem. Given that my focus is on *how* they worked, rather than *what* they worked with, I can merely describe the products as "products" and still provide the details needed for analysis. Furthermore, I have given pseudonyms for all employees, so potential outsiders cannot find the company this way. Lastly, I have renamed the parts I mention.

The other side is that of confidentiality internally in the organization. The problem here is that on a day-to-day basis, I have been in contact with only 5-9 people in total. Quite different people at that. Therefore, I have been unable to anonymize them to an extent where they will not be able to recognize each other. At least, I have not been able to do so to a degree where I feel confident they will not. My solution has been sending potentially problematic anecdotes or descriptions to the person who it concerns, before putting these into my thesis inquiring if they were comfortable with their boss and coworkers reading this (Davies 2008, 58).

After the Fieldwork

Coding

Using Nvivo, I have been through my entire dataset. I followed Robert Emmerson's advice and started out doing open coding, where each piece of data is coded according to its apparent qualities, and later closing in on a few relevant codes, using these for closed coding (Emerson, Fretz, and Shaw 1995). I failed in making the shift quickly enough and therefore spent time coding with far too many codes without sufficiently strict criteria.

While coding gives a good overview, it does come at the cost of some details that undoubtedly has slipped me, when going through the vast amount of text produced. I can only hope that nothing too relevant to my analysis got "through" my coding, as going through it twice, is simply more work than the timespan of writing a thesis allows.

Rubber Duck Anthropology

Andrew Hunt and David Thomas have made a practical guide for "pragmatic programming", in which they suggest "rubber duck programming". This is a method for debugging code where one out loud explains the code, step-by-step and how it should work, to a rubber duck (or any person or thing that will not answer back). The idea is that vocalizing the process which is supposed to happen, will make the programmer understand why it does not work, and what the problem is (Hunt and Thomas 2000). Though not a programmer, I have used a similar method, explaining to my computer screen, whiteboard or dictaphone out loud, why a certain argument or concept is just the right thing to apply. While it probably seems odd from the outside, this has been a heavily used method when analyzing and building arguments, as vocalizing it, oftentimes reveals the logical mistakes.

Analytical Methods

As some of my methods are described as I use them, I have in this section only included the ones that would otherwise cloud the analysis.

Phronesis

Looking for Phronesis has included many methods. The first step was to break down Phronesis into the three virtues, the intellectual, Episteme and Techne, and the ethical virtue, Ethos (Aristotle 2000, 107). Looking for Episteme was the first. Here, I went through my empirical materials, finding examples of the engineers referring to the decontextualized knowledge they possess from education. This is a rather simple method to use, however efficient.

Looking at Techne required analyzing situations where the engineers *do* rather than *talk about doing*. This meant finding the most interesting situations from my 1350 pages of notes, writing them "out" so that a reader would be able to follow what happens and then dissect them.

Looking at *expertise and learning* how to do these things, required another method, and analytical framework. I here went to Dreyfus and Dreyfus, and their model of learning (Dreyfus and Dreyfus 2005). Using Dreyfus and Dreyfus analytically was done by a bit of back-and-forth with my data and their descriptions. Sort of tinkering. I have therefore outlined the different stages of their model, as honest as possible to their own description. Thereafter, in each step, I have shown how this exact level of understanding has influenced the everyday life and relationships between my informants.

The Good, the Bad, and the Ambivalent

Cathrine Hasse explains; "***in the beginning, when a researcher is in a new context, nothing makes sense, and at some point, everything just seems too self-evident***" (Hasse 2011, 152). My method for analyzing characteristics and normativity "the good and bad" has been to mix two different theories; Clifford Geertz ideas of common sense, and Axel Hornets ideas of recognition.

I have been looking for what Geertz calls "common sense" that is to focus on what was not said, or maybe rather, that which no one had to say, because everyone, in the context, *of course,* agrees. Common sense is described as an extremely authoritative understanding, seen as self-evident and usually unquestionable. Though far from the same from culture to culture, or maybe even from person to person, the logic behind common sense is used on an everyday basis, and is a big part in forming and transforming both people, their actions and, by that, the physical and social world (Geertz 2009, 778).

Another theoretical aid in defining the good and bad in the engineering context is Axel Honneths idea of recognition. I have chosen the idea of recognition due to its operationalizable method. I did not intend to look at values or ethics before going into the field. Therefore, my observations say nothing about either. I did, go in with a focus on interaction. Therefore, I have been able to go through my notes and find praising as well as frowning as reactions to people actions. Honneth has an extensive theoretical work (Honneth 1995; van den Brink and Owen 2007b), however, I shall limit the influence to what Van den Bring and Owen calls "relations of solidarity" where, preferably high-status, members of a social context recognize the social value of achievements as good (van den Brink and Owen 2007b, 17).

My method for finding normativity is thus to look at a situation where one or more informants are doing one thing, and others are somehow approving or disapproving of this method or goal. Approval is either that it is explicitly said that something is done right or well, or people smiling and talking in a calm manner either when looking at equipment working (or not working), or when talking about a method. Disapproval is found when peers either explicitly correct behavior or, in most cases, simply refuse to recognize the behavior as acceptable. This method also proved, unexpectedly, to uncover a lot of ambivalence.

When studying ambivalence; the analysis will often become ambivalent. And given the academic ambition of coherent analysis, ambivalence and changes in how problems are dealt with from day to day, is at best problematic. However, as Venturini explains, it is important to take in the ambivalence, as one studies people, who are ambivalent by nature, making a coherent analysis about what is not coherent is at best a lie (Venturini 2010).

Writing Culture

In recent anthropological writings, a lot has been about just that, the writing. Reading books like "Self' in Alive in the Writing: Crafting Ethnography in the Company of Chekov" (Narayan 2012), one will learn about different writing styles, and how to capture the attention of the reader, by learning from fiction. This, begs the question of how to represent the informants, and the situations you want to analyze. Because on the one hand, one cannot bring in everything – there will always be smells, noises, or even entire conversations that have to be left out, in order to create a text. On the other, one must stay true to the reality of what was observed and experienced. At the same time, it is important to remember that anthropology works with the, sometimes mundane, everyday life of people.

My approach to the balance is strongly inspired by the British novelist and film director Alfred Hitchcock. He explained, in an interview, that "*drama is life, with the dull bits cut out*" (Hitchcock 1960). To Hitchcock sensations in drama was about making the mystery interesting and unfold the plot.

The "mystery" in ethnographical writing is the research question at hand; this is what as well the reader as the author wants to learn about. And the "drama" shown is the situations, or aspects of situations which is the most helpful to the anthropologist, in showing what the answer to the question is.

This also means that informants, in the ethnographic description, to some extent will function as characters. Though an ethnographer should never lie, it is necessary to put forth some aspects. Furthermore, every description must have an analytical purpose, for ethnography not to become a long and meaningless description. Consequently, informants will always be reduced in writings. In my work, this becomes clear when a bright intern, Felix, is mostly described in situations where he does not fit. This is a mean of describing the life and ambiguities of the engineers, not a testimony to a useless one.

Chapter 4: Knowledge, Skill, and Intuition

This chapter introduces two tenants' of Phronesis, uncovering the intellectual virtues Episteme and Techne within technological development. I argue that both an elaborate repertoire of decontextualized knowledge and practical skills are central in development. Not all skills are equal though, craft skills are needed, but not necessarily mastered, while tinkering, the art of combining what is at hand to achieve a goal, is paramount.

After this, I analyze expertise, experience, and intuition in technological development. Here, I use Dreyfus and Dreyfus' model of learning and expertise to argue that while experience has provided both expertise and intuition to some, it is not true in all realms of their work. I then revisit the concept of Episteme, discussing how tests are locally constructed epistemic facts that cannot be questioned. Lastly, I show how these facts even overrule the ideas and intuition of the experts.

Like Venturini, I would like to point out that my distinction between knowledge, skill, and intuition is rather artificial. While it has an analytical purpose, it is not perceived by the people in question as different entities (Venturini 2010, 259). Before doing that, I provide a little context for the projects of the company. After this, I briefly explain how plans and goals work within the context.

The chapter concludes that though Episteme (knowledge) and Techne (skills) are imperative for technological development, it is the ability to combine and balance them intuitively with experience that pushes development forward. Intuition will sometimes be wrong, misleading the attention away from the goal. However, due to the hierarchy of knowledge, Episteme, from testing, will overrule the misguided intuition, and allow the team to achieve their goal.

Innovation by Duct Tape

A constant goal during my time in the company was downcosting: Lowering production cost per produced unit. This was the emic word used in the company, though it does not seem to be a mainstream term. Downcosting includes a wide array of processes. Some are about producing the same parts cheaper by bulking up production. Some are about changing expensive pieces of software with cheaper or free versions. Yet others are about replacing hardware with cheaper versions, which, for the sake of the product's performance, execute just as well, or maybe even better.

Downcosting, like all sorts of development, is not easy. The CEO of the company explained that when trying to further develop a given product it is a hindrance, it already works:

> "When nothing works, you can change anything for free. It does not get any worse. However, when something is working and customers have expectations for your product. Well then, if you change something and it does not work, you have the trouble"

Risky as it is, changing a component that costs several hundred dollars, to one bought for less than twenty-five, may well be worth the extra work of testing and fitting. If successful, the finished product will sell at the same price, thus improve profits drastically, or price per unit may be lowered, improving market shares. The worst-case scenario is learning that the component was inadequate. Nevertheless, this will still add to the knowledge base of the company, and to the understanding of the products and components already in use. The CEO explained that in development, learning is constant and crucial:

> If I had a specific idea of the product 12 months ago, it would never be what we have today. It is only because we had this construction and learning process that we got this close to the goal. And we are not really there just yet!

One of the interns, Arthur, was testing a cheaper component, which may prove to be an adequate replacement for an expensive part of the product. It was the plan before Arthur started that this would be at least one of his tasks. Exactly how he was to proceed with this task was up to him. From the start of his internship, which correlated with my fieldwork, he was reading up on specifications and performed minor tests at his desktop. At this point in his work, he could get no further in this manner, so they had to test it "live" on a working prototype – The Monster. The first of many tasks was fitting the extra equipment into a design already just the right size for the components already inside. Allow me to show you the process:

> Arthur is looking at The Monster. Then at the handful of parts, he must fit in there. A battery the size of a large hole puncher, a fistful of wires and the components he is about to test as well. All this will never fit into The Monster. "I found a shoebox!" Percy yells from the storage room. A small snicker flows through the office, but the shoebox is chosen. The other engineers discuss how waterproof it should be, but Arthur is already trying to fit the components in there.
>
> For the next hour or so, Arthur is tinkering to fit the parts into the shoebox. At some point, he decides to zip tie the shoebox onto the frame of The Monster, which lives up to its name right now. He gives it a few tries, as the holes he punches in the box do not really fit. A few extra holes do not present much of a problem. Once the box is secured, he puts in the battery. After a few seconds of inspection, he decides it does not fit, and then tries another corner. He tries to put in the board, but it does not fit with the battery right now. He carries on trying repeatedly to find a way to fit all the different parts into the box at the same time. Quite a few times, he starts all over, taking out all the stuff and beginning once more. At one point, he smiles triumphantly: "*I did it!*" Percy, barely looking down from his computer, comments that Arthur forgot the connector, and so he must begin again. Eventually, all the parts end up fitting into the box and are duly secured.
>
> Arthur then starts to apply the wires, which will connect the components inside the box, as well as connect them to The Monster. This reveals a crucial mistake in his method: Once every board, battery, and component is secured into the box, applying wires proves impossible; there is no room for the wires, let alone the hands applying them. He must take everything out of the box once more. It also proves problematic that all the wires are too long. They simply take up more space than the box allows.

> Either that or the shoebox is too small. Once again the fitting begins. Rick has left the room. He needs more silence to work. The two remaining engineers are sitting at their computers, each with their headset on. Trying to focus.
>
> Considerably later, the batteries, components, boards, and wires all, miraculously, fit into the box. When Arthur needs another hole in the box for a wire, he simply punches it. Wrong holes are covered up with duct tape.
>
> Everything is in place, and Arthur attempts to close the box. This is not possible, and for a moment, he almost seems like all hope is lost in despair. Without noticing, I hand him the masking tape lying next to me, and the box is shut. Imagine The Monster, already a pile of quick fixes, now with a shoebox that has wires sticking out at all sides, and closed with quite a bit of tape. From my stool, I laugh a bit, complementing the pragmatic and almost comically low-tech approach to equipment worth several hundred thousand danish kroner. Kent laughs while claiming that any prototype worth its own weight must be improvised, and Arthur ads: "Innovation by duct tape!"
>
> By the time Arthur is done with his work, Percy comes to check that everything is attached properly, so nothing will hotwire when powered up. He looks up, "Should we try to turn it on?"

The first time I observed someone build during my fieldwork, I was astonished that their guesswork ever ended up making sense. When looking at the processes one thing became clear: This is far more than mere guesswork. However random the process might seem in the making, and it often does, actual random actions would take forever to result in a working model. In addition, even as the parts were chosen beforehand, there was nothing random about them either. It was not any old gabble of parts and wires in Arthurs' hand, they were, obviously, the ones he thought essential for the project in question.

Plans or Goals?

Lucy Suchman explains that a plan, at least in some views of the term, is a "prerequisite to and prescribe action at every level of detail" (Suchman 2007, 51). Included in such a plan is both a goal of the action and a guide to action; should one follow the guide, the result will occur (Suchman 2007, 51,55,57). In this view, context, simply becomes an obstruction for a goal (Suchman 2007, 53).

Before Arthur started this activity, there was no plan, in the sense of predefined actions, which would lead to a goal. Moreover, there were no instructions. There were neither schematics or in any manner a “right” way to conduct this work. There was a goal; to build a prototype good enough to test if the parts were worth investing more time in. But no predefined “right” way to do it, nor could he ask anyone who had done it before. Furthermore, the goal was vaguely defined, as “good enough to test on”, does not have any definition. In other words, he had to make rapid judgments constantly, trying to verify whether the present set-up was closer to the goal, and if not, what might be improved. Suchman argues that when conducting action, plans become obsolete and that people will “fall back on whatever embodied skills available” (Suchman 2007, 72). However, what is the nature of these skills, how are they put to use, and what guides them?

Episteme – the Art of Knowing

Episteme, to Aristotle, is the intellectual virtue of finding and understanding “true” knowledge, modernly understood as scientific knowledge (Flyvbjerg 2001, 5; Aristotle 2000, 109). This is the kind of knowledge that can be learned from books or lectures, or if one is experienced enough, can be achieved by oneself using a set of specific (scientific) methods – in Aristoteles’ words, Episteme, is what can be demonstrated (Aristotle 2000, 108). Epistemic knowledge has to be so removed from context that it will be true in any context, and thus could not, have been otherwise (Aristotle 2000, 108,110,115). This notion of knowledge that is understood as true even without context ties closely to what Lene Kaufmann call ”general” or “sound” knowledge, meaning knowledge that is brought forth in a systematic matter, and that at least in the western knowledge context, is considered “true” or “scientific” (Kauffmann 2014a, 2014b).

In the episode of Arthur trying to build the shoebox prototype, Epistemic knowledge is not very clear. This is true for the majority of my work. This is not the same as it not being there, or relevant. Arthurs training in engineering has provided the vast repertoire of knowledge on physics, mathematics, programming ECT. This understanding is essential to understand what he is even trying to do. Before the episode shown above, Arthur had spent a month reading up on specifications, trying to calculate whether this part was compatible with the rest of the equipment. Without his background knowledge, Arthur would never have been able to recognize what the different data implied, let alone make an analysis of them. It would have been impossible to build a working prototype without understanding the functions and roles of the different components. Later in this chapter, I will study how the engineers themselves created local epistemic knowledge, through “scientific methods”.

As engineering is an applied science, Episteme is not always visible. “School knowledge” was often referred to in a slightly condescending manner, however often used. When disagreeing on the proper way to conduct this or that, it was not unusual that people ended up extracting the mathematics of something, trying to “figure out the math, and then understand the process”, as an engineer explained. The epistemic knowledge also overruled some ideas, on the note that if the mathematics or theoretical mechanics were not sound, there was no reason to try it “in real life”.

Knowledge, or the people applying it, could be seen as “too academic” as was the case with a potential consultant. It was discussed whether or not he was the right man for the job, and while there was agreement that he surely understood the chemistry, his Episteme, it was also agreed that he might be too academic, and therefore not helpful in finding a solution, as he rather study the problem. He did not possess Techne, which shall be the subject for the next section.

Techne - the Art of Tinkering

“*Mere thought, however, moves nothing; It must be goal-oriented and practical*” (Aristotle 2000, 104)

The next intellectual faculty is what Aristotle calls *Techne*. This is the faculty used in all arts and construction (Aristotle 2000, 104). At the time of Aristotle a mason and an artist were not seen as inherently different, and “engineer” was not yet a profession (Crisp 2000). *Techne* refers to the making of things or conduction of trades, where there is a plan or goal, and the maker uses his skill to realize this. Not too different from when Sartre refers to creating a letter opener; there are a predefined function and form, and the maker is trying to create this (Sartre 1984, 12–14). Techne, in contrast to Episteme, is embedded in context and is regarded more as a knowledge of how to do different things (Aristotle 2000, 105,108), or, in more modern terms, know-how (Flyvbjerg 2001, 6–8).

While there are many sorts of handicraft skills at play in what Arthur is doing, wire cutting, hole punching, soldering ECT, he is not a handicraftsman in any of them. Having a background in farming, trained in repairing and building, I often cringed at his minor mistakes. The primary Techne, Arthur is applying here is what I call tinkering; the ability to do a pragmatic adaption of technology into context with the desire to meet an, in this case ill-defined, end (Mol, Moser, and Pols 2010, 14; Rieder 2017, 3).

In a renowned essay by Nobel-Prize winning biologist, François Jacob, evolution and engineering are set up as a dichotomy. In Jacob's perception, engineering is the process of an expert knowing exactly what to create, how to create it, and what to create it from. The engineer will have the exact tools chosen for this job, ready and will with these strive towards the perfect creation. To Jacob, engineering is about creating perfection (Jacob 1977). In contrast, Jacob argues, evolution is based on tinkering. That is, to Jacob, the process of taking what is available and try combinations until something works. In Jacob's terminology, tinkering creates functional imperfection. Jacob explains that the key difference is

" [while products of evolution]are valued for their ability to survive long enough to procreate, the engineers' design is valued by its perfection" (Jacob 1977).

I know little of evolution, and shall not contest a biologist on how species came to be. Yet, I can and will contest this perception of engineering. Jacob seems to buy into a somewhat popular assumption of engineers who operate from an exact plan and understand the exact outcome of their every action, and how to achieve their goal. I, on the other hand, will argue that a lot, if not all, progress is made much more pragmatically; that the end solution is a product of numerous, failed or successful, attempts, and that the goal is seldom perfection but rather "good enough" solutions: functional imperfection.

The latter becomes evident as after products, from both "my" company, and most software as well, are released, updates are still coming from time to time. In the company, I worked in; it also became visible in Charles' attitude towards "finished" products already sold: "it's always some level of prototype. No matter what they say".

Jacob's definition of "tinkering" is, I would say, rather sound. The processes of utilizing whatever available in the immediate area and combining into something new(Jacob 1977). This is not always done with a predefined plan. In the shoebox example above, the only known goal is to make something that is good enough to be tested. No one has a defined parameter for what "good enough" means.

Regarding Arthur's process, he had, as Jacob says, some parts which were carefully selected for the job. He also had some vague idea of a goal. Everything else was tinkering. The box that became the frame of the prototype was chosen due to one quality; it was present. The choice of screws was based on the box of screws standing on the table from the day before. The organization, and reorganizations, of the parts in the box, was a long series of attempts, during which, he explained later, he randomly tried out different constellations until something looked right. This is tinkering.

Tinkering with a goal of something being good enough, not perfection. Therefore, though skills, in the understanding of craft, are applied, it is by no means done so expertly, nor is mastery expected. Making something that looks good and can last long, is unnecessary before the starting production of a finished product. Tinkering, on the other hand, is paramount in development, especially when building prototypes. Anything more than tinkering to form a make-do solution would require more time and other recourses, thereby making the prototype, and by extension learning if the part was good enough, more expansive. In other words, not only would "perfection" be more problematic to build, it would defeat the purpose of a cheap and good enough prototype, which was the goal of this action.

Intellectual Virtues

Suchman argues that when it comes to action, plans become obsolete, and people fall back on whatever embodied knowledge they already have (Suchman 2007, 72). Above, I have shown the differences between Episteme, the virtue of knowing, and Techne, the possession of craft skills. I also argue that one cannot truly be put to use without the other. Had Arthur not had background knowledge, nothing he was doing would make any sense to him, and had he not known how to build, the prototype would never become more than a mere thought. Had Arthur not known how to tinker, someone would have had to make an extensive plan on how to build this prototype. Said plan would require the knowledge that Arthur learned while making it. In other words, Arthur applies his knowledge and skills in order to learn something new about the equipment.

There was no pre-described course of action beforehand, only a vague goal of something that worked well enough for testing. In addition, there was not even any definition of when it would be good enough for testing; only that good enough was good enough. Arthur had to apply both intellectual faculties, and make sound judgments of whether each and every step was getting him closer to his ill-defined goal – he had to, as Herve Varenne explains, figure it out. This is a pragmatic argument, that all of human existence is attempting to understand context, circumstance, and past, and try to figure out the best way from there (Varenne and Koyama 2011).

This exact position, figuring it out, has given me a lot of trouble analyzing. Arthur has to do something *right* that has no predefined, or maybe even defined, way of being right. But how does he make this decision, and how does he evaluate if his actions help him towards the goal? I have chosen to call this intuition, and I shall discuss this in the next section which will also discuss *how* this intuition is achieved.

Experience, Intuition, and Expertise

In the previous section, I discussed Ethos and Techne. With Aristotle, these are purely intellectual virtues and has little to do with putting parts into a box. Though he describes "practical goals", he does not seem to discuss actions (Aristotle 2000, 107). In everyday work, people do not use this distinction as to which intellectual faculty they are applying. They simply apply their knowledge and skills to get on with their projects. In addition, a lot of this process has more to do with experience and a bodily sensation, than it has to do with understanding the epistemic knowledge behind the work.

In this section, I use Hubert and Stuart Dreyfus' model of learning and expertise. The model has five stages that, phenomenologically, describe and examine different levels of knowledge or expertise in a certain field. The section is structured on these stages, and each opens with a description of the stage based on Dreyfus and Dreyfus, followed by an empirical discussion. While the model has been criticized for lacking evidence and being simplistic (Gobet 2017; Gobet and Chassy 2009), it is still widely used (Flyvbjerg 1991, 2009, 2001; Breazeal et al. 2006; Billett 2004). My use of the model is twofold; to show the emergence and importance of experience and intuition, as well as examine why sometimes the same person will act as an expert while other times seek out more structure and guidance.

Stage 1: Novice

When a learner is new to a certain task, an instructor will attempt to remove all context and set up some simple rules. In the Dreyfus and Dreyfus example, a student driver will learn to use the pedals in a traffic-free parking lot. Important to this stage is that the learner knows close-to-nothing, and attempts to follow the rules that are instructed. Students will learn what is important to recognize and practice detecting it. At this stage, all actions are rule-based, and there are little or no understanding of context (Dreyfus and Dreyfus 2005, 782).

Within my fieldwork, there were no novices. All my informants had at least a few years of training and education in engineering, physics, or mechanics. However, like any other model of social behavior, the levels of expertise are grounded in context. Thereby follows that behaviors of novices are to be found when people are engaging in something all new. The best example of this was not one of the engineers, but rather a customer. I was following the company’s sales clerk for a day when delivering a unit. When buying a unit, a one-day introduction is included. This is an acknowledgment that the equipment, though built to be user-friendly and intuitive, is not self-explanatory. As Percy, responsible for building the interface, explained it is not the ambition that anyone can just use it, the ambition is that customers can use it correctly with little instruction. At the beginning of this day, the sales clerk instructed while the people who had to learn to operate were listening. The sales clerk showed how the equipment reacted when exposed to different inputs and tried to explain some of the routines in operating and maintaining the equipment – while stressing the importance of proper conduct.

Within a few minutes of our arrival, the sales clerk commenced by offering the controller to the customers. So that they, as early as possible, could both try it out, and get a *feeling* of how it works. The first few minutes of experience the customers got with their new equipment was highly decontextualized from the working environment they usually had and designed to be risk-free. There was virtually nothing they could do, which would do any damage to the equipment, themselves, or anything else.

Stage 2: Advanced Beginner

As the learner gains experience, he or she will increasingly interact with the context with falling need for supervision and predefined rules. The learner will begin to understand what is significant to context, and with sufficient practice, will begin to link these elements to appropriate actions. Instead of shifting gear at a certain speed, the student driver is increasingly relying on the sound of the engine. At this point, other than the instructed rules, the learner will start to build their own rules. The rules understood at this level are so complex that they would not have been teachable to someone without previous knowledge. The rules of what is being learned become ever more complex and contextual. But the learner still follows rules (Dreyfus and Dreyfus 2005, 782–83).

As the customers got a few minutes to “play” with the equipment, it was still risk-free. The worst that could happen at this point was that something might make an unpleasant noise, for which the sales clerk quickly explained both the cause and the remedy. After making sure that the customers had a feeling of how to conduct the equipment they moved on to the prepping of the equipment, and not thirty minutes after arrival, the customers initiated the first real-world application of the new equipment. Still under guidance from the sales clerk looking over their shoulder. However, the goal for the day was reached; the costumers were capable of operating the equipment, slowly but properly.

Stage 3: Competence

As experience grows, the amount of potentially important elements becomes overwhelming, and the ability to choose the significant ones will evolve. The learner will attempt to consider all information at once, fail, and then start to develop strategies for identifying the crucial factors as intuition slowly starts to build. At this stage, fear of mistakes becomes relevant. At the previous stages, if the rules learned proved inadequate, this was the instructor's error and responsibility, but now the outcome is a result of the learner making a choice. It is important to note here, as this is a phenomenological theory that the body and emotions of the learner are important, both as giving directions to the choice at hand, and to provide a response for the learner when it becomes clear if a choice was made right or not.

The teacher, instructor, or available authority remains important. If too rigorous or hard on mistakes, the learner will be risk-aversive, attempting to not do anything that might be "wrong", and thus lose the possibility to do something new, right. To put it a bit simplistically if unwilling to take risks, a learner will never progress. To be able to master this level, and go beyond, it is paramount that the learner takes responsibility for successes and mistakes in order to improve (Dreyfus and Dreyfus 2005, 783–86).

This level is where I would argue the earlier-mentioned customers were at the end of the introduction day. At that point, they understood the basics of both the software and hardware systems. One reason these customers could reach this stage so rapidly, was, as Dreyfus and Dreyfus explain, that what they sought to learn was both somewhat simple, and did not suffer from too much pressure decisions being instantly right (Dreyfus and Dreyfus 2005, 788–89). In this context, there was always the time and possibility of correcting errors, in case the customer made one. Furthermore, the equipment and situation provides virtually no possibilities to make critical errors. Unlike a surgeon, which Dreyfus and Dreyfus explain, can make minor mistakes that are instantly irreversible and critical (Dreyfus and Dreyfus 2005, 790).

The customers also had an advantage that Dreyfus and Dreyfus seem to underestimate, as the customers used experience from other realms of their lives. They used their prior knowledge of computers and software systems to better and quickly understand the user interface of the equipment. They used their knowledge of products similar, though less advanced than the present one, to guess and learn how to maintain and operate it. Finally, they used their extensive knowledge and experience performing the job that the equipment was to aid to estimate if it performed well enough, and establish the consequential amount of human labor involved in their future production process.

Also at the stage of competence, in a more complex learning process, was one of the interns, Felix. One of his jobs, during his internship, was to test a new component, a cheap potential substitute for an expensive one. Same goal as Arthur, but a different part. This was a hard task for Felix. Not because he was an untalented engineer, and he lacked neither Techne nor Episteme. But because he lacked experience. He was a bit younger than everyone else was, and had a demanding time using his intuition as grounds for decisions. Consequently, he constantly asked for parameters and critical test values, looking for the rules and patterns he did not yet understand. However, the only answer he received while I was present was: *It is right when it is right!* Charles also explained to Felix that a "right" answer is only found in school, not in the real world. When, during an interview, three months into his internship, I asked *when* a certain level would qualify as good enough to be good enough, Felix deflected the question, insisting that such decisions must be someone else's responsibility.

Felix, in other words, was still looking, or hoping, for instruction and a clear definition as to what was right and wrong. In the interview, he also explained that he preferred having the possibility of a correct answer. Unfortunately, this was not his job. The CEO explained that if the company already knew the right answer, there would be no need for an engineer to do anything; they could simply look in the manual. Felix' role, therefore, was to apply the experience and discrimination he was still building. This caused conflict, not only for Felix, who expressed negative feelings of being dealt too much responsibility but also for his colleagues who did not seem to recognize that Felix was not yet up to par in the job. This approach from management and staff to Felix' position might have been an attempt to conduct social learning, seeking to push Felix onto the level of proficiency. In case this was meant as a learning experience for Felix, consciously or not, it failed. He never grew to be comfortable with his tasks and responsibility, while I was there.

Stage 4: Proficiency

Once information-consummation and rule-based thinking are replaced by involvement and responsibility, the learner will reach proficiency. Proficiency can develop only when knowledge and experience are assimilated, and embodied so that the initially learned rules are gradually replaced by situational discrimination and associated responses. Actions that in earlier stages were hard and stressful, due to the burden of responsibility, now become gradually easier and more automatized for the learner. By now, the learner knows what is important to understand about the context, and will, increasingly intuitively, determine which parameters to choose from. However, at this stage, the learner will still fall back on some of the rules learned, in choosing the best way to react to this situation. Dreyfus and Dreyfus explain:

"A student at this level sees the question that needs to be answered but has to figure out what the answer is" (Dreyfus and Dreyfus 2005, 786–87).

This is the stage where most of my informants were, in most situations. I shall argue that development will often take place here. Going back to the situation of Arthur, trying to build a working prototype, he was aware of the goal and the important contextual factors to consider (heat, space, cables…). However, he did not, without thinking, have a right solution. Even though he may have had some intuitive knowledge of strategies not to approach, he did not know exactly which ones to pursue either. Where Dreyfus and Dreyfus argue that a doctor can make the right choice in a matter of seconds (Dreyfus and Dreyfus 2005, 789), Arthur not only had to think his way through different options, he had to tinker with and test them to see if they appeared successful.

I claim that most development will be done at this stage of expertise as one, obviously, cannot have a lot of experience in performing tasks one has not done before. Dreyfus and Dreyfus argue that the choice made by an expert is based on the vast experience of similar cases (Dreyfus and Dreyfus 2005, 787). If anyone truly knew how to build this prototype, there would be no need for someone trying to figure it out. Though experience helps a lot in this case, no one has a clear idea of how to do this exact build the right way. Arthur, in contrast to Felix, is experienced or confident enough to have some inkling of when "good enough" is good enough. In addition, his ability to make this judgment was complimented by the other engineers in the room. A quick note here is that he also expressed nonchalance, discussed in chapter 5.

Stage 5: Expertise

> *"[while] the proficient performer immersed in the world of skillful activity sees what needs to be done but decides how to do it, the expert not only sees what needs to be achieved […] he or she also immediately see how to achieve the goal*" (Dreyfus and Dreyfus 2005, 787).

At this level, there is an innate intuition of what to do with little or no thought, as on why or what the alternatives might be. For anyone to be an expert, they must have an immediate intuitive situational response. When a driver becomes an expert, the foot simply lifts when speed feels too high; there is no need to think at all. Once one becomes an expert, there is no conscious thinking, the expert simply launches what experience says works, and usually, it works. At this point, it is not abnormal that the expert no longer recalls the rules learned as a beginner and thus may have a hard time trying to explain said rules (Dreyfus and Dreyfus 2005, 787–88).

The fact that experts no longer remember the rules, which the non-experts must possess, seems to be the cause for some of Felix' troubles. Not only did he fall short on the rules, because of lacking experience, also the people of authority were so immersed in their fields that they did not truly comprehend what he asked for, therefore, they were incapable of providing it.

Expertise is both easy and hard to discuss in the context of my fieldwork. This conundrum ended up providing a new insight: expertise, as a phenomenon, is tied to as well context as content. Therefore, it was easy to find examples of expertise; Rick, a programming engineer, radiated all signs of expertise. In his own words, he had an intuitive understanding of which part of the code was "misbehaving" when the equipment did not work as planned, and he mastered his own programs to a point where he had a hard time understanding what the rest of us did not understand. However, he expressed mixed feelings when asked to prioritize; this was not his field of expertise.

Everything Is Priority A – Expertise and Non-expertise

> "*So that lasted 20 minutes – that is one quick era*." Charles fails to hide his chuckle at his own joke. We are in the middle of a prioritization meeting and after carefully prioritizing the extensive list of tasks, the CEO adds, "Oh. But of course, we start with what is done fastest. And what the customers need the most"

While the CEO was still prioritizing, all were complimenting the fact that they had someone making these decisions for them. Rick explained, "*Then I can spend my time programming*". A lot of conflicts and frustrations in the company came from lack of clear prioritizations. The CEO explained that he had hired a bunch of experts and expected them to act likewise. I assume he meant that other than being able to do their tasks, people would also be able to prioritize themselves. Turning to Dreyfus and Dreyfus, he was somewhat rightful to expect this: From vast knowledge and experience, the expert is thought able to choose the exact right move, or, in this case, priority (Dreyfus and Dreyfus 2005, 788).

What becomes apparent in the analysis of expertise is that experts tend to have a specific field of expertise, in which they can manage intuitively and with ease. As a result, conflict arises when expertise is expected in other fields. While being an expert programmer or hardware developer, one may not be an expert in prioritizing what, from a business or customer, perspective makes the most sense to do first. More than that, to be able to make these choices one also needs have an elaborate idea of what the rest of the company is doing. Therefore, the need for someone with an expertise, or at least interest, in both prioritizing and overview of recourses is needed. Without, conflict on what to do and when arises.

More than a mere example of the need of priorities, this is also a part of a general argument: As expertise is bound to content and context, an expert in one field is not automatically an expert in any field. When an expert acts outside his or her field of expertise, the expert will not act like experts, but rather seek out rules and guidance. Just like the case of Felix, if these rules are not to be found, conflict arises.

But what does expertise and intuition look like when it works?

"It Smells a bit Like Board" Intuition in Engineering

During a session of problem-solving, involving Charles, intuition became clear. More people were involved, but it would only cloud the description, to add people not doing much in the project. Charles was trying to establish the cause of a problem involving some equipment. After being positive that there was a problem, Charles, before touching or looking at anything, explained that this "smells like board". He was not referring to the smell of the circuit board, but that the error, which for some unknown reason kept happening, seemed connected to an error on the board. Without question, his intuition was accepted; the fact that Charles meant it smelled like a board became the foundation for their approach to debugging.

"Debugging" is a process of identifying and removing a "bug"; namely a problem or error that the system suffers from. The term originates from an actual bug stuck between some computer parts, instigating a hotwire, and thus History's first computer bug (Kreiser 2017).

The role of intuition is essential. As the products build is a rather complex system, consisting of thousands upon thousands of physical parts combined with a few million lines of code, it is impossible to go through everything systematically. It would take years. Neither Epistemic knowledge nor Techne would be enough. A thorough understanding of both computers in general and the specific parts is needed, as well as craft skills enough to conduct the processes. However, there also needs to be an immense experience and intuitive relationship with the equipment's "behavior". This error could not have been explained in a manual.

In the context, Charles could just *feel*, without being able to explain why afterward, that this somehow "smelled like board". Had his intuition pointed towards software, he would instead have started looking through the code. Furthermore, beyond this feeling that it was probably a board, of which there are quite a few inside any computing unit, he also had an assumption as to which board. He explained, it somehow made the most sense to him if it was this exact board. More so, he had quite a precise idea of where to start on this board, and what kind of component was the most likely candidate to cause this specific sort of problem. He thus combined his broad epistemic knowledge of computing parts with his understanding of this very board, and what constitutes a misbehavior like this one, to be able to pin out the nature of the present problem. He followed his instinct, and after a few attempts, found the exact component, roughly 2 mm in size, not soldered in the proper way and therefore causing irregularities in the equipment.

One of the interesting aspects of intuition is that it is not solely an intellectual process, as Aristoteles Episteme and Techne are. In the phrase "smells like board", Charles explains having a *feeling* of where to start looking.

Dreyfus and Dreyfus also argue that intuition is not placed solely in the brain, but rather exists as a feeling of the right thing to do: "*the grandmaster experiences a compelling sense of the issue and best move*" (Dreyfus and Dreyfus 2005, 787).

Here, a complex problem was identified and solved with little effort. This was thanks to Charles' expertise, experience, and not least intuition. Later I shall show that intuition sometimes causes problems, but for now, we shall dwell a bit on the creation of local Epistemic knowledge.

In Testing We Trust: The Creation of Local Epistemic Knowledge

Though never explicated, a lot of the work done, in both development and debugging, was based on the scientific method. The scientific method is a constant circulation of: Observations, Hypothesis, Predictions, Experiments, and Conclusion – which usually lead on back to new observations, or reviewed hypotheses about said observation ('Scientific Method' 2018b; 'The Scientific Method' 2016; 'Scientific Method' 2018a; 'Khan Academy' 2014).

Figure 1 Simplistic, yet accurate, illustration of the scientific method. Borrowed from Wikipedia

There is an ongoing debate as to the exact nature of the scientific method and to whether or not it is scientific, overly abstract, too simplistic, without empirical proof, only specific to the natural sciences, and especially whether or not one can discuss it in "applied sciences", i.e. medicine and engineering (Gauch 2003, 1–20). My objective in this thesis is not discussing how useful the scientific method may or may not be. I am referring to it because of the extensive, yet inexplicit, use of it that I observed during my fieldwork. I shall argue that following the scientific method, especially the "testing" part, is a way to produce local epistemic knowledge.

“Local epistemic knowledge”, is a term of my own invention. With Aristotle, Epistemic knowledge would be knowledge that is decontextualized and thus always true in any context. Furthermore, this knowledge must be something that could be demonstrated (Aristotle 2000, 104). Like Hasse found the experiments to be the basis of physics as both learning and demonstrating principals (Hasse 2000, 151), the act of testing is both a method of learning and the demonstration of knowledge to be true.

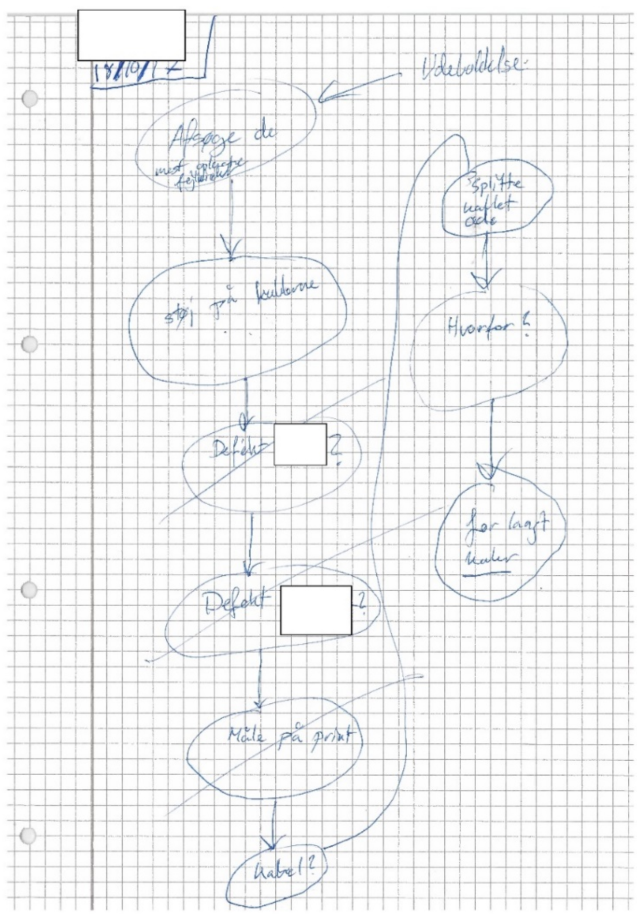
Continues testing, changing different parameters, is seen as proof enough that this is true in at least some decontextualized form. The reason that I choose to call it local epistemic, is that there is no ambition to try to communicate this to the rest of the world. The implication of this newly learned “fact” is never beyond the walls of the company. Within the company, however, it is as Aristotle argues about Episteme, what cannot even be discussed (Aristotle 2000, 104,107,120). Allow me to show the creation of such Episteme.

One of the units sold had many errors seemingly relating to the same underlying problem. Though the engineers had had it returned several times and changed seemingly every piece of hardware in it, it continued committing the same error. The outmost frustration for the engineers was their complete cluelessness as to the cause of the said error. It was a lively topic for discussion whenever it became clear that yet another attempt to fix the problem had not worked.

> We have the unit back in the shop. Charles is doing some testing and right now it behaves, as it should. Which is even stranger. “Aha! So, you must tickle its tummy! Great! We’ll say that to the customers”, Charles lashes out. Not having an answer, or even an idea of an answer is taking its toll on everybody.
>
> They do a bit more testing and are incapable of reproducing the error – making it impossible to define what is wrong, as one cannot study an observation that cannot be reproduced. Charles notes that right now the motors are just running, there is no stress on them. They apply a rig, built a few days before, and designed to put stress on the motors. While running, they do some more testing, and there seems to be something wrong with the signal. “But... why?” Charles is scratching his head. Given what we know, none of this makes any sense. They discuss a few theories and conclude that the central communication-hub might be blown. “At least that’s testable,” Charles says as he prepares to change the part.
>
> This was not the problem. “It just can’t be the wires,” Charles says as they are all looking down into the belly of the unit. “Nothing makes sense, really,” Rick adds. They

> do some more tests and get no closer to an explanation. The error does not even occur the same way in each test. They change another part, and it seems to work. “Now, let’s see if we can kill it again”, Charles cackle as he closes the box, ready for yet another test.

Though there are debates on the scientific model, it is clear from the language and progress described here that at least to some extent it is applied. What is also visible here is the presence of many tests and hypotheses as to what might be the cause of the problem. Though I did not at the time note down the start date of this particular problem, I can establish, from my notes that the engineers must have spent two months, more or less consistently, applying different theories to the cause. Charles, the engineer responsible for hardware, drew this model of the process, once it was done. I have blocked out some of the more context-specific terms to preserve confidentiality.



What Charles illustrates here, is the "main" theories of what might have caused the problem. One interesting aspect here is that Charles himself calls this process "elimination" [Danish: udelukkelse]. Close to what Karl R. Popper calls falsification, the process of constantly questioning the grounds of the hypothesis, in an attempt to disprove it, and thus, over time, develop stronger theories (Karl R. Popper 1973; Sjørslev 2015, 87).

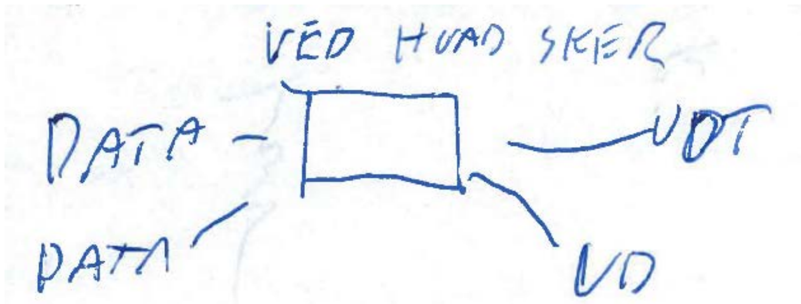
This depiction illustrates the way most problems were dealt with; someone made an observation, the engineers started testing different hypotheses in theory, either by calculations or by discussing possibilities with each other. The ones that were not unprovable were tested.

The role of intuition here was therefore twofold; to make good suggestions regarding the cause of the problem and to select which theory to try out first, in case there were more than one. This choice would have numerous reflections and reasons. Oftentimes the ones weighing in was how sound the theory seemed to the one making the choice, and how testable it was. If two competing theories had to be tested, and one seemed more likely than the other, it would still oftentimes be the one that was easiest or fastest to test that came first.

The model Charles drew, explains the theories, which, to him, seemed most plausible yet proved to be wrong. My choice of words proved to be wrong, is no coincidence. For every theory that was crossed of Charles list was indeed proven to be wrong, following the scientific method, and relying on test data. This data is seen as unquestionable epistemic facts.

The creation of epistemic knowledge in the context did indeed build on the scientific method and learning. If not step-to-step, then still in the underlying premises of learning as knowledge production, knowledge, and especially the language. Therefore, this process did start with an observation; the equipment did not behave the way it was supposed to. It was described as "*an observation a customer made*". This begged the question as to why. The reason that the question was "why", and not "how do we fix it" was that solution is understood as following the right diagnosis.

Then came the hypotheses. There were many different ones, and some sort of testing followed all. Either "in theory" where the hypotheses are discussed, or in practice by performing a test on the equipment. The act of testing was explained as "*assessing if something behaves the way one expects*" . Before a test, there would be a prediction. If the prediction came true, the hypotheses were true. If not, the hypotheses were false. An engineer illustrated the testing process like this



Showing that they would give a known input, and estimate whether or not the output was what they expected, thereby learning whether the prediction was right or not.

In the example above, the hypotheses were that it was the communication hub was faulty. The test of this hypothesis was to change the hub with a new one. The prediction was that if the equipment worked properly with the new hub, the hypotheses would have been true. However, changing the hub did nothing, so they learned it was not the hub, and thus the hypothes proven false.

Oftentimes, this is not done in that exact sequence, and a lot of the critique on the scientific method is that the sequence never occurs in that order (Gauch 2003). Though they do not rigidly follow the process from the scientific method, they still subscribed to it or at least based their own methods on it.

As far as the method of a test is accepted amongst the engineers, what is learned becomes local Epistme. There was never a discussion of the results' validity. Sometimes methods were questioned if results seemed counterintuitive. But if the test is performed in a manner that is agreed upon as correct, test results are seen as what can be demonstrated, and knowledge which could not be otherwise and thus local Episteme. In the next section, I shall open up for the relationship between expertise and Episteme.

The Limit of Intuition: Tests and Hierarchy of Knowledge.

As shown above, intuition is important. It might save countless hours to have someone make an educated guess as to where to start. Dreyfus and Dreyfus argue that intuition of an expert will usually be right (Dreyfus and Dreyfus 2005, 788). The "usually" part, however, implies that sometimes intuition will be wrong.

Intuition came in the way when trying to solve the problem mentioned above. As this was a hardware problem, it started out on Charles' table. To him, initially, it appeared to be some sort of electric noise somewhere. In his mind, it had to originate from one of the motors. Therefore, *of course*, the engineers started looking at and replacing the parts in contact with the motors. This was not questioned as the authority of Charles' intuition was what Geertz would call common sense (Geertz 2009).

The first attempts at this were basic; such as the tightening of some screws which might have gotten loose, and thereby cause the interference. Then proceeded to change the entire motor. No difference. As time passed, they ended up changing most of the parts somehow connected to the motor and got nowhere closer to a solution. Tension was starting to build. Not only was there a problem with a customer's merchandise they were unable to solve, thus providing a bad service. The graver issue, the CEO explained, was as long as they had no idea of the cause of the defects, these could potentially occur in all units already built. To make matters worse they would be unable to secure the next generation from this error as they did not know the cause of it. As I explained earlier, this went on for weeks.

Returning to Dreyfus and Dreyfus, we here see that solving this problem is not purely intellectual. The emotions of frustration is a response to this problem. The next example is from the third or fourth time, they had shipped the unit back to the shop to see if they could perhaps solve the malfunctioning this time.

> Charles looks through some manuals. The CEO enters the room. Tired eyes and drowsy voice: "Have we tried changing all the electronics?" "No! That's it!" Charles almost spits in defiance. A few moments go by without anyone making the least sound. All are either looking at their computers or just staring into the air. "Are the spikes the same size?" Percy asks quietly. Without changing his face, Charles dismisses whatever theory Percy was pursuing. "So… If we stress the motors, can we reproduce the error?" The CEO asks. "*Problem is*" Charles begins, "*that we don't even know what we are looking for. It seems that our best guess is a noise, and then it just dies*". The CEO looks at the unit. "*So, what's left inside that we haven't tried to change yet? Just brainstorming here.*" The silence is deafening.
>
> The CEO looks focused: "so if we put it on the rig, do we get the error?" "*The error seems to be a noise*." Charles replies. "*But easier to work with in here, than outside*?" the CEO almost whispers, as if something might break if he talked loudly.
>
> They rig up the unit and start stressing the motors. Nothing happens. It feels like a funeral in the shop. In sheer frustration, the CEO suggests that they jam a stick in the motor – just to see what happens. They start up the motor, as he presses the stick into it, putting a lot more pressure on the system than the rig can. Then, in the sea

> of burnt rubber smell, and the sound of a stick jumping on a wheel: The sound. The particular sound that indicates the problem. The one symptom they had to diagnose from appears. People look up. A cautious optimism seems to spread in the form of smiles around the office. For the first time, they are successfully able to reproduce the error. It turns out that if the motor is stressed sufficiently, it makes the sound, and if stressed a bit more, it turns off. This is the first breakthrough concerning the solution of the problem since it first appeared.
>
> This supports a theory the CEO presented on the very first day of this elusive error. A theory that Charles, the expert on the field, thought so implausible, that there has been no further conversation about it.
>
> To further test the theory, they must jump some cables, and Charles gets to work while the CEO leaves the room for a while, "*If this works, I must hear of it the next six months*!" Charles exhales. Almost as if he hopes that, it will not.

What becomes evident here is first that the intuition, though usually right, gets in the way. The CEO had presented this theory the first time we came across the problem. But not until this day was it tested. Another aspect that becomes apparent here is that though intuition and expertise are respected, they are both overruled by testing; or rather, by the result from the test, the local epistemic knowledge. This overruling is interesting when we just saw that intuition and especially that of an acknowledged expert has so much weight. The results produced are seen as truth, Episteme, and therefore something that cannot be discussed, and in Aristotle's words: "Cannot be otherwise" (Aristotle 2000, 104). Charles could have contested this, arguing that the observations were irrelevant or something of the like. The fact that he did not even argue, though annoyed to be proven wrong, witnesses the hierarchy of knowledge; nothing is above Episteme.

This project was not done yet, and as time went by it became so intense that even I, a non-engineer, became part of some of it:

> They test a bit further but get no new results that help them understand the problem. The only achievement is that we can now reproduce the error, not explain it. The CEO suggests switching some of the boards and Charles replies that he had been supposed to leave some 15 minutes ago, but agrees on doing it. While talking their way through this test, they agree that when nothing makes sense anymore, one must

try out something that makes no sense. That is what we are doing right now. As Charles prepares for the next test, the CEO asks what he thinks is going to happen. "*The Impossible*", Charles replies while getting the last wire into place. They switch on the motors and get no new results. Charles needs to go now, but the rest of us stay.

"*So... Why did we not get this problem earlier? And why only on this unit?*" The CEO asks. Rick suggests that the motor might be faulty. Percy explains that they have changed everything so many times, that it simply cannot be. I, from my stool, suggest it might be the software. Rick explains that this is utterly impossible but still spends some 20 minutes making sure.

They agree to draw the "chain" meaning all mechanical or electronic parts connected to the misbehaving motor. Then single them out, one by one, until they find the error. We are all tired, but as this is the first progress in weeks, going home does not seem to be an option. They replace the cables between the motors to see if the error follows. The CEO exclaims that this might be fun and jokes about starting a betting pool on what will happen next. Percy says he hopes that the problem stays with the motor because that brings us closer to a solution. Test. Five times. Same result. The problem did move so we are back to square one. They proceed to move some other cables. No difference.

They discuss implication of results, as the CEO asks: "*What are we even testing at this point*?" He also comments that he is glad someone is happy. I, admittedly, had the time of my life partaking in an evening with three engineers, usually experts in the activity they perform, having little clue as to what they were doing.

As evening comes, we are still going strong. It has now been more than an hour since the CEO proclaimed that this was the final test for today. People do not seem willing to stop at this point. For no apparent reason, they agree on trying on another wire from the control unit to the motor. They claim that this will make no difference; they just want to make sure. There **is** a difference. The error still occurs but to a reduced degree. Rick shows on the computer that there is a difference between the tests involving different wires.

"*Could that explain it*?" The CEO asks. "*Too long wires*?" Percy is skeptical. "*But we changed into these wires a few months back"*, The CEO explains while looking at the wire no longer connected. This is easily tested. Percy attempts to remove the insulation from the wire so that the inner wires can be taken apart. I lose patience with bad handcraft and do it for him. Test. No symptoms. Put them back together.

> Test. Symptoms reproduced. The CEO is jumping up and down. Rick smiles looking at the graphs on the computer, while Percy mostly looks tired. Still, a smile gets out. “We” found a solution.

The next morning, Charles was back in. As he was the one responsible for hardware, he was doing continuous reproductions of the final test we had done the day before. He was annoyed as it became more and more clear that this, the slightly too long cable, had been the problem all along. He continually explained that it just could not be. Trying to find a way for the results, still seen as Episteme, to be true, while not pointing towards the cable. Eventually, acknowledging the hierarchy of knowledge, he budged and started looking for a way to fix the problem.

Intuition, Improvisation, Knowledge: The Method of Technological Development

During one of the next days, Charles was still tinkering to make a proper long-term solution: “*This is fifty-fifty method and guesswork*,” he joked while moving some cables around. I dare say he was wrong. It was all method. What he called guessing was rather improvised tinkering and applying his expertise and intuition, trying to learn which of many possible solutions might be the best one.

In this chapter, I have demonstrated that Episteme is the broad understanding of the many different sciences that technological development builds on, as well as knowledge of the specific parts used. I also expanded the idea of Episteme, with local Episteme, test results, that cannot be questioned. Techne, within the context, is both different craft skills, which must be present but not necessarily mastered, while tinkering, the art of utilizing what is at hand, is constantly used. While the two might exist somewhat separately, they must be combined.

I then took on a study of how these intellectual faculties are combined and acted out. The method here seems to be intuition. I did this through the five stages of learning, presented by Hubert and Stuart Dreyfus. This intuition and expertise allow the team to make faster and better solutions, but expertise only comes with experience and time, and by no means easy. Intuition can also get in the way and result in lost time. However, the hierarchy of knowledge, placing locally produced epistemic knowledge on top, remains and so intuition must yield for test results.

This is only half of the Phronesis. The unification of Episteme and Techne can only be true Phronesis when it is carried out in order to promote and aid the true values of society. These values will be the topic of the next chapter.

Chapter 5: Ethos and Characteristics of Technological Development

Returning to Aristotle, Phronesis requires Episteme (knowledge), Techne (skill), and Ethos use of these for the betterment of society (Aristotle 2000, 151). In the previous chapter, I have demonstrated that the locally relevant Episteme is a broad understanding of different forms of science, as well as understanding of the specific parts the company uses. I also demonstrated that tests results are locally produced Episteme. Techne is both a mix of craft skills, applied but not mastered, as well as tinkering; the ability to combine what is available and make do. These are combined, and that this is done on a basis of experience, intuition, and expertise.

In this chapter I shall discuss another and more fuzzy aspect of Aristoteles use of Phronesis, that is "*concerned with that is good and bad for a human being",* also understood as the virtues of Ethos (Aristotle 2000, 107). The same is true for Flyvbjerg's use where Phronesis becomes the strive to become a better political animal, and aiding society (Flyvbjerg 2009, 14). Aristotle goes as far as to argue that *"… One cannot be practically wise [possess Phronesis] without being good*" (Aristotle 2000, 117). This "goodness", must be so habituated that it becomes personal character (Aristotle 2000, 60).

The engineering practices I observed had little to do with the betterment of humanity. As far as what has gotten into my notes anyway, little time was spent discussing ethics. This is not bizarre, as they were not philosophers at a conference, or young social scientists learning about method; my informants were engineers. Their function, at least in their job, is to do engineering and create the technology that forms the world (Wood 2012), not necessarily take ethical stands in society. My solution to this conundrum has been looking at "the betterment for mankind" as normativity – what is seen as the good, better, or right way to act in a certain social setting (Broncano and Vega 2015).

David Wood, professor emeritus of civil engineering at the University of Bristol, explains that the goal for any *civil engineering* is the creation of technology that has an application for, at least some, of the population (Wood 2012). True as this may be, the creation of technology was neither a normative *good* or a value in the company.

Still, there seemed to be right ways to do things. Even though no one could explain how or why. These "right" ways to conduct oneself is, I will argue, based on values. And actions are a representation of these values.

I argue that, like so many other aspects of social life, what is Phronesis depends on context. "*What is healthy or good is different for man and fish*" Aristotle argues, and continues: "*It is obvious that wisdom [Phronesis] and political science could not be the same […] [as] Each kind of good has a different science…"* (Aristotle 2000, 109). Hubert Dreyfus supports this, in an interview with Bent Flybjerg: "*to be good in ethics, is to do what counts as good in your culture*" (Flyvbjerg 1991, 103). Therefore, in this thesis, I will work with Ethos as what is seen as good or bad in the context. But how to find what is seen as locally good? My solution has been to look for different forms of recognition.

Values and Characteristics

Annemarie Mol, Ingunn Moser, and Jeanette Pols worked with ethics as what is understood as "good and bad" as well. The context was different; they worked with care. Yet, they made some general observations on normativity. The first point I wish to introduce is that "… *different kinds of 'goods', reflecting not only different values but also involving different ways of ordering reality*" (Mol, Moser, and Pols 2010, 13). This was also true for my fieldwork. For example, discussions on priorities in chapter four had a lot of value and reality ordering as well; is it good to do the customers perspective, or should one focus on the business case? And how to make this choice?

The next point from Mol Et al. is that while there will always be many different values in any situation, what becomes practice is a negotiation of these. Not a Juürgen Habermas idea of deliberative negotiation where there is time to take all inputs into account and have a discussion until all agree (Bohman and Rehg 1997, x–xii), but rather a negotiation through practice. People are tinkering solutions, and try to make compromises (Mol, Moser, and Pols 2010, 12–14).

Mol et al found an "Ethos" of care: "*try again, try something a bit different, be attentive*" and that good care is based on "*persistent tinkering in a world full of complex ambivalence and shifting tensions*" (Mol, Moser, and Pols 2010, 14). I have defined some 'goods', or virtues, for development. I also argue that normativity must contain both the good and the bad, and thus have contrasted the virtues with "bad's" or vices. Like Mol et al, I have found constantly changing values, different from situation to situation, and ambivalence. There seems to be nothing that is always right or wrong. Consequently, for each vice and virtue, there is a discussion.

Aristotle explains that certain characteristics are bound to different forms of good and bad; such that a man who is generous will do things that people understand as generous, and not things people understand as being not generous (Aristotle 2000, 55,60,61,67). Fernanso Broncano and Jesus Vega made a similar point stating that within any domain, there will be characteristics and actions that are praised as good or blamed as bad. They define a such domain as constituted by a, somewhat, shared understanding of these good and bad actions and characteristics (Broncano and Vega 2015). In this chapter, I consequently understand desired and renounced actions as enactments of values, and character as habituated actions. In order not to use too many words, which, in the context of this paper, means essentially the same, I have chosen to name them all vices or virtues. In my method for finding these, I use Axel Honneth's idea of recognition. As explained in my methods section, I only use the notion of recognition as to define what is understood as good or bad in the local context.

Introductory Values

On my first day of fieldwork, I was not the only new face. The interns Arthur and Felix, and some other people started the same day I did. Amongst presentations of products, and introductions to the grounds and people, there was also a 5 minutes introduction to the "values of the company", done by the CEO. These were, he explained, "*not official, but very important!"*

The first value he introduced to us was that of asking questions. He made clear that development was not a one-man operation, and that no one knew everything. Therefore, it was crucial that when something was not solvable, one should ask. Maybe someone else already knew the answer, or otherwise, answers were better found with more minds, he explained.

The next value introduced was that of honesty when making mistakes. Mistakes happen, he said with a cup of coffee in his hand, and when we share what we do wrong, other people might be able to learn from them, and this can prevent someone else from repeating the mistake.

It was also explained that humor or at least a lightheartedness was important. Several times the mantra was repeated, "*Never too much work for having fun, never too much fun to get work done*"

The last value, that I have chosen to show, is that of "quick fixes", the faster and usually worse solution to a problem. In the CEO's explanation of values, quick fixes were the death of development, and ought to be avoided at almost any cost.

These were the somewhat official values. At least, it was the CEOs narrative of values. However, as we saw with Mol et al, values are more than articulated principals. Values are contextual and negotiated through practices. It becomes something people do, rather than think or feel.

Virtues in Technological Development

Here I demonstrate the virtues seen as good and desirable. This is not the same as people following them blindly, or consistently, but rather ideals to seek.

Pragmatic Improvisation

The first virtue I would like to point out is that of pragmatic improvisation; i.e. making something that meets up with the desired parameters while taking a minimum of time and recourses. One could say that this virtue is the celebration of tinkering. Such as Arthur's building of the prototype seen in chapter 4 that ended up with Kent recognizing this method in saying that any prototype worth its own weight has to be improvised.

A strong example of the application and celebration of pragmatic improvisation emerged as I helped with a minor project. In the equipment produced, there are many wires. These are not pretty, and get cut in different ways when operating the equipment. Someone suggested running the wires through the frame as a joke. All laughed for a bit and then decided to try it. Though, not my project, I was invited to partake as best I could. If this was to be an applicable solution, we had to come up with a way to do it with every future unit, replicable and cheap. With that goal, we began on an early Wednesday morning:

> After a bit of conversation and deliberation, Charles comes up with an idea: After drilling the holes, we run a thin nylon thread through the frame, then use it to steer a rubber tube into the frame (to protect the wire), and then bring the wire through the tube. Seems simple enough.
>
> The first obstruction was to get the thread through the frame, as the inside of the frame is it neither straight nor smooth. The thread flossed when we tried to push it through. We then tried putting a vacuum cleaner on one of the holes, sucking the thread through, but that somehow created turbulence inside the frame and the

> thread did some impressive knots. As we went through the different suggestions and attempts, we laughed more and more while trying to conceive of a new way to do this. As time went by, Charles came up with a solution, mostly relying on gravity – now we had a method to get the thread through the frame.
>
> Next step was to get the tube into the frame. We feared this, as we assumed that it would cause more trouble than a mere piece of thread. We were wrong. The vacuum cleaner that had failed earlier worked; as the tube was smooth on the inside, one could vacuum the thread through the tube in seconds. Then a bit of skillful tinkering and the tube was in place inside the frame.
>
> We were only three people on this task, and I at this point did little more than take notes. Yet, the entire office was somehow involved. If nothing else because it was amusing to follow. From their desks, people were acknowledging our solutions as something from MacGyver.

The method used here was improvised, and based mostly on tinkering. We had no idea or plan beforehand on how we should get the wire inside, and whenever one of us came up with a new idea, it was hit or miss. Other than the methods that ended up working, we also learned a lot about how not to get this job done. The broad acknowledgement of this procedure, as well as the praise we received later on a "job well done", indicate that this informed guesswork and tinkering of ours was the appropriate way to invent new methods for production. This situation, also provides a hint of the next virtue, humor.

Humor

Humor is an important virtue, and desired character. I have not too few noted situations, where people are joking – looking for castles for sale as a new headquarters, and discussing the increased productivity in making the office chairs useable as toilets. Humor is not just for vocation and break time. But important in work as well. Let us go back to the thread-through-frame project:

> The last stage of this was to invent a way to get the wire through the tube. I thought that it would be too risky to take the thread out of the tube. Somehow I convinced them which became one of our problems. When the thread was in there, there was

> too much friction and not enough room. I then came up with the idea of using some sort of lubrication – in this case, we agreed on soap.
>
> While the handling of a slippery wire in itself might provide some comedy, it fainted next to three guys trying to lube a piece of plastic to drive it through a tight opening. We had to take several breaks due to laughing. More than simply trying to get the wire in, we were also joking about the knowledge of lubrication that we all somehow seemed to share. The rest of the office, not working on our mini project, did little work during this time, as people were occupied enjoying the entertainment we unintendedly provided.

What this example shows is that a lot of the motivation to do the somewhat strange, hard, and time-consuming comes from humor. Even after we had finished, this episode was discussed a lot, and the three of us were recognized for not only getting the job done but for our approach. In later discussions of how to do something in a *good* way, this was brought up with reference to *that* morning. Going back to the Introductory values, we here followed the one on humor. Maybe we did not entirely stay by the credo, as we had to take breaks to laugh off, but we certainly met this task, as annoying, hard, and slow as it was, with both smiles and laughs. The ability to smile and joke seemed to help us stay on point in a situation that was in many ways challenging and provided more setbacks than progress. This tie closely into the next virtue, tenacity.

Tenacity

The third virtue has been somewhat troubling to name, and find, as it appears to be mostly unsaid, even though it is central. It is, as Geertz would say, a common sense (Geertz 2009, 771–72). In the introductory values, the CEO explained that "quick fixes" are bad, but did not offer an alternative. I have chosen to call it tenacity, though this is probably not the optimal word. Tenacity, in this context, refers to the ability and will to take on the hard problems, and keep on them, until they are solved, instead of some easy solution that is a lot worse, but just works – the quick fix.

Tenacity seems to contrast the pragmatic improvising, which is to be done as fast and cheap as possible. Tenacity is rather an expansion: When "just" testing if something might work, the quick fix is the go-to. However, for something to be good enough to be implemented in finished products, a lot of work has to go into it.

Furthermore, the pragmatic and fast solution is oftentimes a mean to solve a larger problem, as we saw with Arthur earlier; the prototype was supposed to aid learning if the parts were suitable.

Tenacity is hard to come by. One of the reasons, explained by the CEO one of the world's largest R&D's, Astro Teller, is that it is incredibly uncomfortable to spend a lot of time on a problem that may have no solution at all. In Tellers experience, people tend to diverge from hard problems and solve easier tasks instead (Teller 2016). I too found many procrastinations, minor tasks taken on instead of getting to the hard problems (Merriam-Webster 2018). Another resistance to tenacity is the speed at which technological development, a part of a capitalist system, is hoped to progress with. Tenacity is both a central but also oftentimes contested virtue. People mostly refer to it as a reason for doing something in a certain way, with reference to doing it *right.*

As Mol et al, explains, questions of good and bad are usually about different principles, which has to be negotiated and oftentimes compromised (Mol, Moser, and Pols 2010, 13). Where Mol et al. found little talking negotiation, I had access to development meetings where principals were the subject of conversation. The next example is from a meeting on a technical error.

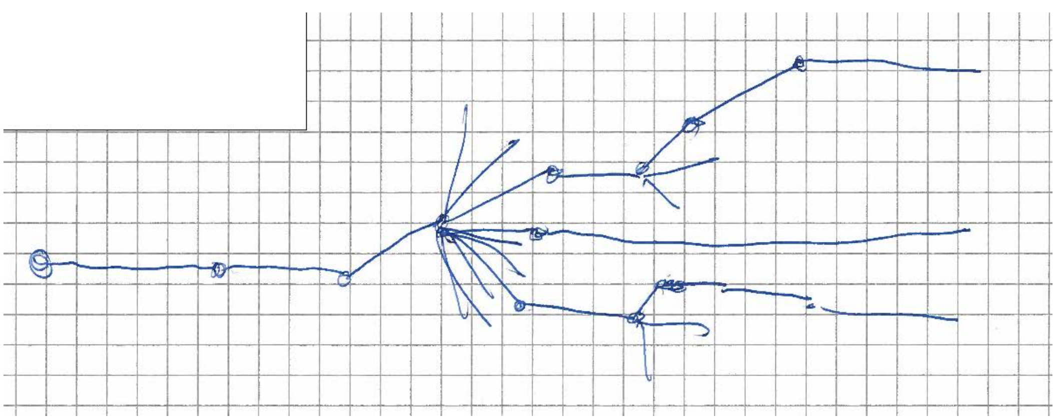
> The problem was somewhat small, yet very visible for the customers. One of the engineers, Rick, wanted to go through the program to calibrate and fine-tune the various lines of code connected to the error. This might take weeks or months. The sales clerk argued that they could simply make an extra sequence, working on some other parameters that already worked, as he wanted the product to work ASAP.
>
> Rick argued it would create new problems with more code to an already complex network of codes upon codes. The more codes, the more the computer's processor has to work, and the more can go wrong. The other reason Rick disliked the idea of a quick fix was that in his perspective, this minor error was a symptom of the original code not being calibrated sufficiently. With *better* calibration and coding, this, and many other problems would disappear, according to Rick. But more importantly, the code would be *better*.
>
> The sales clerk did not like the expanded timeline for the solution, yet he eventually folded, partly due to pressure from the CEO, and partly because Rick convinced him that an extra sequence would only solve one problem. It was perhaps a solution, but not a *good* one. After this meeting, the CEO explained to me that while one

> oftentimes feel like just treating symptoms, it is *always better* to prioritize robustness of products.

This was a negotiation of principals. The sales clerk wants the product to work fast, but eventually recognizes the importance of better products and, therefore, the demand for tenacity. Rick wants to make a code that is as good and close to perfect as possible, with little interest in when the product will be ready to show off. The CEO has a “leg in both camps”, but ends up agreeing with Rick.

I assume this, to the CEO, is also an economic consideration, due to his reference on robustness. He oftentimes explained that, robust products are better to sell, as they require little maintenance done by the company while making the customers happier. However, what seems to be the strongest argument here, even for the sales clerk, is that extra time spent tackling the larger underlying problem provides a *better* solution than a quick one only solving one problem while potentially adding new ones.

A different example of tenacity was a “minor” project Kent had. At least they thought it would be minor. Kent was supposed to reconfigure some manufactured parts used in the equipment to make them more customizable. This was thought to take a few hours but ended up taking several weeks. During the time he was immersed in the work, he oftentimes expressed how annoying it was, as the solution seemed to be simple, but just kept on slipping him. Below is his own representation of how, he many times had an almost right solution, but then had to discharge that one, and try all over again.



At last, he succeeded to make a cheap and reproducible solution. This was celebrated not only by him but by his colleagues as well. Even after he left, the discussion of this feat went on through lunch where Percy explained that this feeling of doing something that has been an impossible problem for so long, was the best thing that could happen to an engineer. They explained, like Teller from earlier, that even though harder problems are a lot of work just to stick by, the reward when solved is much greater. They all agreed how important it was to help colleagues to focus on problems. They did not use the term "recognition", but they might as well, as they talked about shoulder patting and encouragement.

Nonchalance

The last virtue I wish to present is nonchalance in working with as well big problems, as in making mistakes. This is closely tied to humor, as smiling seemed to be a sign that whatever was happening was not getting under the skin, and tenacity, as the confident attitude that something will work out eventually seems to enable persistence, even when facing setbacks. This relaxed attitude towards mistakes and problems was so striking that I only noted the first few days of fieldwork, after that it became common sense to me as well.

> While getting coffee, I heard a loud noise, a small outburst and then complete silence. I ran into the workshop to find Charles trying to pull come wires out of a motor. He had been running tests and the wires got stuck in a moving part, and had torn the computer parts, and damaged quite a bit of the unit he was working with. A mistake like this is not only potentially expensive; it can also be dangerous, as the equipment can easily snap a finger.
>
> This was not stressed, as Charles just began removing the wires trying to estimate how much damage had been caused. All the while, Rick was standing next to him, and they were chatting about this and that. I asked if the potential damage of expensive equipment was a problem, and was told that these things happen, and luckily, it only tore up the inside of the equipment, and nothing else in the office. The subject rapidly changed into sometime in the past where a former colleague had mashed up a wire, so they had to postpone a demonstration. After this, a discussion about the best brand of screwdrivers was initiated, as if nothing had just happened. I went back and got my coffee.

The relaxed attitude towards potentially expensive and dangerous slips resonates with the introductory value of being open about mistakes. No one was going after Charles' throat. This is another day at the office. Nonchalance is an important factor in many different contexts. As Catherine Hasse noted, nonchalance towards big problems is imminent to be accepted as a physicist (Hasse 2008, 2000, 240–42). The CEO explained how to get people to be more innovative, appreciating this virtue:

> *"… The optimal is that they have a zest and desire and that they think it is fun that [you] give them a feeling that they are a part of doing something that is different from what they usually do. Well, it is also important to have a very relaxed atmosphere, meaning, there cannot be too much pressure on people. They have to be allowed to make mistakes, be allowed to try something stupid from time to time. Without punishment. Best-case scenario, you can make some fun of it, so there must be a possibility for mistakes. If you do not have the possibility of failure, you cannot come to the good solutions."*

It is interesting that he almost cites Dreyfus and Dreyfus who argue that in order to succeed, a student must be given responsibility enough to make mistakes, and take responsibility without authorities punishing too hard (Dreyfus and Dreyfus 2005, 788–89). These virtues are, as I said, context-specific, and have to be learned, and therefore taught. This is not done explicitly, but more by exemplifying "good" behavior while explicitly not recognizing the "bad" (van den Brink and Owen 2007b). This one virtue was explained, but only once in our introduction meeting.

Learning virtues

Learning these seems to be a product of experience both with development, but also with developers, exemplified in my own reaction to the situation with the wires that got stuck in the motor. I, a social novice, feared the potential danger of ruined hardware and dangerous situations, while the experienced engineers merely recognized it as problematic.

As we saw with the discussion of expertise, some of the rules are only visible when people are sufficiently experienced, and only then will there be a relaxed attitude towards the burden of responsibility (Dreyfus and Dreyfus 2005, 789). Like before, the little less experienced Felix will be the example of learning, only this time values. The situation I am about to show revolved around a part of the equipment that appeared to be faulty – and an expensive part at that. I have chosen to call it "Qinz".

> There is an error on the Qinz, just as Felix was about to do a test. "*Well*", he says, "*I just have to give up then?*" Charles is quick to answer while looking puzzled by the suggestion: "*No! We just burn another Qinz*!" Though he smiles while saying this, it is not a joke – he changes the Qinz and turns on the equipment again. Same error.
>
> Some time goes by; they attempt to look at schematics to find an explanation. Well, Charles is looking for the most part while Felix seems discouraged. Though focused, Charles seems to have a good time, he smiles and continually jokes about how expensive this error is if it is built in all their sold units. I dared to ask Felix if he felt this funny, he barely opened his mouth when muttering "*no*".

What is seen here is different attitudes towards problems. Where Felix from the beginning wish to give up, and the entire time during this session expressed discontent, Charles, the more experienced engineer seems to be in his element. Following my analysis of virtues above, Charles being both pragmatically improvising as they go along, he shows humor while problem-solving, he has the tenacity to keep on the problem even though it is hard, and all the way through has a nonchalant attitude. While he is doing this, he also sets an example; and the other engineers in the room compliments and recognize the work afterward.

Felix, on the other hand, is by no means in his element, he only follows Charles, and does little to help. He expressed several times throughout this that he thought they should just quit. This could be interpreted as an educational situation, or what Hasse would call cultural learning, as Charles is attempting to change Felix' perception and ground for reflection (Hasse 2011, 150,153,170,17).

This might be seen as part of Felix' internship as well. As explained earlier, Dreyfus and Dreyfus argue that the more proficient a learner becomes, the more relaxed the relationship will be with responsibility (Dreyfus and Dreyfus 2005, 789–90). While Dreyfus and Dreyfus spend little time explaining what this relaxed relationship looks like, I would argue that Charles' almost lack of response to the potential of wrecking expensive equipment might be a clue. This characteristic attitude is, as explained above, shared between the more experienced engineers. Both with the Qinz, but also with the wires in the motor, and the example from chapter four, where some guessing, tinkering, and jamming a stick into expensive equipment were seen as the proper way to go about a large problem.

Here, Felix does not buy into any of these attitudes. Maybe this is due to lack of experience. Maybe he is not there yet, on the Dreyfus and Dreyfus model, or maybe this is, simply, because he does not have these personal characteristics. Whatever the reason, the fact that he did not share the virtues, gave both him problems understanding the context, as it gave his colleagues problems understanding him, evident in Charles' puzzled expression as Felix suggests quitting when learning about the error.

It is still noteworthy, that the virtues are ideals, not always followed. As shown in chapter four, even the experienced engineers were stressed and edgy after two months of not being able to solve a problem.

Vices in Technological Development

There can be no normativity with only good. Consequently, I explore the vices of engineering as well. While finding the virtues meant looking for patterns that occurred often, and that was positively recognized, finding vices meant looking at what happened little, and was not recognized, or even directly commented on as bad or wrong. This means that I have less empirical material, as they were not as often displayed.

Overly Control

The first vice is overly control. The CEO explained in an interview that too control and documentation is the optimal way to prevent or kill innovation. It seems that to some degree, saying "*no*" to any idea is bad. Some freedom to fail is necessary in the name of progress. More than just the CEO's attitude, this was also true for the developers.

Maybe even more so as Percy explains: "*Well function X that I built? He [the CEO] said that this could not be implemented. In addition, that it would be a waste of time and so on. So I did it anyway. And it turns out to be a very used function*".

Furthermore, there were almost formalized systems of getting away, even if one suspected a "no" from the CEO. If one had an idea they wished to "get through", but seemed to think the CEO would disagree with, the way to go about it was to make sure someone outside the company, oftentimes a test person or customer, heard about it and then suggested it to the CEO. In that way, the engineers could bypass the CEO's ability to say no, and instill the notion that "*good ideas come from the top. He [the CEO] likes it that way*", an engineer explained.

Too much control and "no" seen as a vice harmonize with pragmatic improvisation seen as a virtue; one cannot make the improvised and surprising solutions if there are too many restrictions and demands for documentation of the process. When explaining a silly experiment, Kent said that he could test his new function in many ways, and this one would allow people a laugh as well. Even though it took a lot more time and recourses, this was not reprimanded in any way. It held true, people did have a laugh, acknowledging the extra effort, as well as his progress.

People had quite free hands to do what they saw fit for the company. While this freedom meant that a lot of projects and minor tests that are done “for fun”, ended up being implemented because it turned out to be a good solution, the freedom also seems to be a struggle for Felix. As Sartre explained, with freedom comes responsibility (Sartre 1984, 50), and as we saw above with Dreyfus and Dreyfus before one gets a certain level of experience, responsibility is problematic. In other words, Felix’ freedom to decide how to go about a problem, as a consequence of the company trying not to make strict rules, was the opposite of what Felix asked for when inquiring for critical test values and procedures.

Conventional Thinking

The next vice I found during my fieldwork was conventional thinking. The CEO explained that as long as people try to do what they usually do, nothing new comes around. He also explained that the entire way they had built their equipment was almost in defiance of conventional thinking, beforehand established theoretical work, and acknowledged research:

> *“… [Development engineers] would never make a product like ours. A lot of it is ‘not good enough’. I mean, we have a [COMPONENT] that is not nearly robust enough for what we [use it for]. Our internal communication is not suitable for this kind of thing, in theory. Our motors are made for [SOMETHING COMPLETELY DIFFERENT], and not nearly precise enough for our use. Our batteries are dangerous, and so on. These are some of the advice I have got through the process. From smart people whom I respect. In addition, I chose to listen to none of them. Thank God!*
>
> *It seems paradoxical. The researcher, who got the initial idea, said that the way we were building it was impossible. Everything was a stupid idea. But it works. It does. We might have been a bit lucky, it could have gone bad. But because these things work, we have saved a lot of money […] The competitor have had some custom made*

> *parts that might be better in theory, but they are almost five times more expensive. And ours work […] also, we have almost no production time, compared*."

This vice is, however, constantly negotiated, as doing something new includes a risk – if right now, something is working, changing parts may be a waste of money. Worst case, it can damage equipment, sales, software etc. In an interview, the CEO explained: "*conventional thinking is a major problem. Also, one we start to see in the company. We are already now that old that we have become stiff-necked creatures of habit who does not think new or creative*" *[Danish: stivnakkede vanedyr]*.

As Mol et al. explained, values are not black and white, and ambivalence is always to be found (Mol, Moser, and Pols 2010, 1,15). Tommaso Venturini argues that ambivalence and controversies are so much a constant in life that social research ought to focus on it, and at least cannot ignore it, just because it makes a more linear or coherent argument, as this would then be more distant from the reality the theory is attempting to describe (Venturini 2010, 258–59).

At one point, the company needed a communication software. As this was a company of many skilled engineers, there were several suggestions. Still, they ended up buying TeamViewer, an established third-party program. I was surprised, as this happened a few days after an entire lunch where people praised new solutions.

The reason for this choice was that the program already worked. Consequently, they would have to spend next-to-no time on it, as other people update TeamViewer. Charles explained that with the prices TeamViewer offers, few paid engineering hours would have to go into an alternative for it to become more expensive, while it was almost impossible to think of a more stable solution.

So how is conventional thinking then a vice? How is it sometimes *good* to buy the off-shelf system, and other times *good* to go completely haywire on the advice of experts? It becomes a question of values and economics. If going with the stream gives a *better* product with less work, it is the right and a good way to go. If it seems that going against the mainstream, even though it takes work and is less secure, will give a potentially better product, and thereby pay off, then it is at least worth trying. The willingness to work on something that is 'better than easy' also refers back to the virtue of tenacity, and leads us to the last vice; sloth

Sloth

Certain kinds of sloth are negative, though not necessarily in the conventional way of thinking the word. People going for an easy solution that works is not always a problem – there is no need to reinvent if something old works well enough. Some of the critical parts of the equipment were chosen due to their quality of being easy and cheap to buy, rather than the ones that are more expensive though more advanced. Also, the company did end up buying TeamViewer.

Sloth can take many forms. The three demonstrated here are accepting easy solutions instead of good ones, unwillingness to do what it takes to finish a job, and intellectual sloth asking for a solution one is supposed to find himself.

Looking for an easy solution, instead of a good one was almost forbidden for the new employees in our introductory values, with reference to “quick fixes” as the death of development. This is more than talk; quick fixes are not only frowned upon but also directly contested, as we saw with Rick and the Sales clerk earlier.

Unwillingness to “go the distance” is a vice as tenacity was a virtue. The people staying the evening with the stick in the wheel was good. But even speaking about giving up because something seemed problematic was, as we saw with Felix and Charles trying to fix the Qinz, strongly frowned upon, and truly not accepted as “good”.

Lastly, Intellectual sloth. As it is good to be able to make a right judgment based on intuition, asking for exact parameters is a bad way to go. Felix, the engineering intern, had the task of defining whether some new parts were good enough. He spends the first month asking *when* something was good enough, and it seemed he always got the answer that it is good enough when it is good enough. Instead of seen as a token that Felix did not feel comfortable to make the decision yet, it seemed to be understood as sloth. As if Felix was trying to get the others to do his work for him. There is a fine balance between learning, on the first day, that one can, and indeed *should* always ask for help when needed, and repeatedly asking for the solution one is hired to find.

The Good, the Bad, and the Ambivalent: Ethos in Technological Development

As Mol et al found in the study of care, “good and bad” is about values and negotiated practices (Mol, Moser, and Pols 2010, 11). What becomes societal values are oftentimes ambivalent, contested, and repeatedly negotiated through different forms of practice and compromise. In this chapter, I have analyzed and discussed the normativity and desired, or despaired actions and characteristics in technological development, arguing that these are enactments of values. The chapter started out with returning to Aristotle, and discussing "the betterment for mankind", and I argue that this is tied to local values.

I then explained how, on my first day of fieldwork, I got a non-official list of company values, stating that is was good to ask questions, being honest when making mistakes, and having humor in ones work, and bad to attempt solving problems with quick fixes.

I have then compared this list to what I, through my work, found to be inexplicit values, both vices, and virtues. I found these virtues to be pragmatic improvisation, humor, tenacity, and nonchalance. The vices found are overly control, conventional thinking, and sloth.

This analytical chapter concludes that though these values might be the prevailing ones, they are far from self-evident, uncontested, or stable. Not only must they be learned and thought, but also as Mol et al found, these values are continuously negotiated, and also ambivalent. Therefore, the values become more guiding than ruling.

Chapter 6: Conclusions

I have in this thesis studied technological development, and developers based on a three-month fieldwork. My primary framework for the analysis has been Aristotle's work on Phronesis, Episteme, Techne, and Ethos as well as Hubert and Stuart Dreyfus' model of learning. I have presented and analyzed my empirical findings, and shown how processes of development are dependent on the balanced combination of both knowledge, skill, and experience. Other than these abilities, I have also demonstrated that development is based on learning processes, and little on plans. Lastly, I have studied what values influence the everyday work, and therefore looking for as well vices as virtues in technological development work. Further, I have discussed how these values are learned, and how stable they might be, arguing that they are constantly negotiated.

Summary

<u>Chapter one</u> introduces The Monster, the company, as well as the people. Other than that, it introduces my research question and discusses its relevance.

Chapter two qualifies my position within the different research traditions on which my thesis is built: Innovation studies, STS, the philosophy of Aristotle, pragmatic anthropology, recognition, and the phenomenological learning theory of Dreyfus and Dreyfus.

Chapter three describes my way to the field, fieldwork methods, as well as drawbacks of these. Lastly, I go on to discuss analytical methods and strategies.

Chapter four has three purposes. It opens up the discussion of the ancient Greek philosopher, Aristotle, in the context of present-day technological development. I set out with a short discussion of plans as predefined actions, versus actual action, and show how, at least in the context of my fieldwork, plans on the everyday level are almost non-existent. However, goals for actions remain.

I then unravel what relevant Episteme and Techne exist within the context. Episteme is understanding of natural sciences, computing, programming as well as deep understanding of the parts used in the equipment, is constantly applied. Techne covers basic craft skills and tinkering, the ability to make do with what is available, an approach which is regarded higher, and used more than craft skills.

Neither Episteme nor Techne is sufficient on their own. They have to be combined in the pursuit of a goal. Being able to apply the combination in a proper way requires intuition. Intuition, ironically, does not come intuitively. I draw from Dreyfus and Dreyfus' model of learning to argue that intuition requires massive experience to build. I then demonstrate how the intuition of an expert is not only locally recognized; it also works for the benefit of the company, creating good solutions with little time. I then expand the discussion of expertise by demonstrating that experts in one field do not necessarily act like experts in other fields.

I then briefly return to the discussion of Episteme by demonstrating that what is learned through the proper procedures, mostly relying on the scientific method and testing, is locally recognized Episteme. I show how this both informs and challenges the ideas and theories the developers have about the functionality and courses of errors in the equipment they design.

Lastly, I explore what happens when expertise and epistemic knowledge conflict. As test results are local Episteme, the arguments of an expert can and does not override test results. Even after the expert argues that results make no sense, he yields for the data, and work from it, instead of against it.

Chapter five takes on the social and normative values and rules of the development context. I discuss how to locate such values, and find, inspired by Axel Honneth's work on recognition, that actions that are either recognized as good or bad, reveal values. I outline the official company values, presented on my first day, to discuss these with the vices and virtues I have been able to find. The virtues are:

Pragmatic improvisation, the act of intuitive appliance of Techne and Episteme, and a willingness to be creative and form make-do solutions, based on what is available. *Humor* is present in seemingly all aspects of development, as both a relief, as well as a motivator to take on hard problems. *Tenacity*; is the ability to keep on a hard problem, even though it would be a lot easier not to. *Nonchalance;* is a relaxed attitude towards problems and mistakes.

Contrasting these virtues are vices. These are *overly control*, in the form of registration, strict planning, or harsh punishment for errors. *Conventional thinking* is always seen as a vice, but when it proves more practical, it is an accepted strategy. *Sloth* took three forms in my analysis: 1) accepting easy solutions instead of good ones, 2) unwillingness to do what is needed to finish a job and 3) intellectual sloth, asking for a solution one is hired to find.

There is no argument that these virtues and vices are general to society. Or even that these are true to all aspects of my informants' lives. Maybe, not even to all aspects of their work lives. I, with reference to Broncano and Vega and Mol et al, argue that all values, and thereby virtues and vices, are contextual, and always negotiated within the context. This ambiguity presents ambivalence in the analysis, in the form of situations where people by no means live up to the virtues. I leaning on Venturini, argue the demonstration of ambivalences made the analysis stronger.

The answer to my Research Question

I will have to answer my research question a bit backward. It was:

Within a local context of technological development, what constitutes the everyday work and learning practice, and how can this be analyzed as virtues of Episteme, Techne, and Ethos?

Within the local context of technological development, Episteme is the broad knowledge of natural sciences, computing, and programming, as well as an understanding of the specific parts used in the equipment. Test results provide an expansion in the form of local epistemic knowledge. Techne is both basic craft skills, and the ability to tinker. Ethos covers the virtues of pragmatic improvisation, humor, tenacity, and nonchalance, contrasted with the vices of overly control, conventional thinking, and sloth.

The everyday work practice is a constant negotiation and balancing of Episteme and Techne. The balancing requires both a goal to strive for, as well as experience and intuition to understand how to balance it in order to reach the goal. More than this, understanding the present situation or problem, based on experience, determines how to move forward. Whenever a new situation occurs, and there are no past events to steer from, one must try different solutions, and learn which was the most suitable for the pursuit of the goal.

Being able to do the job is not enough though, in everyday work life it is also important to abide by the local Ethos, by seeking the virtues, and thus be pragmatic, humoristic, tenacious and express nonchalance. While averting the vices, and thus not be too controlling, think conventional or slothful.

Phronesis

Using Aristotle aided me in analyzing the different aspects of technological development. Yet, the most important term, the one that sparked my interest, is seldom used. I started out explaining that Episteme, Techne, Ethos, and experience are tenants of Phronesis. So what is Phronesis?

Phronesis is both the culmination of, as well as the above, the tenants. Phronesis is the practical manifestation and excellence of applying knowledge, in good character, as the right decision when working towards a societal accepted goal (Aristotle 2000, 110–17).

In the local context of technological development, Phronesis is the appliance of deep understanding of external knowledge, as well as the parts in use. This knowledge has to be put to use, striving for the betterment of the products, by either developing them or defining, and eliminating bugs. The Phronetic process must be carried out by expertise and intuition, both products of experience. The solution ought to be improvised but not a quick fix, and carried out tenaciously with a sense of humor while radiating nonchalance as if this was not that much of a problem, to begin with.

Phronesis thus becomes a combination of all the things seen as positive within the field. No one actually embodied Phronesis. Though some are surely closer than others, in some situations, no one seemed to be able to have the entire palette at once. So maybe I did not find Phronesis at all, or maybe it is supposed to be a better version to strive for, than what already exists.

Implications and discussion

Navigating Without a Map

Processes of development and innovation are often explained as linear, working towards a goal with a plan (Cooper 1990; Amabile et al. 2005; Findlay and Lumsden 1988; Racine 2014). This is a staggering contrast to my findings. After conducting this thesis, it seems that Varenne and Kayomas description of life, as a constant confrontation with new and unique situations, which always begs the questions: What's next (Varenne and Koyama 2011).

> "*If I had a specific idea of the product 12 months ago, it would never be what we have today. It is only because we had this construction and learning process that we got this close to the goal. And we are not really there just yet!"* – The CEO

I have shown how development process emerges from a constantly growing knowledge base, which forms a map for the possible and the impossible. The growth is based on learning from multiple pragmatic and improvised steps. Each prototype, experiment, and test pushes development further, but not always in a useful direction. Only after each step is it possible to validate whether or not it was fruitful or futile, yet even futile steps add to the knowledge if nothing else in showing where not to go. Development is not the art of following a map or plan, but rather to understand the present context, and accumulated knowledge, and use this to estimate the best available course.

Developers apply their background knowledge as well as an understanding of the equipment they build to establish the best way to move forward, given the present knowledge. They then combine skills in taking the best possible step with as few recourses as possible.

There are goals that give direction to these steps, and forms the base from which to validate whether or not it was right. Meanwhile, the accumulated knowledge also helps evaluate the goal, which changed, if it turns out to be an impossible way to go. I found no evidence of a master plan. Rather, even the goals were fuzzy, and based on "good enough when good enough". Certainty was scarce, other than in cases of something being wrong.

Development is a trip in an unchartered landscape, and while there may be a goal, it is only the steps and missteps that illuminate the path.

Linear and chaotic ideas of development

If my analysis is credible, and to any extent true, this begs the question of how so much research, as described in the introduction, can work with development processes as something linear. How can work like that of Coopers (1990) stage-gate model be seen as viable? My answer is perspective. In two different meanings of the word.

One is that of time. As Søren Kirkegaard noted life is to be lived forward and understood backward (Kirkegaard n.d., JJ 167). So while my perspective has been on what happens on a daily basis and ended up focusing on many of the discrepancies, this will be what I find. If one were to employ methods of asking people what happened when they developed something earlier, it seems reasonable that they would give a linear explanation. Just like the two months of debugging, that in Charles' drawing became nine points.

The other is that of perspective from position. My focus has been on the developers, and their everyday life and work. My position was in the middle of their workshop, and processes. The Stage-gate model is not made from a developers perspective, and it is not an analysis of such. It mentions nothing of everyday life. It is an analysis of development from a management position. Designed to, for better and worse, be distant from the everyday activities, to provide a broader picture, deployable for other ends. consequently, we come to so radically different conclusions.

Future Research

I would like to claim to have made an exhausting study of all aspects relevant to technological development. Yet, it would be far from true. Here I outline the two most promising areas, which I did not have the time focus on.

The relationship that the developers have with the equipment could be a subject of study. On several occasions, people talked about the codes they were building in the first person; i.e. Percy would ask Rick if he should be the one to do this, or it made more sense Rick did it, and if he had the extra time. What they were discussing were which of the programs they respectively worked on should do it. It seems to be an extreme version of either embodiment, or maybe a turned around version of mediation; instead of technology as an extension of the body/mind, the body/mind becomes an extension, or integrated part, of technology.

Another interesting aspect was the vast organizational network around a technological startup. The networks of investors both public, private, and combined the tremendous amounts of recourses gathered through different projects, and the different motivations behind all these could indeed be a promising study to undertake.

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Appendices

Appendix 1 – contract with host company

All identifiable names are boxed out

[redacted]

Studentermedhjælper

Navn:
Adresse:
By:
Telefon nr.:
E-mail:
CPR nr.:

Aftalens parter og arbejdssted

Medarbejderens arbejdssted er den samme som [redacted] arbejdsadresse. Medarbejderen er indforstået med at arbejdsstedet kan ændres, hvis virksomheden flytter. Medarbejderen er i vidt omfang indstillet på at arbejde hjemmefra.

Formål:

I forbindelse med sit speciale, skal vil Stephan Hansen(medarbejderen) udføre feltarbejde hos [redacted] Formålet med dette feltarbejde er at indsamle empiri til speciale på Antropology of Education and Globalization ved Aarhus universitet. Derudover kan der efter specialeprocessen publiceres resultater fra feltarbejdet, såfremt disse overholder nedenstående aftale. Dette dokument tjener som en forventningsafstemning, og beskriver de forhold parterne er blevet enige om før feltarbejdet starter.

Feltarbejdet:

- Feltarbejdet vil finde sted fra august til og med oktober 2017, hovedsageligt på [redacted] adresse
- Under feltarbejdet vil MEDARBEJDEREN være til stede hos [redacted] gennemsnitligt 30 timer om ugen og vil for så vidt muligt deltage i det daglige arbejde. Altså 350-400 timer i alt.
- MEDARBEJDEREN vil under feltarbejdet på mange måder fungere som en deltidspraktikant, og har på forhånd indvilliget i følgende opgaver:
    - Test af [redacted]
    - Udfærdigelse af brugermanualer
    - Observation af brugere ifm. test
- MEDARBEJDEREN er indforstået med at han skal bestræbe sig på ikke unødigt at forstyrre processer der foregår i arbejdstiden
- [redacted] er indforstået med at MEDARBEJDEREN ikke fungere som fuldtidsansat, og at han ofte vil være til stede med det formål at observere, og dermed ikke udføre et arbejde for [redacted]

1

[redacted]

- MEDARBEJDEREN er indvilliget i ikke at nævne [redacted] navn i forhold til både publikationer, samt samtaler om disse
- MEDARBEJDEREN vejleder vil, efter underskrivelse af denne forventningsafstemning, have adgang til navne, og vil være underlagt samme krav om ikke at udtale sig om [redacted] eller deres navn og virke.

Publiceringer:
Det e[redacted]s ønske at såvel virksomheden som ansatte og partnere fremstå uidentificerbar i enhver form for publicering der laves på baggrund af MEDARBEJDERENs Feltstudier. Derfor er følgende aftale indgået

- I enhver publicering vil MEDARBEJDEREN afholde sig fra tekniske detaljer om udstyr udviklet hos [redacted] så eventuel kopiering af udstyr ikke vil være mulig på baggrund af MEDARBEJDERENs publikationer
- MEDARBEJDEREN er indvilliget i at lave specialet hemmeligt, såfremt pseudonymisering i tilstrækkelig grad ikke vil være mulig
- I publikationer vil [redacted] blive pseudonymiseret i en sådanne grad at de ikke vil være direkte genkendelige. Dette gøres ved hjælp af:
  - Ændringer af centrale detaljer, dog uden at disse vil være misledende i forhold til analyse
  - Underlægge alle virksomheder, steder og personer pseudonymer
- Før publicering vil [redacted] modtage de uddrag af publikationen der beskriver dem og/eller deres arbejde. [redacted] have mulighed for at kræve at detaljer sløres yderligere før de kan publiceres.
- [redacted] ikke have indflydelse på andre forhold end hvorvidt detaljer om virksomheden er tilstrækkeligt Pseudonymiseret.

Udstyr
Medarbejderen sørger selv for al nødvendigt elektronisk udstyr.

Løn
Medarbejderen modtager ikke løn under praktikopholdet.

Tidsrapportering
Medarbejderen indrapporterer timeforbrug hver dag efter endt arbejdsdag.

Medarbejderhåndbog
Medarbejderen er forpligtet til at holde sig orienteret om indholdet i medarbejderhåndbogen og følge de retningslinjer, der er angivet heri.

[redacted]

Tavshedspligt

Medarbejderen er forpligtet såvel under som efter ansættelsen til at iagttage absolut tavshed med hensyn til de forhold, som den pågældende i arbejdets medfør bliver bekendt med, og hvis hemmeligholdelse ifølge sagens natur er påkrævet eller bliver pålagt af den foresatte.

Hvis medarbejderen fratræder sin stilling, skal alt materiale og lignende tilhørende arbejdsgiveren straks afleveres tilbage og alle udleverede kodeord slettes.

Knowhow, Ophavsret og Opfindelser

Selskabet har ejendomsret til al knowhow og lignende, som Medarbejderen udvikler under og som et led i ansættelsesforholdet, uagtet på hvilket medium dette måtte foreligge. Dette gælder også uden for arbejdstiden såfremt det er dækket af arbejds- og ansvarsområderne.

Ophavsretten til edb-programmer, der er frembragt af Medarbejderen under udførelsen af dennes arbejde eller efter Selskabets anvisninger, overgår til Selskabet. Ophavsretten til et værk, der er frembragt som et led i ansættelsesforholdet, tilkommer Medarbejderen, men ophavsretten anses dog samtidig for fuldt ud overdraget til Selskabet med respekt af Medarbejderens rettigheder i henhold til Lov om ophavsret § 3.

Opfindelser, der er resultat af opgaver, der påhviler Medarbejderen som led i ansættelsen hos Selskabet, skal stilles til rådighed for Selskabet.

Der gives ikke godtgørelse for Medarbejderens indsats ved udvikling af knowhow, ophavsrettigheder, og opfindelser. For så vidt angår de her i landet patenterbare opfindelser, gælder dette dog med de ufravigelige modifikationer i henhold til den til enhver tid gældende Lov om arbejdstageres opfindelser. Medarbejderen har pligt til at underrette Selskabet om enhver opfindelse som frembringes med angivelse af sådanne oplysninger, at Selskabet sættes i stand til at bedømme opfindelsens betydning.

21.6.2017

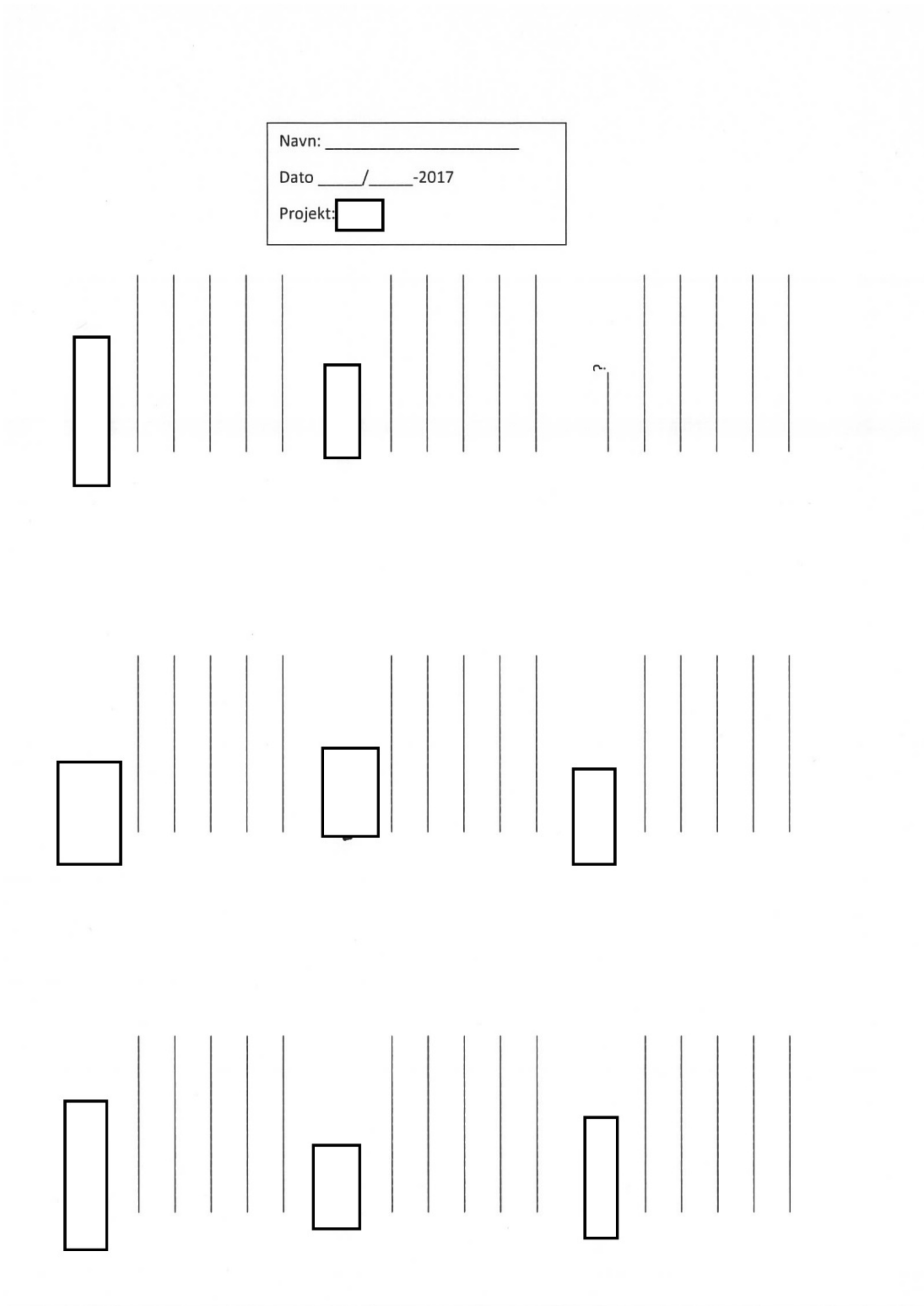
Dato og underskrift[redacted]

21.6.2017

Dato og underskrift: Stephen Hansen

Appendix 2 role-sheet for interviews

Identifiable names are boxed out. Empty line was for whoever left in the company, the interweave felt missing



Navn: ____________________

Dato _____/_____-2017

Projekt:

Appendix 3 interview guide

Minimalistic, and build only to remind me of the questions I had to ask.

[redacted]

Projekt:

Interviewer:

Interviewet:

Dato

Interviewguide 1.3

Gennemgang

Teknika

ansat:

Uddannelse

Alder

Diagram

Definitioner

Kreativitet

problem

Innovation:

Er du innovativ?

Hvornår

Hvad er i vejen for det?

Problem løsning.

Hvilke problemer løser ud i dit arbejde?

Hvordan