# Learning Within a Product Development Working Practice

## An Understanding Anchored in Pragmatism

Bang Mathiasen, John

COPENHAGEN BUSINESS SCHOOL
HANDELSHØJSKOLEN
SOLBJERG PLADS 3
DK-2000 FREDERIKSBERG
DANMARK

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## - an understanding anchored in pragmatism

**John Bang Mathiasen**

The PhD School of Economics and Management

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John Bang Mathiasen

Doctoral School of Economics and Management
Department of Marketing
Centre for Applied Market Science (CAMS)
Copenhagen Business School
Herning, Denmark 2012

John Bang Mathiasen
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# Preface

The subject matter chosen for this PhD, learning within a Product Development (PD) working practice, might give rise to wonder given that I have a theoretical education within supply chain management, achieved practical experience as senior supply chain manager and finally, conducted a great many lectures dealing with supply chain management. Offhand, it may seem an odd choice, but my practical experience, briefly illustrated in the below, triggered the decision to study learning within a PD working practice.

PD implies design of components and clarifications of the assembly process. A side effect of these activities is a routing, which establishes the supply chain; that is, the total journey, which all components must undertake before the product is saleable. Hence, seen from the perspective of the operation, the supply chain to be managed throughout the life cycle of the product is created during the PD phase. Changing a supply chain later on is possible, but it requires a significant effort. When managing a supply chain area, in which a large part of the products had a life cycle of more than 10 years, I realised the critical importance of influencing the PD process. Thus, employees from the supply chain department were often engaged in intense exchanges of views with the PD engineers and substantial resources were devoted to improving the awareness of supply chain considerations during the PD process. Nevertheless, in my firm conviction, these efforts only managed to exert minor influence and consequently, the established supply chains were difficult to handle.

Ever since then, I have wondered why we were unsuccessful in influencing the supply chain of a new product. The involved supply chain engineers had a highly theoretical background as well as practical experience, but it was not possible to initiate learning among the PD engineers as regards the establishment of a more suitable supply chain.

Being able to study learning within a PD working practice necessitates fundraising, getting access to a PD working practice and, finally yet importantly, support from colleagues, family and a network of sympathetic friends.

Without the funding raised by my employer (Aarhus University) as well as the Research Foundation for Central and Western Jutland, I could not have afforded this five-year PhD journey. I really appreciate these donations and not least the working conditions provided by the management of the Centre for Innovation and Business Development. Being sheltered from the daily activities at the university for an extended period has paved the way for this research.

As a main rule, PD is surrounded by a high level of secrecy. This naturally complicates getting access to a PD working practice as access is normally prohibited. Therefore, I am exceedingly grateful for the openness and willingness exhibited by kk-electronic and the two involved customer organisations throughout the period of data collection. They initiated me into the secret of how to create wind turbine control applications. Not once did kk-electronic or one of the customers deny me access to a meeting. Additionally, I was allowed to walk freely around in the office as well as in the pilot production area and talk to anyone of the employees. I want to offer my thanks to all of the involved employees. I really appreciate the support from Erik Grann Gammelgaard and Mark Hvilsted in getting access to the PD working practice including the two PD projects. Furthermore, Peter Hoffmann Andersen and Brian

Slot, being in charge of one of the PD projects, regarded me as a member of the PD group. I have never witnessed such a high level of professionalism in managing a project. Finally, Lars Mønsted, project manager of the other PD project, allowed me to sit next to his desk in the open plan office, which placed me "in the eye of the hurricane". It provided me with an outstanding opportunity to follow the progress of this PD project.

Special thanks are due to my primary supervisor, associated professor Chris Ellegaard. Undoubtedly, he has struggled doggedly to change my world view from being a holistically reflecting practician to becoming a reflecting researcher with an ability to focus on a specific subject matter. Although some of our supervision meetings resulted in the two of us crossing swords, I really appreciate Chris Ellegaard's perseverance and help as it has enabled me to become a researcher; still, I am aware that much more remains to be learned in this regard. I would also like to express my gratitude to my secondary supervisor, professor Christian Koch, for theoretical and methodological inputs. Our centre secretary, Lisa Vestergaard Sørensen, also deserves thanks for an extremely competent proofreading of this thesis, which, all things being equal, has made the text much more reader-friendly.

Finally and most importantly, without the understanding and support from my family, I would **NEVER** have been able to finish this PhD journey. I am not able to put into words my gratitude for the ultimate support from my wife Lene and my two sons Jonas and Rasmus throughout the period. I am greatly indebted to my family – the "to do list" is very long.

Herning, 2012

John Bang Mathiasen

## English Summary

This thesis examines learning within a PD working practice when creating a Wind Turbine Control (WTC) in collaboration with a customer. The focus of the research is on the learning that takes place when engineers conduct a PD activity, frequently referred to as workplace learning. The research addresses how a PD activity unfolds within interorganisational, cross-functional and daily working practices. Using the term *within* has methodological consequences, dictating the study to deal with a PD working practice as it unfolds when engineers conduct a PD activity.

As to the **methodological** approach, the logic applied throughout the thesis is abduction. The abductive logic paves the way for studying how learning occurs in consequence of the engineers' doings when conducting a PD activity within a PD working practice. As this logic rejects any kind of dualism, the engineers' doings are neither the outcome of institutional determinism nor of the free will to act. The engineers' doings both influence and are influenced by the social as well as the technical elements, for which reason the PD working practice in this thesis is defined as a SocioTechnical Practice (STP). In line with the abductive logic, the analysis of learning originates from the doings being conducted within this STP - the empirical domain.

The **empirical domain** unfolds at kk-electronic, be it in interorganisational, cross-functional and daily working STPs. A preliminary analysis results in identification of two PD projects, which become the focal points for further data collection and thus more detailed examinations. Both PD projects deal with the creation of a WTC in collaboration with a customer. The collaboration with one of the customers draws on three decades of close interaction, while the other is still in its infancy. The thesis contains a description of these two PD projects including four longitudinal embedded cases, each of which illustrates the trajectory of a selected part of the PD project. The analytical framework employed to study learning within these STPs emerges along the way. Additional being inspired by the preliminary analysis and the ongoing data collection for the detailed analysis, the theoretical domain is crucial in the creation of the analytical framework.

As regards the **theoretical domain,** the pragmatic learning understanding, which, like the abductive logic, originates from American pragmatism, is a pivotal theoretical position in this thesis. Learning is defined by the transformation of an indeterminate situation into a determinate situation. An indeterminate situation arises due to disturbance in the experience embedded within an STP. A restoration of determinacy creates new experience, i.e. learning, for the engineer. The engineer and the STP, however, are evolving in reciprocal interaction. Focusing on how a PD activity unfolds within an STP makes it possible to grasp this reciprocity.

Accomplishment of PD may be ranked alongside reading and writing text as for instance a scientific article. Reading text and conducting analyses enable a researcher to write text in a new scientific article; in order to read and write a scientific article, a certain level of experience with the phenomenon at hand is necessary. Hence, a PD activity is regarded as ongoing reading and writing doings. To analyse each single doing, Goffman's (1974) framework be-

comes crucial. It paves the way for analysing how the engineers' reading doings of constitutive means within an STP influence their writing doings of a new/modified constitutive means; e.g. drawings and electrical diagrams. The transformation from an indeterminate to a determinate situation is achieved by conducting a strip of doings. A successful transformation enables learning.

The **analysis** of the two PD projects is divided into two chapters; one addresses a well-established PD collaboration, while the other deals with PD collaboration with a new customer. To identify the characteristics enabling or constraining the learning process, both chapters focus on the composition of the STP and the transformation process. First, the composition of the interorganisational, cross-functional and daily working STPs is analysed. Applied constitutive means and the role of the constitutive means are topics to guide the analytical reflections during this part of the analysis. The second subject matter focuses attention on the transformation of the indeterminate situation. In this regard, the anchoring of the indeterminate situation and a continuation of the strip of doings aiming to transform the indeterminate situation guide the examinations throughout the second part of the analysis. The characteristics enabling or constraining the learning process are accessibility of constitutive means, heterogeneity of engineers, ductility/obduracy, openness, anchoring of the indeterminate situation and continuation of the strip of doings.

As for the use of identical topics to guide the analytical thinking across the two PD projects, the intention is not to conduct a comparative cross-analysis. Instead, the motive is to achieve a broader and more well-founded understanding of learning within an STP.

The **cross-analysis** including the **contribution** brings the anchoring of the indeterminate situation to the forefront. The anchoring of the indeterminate situation is influenced by and simultaneously influences the composition of the STP. Besides, the anchoring of the indeterminate situation charts the course for the approach to achieve a continuation of the strip of doings.

An anchoring matrix is presented. It distinguishes between a ready-made indeterminate situation prepared beyond the boundaries of the STP in question and an emerging indeterminate situation arising within an STP. Furthermore, it discriminates between whether or not a convergent interpretation of the indeterminate situation to be handled is achieved. Four different ways of anchoring the indeterminate situation, four different composition of the STP and finally, four approaches to a continuation of the strip of doings appear from the anchoring matrix.

The well-established PD collaboration results in learning within the interorganisational STP and the creation of a WTC. Regarding the PD collaboration with the new customer, the creation of the new WTC does not imply learning within the interorganisational STP. I.e., learning is a potential outcome of a PD collaboration. To enable both learning and PD, the challenge is to avoid that the engineers' reflective experience is led on a wild goose chase or pursues divergent tracks. Being able to generate new experience when creating a new product requires a convergent anchoring of the indeterminate situation.

# Dansk resumé

Afhandlingens fokus er læring indenfor en produktudvikling (PU) arbejdspraksis i forbindelse med udviklingen af en styringsapplikation til en vindmølle i samarbejde med en kunde. Forskningen fokuserer på læringen, som opstår, når ingeniører gennemfører en PU aktivitet - ofte betegnet arbejdsplads læring. Gennemførelsen af en PU aktivitet kræver, at ingeniørerne udfører handlinger. Handlingerne foregår indenfor interorganisatoriske, tvær-funktionelle og i daglige PU praksisser. Begrebet *indenfor* har metodiske konsekvenser; fokusset er at studere, hvordan en PU arbejdspraksis udfolder sig, når ingeniørerne gennemfører en PU aktivitet.

Den anvendte **metodologi** er abduktion. Abduktionen muliggør at studere, hvordan læringen foregår, når ingeniørerne udfører handlinger i forbindelse med gennemførelsen af en PU aktivitet indenfor en PU arbejdspraksis. Idet abduktion er uforenelig med dualisme forkastes institutionel determinisme samt ingeniørernes uindskrænkede muligheder for handlinger. Snarere vil ingeniørernes handlinger påvirke og samtidig blive påvirket af sociale samt tekniske elementer, hvorfor en PU arbejdspraksis i afhandlingen defineres som værende en "Socio-Teknisk Praksis" (STP). Denne STP er det empiriske domæne for ingeniørernes handlinger og således det centrale i analysen og forståelsen af læring.

Det **empiriske domæne** udfolder sig indenfor kk-electronic, det være sig interorganisatoriske, tvær-funktionelle og daglige STPére. Med udgangspunkt i en foranalyse identificeres to PU projekter, som efterfølgende underkastes en omfattende dataindsamling og detaljeret analyse. Begge PU projekter omhandler udviklingen af en styringsapplikation til en vindmølle i tæt samspil med kundeorganisationen. Samarbejdet med den ene kunde trækker på mere end tre-årtiers fælles PU, mens samarbejdet med den anden kunde fortsat er i sin vorden. Afhandlingen indeholder en beskrivelse af disse to PU projekter herunder 4 longitudinale indlejrede cases, der hver især fokuserer på en afgrænset del af PU projektet; de 4 longitudinale indlejrede cases belyser således en del af projektets livsbane.

Genereringen af den analytiske model til at studere læring indenfor en STP har været en fortløbende proces. Udover foranalysen og igangværende dataindsamling til den detaljerede analyse har det teoretiske domæne influeret frembringelsen.

I relation til det **teoretiske domæne** er den pragmatiske læringsforståelse central, hvilket ligesom den abduktive logik tager sit udspring i den amerikanske pragmatisme. Læringsprocessen defineres som værende transformationen af en ubestemt situation til en afklaret situation. Den ubestemte situation opstår som følge af forstyrrelser i erfaringen; erfaringen er indlejret i en transaktionel relation mellem ingeniøren og STPén. En genetablering af en afklaret situation resulterer i ny erfaring; læring for ingeniøren. Ingeniøren og STPén udvikles imidlertid i et gensidigt samspil. Ved at fokusere på, hvordan en PU aktivitet udfolder sig indenfor STPén, gøres det muligt at opfatte og studere denne gensidighed.

En PU aktivitet kan sidestilles med at læse og skrive en videnskabelig artikel. Læsning af tekster og analyser gør det muligt for en forsker at skrive en videnskabelig artikel, hvilket imidlertid kræver omfattende viden (experience) hvad angår det pågældende emne. Dermed

betragtes PU aktiviteten som vedvarende læse- og skrivehandlinger. Goffmans (1974) "Frame Analysis" er et centralt bidrag til at analysere hver eneste af disse læse- og skrivehandlinger.

Den udviklede analytiske model åbner op for at analysere, hvordan ingeniørernes læsehandlinger af konstitutive elementer indenfor en STP influerer skrivehandlingerne i et nyt/modificeret konstitutivt element; fx tegninger og elektriske diagrammer. Transformationen fra en ubestemt til en afklaret situation opnås ved at gennemføre en sekvens af handlinger, hvilket muliggør læring. Analysedelen er funderet i dette.

**Analysen** af de to PU projekter er opdelt i to kapitler. Et kapitel omhandler det veletablerede PU samarbejde, mens det andet kapitel belyser PU samarbejdet med den nye kunde. For at analysere karakteristikaene, der muliggør eller begrænser læringsprocessen, er det analytiske fokus i begge kapitler henholdsvis sammensætningen af STPén samt transformationsprocessen. Indledningsvis analyseres sammensætningen af de interorganisatoriske, tvær-funktionelle og daglige STPére. Anvendte konstitutive elementer samt deres rolle guider denne første del af analysen. Det andet fokusområde i analysen belyser transformationen af den ubestemte situation. Forankringen af den ubestemte situation samt fortsættelsen af sekvensen af handlingerne for at opnå en afklaret situation guider denne analytiske del. Følgende karakteristika muliggør eller begrænser lærings processen: tilgængelighed af konstitutive elementer, ingeniørernes heterogenitet, færdiggørelsesgrad (ductility/obduracy), åbenhed, forankring af den ubestemte situation og endelig fortsættelse af sekvensen af handlingerne.

De identiske fokusområder på tværs af de to PU projekter er ikke motiveret af at udføre en komparativ analyse, men for at opnå en velfunderet forståelse af læring indenfor en STP.

**Analysen** på tværs af de to PU projekter herunder afhandlingens **bidrag** centreres omkring forankringen af den ubestemte situation. Forankringen af den ubestemte situation påvirker og vil samtidig blive påvirket af sammensætningen af STPén. Forankringen af den ubestemte situation udstikker ligeledes kursen for den valgte fremgangsmåde til at sikre en fortsættelse af sekvensen af handlinger.

Funderet i dette præsenteres en forankringsmatrix. Matrixen sondrer mellem en færdiglavet og en opstået ubestemt situation. Førstnævnte er udarbejdet af ingeniører udenfor den pågældende STP, mens sidstnævnte dukker op som et resultat af handlingerne indenfor STPén. Endvidere skelnes mellem hvorvidt handlingerne medfører konvergerende eller divergerende fortolkninger af den ubestemte situation. Fire forskellige forankringer af den ubestemte situation identificeres, fire tilhørende sammensætninger af STPén og fire fremgangsmåder til at sikre en fortsættelse af sekvensen af handlinger fremgår af forankringsmatrixen.

Det veletablerede PU samarbejde resulterer i interorganisatorisk læring og udvikling af et produkt. Et velfungerende produkt udvikles i PU samarbejdet med den nye kunde, men der foregår ingen interorganisatorisk læring. Ergo, læring og PU er et potentielt resultat. For at sikre såvel læring som PU er forankringen af den ubestemte situation central. En konvergerende forankring muliggør, at de refleksive erfaringer konvergerer og ikke ledes på vildspor.

# Table of contents

# Figures

## **Tables**

# Chapter 1. Introduction

Before presenting the considerations and outcomes of this PhD journey in the succeeding 11 chapters, the background and relevance of the research are explained. This discussion is followed by a brief introduction to the empirical domain of the study, making it possible to present the substance of the research including the research questions. Finally, the logic of inference and the structure being applied throughout the thesis are explicated.

## 1.1. The background and relevance of this thesis

Companies located in Denmark are subject to conduct business activities in a high-wage area. The challenging conditions are debated among various groups of stakeholders. The agenda of these dialogues mainly emphasises a need for transforming the current business foundation into a knowledge-intensive foundation.

From a **political perspective**, politicians, various labour unions and the Confederation of Danish Employers focus great attention on assisting Danish companies to become knowledge-intensive enterprises. A great many initiatives are launched to support the companies' entry into the knowledge society. The resources available to facilitate this transformation process are comprehensive and include a significant amount of money. In general, the focus of these initiatives and discussions is an outside-inside perspective on the companies; structural mechanisms at the macro level are considered to be the means to facilitate the transformation.

The creation of knowledge (learning) and innovation seem to be two key words brought to the fore in the discussions. For instance, at a conference conducted at Aarhus University in late 2009, the then Minister of Science, Technology and Innovation emphasised that the ability to create new knowledge and innovation is of vital importance for handling the current financial crisis. Few would disagree with this statement, but the challenge is to translate these two words (knowledge and innovation) into action.

In a **theoretical perspective,** Product Development (PD) and learning have received great attention. Originating from analyses dealing with learning processes at Toyota, Fuchs (2007) considers PD and learning crucial factors for maintaining competitive advantages, while Dyer and Hatch (2004) emphasise the benefits of supplier network learning in a world of hyper-competition. Knowledge is embedded in three social communities, implying that the issue is how to be accepted as a member of Toyota's supplier network (Dyer and Nobeoka, 2000). Likewise, Powell et al. (1996) point out that the locus of innovation within a rapidly developing technological industry, as for instance biotechnology, is to be found within the network of learning. The PD ties (Powell et al. apply the term R&D) are the open sesame to this network, while the main drivers of the dynamic learning system are network experience, diversity of ties and centrality of the network. By accessing this network, it becomes possible to keep pace in the high-speed learning race taking place within biotechnology.

While the above contributions deal with interacting organisational units, another group of research draws on cognition to emphasise PD and learning as crucial means to improve the competitive position of the company. In general, it addresses individual and organisational cognitive constraints. Ruy and Alliprandini (2008) consider learning as a means to manage the PD activities, while Tsai and Huang (2008) and Akgün et al. (2006) describe learning as a method for understanding market and technological uncertainties in an attempt to improve the PD activities; and in this regard, Lynn (1998) accentuates "Time to Market" and product success rate. In the same vein, to be successful when conducting PD, the organisation has to learn faster than its competitors (Liepè and Sakalas, 2008). Instead of seeing the handling of uncertainties as a learning race, Meyers and Wilemon (1989) illustrate how a new "technological wave" affects the business foundation and thus makes demands on learning.

Common for the above theoretical positions is a decontextualisation of PD and learning which Peltokorpi et al. (2007) describe as being rather problematic in as much as PD, learning and context are inseparable in the real world. Brown et al. (1989) emphasise that PD activities apply knowledge and at the same time trigger learning. Thus, PD and learning are both situated in action and enabled through action. Brown and Duguid (1991) point out that PD, learning and working form a community of interpretation. Likewise, Nonaka et al. (2000) indicate PD and learning (Nonaka et al. term it knowledge creation) to be situated in a contextual "Ba". Miettinen et al. (2008) agree with these viewpoints, by which PD, learning, network collaboration and acquisition of new competencies develop simultaneously when conducting activities.

An **empirical perspective** on the phenomenon makes it possible to shed light on how companies translate PD and learning into action in "the real world". The empirical basis for explaining this draws on a case collection of 20 Danish companies (Mathiasen and Gammelgaard, 2007). Each of the cases expresses a managerial world view of the changeable conditions as well as the applied approach to ensure an ongoing development of the business foundation.

The 20 companies have in common a conscious focus on ensuring a continual development of the company. The case companies reflect on new demands from their customers or opportunities to increase business. The companies do not adopt a wait-and-see attitude; instead they are all proactive, enquiring and reflective in terms of the new situations they are facing. Hence, across the companies, the managers have a positive learning attitude in the effort to improve their competitive position as they acknowledge that the future is inherently unpredictable. In this regard, they have realised that the knowledge gap between the practical world and academia obstructs the learning process. Instead, the case companies regard learning, and thus the ongoing development of the business foundation, to be enabled by specific situations in which the organisation is facing a challenging customer and/or supplier.

19 out of the 20 companies contribute to a certain extent to their customers' PD processes, implying that these are the most frequently applied activities used to stimulate the progress of the business. 11 companies contribute actively to the creation of the product specifications, while the PD activities of the remaining 8 companies mainly address production preparation or the like. Drawing attention to the former group of companies, the collaboration triggers intense interorganisational as well as intraorganisational interactions.

Especially the intense interorganisational collaboration with demanding customers is considered a crucial foundation for enabling PD as well as learning. The next section elaborates on this, and, in the process, it introduces the approach taken to the substance of the research and the empirical domain.

## 1.2. Approach to the substance of the research and the empirical domain

kk-electronic a/s (kk) is one of the 20 case companies mentioned above. The CEO gives credit to one demanding customer for kk being among today's leading actors on the market for Wind Turbine Control (WTC) applications. At the time of preparing the aforementioned case collection (2006/2007), collaboration with that particular customer was very intense, for which reason kk from time to time posted some of its engineers to the customer's organisation.

The **PD** collaboration between the two organisations is characterised by a low level of formalisation, which appears from the below quotation.

> *"There are many things which aren't documented, they go without saying. It could be something they* (the customer, author) *want to have fixed. All they have to do is call, and then we start the development straight away. We need to exploit this as a competitive advantage. Why do they want to make business with us? An outsider wouldn't be able to fathom that, and the reason is not to be found in our documents, it's just not there."* (CEO kk-electronic, 2006).

Thus, the interorganisational activities are rather informal and direct. Given that the two organisations have collaborated for some time, the intraorganisational PD activities conducted in kk are characterised by a sound understanding of what this customer wants.

Drawing attention to **learning**, the process is mainly enabled through PD collaboration with this specific customer. Learning occurs when the engineers are faced with problems they are not able to solve offhand. Therefore, as it appears from the below quotation, the engineers often initiate PD activities in an attempt to find an appropriate solution for the customer.

> *"We have employees who say, "if we do it this way, it will work". Therefore, we let them work on it; for example if they want extra features in it or find out that they have overseen something in the contract. It could be a case of a slight voltage difference in something, and they say, "oops, we read that wrong, it needs a thing put in there"."* (CEO kk-electronic, 2006).

Accordingly, rather than being deliberate managerial processes, PD and learning are situational and both activities take place when the engineers find appropriate solutions for the customer. PD is not simply to come up with new ideas; it calls for continuous collaboration and interplay involving the customer's organisation. Likewise, learning is not a static phenomenon, but draws on and emerges in the collaboration between engineers having different organisational and/or functional affiliations.

Summing up, the empirical domain of the research is kk. The next section concretises the substance of the research. The research draws on the process of abduction. Thus, rather than being predetermined hypotheses, the research questions presented in the next section have gradually emerged from an ongoing interplay between the empirical and the theoretical work.

## 1.3. The substance of the research – the research question

The purpose of this research is to develop an understanding of and make a theoretical contribution to the literature on how learning takes place when conducting PD in collaboration with a customer.

*How does learning take place within interorganisational product development working practices?*

To acquire a theoretical understanding of this phenomenon, a literature review is carried out on learning and PD and, more importantly, on how learning occurs in a PD context. Hence, the second research question:

*Which underlying perspectives are prevalent in the literature dealing with learning in a product development context?*

The intention of the review is to gain a broad overview of the literature and the various prevalent perspectives of learning in a PD context.

Based on the literature review and a pilot case, the pragmatic learning theory is introduced to contribute to the extant understanding of learning when conducting PD in collaboration with a customer. It is expected that pragmatic learning will be instrumental in generating new insights into this learning process.

*How does the application of pragmatic learning theory contribute to our understanding of learning within interorganisational product development working practices?*

The research questions consist of three key concepts: **learning**, **PD** and **working practices**. The applied understanding of these three concepts and "**interorganisational PD working practices**" is presented below.

Drawing on Dewey (1938:chapter 6), **learning** is defined by the transformation of an indeterminate situation into a determinate situation. An indeterminate situation arises due to disturbance in the experience embedded within a working practice. A restoration of determinacy creates new experience, i.e. learning, for the individual. The individual and the working practice, however, are evolving in reciprocal interaction. Focusing on how an activity unfolds within a working practice makes it possible to grasp this reciprocity (Elkjær, 2005:128). Hence, the focus of the research will be on the learning that takes place when employee(s) conduct specific work activities, frequently referred to as workplace learning (Cairns and Malloch, 2011). The work activity under study is the **PD** carried out in connection with the creation of a WTC to a customer.

**Working practice** is the inseparable (transactional) interaction between the individuals and the environment (Dewey, 1938:32-34), for instance between PD engineers conducting a PD activity within a meeting room or in the production area by the use of drawings, laptops and/or the physical product. The working practice is the setting in which learning takes place as the individuals are conducting a PD activity in the attempt to transform the indeterminate situation into a determinate situation.

**Interorganisational PD working practices** unfold as a WTC is created with a customer. Many PD activities take place and each PD activity both constitutes and is constituted by the social as well as the technical elements. Hence, a PD working practice can be categorised as a SocioTechnical Practice (STP). As the creation of a WTC with a customer takes place between employees in different organisational units, three different types of STPs unfold: 1) an interorganisational STP, 2) a cross-functional STP and 3) a daily working STP.

Applying in an STP this understanding of learning paves the way for examining whether or not learning takes place when conducting a PD activity. This leads to the final research question:

*Which characteristics enable or constrain the learning process?*

This research question addresses the process characteristics of learning and allows for analysis and elaboration on the factors that enable or constrain the learning process. An enabler makes it possible to transform the indeterminate situation into a determinate situation; i.e., learning occurs. A constraint restricts the transformation from the indeterminate situation into a determinate situation; i.e., no learning occurs.

By generating knowledge of these learning process characteristics, the research contributes to scientific knowledge of learning in PD and helps companies understand why and when learning can be achieved successfully.

## 1.4. The applied logic and structure of the thesis

This section introduces the reader to the logic applied throughout the thesis and, in addition, it illustrates the structure of the 12 chapters making up the thesis. Given that the structure of the thesis has much in common with the applied abductive logic, the two subject matters will be explained simultaneously.

In accordance with the abductive logic, reflections spring from an indeterminate situation within the empirical domain triggering interplay between observations and reflective thinking; that is, interplay between the empirical and theoretical domains.

Figure 1.1 on the next page is an attempt to mirror the applied logic throughout the research in relation to the 12 chapters. Chapters 2 and 8 in the left part of the figure are based on the empirical domain, while the theoretical domain forms the basis of chapters 4, 5, 6 and 7 depicted in the right part of the figure. Chapters 9, 10 and 11 make use of both domains, illustrated by the positioning of these chapters at the centreline of the figure. Likewise, the introductory chapter 1 as well as the concluding chapter 12 draw on both domains. Finally, chapter 3, appearing at the top of the figure, elaborates on the applied abductive logic and discusses the interpretivist metatheoretical position and the methodological consequences in this regard.

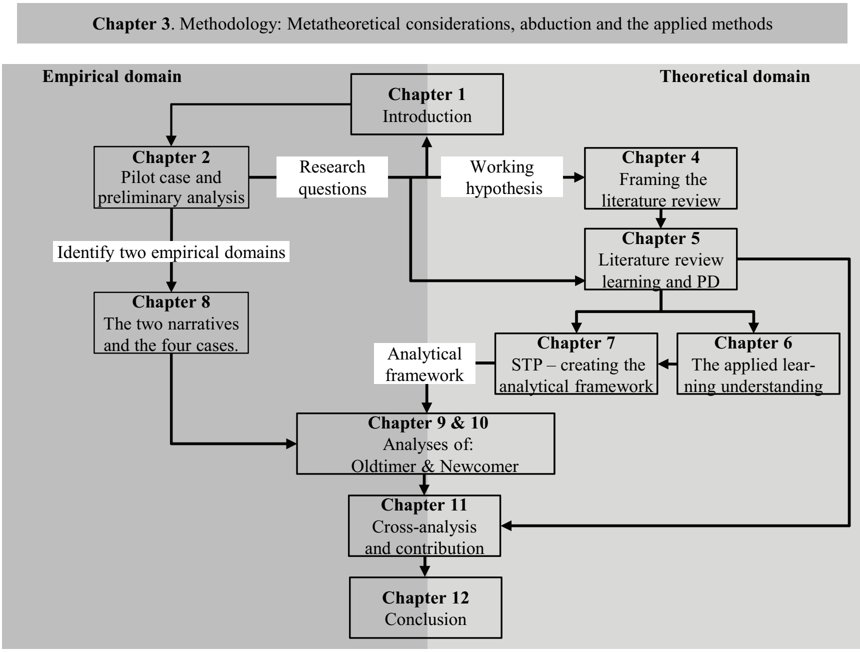


Figure 1.1. The structure of the 12 chapters of the thesis.

As it appears from figure 1.1, chapter 2 presenting the pilot case and the preliminary analysis makes it possible to:

- Gradually infer the research questions. This is illustrated by the arrow returning to chapter 1.
- Create a working hypothesis which frames the literature review; this is illustrated by the arrow pointing to chapter 4.
- Draw on the preliminary analysis and the literature review to identify the theoretical perspective being applied in this thesis. This is depicted by the arrow pointing to the lower part of the chapter 5 box.
- Identify two empirical domains to be subjected to further and more detailed analyses. This appears from the arrow to chapter 8.

Chapters 4 and 5 are interconnected. The former creates a framework which forms the basis for the actual literature review conducted in chapter 5; i.e. the review is created in two steps. Chapter 4 applies the learning literature to identify two learning extremes and the PD literature to pinpoint two PD extremes. By combining these extremes, four different categories appear; chapter 5 then draws on these four categories to reach a theoretical understanding of learning within a PD context.

This theoretical overview is discussed along with the preliminary analysis in the concluding part of chapter 5, which thereby produces the input to the following two theoretical chapters.

Accordingly, an individual is neither unlimited to act on its own free will nor a passive human being which is institutionalised by the working practice. Likewise, the working practice consists of social and technical elements which constitute each other; it is an STP. Apparently, this theoretical understanding has not previously been applied to the study of learning within PD working practices.

Hence, chapter 6 brings a learning understanding originating from American pragmatism to the fore. As this learning understanding does not explicitly address learning within an STP (the working practice), it is necessary to turn attention to another theoretical perspective agreeing with the pragmatic position. Thus, in the first part of chapter 7, theories illustrating PD in an STP are discussed. The second part of chapter 7 sheds light on the construction of an analytical framework. This creation is inspired by the work of Pentland (1992) who combines the pragmatic learning theory with the work of Goffman to analyse learning within two call centres. Hence, the analytical framework combines pragmatism, PD theories and Goffman's (1974) frame analysis.

The analytical framework is applied to analyse the two narratives and four cases described in chapter 8. While the two narratives are identified in chapter 2, the four cases emerge gradually during the detailed data collection/analyses.

The two analytical chapters 9 and 10 have equal status, for which reason there is no progression in the analyses between the two chapters. The Oldtimer narrative and the two related cases are analysed in chapter 9, while the Newcomer narrative, including the two cases, is the focal point of chapter 10. The outcome of both chapters' analyses can be summarised to address the composition of the STP, the anchoring of the indeterminate situation and the continuation of the strip of doings; i.e. the transformation of the indeterminate situation into a determinate one.

The two analytical chapters prepare the ground for a cross-analysis and the contribution of the thesis, which constitute the subject matters of chapter 11. Three issues are in focus; the anchoring of the indeterminate situation, the composition of the STP and the continuation of the strip of doings. An anchoring matrix depicted in figure 11.9 summarises the findings.

# Chapter 2. Pilot case and preliminary analysis

This chapter introduces the reader to kk-electronic a/s and two different customer segments. The purpose of the chapter is to be familiar with the focal business processes, the tone of communication between those conducting Product Development (PD) activities and the technical terms being used by the engineers; such an understanding is crucial for an abductive researcher. Another purpose is to identify the PD project(s) to be subjected to further and much more detailed data collection and analyses later on in this thesis. A third purpose is to create and thereby make it possible to draw on an empirical understanding when addressing the literature review and to identify a theoretical perspective after having conducted the literature review.

The chapter starts with an introduction to kk-group a/s, followed by a description of the focal organisation of this research, the business foundation, the product to be developed, customer segments and finally, how the PD activities are conducted in relation to two customer segments. At the end of this section, two PD projects are identified. Section 2.2 presents a first-hand understanding of the two PD projects; in other words, a preliminary analysis.

## 2.1. The pilot case

kk-group a/s is located in Central Jutland, Denmark. It consists of two business units, kk-electronic a/s (kk) and ELOGIC a/s. A production subsidiary has been established in Poland to carry out batch production. Furthermore, in cooperation with the China Shipbuilding Industry Corporation (CSIC), a Chinese Joint Venture (JV) is established in November 2008.

The focal point of this research is to examine learning in the setting of conducting PD in collaboration with a customer. As ELOGIC engages in assembly of standard components and kk develops and produces complex products with a rather high level of customisation, the scope for the pilot case is narrowed down to only addressing kk.

kk develops, produces and delivers customised solutions to the energy sector and embedded electronics to different industrial segments. The development and production of embedded electronics take place in Herning, whereas all activities dealing with the energy sectors are conducted in Ikast. The energy sector accounts for the majority of the turnover, the wind turbine industry being the principal contributor. Hence, the scope of the pilot case is further limited to address the wind turbine area of business only.

### 2.1.1. The focal organisation creates Wind Turbine Control

kk has developed and produced Wind Turbine Control (WTC) applications ever since Christian Riisager[1] laid the foundation to the modern wind turbine industry more than three decades ago. kk has been in the wind turbine industry since then and the company is well-established within the market for onshore as well as offshore WTCs.

Prior to the current financial crisis, the level of activity within the wind turbine industry was on a constant upward trajectory; the challenges lay in ensuring the necessary capacity in

[1] The first wind turbine developed by Christian Riisager was a 22 kW (kilowatt) wind turbine.

relation to employees, production equipment and materials. Additionally, three acquisitions of competitors since 2004, a doubling of the capacity in the Polish production subsidiary in 2006 and the JV in China resulted in a significant expansion of staff.

### 2.1.2. Business foundation

During the last couple of years, kk has formalised and standardised the production set-up. Furthermore, the workload has been distributed between the Danish and Polish production facilities, implying that all prototypes are produced in Denmark, while the mainstream production has been transferred to Poland.

In terms of PD activities, a similar transformation has yet to be implemented. Hence, the current approach is to conduct as many as possible of the PD activities in-house, which is exemplified by the following statement made by a kk manager.

> *"The first 25 years we did everything ourselves,"…"you must bear in mind that the whole organisation is built around PD – it is the core of the organisation."* (Manager 1).

The management emphasises a great need for reusing existing product platforms whenever possible. This managerial focus addresses the notion that the creation of a WTC ought to be based on 80% reuse of known solutions and 20% customisation. kk terms this way of thinking "the virtual stock".

The virtual stock concept draws on the idea of placing all technical solutions created in "a warehouse". For instance, when the engineers have created a WTC, e.g. a 5.0 MW WTC, this becomes a "standard solution" and consequently, it is placed in the virtual stock. As illustrated in figure 2.1, when one of the two sales business units negotiates/carries out an order for e.g. a 5.2 MW WTC, a 5 MW WTC is retrieved from the virtual stock and forms the basis for the further PD activities. Given that the technological platforms being applied to create the WTCs to the two groups of customers are rather different, it is not possible to reuse technical solutions across the two sales business units. This is a deliberate strategic decision, by which kk seeks to avoid jeopardising its relationship with the aforementioned demanding customer.[2]

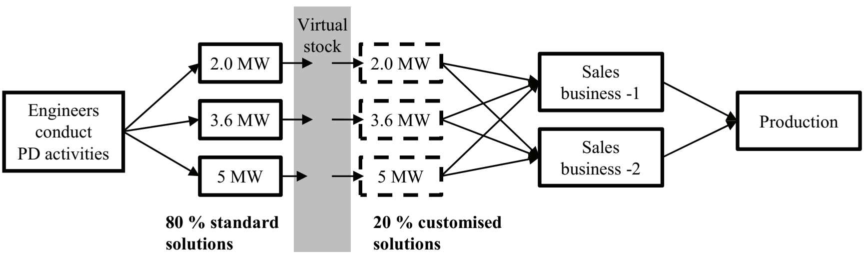


Figure 2.1. The virtual stock principle.

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[2] As regards the "demanding customer", I refer to the description in section 1.2.

### 2.1.3. Wind turbines in relation to WTC

A wind turbine consists of various sub-systems, among which the WTC created and produced by kk is considered a crucial sub-system. Focusing on the WTC, the deliveries from kk include three main modules, the yaw[3], the pitch[4] and the converter.[5]

The most common technological platform applied by kk's customers consists of a low-speed shaft being pivoted by wind pressure on the three blades, a gearbox, which increases the rotation speed, a high-speed shaft and, finally, the generator. To ensure a stable frequency adjusted to the specific country, a full power converter technology (FFIG) is applied. That is, all power from the generator will be converted.

However, kk's key customer (the aforementioned demanding customer) – designated Oldtimer in this thesis – has recently launched a technology project dealing with a new technological platform that draws on a direct drive system that does not make use of a gearbox to increase the rotation speed. The design of the generator is changed due to the lower rotation speed of the shaft, which makes this component increase in size. At present, a test version of this gearless wind turbine is being subjected to a field test.

Another group of kk's customers consists of newcomers within the wind turbine industry. The technological platform being applied by these customers depends on the geographical location. Normally, newcomers from Europe focus on direct drive and FFIG. In relation to newcomers from the Far East, the tendency is to design wind turbines with gearbox and double fed induction generator (DFIG) converter technology. The DFIG technology converts only a part of the power from the generator, while the majority of the power is transferred directly from the generator to the grid.

### 2.1.4. Two customer segments

As indicated in the above, kk has two groups of customers. All newcomers belong to the same customer segment, while Oldtimer, due to its size, makes up the other customer segment.

Oldtimer is a global player within the wind turbine industry and has produced a great many offshore as well as onshore wind turbines. Both types of wind turbines are considered to be very reliable, making Oldtimer enjoy a good reputation in the wind turbine market. The interaction is (was) characterised by intense collaboration, as kk has created WTCs to

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[3]A yaw module turns the nacelle and thereby the blades into the optimal position depending on the wind direction. Continuously, the application ensures that the three blades are perpendicular to the direction of the wind. Technologically speaking, a yaw module is regarded as being rather simple.

[4] Pitch is a complex technology that makes it possible to achieve competitive advantages, as this application has a strong influence on the output of a wind turbine. For instance, in a 2.0 MW pitch-controlled wind turbine, the pitch application measures the output of the wind turbine several times per second. If the power output exceeds the 2.0 MW limit, the pitch application will turn (pitch) the blades slightly out of wind. If/when the power output drops, the blades are turned back again. Thus, the application adjusts the three blades in accordance with the actual direction of wind and wind velocity.

[5] Because grid frequency is not standardised, but varies from country to country (in Denmark, it is 50 Hz), it is necessary to adapt the power output from a wind turbine to a specific frequency. In addition, a converter enables the generator in the wind turbine to spin with its own rotation speed. Briefly, it decouples the generator from the grid. This indirect grid connection allows the rotation speed of the generator to fluctuate with the velocity of the wind. Thus, the frequency output from the generator can vary as the converter transforms the "fluctuating alternating current" to direct current, whereupon it is converted back to alternating current adapted to the specific country. From a technical perspective, the application is rather complex.

Oldtimer ever since the industry was in its infancy in the late seventies. Thus, there exists a well-developed mutual understanding among the employees. The reason why "was" is placed in brackets is due to the fact that Oldtimer has cancelled an exclusive agreement between the two companies. In addition, Oldtimer has decided to develop all Software (SW) in-house, implying that kk now only creates the Hardware (HW) part of the WTC.

The cancellation of the exclusive agreement makes it possible for kk to search for new customers. In such an attempt to attract new customers, kk establishes a New Business Department (NBD) in June 2008. The common denominator of this group of customers is that it consists of organisations lacking in wind turbine experience. At present (March 2009), kk interacts with a number of newcomers and the first deliveries have been executed. However, in contrast to Oldtimer, the collaboration between kk and newcomers calls for exhaustive interaction both interorganisationally and cross-functionally.

### 2.1.5. PD activities

kk categorises its PD activities into three groups, giving rise to three different Time To Market (TTM) objectives. As it appears from figure 2.2, a level one product is "well-known in the production" and all product and production documentation is available. A level two product requires some customisation and finally, a level three product calls for development of new applications/solutions.

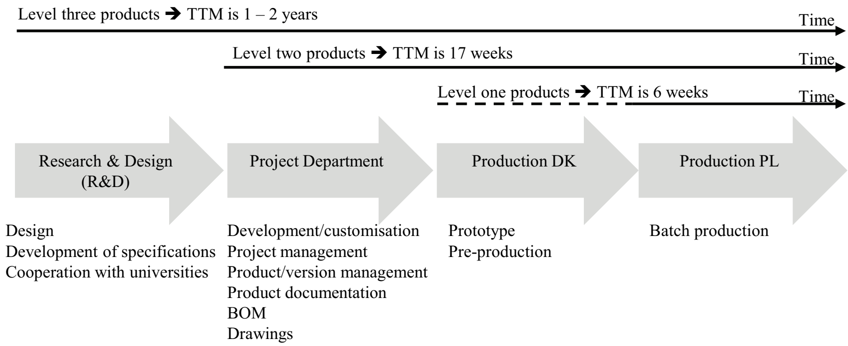


Figure 2.2. Time To Market and PD activities to be conducted.

Across the two customer segments, the PD and production activities are divided into a number of phases dependent on whether it is a level one, two or three product. Thus, after technical and commercial issues have been clarified with the customer, the PD task is handed over to either Research & Development (R&D) or the Project Department, after which the agreed PD activities are conducted. Within each of the four phases depicted in figure 2.2, a number of PD activities have to be conducted; these are described below the four arrows. However, this explication does not illustrate the immense complexity of the PD activities being conducted with newcomers, or for that matter in the collaboration with Oldtimer.

Hence, the next two sections explain the PD activities conducted in relation to Oldtimer and newcomers, respectively.

### 2.1.6. PD in relation to Oldtimer

Figure 2.3 visualises the Oldtimer PD process.[6] The light grey box deals with the clarification process, which starts when Oldtimer sends an order proposal to kk. A commercial project manager is allocated to the project and he interacts with a project manager from Oldtimer. Furthermore, the Project Department assigns to the project a technical project manager who is responsible for all technical subject matters.

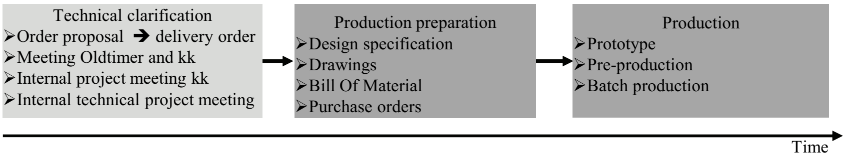


Figure 2.3. PD activities in relation to Oldtimer.

Usually, the two kk project managers and Oldtimer's project manager hold an interorganisational meeting every two weeks. Furthermore, two types of cross-functional meetings take place internally at kk. One addresses coordination among engineers, blue-collar workers and employees from purchasing/logistics, while the other meeting has a much more technical fulcrum. These meetings result in the drawing up of a technical document in which kk describes how to "customise" and produce the WTC. This documentation is sent to Oldtimer for approval, whereupon kk receives the order – a delivery order.

Before starting the production, the received specifications are examined. They constitute the input to the PD activities visualised in figure 2.3, the dark grey boxes. The Project Department has a procedure for translating the specifications and preparing the necessary product and production documentation.

The first PD activity is to pick out a WTC from the "virtual stock", after which the necessary modifications are carried out in accordance with the approved specifications. The PD activities focus on producing comprehensible documentation, which is subsequently handed over to the responsible production department, either prototyping, preproduction or batch-production; the two former are situated next door the Project Department, while the latter is in Poland.

Despite the fact that the aforementioned cancellation of the exclusive agreement and insourcing of SW activities imply some changes, the three decades of intense collaboration still influence the interorganisational PD activities. For instance, after meetings at kk, the employees from Oldtimer are passing by the desk of the kk employees, who did not participate in the meeting, in order to clarify technical issues. On the one hand, these informal coordination meetings are occasionally regarded as being problematic; on the other hand,

[6] The explanation draws on observations, interviews and perusal of different documentation dealing with the PD process.

however, this mutual understanding is the reason why kk is able to produce a WTC to Oldtimer.

> *"The quality of this document* (delivery specifications received from Oldtimer, author) *is inadequate. If I did not have a good understanding and knowledge of Oldtimer's requirements and wishes, I would not be able to build a breaker panel from this document. It is necessary for me to read the text between the lines. Another supplier would not be able to produce a breaker panel based on this document."* (PD employee).

### 2.1.7. PD in relation to newcomers

Only a few PD projects have been conducted under NBD direction, for which reason the experience in this regard is still in its infancy. The kk organisation is working determinedly to improve the procedures for guiding the interaction with a newcomer; i.e., procedures have been created to manage the PD process.[7] Thus, the PD process is divided into two phases. The first phase deals with technical and commercial clarifications in close collaboration with the newcomer in question, while the second phase addresses customisation, production preparation and the physical production.

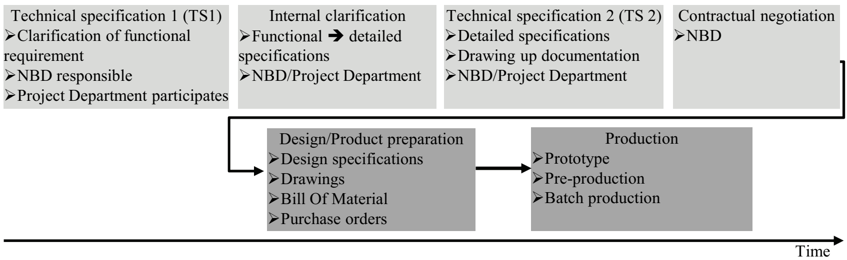


Figure 2.4. PD activities in relation to newcomers.

An employee from NBD has formulated a model outlining the PD process to be followed. This PD process model is shown in figure 2.4. It starts with clarifications of technical as well as commercial issues. The clarifications take place in a number of steps, which appear from the four light grey boxes in figure 2.4. This first phase takes place between NBD and the newcomer in question. On average, this phase lasts for twenty weeks and includes both face-to-face meetings and questionnaires to be completed by the newcomer. In addition to these commercial and technical clarifications, a crucial purpose of this phase is to pave the way for improving the mutual understanding between NBD and the newcomer.

[7] As emphasised in the previous section addressing Oldtimer, the explanation draws on observations, interviews and perusal of different documentation dealing with the PD process with a newcomer. Obviously, the explanation does not illustrate the actual PD activities taking place when developing a WTC to a newcomer. In addition, other terms are applied to the documents. For instance, the TS1 is termed **miniTS** while the TS2 is termed **TS-document**.

The second phase appears from the two dark grey boxes in the above figure. It is managed by a project group, which organisationally belongs to another part of the kk organisation, i.e., the PD task is handed over to the project group by the responsible salesman.

Roughly, this second phase has much in common with the Oldtimer PD activities, for which reason it will not be further elaborated in this pilot case.

Collaboration with a newcomer is characterised by the fact that the agenda is to develop a wind turbine producing electricity. Accordingly, the technical subject matters seem to be at the top of the list of priorities; however, emphasis is also on proving kk's trustworthiness as a WTC supplier.

The starting point for doing so varies from newcomer to newcomer. For instance, the relationship building activities initiated in connection with a newcomer from the Far East have turned out to be rather complex and unpredictable. In contrast, improving the mutual understanding with a European newcomer has proven to be more predictable and effortless. Just after visiting the last-mentioned newcomer, the technical salesman comments *"we are at the same wavelength"*.

#### 2.1.8. The selection of the two PD projects for further study; Oldtimer and Newcomer

The pilot case helps to identify two PD projects to be subjected to additional data collection and analyses. These PD projects are selected because they are expected to require different PD activities, implying diverse forms of PD collaboration.

While the collaboration with Oldtimer draws on three decades of close interaction, the collaboration with the Far Eastern newcomer is still in its infancy; the latter customer is designated "Newcomer" (the first letter is written in upper case). Oldtimer is located close to kk and from time to time, employees from the two organisations are passing through to clarify a technical subject matter. The opposite is true for Newcomer, as this company is located far away from kk and because this PD project constitutes the first collaboration between the two organisations. In addition, the differences in technical WTC development experience make for a larger difference between the two PD projects. This gives rise to two different set of guidelines for kk employees throughout the PD; figure 2.3 and 2.4 illustrate these guidelines.

The selection does not follow a replication logic (Yin, 2003:47) in an attempt to conduct a comparative study. Rather, the intention is to learn from the two PD projects (Stake, 2000:446). It forms the basis of a broad empirical understanding and, in doing so, to minimise the likelihood of idiosyncratic findings (Pentland, 1992:534). It is assumed that the variety between the two PD projects will provide insight that will pave the way for examining the complexity of the learning process.

The remaining part of this chapter addresses a first-hand understanding of two PD projects.

## 2.2. First-hand understanding of the two PD projects

kk is characterised by a craft-based history in which R&D is setting the agenda. Irrespective of whether the PD activities take place in cooperation with Oldtimer or Newcomer, the approach to conducting the PD activities draws on three decades of intense collaboration with

Oldtimer. This way of doing business forms the backbone of the organisation;[8] in the internal kk jargon, it is termed the "*Oldtimer mindset*".

The PD activities addressing the commercial and technical clarifications are diverse across Oldtimer and Newcomer. Oldtimer is exceptionally well-versed in wind turbines, for which reason this customer is very much aware of its needs and requirements in terms of the WTC to be created by kk. In contrast, Newcomer's experience with wind turbines in general and WTCs in particular is rather limited. Newcomer does not have a clear sense of its needs and/or wishes as regards the WTC to be created.

Addressing Oldtimer, the creation of the specifications and the subsequent production preparation and physical production of the WTC demonstrate the effect of three decades of collaboration. The PD employees draw on technical experience gradually developed with Oldtimer as well as from the "virtual stock principle". It facilitates them to "read between the lines" and thus produce a WTC despite vague specifications.

The previously close and joint performance of the PD activities is affected by the cancellation of the exclusive agreement and the fact that Oldtimer has insourced all SW development, i.e. only HW solutions are discussed. However, during the development of a new 3.0 MW gearless wind turbine, kk is much more involved in the PD activities.

As to Newcomer, this potential customer has previously developed two wind turbines, both suffering from quality problems. Hence, the technological content of the collaboration will probably become important, as Newcomer really needs to be convinced of the reliability of kk's technological platform.

The PD activities performed with Newcomer are expected to be challenging; especially the PD activities addressing the clarifications are assumed to be complex. This calls for an ability to understand Newcomer's requirements. However, a technology gap exists between Newcomer's expectations to a WTC and the solution offered by kk. The management of kk uses an automobile metaphor to illustrate this tension field: *"The creation of WTCs in collaboration with Oldtimer is like a Mercedes; it is a high-end car which is regarded as being very reliable. Yet, a newcomer does not need a Mercedes; it has too many dispensable features available, making it excessively expensive"*.

In addition to the above variety at project level, the execution of a PD activity demonstrates diversity in relation to the involved employees as well as the contextual setting within which the PD activity is conducted.

For instance, the development of a WTC to Oldtimer is usually incremental. A kk employee from the Project Department explains it as *"just being an update of a version 35 to a version 36"*. However, another employee from the same department emphasises that this "update" may prompt rather sweeping PD activities. In the same way, during a PD project, a great number of meetings are conducted. These meetings do not take place in an "empty space", but in various meeting rooms with different decor of furniture and IT systems, for

[8] kk strongly emphasises that the Oldtimer technical platform draws on a WTC-3 solution while the Newcomer platform draws on a PLC solution. Accordingly, it is not possible to reuse solutions across the two customer segments.

instance video conference facilities. From time to time, parts of these meetings take place in the production area. As an example, a casual cross-functional PD meeting conducted during the development of a WTC typically starts with a "round the table". Each of the employees brings along the necessary artefacts to illustrate their understanding of the present situation. All employees provide a brief status of their part of the PD and in this regard, they emphasise any problematic issues. The problematic issues are afterwards discussed by all the participants; if necessary, the employees go out into the production area to continue the discussions. During these dialogues, it becomes apparent that the employees have different levels of experience and/or understanding of the customer's needs.

The two PD projects and in particular the PD activities can be expected to demonstrate variety. The employees have different levels of experience, and the locations in which the PD activities are conducted vary. Accordingly, rather than being homogenous, the PD working practices are assumed to demonstrate heterogeneity. In addition, the involved employees are not a homogenous crowd; each individual has its own ability to understand and carry out the PD activities. In other words, the empirical understanding is that neither the employees nor the working practices are homogeneous.

Most likely, this diversity will influence the learning as well as the PD activities. Thus, a literature review will be conducted in an attempt to gain an understanding of the extant research on learning in a PD context.

## 2.3. Summary

The objectives of this chapter were to:

- learn about the focal business processes, the tone of communication and the technical terminology.
- to identify PD projects to be subjected to further data collection and analyses.
- to create an empirical understanding as a basis for conducting a literature review.

kk's business foundation is PD and production of WTCs. The WTC is a crucial system in a wind turbine and the fact that kk has been operating within this industry for three decades implies that it has a well-established business foundation. As regards the PD of a WTC, the two customer segments are handled differently; for instance, each of the two customer segments has its own procedure for conducting PD. Some terms as well as key components in the WTC are presented. The yaw turns the blades into the optimal position to the wind, the pitch has a strong influence on the output of the wind turbine and finally, the converter adapts the power output to a specific frequency. In this respect, the virtual stock principle is considered a crucial means to facilitate reuse of known technical solutions.

Two PD projects are identified as subjects for further data collection and analyses. Oldtimer is a well-known customer, for which reason a great many WTCs have been jointly developed in the past. Conversely, Newcomer is a new customer for kk, and additionally, this customer has not yet been able to develop and produce a workable wind turbine. It is expected that the two PD projects require different PD activities to be conducted, implying rather diverse PD forms of collaboration. This variety will most probably provide insight that will pave the way for examining the complexity of the learning process.

The PD activities take place in various locations with different facilities; be it in a meeting room or in the production area. The employees make use of these facilities, among other things artefacts and IT systems, to put forward his/her understanding of a specific PD activity to be carried out. The employees apply these facilities differently. In addition, the employees have different levels of experience as regards the PD of WTCs and demonstrate different levels of commitment to the task of carrying out a PD activity. Hence, neither the employees nor the working practices are homogeneous.

Apparently, this diversity influences the learning and PD activities. To become acquainted with the extant research on learning in a PD context and to clarify whether the empirical understanding above has been addressed previously, a literature review will be conducted. In addition, this empirical understanding is used to pinpoint the theoretical perspective being applied to study learning within a PD working practice after the literature review has been accomplished.

Before proceeding with the research, the methodological considerations in relation to this thesis need to be explained. This is the subject matter of the next chapter.

# Chapter 3. Methodology

The research draws on an interpretative paradigm. Originating from Burrell and Morgan's (1979) explications of various positions as regards the interpretative paradigm, American pragmatism provides the basis for bringing the abductive research strategy to the fore. The consequences of this research strategy are explained in order to improve the trustworthiness of the research.

The purpose of this chapter is to account for the methodological approach to the study of learning within a Product Development (PD) working practice.

First, metatheoretical issues are discussed; next, the abductive research strategy is presented in section 3.2, whereupon the quality of the research becomes a subject matter in section 3.3. Section 3.4 addresses the research design, section 3.5 the data collection, while section 3.6 sheds light on the pilot case and the preliminary analysis. The literature review is explained in section 3.7. Then, in section 3.8, the construction of the analytical framework becomes a focal point. Finally, section 3.8 presents the considerations in relation to the detailed analyses.

## 3.1. Philosophy/theory of science

Drawing on an epistemological perspective, Phillips (1995) discusses the many faces of constructivism. He emphasises *"there are so many versions of constructivism, with important overlaps but also with major differences, it is difficult to see the forest for the trees..."* (ibid. p.7). Adding the ontological dimension, it becomes complicated to keep an overview of the various metatheoretical positions. Fortunately, some authors have conducted categorisations in this regard by combining different assumptions of reality with various assumptions addressing how to grasp or gain knowledge of reality. Across various scientific communities, these derived metatheories are in general termed paradigms.

### 3.1.1. Natural science and social science in relation to a paradigm

Kuhn's concept of paradigm has greatly influenced the understanding of a paradigm (Bryman and Bell, 2007:25). Indeed, Arbnor and Bjerke (1997:13) acknowledge the contribution of Kuhn as instrumental for understanding the concept of paradigm. Yet, as Kuhn's interpretation of a paradigm is coined from the perspective of natural science and Arbnor and Bjerke operate within the sphere of social science, the authors emphasise a difference in this regard. They point out that, within natural science, an old paradigm is replaced by a new one after intense debate, while within social science, old paradigms usually survive alongside the new paradigms. Continuing in the same vein, within social science, a paradigm shift does not occur as an evolution of a new paradigm on the back of intensive discussions (Flyvbjerg, 2009:42); instead, the researchers within the particular scientific community abandon an extinct metatheoretical stance in favour of a new promising viewpoint. The lack of continuity between the extinct and the new promising metatheoretical stance is by Flyvbjerg regarded to be the main cause for the stagnation within social science.

Accordingly, natural science draws on an accumulation of experience regarding the assumption of reality and how to acquire knowledge of reality. In contrast, social science is characterised by a low level of coherence as well as a lack of accumulation of knowledge across various paradigms. This diversity of paradigms within social science becomes perceptible when reading Burrell and Morgan's (1979) construction of the phenomenon.

### 3.1.2. Paradigms within social science

Arbnor and Bjerke (1997) interpret a paradigm to consist of four components; these are: conception of reality (ontology), conception of science (epistemology), scientific ideals and ethics/aesthetics considerations. By combining the two former, ontology and epistemology, six different paradigms are identified. One extreme is constituted by an objective approach having a great many similarities to natural science, while the other extreme draws on a subjective stance in which reality is relativistic.

Burrell and Morgan (1979) draw on four assumptions dealing with ontology, epistemology, human nature and the nature of the methodology to construct a subjective-objective dimension. This subjective-objective taxonomy is combined with the extent of changes taking place within society; the two extremes being regulations and radical changes. This gives rise to four different paradigms. Given that the substance of this thesis is a micro-sociological phenomenon, the discussion below only addresses "the sociology of regulation", by which the two paradigms are interpretative sociology and functionalist sociology.

When examining these two paradigms, it becomes obvious that a great many versions of interpretivism[1] and functionalism[2] exist concurrently. The interpretative/functionalist dichotomy has much in common with the continuum proposed by Arbnor and Bjerke (1997). The former draws on a relativistic ontology and a subjective epistemology, while the latter regards reality as being concrete and real, thus reality becomes an external objective phenomenon.

In contrast to Arbnor and Bjerke, Burrell and Morgan's explanations of paradigms demonstrate that a great number of research paradigms[3] are prevailing. While Arbnor and Bjerke narrow down the discussions to three different approaches, Burrell and Morgan open up and thus unfold different research paradigms under the umbrella of, for instance, interpretivism.

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[1] The extreme position within the interpretative paradigm is termed "solipsism" (Burrell and Morgan, 1979:238). This viewpoint denies the existence of a Wind Turbine Control (WTC) in the production area; instead, the WTC is created endogenously in the individual's mind. Ontologically, the WTC does not exist beyond the perceivable sphere of the individual. This high level of relativism causes knowledge to be restricted to the individual's experience; the epistemology is subjective. Thus, the working practice within which the WTC is created only consists of terms and concepts being given in order to categorise reality.

[2] Drawing on an extreme position of a functionalist paradigm, the creation of a WTC system reflects the existence of an objective reality. The WTC being assembled in the production is real, and activities are conducted while I as a researcher am sitting in the office. Hence, the creation of the WTC is factual and thereby just as concrete as the natural world. As reality exists, it is possible to gain exact knowledge of the creation of the WTC. As a researcher, I have to apply an objective approach by, for instance, setting up a hypothesis. Data are afterwards collected and a painstaking analysis makes it possible to verify or falsify the hypothesis. This analytical approach means that the growth in knowledge is a cumulative process.

[3] The definition of a research paradigm is lifted from Blaikie (2010:96). He considers a research paradigm to be *"the source not only of theoretical ideas but also of ontological and epistemological assumptions."*. This definition has much in common with Arbnor and Bjerke's (1997) concept of methodology.

Originating from German idealism, Burrell and Morgan's (1979) explanation of interpretivism has at its one extreme "solipsism" and "hermeneutics" at the other. Ontologically speaking, the former adopts an extreme version of subjective idealism, while the latter advocates objective idealism.

Burrell and Morgan's (1979) illustrations of interpretivism bring into focus two similar research paradigms, namely those of situational ethnomethodology and phenomenological symbolic interactionism. These two research paradigms address an approach to study:

> *"the way in which social reality reflects a precarious balance of intersubjectively shared meanings, which are constantly negotiated, sustained and changed through the everyday interaction of individual human beings. Social reality is for them either reaffirmed or created afresh in every social encounter."* (ibid. p.253).

This viewpoint sheds light on social reality as the individuals' attempt to make sense of the social world in which they live and become. The ontological position is explained to be precarious (ibid. p.252); it is neither realistic nor relativistic. The epistemological position is subjective. The research-related challenges are not simply to identify the social reality as created by interacting individuals, but to explicate how social activities and individuals' actions are emerging and thus creating the social reality.

The worldview applied in this thesis is roughly speaking in line with Burrell and Morgan's illustration of the above interpretivist position. Nevertheless, some aspects need to be clarified, for which reason the explanation in the next section touches on all four assumptions proposed by Burrell and Morgan (1979) for interpreting a paradigm.

### 3.1.3. The applied worldview

If everything is socially constructed, and thereby only represent an endogenous projection of an imaginative social reality, I wonder how to combine the engineers' experience when creating a Wind Turbine Control (WTC) within a PD working practice. Accordingly, I consider the creation of a WTC to draw on a great number of experimentations and calculations of power, ampere, voltage, resistance and strength. The WTC exists, it is real, and the engineers apply various formulas to gain and create knowledge to facilitate the creation of the WTC. This ongoing and gradual creation takes place regardless of whether the researcher is present or not. Likewise, the creation is not merely a single PD activity; it is a web of PD activities conducted in various PD working practices decoupled in a time and space dimension.

**Ontologically**, I operate with the existence of external PD working practices (social realities) beyond my perceivable sphere.[4] Yet, the reciprocal interchanges within these external PD working practices will only have a constitutive effect if they become part of my perceivable sphere. That is, when I conduct observations or interviews within a particular PD working practice, I acknowledge that a number of other engineers are working on the WTC; however,

[4] The concept of perceivable sphere is discussed in sections 6.4 and 6.6.

unless it becomes part of my perceivable sphere, it does not have a constitutive effect in this particular situation.

As for the second and third assumption in Burrell and Morgan's (1979) paradigmatic taxonomy, I make use of a subjective **epistemology**. By referring to Burrell and Morgan's **human nature** continuum addressing the individual's free will to act versus contextual determinism, it becomes possible to be more specific regarding the epistemological position.

Determinism cannot be restricted to either the individual or the contextual setting – or to the relationship between these two entities, for that matter. The engineer is neither a passive individual being institutionalised by the PD working practice, nor is the engineer unrestricted to act on his/her own free will. Instead, it is a situational interpretation of the PD working practice that enables agency. The engineer and the PD working practice are evolving in a reciprocal interaction.

That is, the applied epistemological position is influenced by my background; practical as well as theoretical. I am aware of that when conducting the research. I make a point of being open-minded during the empirical and theoretical studies.

As it will appear from the conclusion of the literature review, American pragmatism is brought to the fore. This has a great impact on the **research paradigm**, the fourth assumption in Burrell and Morgan's paradigmatic taxonomy. Drawing on Dewey's (1938) version of pragmatism, a reflection originates from the indeterminate situation. However, this situational approach conflicts with the general position within German idealism that draws upon Kant's a priori approach to knowledge. According to pragmatism, reflection cannot be a priori to an empirical reality as put forward by Burrell and Morgan (1979:227).

> *"Whilst the world in which men live may be the product of a complex interrelationship between a priori knowledge and empirical reality, for Kant the starting point for understanding this lay in the realm of "mind" and "intuition". It is this basic, uncomplicated assumption which underlies the whole German Idealism."*.

As I regard the observation of an indeterminate situation to be the initiator of reflection, the application of the research paradigm has to be adapted to this. The next section addressing the applied research strategy sheds light on this.

## 3.2. Research strategy – the logic of inquiry

The two extremes in relation to the logic of inquiry are constituted by purely deductive and purely inductive research strategies. Bryman and Bell's (2007:11) definitions of the two logics of inquiry address the relationship between the empirical and the theoretical domain.[5]

[5] The focal point of Bryman and Bell's explanation is the nature of a theory. It distinguishes between whether data are collected to test the validity of a hypothesis/theoretical assumption or to build a theory. The deductive approach uses theories as tools or instruments to predict or to explain empirical phenomena. Briefly, the process of induction is opposite to that of deduction. It creates or modifies theories by using empirically derived data in order to make an analytical generalisation.

In his discussion of Dewey's pragmatic understanding of deduction and induction, Webb (2002:987-988) points out that neither of the two logics can exist in its purest form. Likewise, the first step in a deductive logic decouples the empirical domain, as the focus is to construct a theoretical hypothesis, which afterwards is empirically tested. Explicitly or implicitly, this results in a categorisation of and an artificial boundary encircling the empirical domain.

> *"Deduction does not really "see" anything at all as it serves a control office. Induction does not see anything new either for its main purpose is that of helping us to form habits of expectations."* (Bertilsson, 2004:377).

An inductive approach decouples the two domains as well. If you do not know what to look for within the empirical domain, everything seems to be interesting and the reflective thinking flutters in every which direction. As human beings, we need something to initiate and guide our reflective thinking, otherwise our thoughts stray aimlessly.

Drawing on pragmatism, Bertilsson (2004:384) emphasises that it does not make sense to separate the empirical from the theoretical domain and vice versa; in her words, *"theory and practice, cognition and action, knowledge and ethics..."* are inseparable for all pragmatists.

Accordingly, these two logics are rarely applied in their pure form; instead, various approaches lying between these two extremes are discussed, such as explorative integration (Maaløe, 2002:280), retroduction (Blaikie, 2010:87), systematic combining (Dubois and Gadde, 2002:556) and abduction (Bertilsson, 2004).

The differences between these four concepts are difficult to describe succinctly. Yet, the former, explorative integration, draws on an a priori approach to knowledge; a scenario is constructed from theories, after which this construct is gradually refined in an interplay between the empirical and theoretical domains. The retroductive strategy[6] focuses on establishing a hypothetical model of how structures and mechanisms institutionalise the working practice, while the systematic combining strategy creates a tight but evolving framework to facilitate matching between framework, data sources and analysis. These three approaches draw on an ongoing interplay between the empirical and theoretical domains, in which connection the focus of the two latter is to understand how structures and/or mechanisms constitute the working practise.

Abduction rejects the a priori knowledge approach, which is a central concept in the above explorative integration. Furthermore, the epistemological position of abduction is different. The abduction takes a "within perspective" to interpret how the social phenomenon evolves; a viewpoint which rejects institutionalism as well as the individual's free will to act. Shalin (1986) describes it as studying the "world-in-the-making" process, implying that *"the root of knowledge is not to be found in knowledge itself; it is to be sought in action."* (ibid. p.10). Likewise, Shalin draws on a transactional worldview positioned between the individual and the context to highlight another variation between idealism and pragmatism; the abductive logic regards human action to be *"constituted by, as much as it constitutes, the environment."* (ibid. p.11).

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[6] I am aware of the fact that Blaikie (2010:87) propounds two versions of the retroductive strategy. The one I refer to is the structural version. The other one, the constructivist version, seems to have much in common with the abductive approach.

Using the abductive logic makes it possible to achieve an understanding of how social activities, as for instance the engineers' doings when creating a WTC, are emerging within a PD working practice. The next section addresses the abductive logic applied throughout the thesis.

### 3.2.1. The abductive research strategy

Peirce is credited as the originator of abduction. He interprets novelty as something that gradually occurs by interrupting the continuity of time. Peirce takes as his point of departure a stance in which:

> *"the smooth operation of both deduction and induction in fact hangs on the "substance" nourished by abduction, abduction becomes the key inference. It informs us as to "why something is the way it is"."* (Bertilsson, 2004:376).

Peirce considers a "vague experience",[7] which has a certain impact, to arouse the human organism (an abduction). It initiates an empirical observation (an induction), which is followed by the creation of a working hypothesis to infer what is going on (a deduction). Yet, referring to Bertilsson (2004:385), Peirce's logic of abduction rejects dualism between theory and action, past and present, individual and context.

Referring to Miettinen (2000:64), Dewey further develops the logic of abduction to be applied within a social practice as a method for the individuals to understand real-life problems and not only as a purely intellectual endeavour. The transformation from Peirce's natural science to a social practice is not a straightforward process, as Dewey (1938) sees some limitations in the way this logic is used within natural science.

> *"The difference in their purposes is, perhaps, the biggest difference between Peirce and Dewey; Peirce focuses upon scientific, logical and mathematical inquiry while Dewey uses the insights from scientific inquiry as a resource for inquiry into practical problems of society and individuals."* (Webb, 2007:1070).

Despite the difference in purpose, Dewey's logic has much in common with Peirce's abduction. The trigger for the logic is an indeterminate situation (Peirce's vague experience), and just like Peirce, Dewey rejects any kind of dualism between, for instance, action and thinking, observations and creating working hypotheses, past and present, individual and context.

The starting point for the abductive logic is the empirical domain, within which the individuals live and become; in this regard, the individuals make use of the accumulated experience to interpret "what is going on".[8]

If applying the abductive approach as a research strategy, two issues have to be taken into consideration. First, it is crucial to ensure a continuation of the reciprocal interchanges

[7] Please refer to sections 6.1 and 6.3.1 for a clarification of the vague experience.

[8] Chapter 6 and in particular section 6.7 address this way of thinking, for which reason I kindly refer to these passages. Section 6.3 is an introduction to the pragmatic learning understanding and is thus instrumental in creating an overview.

between observations within the empirical domain and reflective thinking; the latter draws on the accumulated experience. Second, it is important to avoid accepting a stance or solution too early. Both circumstances will result in the abductive logic being cut short. With these two issues in mind, along with the Dewey quotation below, Weick's "Disciplined Imagination" (1989 and 2002) is introduced.

> *"The history of science also shows that when hypotheses have been taken to be finally true and unquestionable, they have obstructed inquiry and keep science committed to doctrines that later turned out to be invalid."* (Dewey, 1938:145).

### 3.2.2. Disciplined imagination as the means to guide the abductive strategy

When conducting research, the oft-heard advice is exemplified by the acronym *KISS*. It suggests that the researcher has to *Keep It Simple, Stupid*. Apparently, it seems to be a valuable advice to follow.

Yet, Weick's "Disciplined Imagination" (1989 and 2002) problematises this old saying. Weick (1989) draws an analogy between research and marine navigation by means of radar signals.[9] When navigating the ship through difficult waters, the captain cannot afford to ignore as much as one single artificial representation being depicted on the radar screen. He does not have the option of simplifying the working practice when navigating by rejecting or removing a group of these artificial representations of the reality. Imagine the consequences of rejecting the echo signals from a tank vessel when navigating through a vulnerable ecosystem! Obviously, he cannot afford to follow the *KISS* advice.

Weick (2002) points out a well-known phenomenon dealing with the fact that people who are most sure of themselves often are those who have the least information available. Such persons tend to avoid variations and diversities when collecting information, as it makes it possible to maintain a simpler picture of the world and thereby a continuation of actions (Weick, 1989:520 and 2002:S14). Weick (2002:S14) describes this phenomenon as:

> *"The mantra "keep it simple stupid" (KISS) may in fact mean, keeping it simple is stupid because it induces stupidity. It takes students of learning to spot the possibility that "kiss" may have the appearance of great strategy but the reality of terrible practice, and then to champion doubt, complication and wary simplification."*.

[9] *"Objects are more likely to be avoided and theoretical problems are more likely to be solved when the problem is represented more accurately and in greater detail with assumptions made more explicit, as a greater number of heterogeneous variations are generated, and as more selection criteria, of greater diversity, are applied more consistently to the variations that are generated."* (Weick, 1989:520). The term "objects" refers to other ships or dangerous items being depicted as artificial representations on the radar screen of the ship. In foggy weather or at night, the captain makes use of these artificial representations as means to navigate the ship and thereby avoid a collision with these dangerous objects. These representations guide the captain's doing. Referring to Weick, given that the individuals have a preference for guiding their doings based on safe interpretations, the captain does not take evasive action before it is too late. Conversely, if making the criteria for selecting among all these artificial representations more explicit and introducing a higher level of variation and diversity when interpreting these representations, the end result will be a more appropriate action on part of the captain. In other words, it will minimise the risk of colliding with the real physical object.

The applied abductive research strategy strives to follow the KISS advise, yet in a slightly different version, implying that I will **"Keep It as Simple as Possible"**. I will introduce[10] variations and diversities in an attempt to become an "agile theorist" (Weick, 2002). Therefore, the applied research strategy is regarded as an evolution process, which emphasises continuation of empirical observations and reflective thinking to ensure the incorporation of variations and diversities.

In an attempt to handle the above, Dewey's (1938) concept of an "end-in-view"[11] is used. An end-in-view keeps the researcher committed to reflective thinking and thereby ensures a continuation of the abductive logic towards a desirable outcome of the research.

Regarding this thesis, the applied end-in-view is to achieve a sufficient understanding of the empirical and theoretical domains to be able to present an answer to the research question. However, it is not merely a question of answering the research question. It is also a matter of answering it in such a way as to make the applied methodology and outcome of the research exposed to public examination and criticism; positive as well as negative. This issue will be discussed in section 3.3, which deals with the quality of the research.

Referring to Weick (2002), to be an "agile theorist" presupposes an ability to carry one's *"hypotheses lightly and be willing to drop heavy tools ..."* (ibid. p.S15). To live out this advice, I draw on Dewey's (1938) "means-consequence relation", which is discussed in section 6.7.1; the consequence part of this relation is often denoted the end-in-view.

Briefly, when carrying out abduction, the individuals' doings enter into the "means-end-in-view" relation, which facilitates to achieve an understanding of the phenomenon. In this regard, the means being applied to guide my reflective thinking towards the end-in-view are observations within an empirical domain (a PD working practice) and suitable theories retrievable from the theoretical domain. As the intention is to conduct an empirically driven research, *I look at the empirical domain by applying existing theories from the theoretical domain rather than seeing the empirical domain through theories.*[12]

To summarise, the research draws on interpretivism. The starting point for a reflection is an empirical observation. The abductive logic takes a within perspective, which paves the way for studying the "PD working practice-in-the making". This makes it possible to understand and analyse that the engineers and the PD working practice are evolving in a reciprocal interaction.

The next subject matter to be discussed is the quality of the research.

## 3.3. Quality of the research

Referring to Burrell and Morgan's (1979) dichotomy between a functionalist and an interpretivist paradigm, the quality criteria applied are rather diverse.

[10] If I reduce the variation and the diversity in an attempt to simplify the research, I fail to realise the full potential of the highly interesting empirical domain to which I have access.
[11] The term "end-in-view" is discussed in section 6.7.2. Briefly, it is a crucial means to guide the reflective thinking.
[12] The substance of this sentence, and thereby this perspective, draws on a presentation by Kristian Kreiner, March 2010, at Copenhagen Business School.

Turning to an extreme position within the functionalist paradigm, some researchers are advocating for objective quality criteria to judge/justify the quality of the research (Arbnor and Bjerke, 1997:233). That is, the criteria being applied to ensure coherence between the truth and the outcome of the research draw on objectivity, reliability and validity. Addressing the former, objectivity calls for an acknowledging subject whose understanding of reality is independent of time, context and personality. The criterion of reliability stipulates that, when reassessing a set of data, the results yielded must be identical to those of the initial assessment. Validity is a matter of whether the researcher measures the phenomenon correctly and thereby achieves an understanding of the truth. An example of a researcher within this paradigm is Yin (2003:34), who sheds light on four issues crucial for achieving a sufficient level of quality. The four issues are reliability and internal, external and constructed validity.

In contrast, an extreme position within the interpretivist paradigm rejects the existence of reality. The outcomes of a research consisting of concepts and theories are considered to be "representations", for which reason the quality criteria have to be in accordance with this (Bryman and Bell, 2007:415). The quality criteria to ensure coherence between the "truth" and the representations of the truth are the extent to which the researchers accept the outcomes of the research and the interpretations made (Arbnor and Bjerke, 1997:234).

The applied research strategy draws on pragmatism. Referring to pragmatism, experience is vital and growing (Dewey, 1933:277). To emphasise that experience (knowledge) is not rigid or static, Dewey (1938:15-16) prefers to denote the outcome of the inquiry a "warranted assertion". The warranted assertion including the research process that has generated this warranted assertion has to be testable for public inquiries as the *"Inquiry is the life-blood of every science…"* (Dewey, 1938:12).

As the outcome of the research process is a warranted assertion which has to be testable, neither the objective quality criteria (reliability and validity) nor the relativistic approach (acceptance and interpretation) can be used in this research.

Hammersley (2002) proposes to take a position between the two extremes and indicates that the *"Assessment of claims must be based on judgement about plausibility and credibility:…"* (ibid. p.73). Hammersley (2007:291-292 and 2009:16) further discusses how to interpret these two validity criteria and the focal point emerging is the likely validity of knowledge claims. Plausibility addresses whether or not these claims are in line with, or at least not incompatible with, the current interpretation of accepted knowledge claims. To support the presentation of evidence, credibility deals with a discussion of the likelihood of the research process being error-free.

Drawing on the work of Hammersley, I find it necessary to elaborate on the concepts of knowledge claim, compatibility with current theories (plausibility) and prevention of errors in the process (credibility).

### 3.3.1. Knowledge claim, plausibility and credibility in relation to the research strategy

Explaining **knowledge claim** requires an account of how I interpret the outcome of the thesis in relation to "the truth". In this regard, I appreciate Nonaka et al.'s (2000:7) discussion of "knowledge to be justified true belief", which triggers a problematisation of whether or not the outcome of the thesis is "true belief" or "justified belief".

It is my firm conviction that this research dealing with learning within a PD working practice does not make it possible to put forward "true belief". Hence, I am on par with Nonaka et al.'s interpretation regarding knowledge to be "justified belief". This viewpoint, which partly rejects the everlasting properties of knowledge, involves not accepting that the quality criteria are solely based on converging interpretations among actors within the particular scientific communities.

Nonaka et al.'s (2000) interpretation of knowledge to be "justified belief" has much in common with Dewey's (1938) pragmatic interpretation of knowledge and thus the applied research strategy explicated in section 3.2. In this regard, the outcome of an abduction is termed a "trial fact", which in addition is "provisional" (Dewey, 1938:117). Thus, in accordance with the pragmatic abduction, the terms "warranted assertion" and/or "experience" are preferred at the expense of the term knowledge which is too static and rigid.

The literature review in chapters 4 and 5 identifies four different theoretical perspectives regarding the phenomenon of interest. An assessment of **plausibility** calls for a comparison between the contribution of this research and the four theoretical categories. These comparisons are presented in chapter 11, for which reason I kindly refer to the theoretical implications in section 11.5 for an elaboration. Obviously, there are some limitations in relation to the contribution, which must be taken into consideration when assessing the plausibility. These limitations are explicated in the concluding chapter 12; section 12.2.

Drawing attention to **credibility**, the data collection draws on triangulation, which, referring to Bryman and Bell (2007:413), improves the credibility of an ethnographical research. Furthermore, Zickar and Carter (2010:305) and Van Maanen (2010:242) describe the role of an ethnographer to encompass much <u>fieldwork</u> and much <u>textwork</u>. Regarding the latter, Cunliffe (2010:231) considers a thick description of people's everyday life as a method for enhancing the credibility when drawing on ethnography. Hence, the description in chapter 8 dealing with the two PD projects and the analyses in chapters 9 and 10 are rather extensive.

In addition, the particular informant has validated applied quotations from the semi-structured interviews, which, all things being equal, improves the credibility. Likewise, kk-electronic (kk) has read and approved chapters 2 and 8.

Dewey (1938:12) emphasises the necessity of opening up the research process, thus paving the way for public examinations of possible errors in the research process. In the words of Henriksen (2003:66), one should strive to improve the transparency of the research. This includes an account of the logical progress throughout the research.

The intention of the following sections is to account for the logical progress throughout this abductive research. After presenting the research design and data collection, the main phases in the research are presented; i.e., the preliminary analysis, the literature review, the analytical framework and finally, the detailed analyses.

## 3.4. Research design

Some of the theoretical contributions addressing learning within a PD context are based on a quantitative approach. On the one hand, a quantitative research design makes it possible to include in the research a great number of informants across organisations, industries, national boundaries, etc. On the other hand, a quantitative research draws on an a priori approach to knowledge in relation to the empirical domain being analysed, which contrasts with the abductive research strategy. In addition, the construction of a survey will result in a decomposition of the phenomenon to be studied into a number of measurable categories. These properties of a quantitative approach preclude taking a "within" perspective on the phenomenon of interest.

Conventional case studies generally address the institutional level, while ethnographic case studies often focus on the individual or a small group of individuals (Harper, 1992:147). Single-sited ethnography paves the way for detailed observations and analyses of a particular setting. However, ethnography is not confined to single-sited studies (Van Maanen, 2010:244).

Multi-sited ethnography is used in two different ways (Neyland, 2007:68). One approach is to access multiple ethnographic field sites by, for instance, involving two or more focal companies in the research to obtain an understanding of learning within a PD working practice. The other multi-sited ethnographic method is to access one field site; i.e., one focal company. Within this focal company, the ethnographer follows the subject matter of the research through and between different organisational practices (Neyland, 2007:70), by which the engineers can be tracked across the different settings that make up their life worlds (Van Maanen, 2010:245).

Addressing the former multi-sited ethnography (two or more focal companies), the ethnographer selects a number of field sites to access. The intention is to achieve an in-depth understanding of what is going on within each of the selected field sites. According to Neyland (2007:71), this multi-sited ethnography makes it possible to achieve a more well-founded knowledge claim as compared with the other multi-sited approach. However, gaining access to a working practice is resource demanding (Bryman and Bell, 2007:444). Given that I have a well-established network of interesting companies, I was convinced that it would not be a problem to gain access to a PD working practice. Nevertheless, it took me more than eight months to access one interesting focal company on account of the high level of secrecy surrounding PD, normally prohibiting outsiders from access.

As for Neyland's (2007) other type of multi-sited ethnography (one focal company), the ethnographer moves between different working practices within the focal company. This multi-sited research is designed around chains, paths or the like. The ethnographer establishes some form of association or connection among the locations (working practices), which in fact defines the argument of the ethnography (Marcus, 1995:105). In this multi-sited ethnography, the propositions are not developed a priori, but emerge *"from putting questions to an emergent object of study whose contours, sites, and relationships are not known beforehand..."* (Marcus, 1995:102).

Applying abduction as a research strategy requires that the researcher is able to understand the manner of speaking and the technical terminology applied (Blaikie, 2010:90). In the same way, an ethnographer needs to spend much time within the PD working practice to obtain a detailed and profound picture of what is actually going on (Neyland, 2007:17). I.e., a multi-sited ethnographic case study is time-consuming; especially if accessing more than one focal company. This, in combination with the aforementioned challenges of accessing a PD working practice, gives preference to a multi-sited ethnography within one focal company.

Regarding the above-mentioned knowledge claim, some researchers advocate multi-case studies. Eisenhardt (1989:545) suggests having between four and ten cases in order to be able to draw analytical generalisations. Likewise, Yin (2003:47) describes the advantages of including six to ten cases to make the study more robust. This analytical generalisation draws on a replication logic (Yin, 2003); each case must be carefully selected to either predict similar results (literal replication) or contrasting results (theoretical replication).

If this replication logic is the applied criterion for determining the number of cases to be included in the research, it will result in a homogenisation of the cases. All things being equal, an increasing "theoretical saturation" (Bryman and Bell, 2007:460) causes all subsequent cases included to be studied through this accumulated understanding; in other words, an a priori understanding of the subsequent case(s) included emerges, reducing the potential to learn from the case(s).

The replication logic (Yin, 2003) addresses a comparison between the cases; either a literal or a theoretical replication. Referring to Stake (2000:444), this comparison logic obstructs the opportunity to learn from the case(s). As the intention is to learn as much as possible from the empirical studies, the replication logic is not applicable in this research.

Likewise, I wonder how it is possible to achieve a sufficient understanding of a PD working practice when staying outside the empirical domain. In the same way, how do you determine whether you are facing a critical or an extreme case (Yin, 2003:40) to justify a single-case design without an in-depth/sufficient understanding of the PD working practice?

Thus, Marcus' (1995) multi-sited ethnography within one focal company is selected. The intention is to gain extensive access to PD working practice(s) in an attempt to optimise the learning opportunities from the empirical work. Thus, kk is the (only) focal company of the research.

In this research, the focal point for the study of learning is to grasp how a PD activity unfolds within a PD working practice. Marcus (1995) suggests six different approaches to design a multi-sited ethnographic research. One of these is to "follow the thing" (ibid. p.106). Selecting a PD project as the thing to be followed makes it possible to study how a PD activity unfolds within different working practices. In other words, the PD activities to be researched are identified within kk, be it within interorganisational, cross-functional and/or daily working practices.

Drawing on Shalin (1986:10), for the realist, reality is ready-made and complete, while for the pragmatist, reality (the PD working practice) is still in its making. This implies that it is necessary to postpone the selection of the PD project(s) to be included in the research until sufficient understanding has been achieved; in the words of Marcus (1995), the identification of the thing to be followed is postponed.

Accordingly, the research process has evolved along the way. On the one hand, this has had implications for the efficiency in relation to my research, making it more time-consuming. On the other hand, it has also resulted in opportunities and, from time to time, I have been lucky to be at the right place at the right time.

The next section sheds light on the selection of the PD projects and cases to be included in the research.

### 3.4.1. Selection of PD projects and cases

Having decided on the multi-sited ethnography within one focal company and the "thing to be followed", next is to decide on the number of PD projects to follow and cases to create.

Figure 3.1 presents a timeline illustrating the identification of two PD projects and four embedded cases. The light grey area of the figure addresses the research activities in the preliminary phase, while the dark grey area indicates the activities in relation to the detailed analyses; the method for data collection depicted at the centreline is explained in the next section 3.5. As it appears from the figure, the selection of the PD projects and cases is postponed in order to achieve a sufficient level of understanding before restricting the data basis for the research.

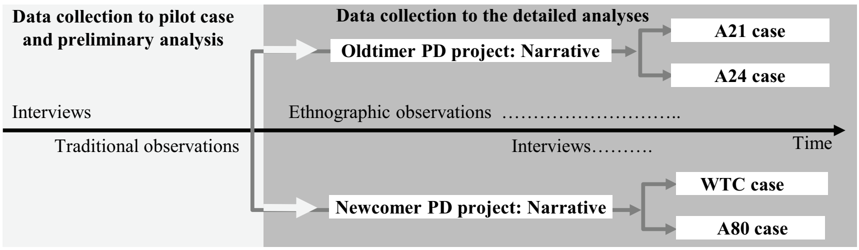


Figure 3.1. The two PD projects and the cases.

Flyvbjerg (2006:228) indicates that it is possible to generalise on the basis of a single case study. Despite some labelling Yin as an exponent of positivism, Yin (2003:39) takes a similar approach and puts forward five rationales in support of a single case design. All of these deal with the nature of the case being either critical, unique, etc. Stake (2000:437) explains three types of case studies. An intrinsic case is interesting in itself. The instrumental case is a particular case providing insight into a phenomenon. The two types of case studies, however, are extremes on a continuum; i.e., there is no line distinguishing these. The third type is the collective case study, which is a kind of instrumental case study drawing on several cases.

However, the preliminary analysis does not reveal any intrinsic, critical, unique or extreme case to justify the selection of only one PD project.

Drawing attention to the discussion of the multi-case study in the previous section, this approach regards the generalisability of a case to be related to what can be learned from the particular case. What can be learned from the particular case is related to whether the case is like or unlike other cases; i.e., the replication logic.

Stake (2000:444) considers this comparison logic as *"actually competing with learning about and from the particular case."*. Stake suggests incorporating case(s) from which we expect to learn the most.

The selection of PD projects and cases are in line with Stake's approach. In other words, the opportunity to learn is a crucial parameter in the selection process. Incorporating diverse PD projects paves the way for a well-founded empirical understanding, making it possible to identify and analyse the characteristics enabling or constraining the learning process.

The criterion for selecting the PD projects and the cases to be created draws on Stake's collective case study approach. The focus is to search for variety among the selected PD projects and cases. I appreciate Stake's (2000:447) final sentence in the section dealing with case selection in which he points out *"opportunity to learn is of primary importance."*.

The preliminary analysis outlines two PD projects to be subjected to further examinations, namely those of Oldtimer and Newcomer. Subsequent ethnographic observations with regard to these two PD projects and the accomplishment of interviews make it possible to draw up two narratives and four embedded cases. Yet, rather than being a sequential process as illustrated in figure 3.1, it has been an iterative process involving data collections, creation of the analytical framework and preliminary analysis.

Focusing on the identification of the PD projects as well as the drawing up of the narratives and embedded cases, the intention is not to prepare for a comparative analysis. Instead, the objective is to achieve a broader and more well-founded understanding of the empirical phenomena and thereby *"reduce the likelihood of idiosyncratic findings."* (Pentland, 1992:534). Stake's (2000) variety criterion for identifying instrumental cases is used.

The considerations forming the basis of the selection as well as the presentation of the narratives aim to improve the understanding of the composition of an interorganisational, cross-functional and daily working STP. In this regard, the PD with Oldtimer draws on three decades of close collaboration, while Newcomer is a new customer.

Addressing the selection and description of the four embedded cases, the criteria applied facilitate analyses dealing with how the indeterminate situations turn up as well as how the engineers transform the indeterminate situations into determinate situations. As for the selection of the two Oldtimer and two Newcomer embedded cases, the intention is to enhance the empirical understanding and thereby the learning opportunities of the two PD projects. By bringing the trajectories to the fore, it becomes evident that:

- ➢ The trajectories charted in the two Oldtimer embedded cases are continuously aligned. Despite this ongoing adjustment, the engineers have to make an effort, as the specifications of the A21 are too obdurate while the specifications of the A24 occasionally are too ductile to enable a continuation of the learning process.

- The trajectories of the two Newcomer embedded cases are subjected to a radical change after signing the contract. The two cases, however, differ from each other. Regarding the WTC case, the trajectory deflects just after signing the miniTS, while the A80 trajectory is radically changed after signing the TS-document.

The two narratives do not have a common structure; yet, each narrative addresses the tasks to be handled by the employees as well as the various STPs for conducting these PD activities. The presentation of the narratives is thematic as the intention is to shed light on the composition of the various STPs.

The four embedded cases are more narrow in scope. Unlike the narratives, the presentation of each of the four embedded cases follows a chronological timeline, making it possible to identify the unique trajectory.

By doing so, the composition of the various STPs as well as the trajectories illustrated in the embedded cases becomes perceptible, which paves the way for analysing the characteristics enabling or constraining the learning process.

The next section sheds light on the data collection.

## 3.5. The data collection

The data collection consists of observations and interviews. These are accomplished in the period from January 2009 until January 2010. On average, I visited the company three full working days each week in this period. The data collection is divided into two phases.

The **explorative phase** takes place from January 2009 until May 2009. The data collection method employed is traditional observations, small talk in the open-plan office and production area as well as individual and group interviews with 14 employees.

Prior to and during the period in which the unstructured interviews are conducted, I benefit from collaborating with a gatekeeper who helps me identify the informants to be interviewed. The criteria used for selecting the informants imply that different hierarchical levels and all functions influencing PD are represented. The interviews are not taped; instead, I take notes. Immediately after each interview, a detailed summary is written.

In addition, I participate in four meetings, including a video conference with the Polish subsidiary. During these meetings, I am careful to assume the role of a complete observer (Bryman and Bell, 2007:454). Notes dealing with the content of dialogues are written down; immediately after the meetings, a summary is made.

I have a desk in the middle of an open-plan office available to me.[13] When sitting at the desk, I participate in small talk and observe what is going on around me. In this regard, notes are continuously made. As it appears from the next paragraph, the preliminary analysis enables me to identify two PD projects, Oldtimer and Newcomer, which are in focus during the second phase of the data collection.

[13] To set the record straight, I was not involved in the daily business activities taking place around me.

The **second phase** is conducted from May 2009 until January 2010. During this period, I participate in 56 meetings, accomplish 16 semi-structured interviews and a desk is available to me in two different open-plan offices. Frankly speaking, in this period, my office at the university is relocated to kk; being an ethnographer calls for lengthy and sustained fieldwork (Van Maanen, 2010:242), which from time to time may prove problematic as people initially are prone to wonder and suspicion. However, only in one meeting,[14] did I notice distance and hesitation in the beginning. After explaining the purpose of my participation, it disappeared. Addressing the semi-structured interviews, the first period of nearly all interviews is characterised by the informant demonstrating thoughtfulness and/or hesitation. It might be due to the fact that the interviews are taped, which I obviously ask for permission to do. Except for one of the informants, this hesitation fades gradually away during the interviews.

In this second phase, the collection of data is deliberately divided into two steps. Ethnographic observations are conducted throughout the period, while the semi-structured interviews are conducted from 16 November until 14 December 2009. By postponing the interviews to the end of the data collection period, it is possible to take into consideration the acquired in-depth understanding of the two PD projects when constructing the interview guides. Thus, each of the interview guides is tailored to the informant in question, for which reason none of the 16 semi-structured interview guides is identical.

The identification of informants draws on two considerations. First, the ethnographic observations unearth some aspects of doings within the STPs that seem to be beneficial for subsequent analyses. Second, by taking the role as a complete observer (Bryman and Bell, 2007:454), I identified the employees who influence the STPs in relation to the potential subject matter for subsequent analyses. Thus, the group of informants is deliberately restricted to employees who either directly influence or are directly influenced by the particular STPs.

The identification of the STPs for conducting the ethnographic observations differs for the two PD projects. Regarding Oldtimer, the two kk project managers forward all notices of meetings directly to my e-mail address, be they interorganisational and cross-functional meetings. In the Newcomer project, I have to be more proactive and in this regard, I make use of my network to be mindful when a meeting is planned. As I am normally sitting next to the project manager and the engineers, it is not considered a problem to get access to the interorganisational and cross-functional meetings.

The duration of the meetings varies from 15 minutes to more than 8 hours; on average, they last approx. 95 minutes. None of the meetings are taped. Instead, all observations are recorded directly in an MS Word document by using a laptop; for instance, the dialogues among employees, body language, how they use artefacts, mobile phones, laptop, blackboard, characteristics of the room, whether or not the IT network runs, is a person reachable by the mobile phone, etc. In particular, the observations address the indeterminate situation initiating the PD activity and how this specific situation unfolds within the STP. For instance, do the engineers succeed in handling the indeterminate situation? Moreover, as this is a longitudinal study, I am very aware of whether this specific subject matter has been an issue previously, providing the basis for an analysis of the sustainability of the achieved determinacy.

[14] The agenda of this meeting conducted 16 September 2009 is Intellectual Property Rights.

After each meeting, I type up the observations and make a note of my spontaneous reflections. In this regard, the size of the MS Word document averages 42 KB, corresponding to 5 standard pages.

All 16 semi-structured interviews, eight from each of the two PD projects, are taped and 80% are transcribed by myself. On average, the length of each interview is 60 minutes. All quotations being applied have been sent to the informants for verification as well as for ethical reasons.

## 3.6. Pilot case and preliminary analysis

The pilot case and preliminary analysis are created while I am sitting at the desk in the open-plan office at kk. The intention is to be inspired by the working practice when conducting this part of the research.

In relation to this preliminary phase of the research, the phenomenon of investigation is rather loosely defined. Yet, it addresses the composition of various STPs that unfold in consequence of PD collaboration with different customers. In striking contrast to the "within" perspective applied in the detailed analyses, this preliminary analysis takes an "outside-inside" perspective on the composition of the STPs. Another contrast is the unit of analysis, which in the detailed analyses is the PD activity within an STP. In this preliminary analysis, the unit of analysis is the working relationship with a customer.

The intention of the preliminary analysis is triple. First, the purpose of the analysis is to facilitate an identification of potential PD project(s) to be the focal point(s) for the detailed analyses and furthermore, to pave the way for getting access to these STPs. Second, the preliminary analysis has to impart a pre-understanding of the phenomenon. In this regard, it is crucial for me to internalise the everyday language and working routines applied by the engineers. This calls for an understanding of the everyday abbreviations as well as technical/social expressions.[15] Third, to ensure coherence as well as a common thread in the literature review, a working hypothesis is derived by comparing the preliminary analysis with the research question of the thesis. This working hypothesis guides the construction of the review framework as well the literature review.

## 3.7. Literature review

Referring to Tranfield et al. (2003:209), a systematic review differs from a traditional narrative review in that it adopts a replicable and scientific methodology, causing a transparent review process. However, Hammersley (2001:547) is searching for evidence to support that a systematic review produces more valid conclusions than a narrative review. In line with this viewpoint, Bryman and Bell (2007:104-105) consider it to be inappropriate to structure the review too much if the intention is to achieve an understanding rather than accumulate knowledge of a phenomenon.

In this thesis, the purpose of the review is to obtain an understanding, rather than accumulate knowledge, of learning in a PD context. Nevertheless, drawing on Weick

[15] Examples of everyday abbreviations: MiniTS, TS, ePM, FAI, DFIG, FFIG, A21, Mo215362. Examples of technical/social expressions: "The strategy for…", virtual stock, yaw, pitch, converter.

(1989:516), the construction of a framework for conducting the review and the performance of the literature review have to be as explicit as possible. Thus, the review consists of four iterative phases:[16]

1) Framing the literature review. Please see sections 4.2-4.4.
2) Including a theoretical contribution in the review: the selection process. Please see sections 4.1 and 4.5.
3) The review process and interpretation. Please see section 5.1.
4) Presentation of the literature review. Please see sections 5.2-5.6.

The next section addresses the construction of the analytical framework.

## 3.8. Construction of the analytical framework

The analysis of the literature is compared with the above-mentioned preliminary analysis, by which a gap in the literature appears. It brings to the fore American pragmatism, which rejects the individuals' unrestricted free will to act as well as contextual determinism. The constitutive means to guide the individuals' interpretations and doings are social as well as technical. This viewpoint draws on an understanding that regards *technology to be shaped by social interaction and simultaneously society shaping*.

The creation of the analytical framework draws on three pillars. The first is American pragmatism, which is instrumental in rendering visible the applied learning understanding. The second draws on PD theories, which consider the creation of a new product to take place within an STP; in this STP, social and technical elements are inseparable. The third pillar is inspired by the work of Pentland (1992), who employs Goffman's concept of doings and American pragmatism to interpret and analyse learning within a technical service centre.

The parallel data collection in relation to the Oldtimer and Newcomer PD projects transpires to influence my interpretation of the analytical framework. Thus, the creation of the analytical framework has been an iterative process, causing many concepts/terms to have been either removed or concretised late in the process. This approach is in keeping with my intention to "look at the empirical domain by applying existing theories" as emphasised in section 3.2.2.

The last subject matter to be discussed in this methodological chapter is the analytical approach.

## 3.9. Detailed analyses

Roughly speaking, the analyses are divided into three phases. The first two phases address identification and understanding of the characteristics enabling or constraining the learning process. The research is empirically driven, for which reason the ambition is to learn as much

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[16] This division into four phases draws on the work of Tranfield et al. (2003:214-219) and Randolph (2009:4). However, I acknowledge the advices from Hammersley (2001) and Bryman and Bell (2007) with regards to avoiding too much structure in the process.

as possible from the two PD projects. Due to varieties between the two PD projects, the PD in collaboration with Oldtimer and the PD in collaboration with Newcomer are analysed separately. A comparative logic would have reduced the opportunity to learn from each of the two PD projects (Stake, 2000:444). In the third phase, a cross-analysis is conducted. Again, the objective of the cross-analysis is to learn from both the analysis of Oldtimer and the analysis of Newcomer, rather than strictly comparing the two analyses. Thus, the cross-analysis gathers the threads from the analyses of the Oldtimer and Newcomer PD projects in an attempt to make visible the implications of the research.

In the first phase, the focus is on achieving an overview of all ethnographic observations and semi-structured interviews; the intention is to be inspired by scrutinising the collected data. I slavishly read all 56 MS Word documents containing the ethnographic observations as well as the 16 transcribed interviews. From time to time, it is necessary to listen to the taped interviews in order to understand the essence of a sequence from an interview. I make a great many drawings, either by hand or in MS PowerPoint, to guide my analytical (reflective) thinking. Although the majority of the drawings turn out to be worthless, this (visual) abduction facilitates to create two rather simple types of displays to code the data. 14 displays are created.

By examining how a PD activity unfolds with an STP, the analytical framework paves the way for grasping that the individual and the STP are evolving in a reciprocal interaction. A PD activity is regarded as a PD strip of doings. The analytical framework facilitates to analyse a single doing. Thinking is an element in the doing. It is not a step-by-step thinking-and-doing process, but a thinking-in-doing process. This thinking-in-doing process does not take place in an empty "space", but within the composition of the STP when engineers conduct a PD activity – a PD strip of doings. In this regard, the composition of the STP influences the engineers' thinking-in-doing and the STP is influenced by the engineers' thinking-in-doing.[17]

The above displays and analytical framework form the basis for the analyses in the second phase. The analyses of Oldtimer and Newcomer are divided into two parts. The first part of the analyses is thematic. The focal point is to identify and analyse the characteristics enabling or constraining learning when conducting a PD strip of doings within an interorganisational, cross-functional or daily working composition of the STP. The second part of the analyses is chronological. It focuses attention on a sequence of events to understand how the engineers are conducting a PD strip of doings within different composition of the STP.

During the analysis I place my *"best intellect into the thick of what is going on."* (Stake, 2000:445). In line with Stake, in a multi-sited ethnography, the "what is going on" is not developed a priori, but emerges along the way (Marcus, 1995:102). Thus, to understand "what is going on" and thereby identify the characteristics enabling or constraining the learning

[17] *"The individual is not a 'free agent' or subjugated to the community, but may or may not be committed to participate in events as part of the organizational life and practice. This is an empirical question that can only be answered by mapping the **trajectory** and **conditional matrix** of a specific situation or organizational event."* (Elkjær, 2004:429).

process, the following subject matters gradually become the means to guide my reflective thinking:

- In the first part of the analysis, the gradually emerging subject matters are the constitutive means and their different roles in relation to the composition of the STP.
- As for the second part of the analysis, the gradually emerging subject matters are the anchoring of the indeterminate situation and the continuation of the strip of doings.

The analyses of Oldtimer and Newcomer reveal characteristics of the enablers and constraints. During the analyses, a categorisation of the enablers and constraints for the learning process gradually emerges. The enablers and constraints are categorised into the **composition of the STP**, the **anchoring of the indeterminate situation** and the **continuation of the strip of doings**.

As for the third phase, the cross-analysis is designed to learn from (Stake, 2000) and thereby build on the analyses of Oldtimer and Newcomer. Thus, the analyses of Oldtimer and Newcomer, including the data collections in this regard, form the basis for the cross-analysis.

The bridge-building between the analyses of the two PD projects and the cross-analysis conducted in this third phase is constituted by the categorisation of enablers and constraints into the **composition of the STP**, the **anchoring of the indeterminate situation** and the **continuation of the strip of doings**. The anchoring of the indeterminate situation becomes central in the cross-analysis. The anchoring of the indeterminate situation is influenced by and simultaneously influences the composition of the STP. In the same vein, the anchoring of the indeterminate situation charts the course for a continuation of the strip of doings.

### 3.10. Summary

The purpose of this chapter was to account for the methodological approach to the study of learning within a PD working practice.

The research draws on an interpretivist metatheoretical position. The research strategy originates from an abductive logic. The discussion addressing the quality of this multi-sited ethnographical research accounts for the concepts of plausibility, credibility and knowledge claim. The research design reflects the selection of a multi-sited ethnography within one focal company. Two PD projects, and thus two narratives, are selected; each of the two narratives includes two embedded cases. The data collection is conducted in two phases. As for the preliminary analysis, traditional observations and unstructured interviews are conducted, while the detailed analyses draw on ethnographic observations and semi-structured interviews. The chapter gives an account of the preliminary analysis, literature review, construction of the analytical framework and the detailed analyses. As for the detailed analyses, the research is empirically driven. Neither the analyses of the two PD projects nor the cross-analysis draws on a replication logic as the ambition is to learn as must as possible from the empirical part of the research.

The next two chapters address the literature review. First, the framework for conducting the analysis is illustrated, whereupon the literature review is conducted.

# Chapter 4. Framing the literature review

A literature review is conducted to acquire a theoretical understanding of how learning occurs in a Product Development (PD) context. The intention of the review is to gain a broad overview of the literature and the various prevalent perspectives of learning in a PD context.

This chapter creates a framework for conducting the literature review addressing learning in a PD context. The framework takes as its outset a discussion of learning and PD literature, respectively. By combining these discussions, four categories dealing with learning in a PD context appear. While this chapter creates the framework, chapter 5 presents a review of the literature in line with this framework.

The objectives of this chapter are to create a framework for a categorisation of the literature being reviewed in the next chapter and to explicate the selection process.

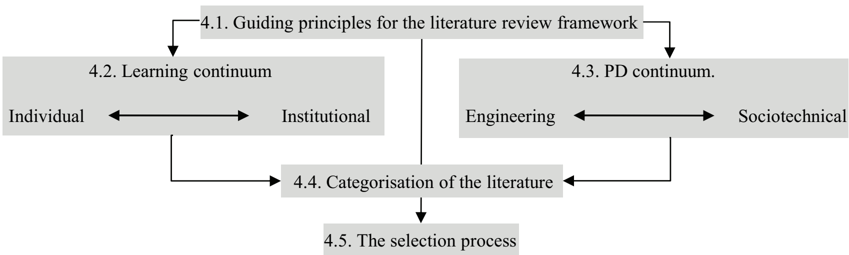


Figure 4.1. The structure of the chapter.

As it appears from figure 4.1, the chapter starts with a discussion of the guiding principles for the literature review framework. Then, the learning and PD continuums are discussed in sections 4.2 and 4.3, respectively. The subject matters for these discussions focus on identifying and categorising theories. Section 4.4 draws on these discussions and presents the categorisation that will be applied to conduct the literature review in chapter 5. Finally, section 4.5 makes use of the guiding principles from section 4.1 to shed light on the selection process in order to include a theoretical contribution in the literature review.

## 4.1. Guiding principles for the literature review framework

A literature review aiming to generate understanding rather than accumulate knowledge is normally wide-ranging in scope for which reason it is not appropriate to overly structure the literature review and the searching process (Bryman and Bell, 2007:104). A viewpoint shared by Hammersley (2001:548-549) and MacLure (2005:394); the latter, however, recommends explaining what the review *"looked for"* (ibid. p.408).

A theoretical contribution is an artificial representation of reality describing, for instance, learning in a PD context. And, at present, I do not have a sufficient overview to reject part of these artificial representations. The question is: Should I simplify the literature review process and thereby run the risk of missing some valuable theoretical contributions, making me resemble the captain of the ship (in the imagery of Weick (1989:519)) who ignores some artificial representations of reality depicted on the radar screen; of course not.

### 4.1.1. The working hypothesis

Weick (1989) considers the development of a theory to be an evolutionary process that has to be as explicit as possible. Hence, when building a framework, it is necessary to ensure syntactic coherence as well as to be aware of the fact that a subjective epistemology gives rise to various interpretations.

To follow the above advice, a working hypothesis[1] is created. The preliminary analysis in chapter 2 addressing the two PD projects provides some cues regarding learning and PD. Combining this understanding with the research question addressing the literature review presented in chapter 1 produces a working hypothesis **to guide the literature review**.

> *"Product development is an "**enabler**" for the learning process. The learning process emerges, resulting in a specific learning content. The learning process addresses "**how** learning takes place", while the learning content addresses "**who** learns" and "**what** is learned".*

The four bold key words in the above working hypothesis will act as the means to discipline my imagination (Weick, 1989 and 2002). That is, when reading and analysing the literature, I will "look for" (MacLure, 2005:408) how the particular researcher conceptualises the *"how, what, who and enabler"*.

### 4.1.2. Different kinds of theories

Flyvbjerg (2009) emphasises that, so far, social science has not contributed with either genuinely explanatory or predictive theories. Referring to Flyvbjerg, social science continuously imitates natural science in that *epistemic* theory becomes the pivotal issue. By focusing on episteme, social science follows the same rules as applied by natural science when establishing the quality criteria for research. An epistemic approach insists that a truly explanatory and/or predictive theory has to be independent of the contextual setting. I.e., the epistemic social science theories used to explain and to predict draw upon abstract and contextually independent elements (ibid. p.51). A viewpoint which Flyvbjerg rejects. Instead of drawing on epistemic-scientific ideals, Flyvbjerg suggests to apply *phronesis* as the methodological approach to study social science. The objective of phronetic research is not to produce explanatory or predictive theories, but to generate inputs to the ongoing societal dialogue and practice (Flyvbjerg, 2009:164).

Beyond doubt, social science has produced a great amount of theories following these *episteme* criteria. Some of these have been conducted by taking a qualitative and/or quantitative approach and the combinations of quality criteria applied in such research are multifarious. Likewise, the majority of the research is to a greater or lesser extent empirically anchored; a few, however, are purely conceptual contributions.

[1] Referring to the abductive logic, a working hypothesis is the result of reflective thoughts drawing on observations. The working hypothesis is constantly challenged as subsequent observations might necessitate that changes be made to it. Hence, I am prepared to *"carry [my] hypotheses lightly and be willing to drop heavy tools in order to become [a] more agile theorist…"* (Weick, 2002:15).

In any case, although I acknowledge Flyvbjerg's viewpoint, the main purpose of the literature review is to open up instead of narrow down and thereby improve my understanding of the prevalent perspectives in relation to learning in a PD context. Accordingly, this literature review will not exclude any scientific work due to its scientific position, its methodological approach or, for that matter, the purpose of the research.

#### 4.1.3. To summarise - the overall guidelines for the framework

Given that theories can be considered as other representations of reality (Weick, 1989:520), the review framework has to span and thus include various interpretations of realities. Furthermore, the theoretical domain is not narrowed down, therefore the review framework must be able to handle research using various methodological approaches as well as research with different purposes, e.g. to prescribe, to describe, to predict, to explain[2] or to ensure the ongoing dialogue in society.

The two building blocks laying the foundations for the categorisation of the literature are learning and PD. However, what are the substance and extremes of the continuums within each of these two domains? These subject matters are discussed in section 4.2, in which the learning continuum is the focal point, while section 4.3 engages in a similar discussion dealing with PD. Section 4.4 presents the applied categorisation.

## 4.2. The learning continuum

Fenwick (2008) conducts a literature review focusing on the individual-collective aspect of workplace learning. She identifies eight distinct orientations that address the relationship between the individual and the collective as recipients of learning. The one extreme describes the relationship as individual knowledge acquisition. This viewpoint draws on the assumption that the individual's knowledge acquisition is cognitive; a psychological orientation to the learning mechanisms. The other extreme, however only number seven on Fenwick's continuum, considers learning to be community-of-practice, at the heart of which are the social/cultural aspects; a sociological orientation to the learning mechanisms. The extreme on Fenwick's continuum, the eighth orientation, regards learning as co-participation or co-emerge. This learning orientation holds the individual and the social/cultural aspects to be inseparable.

[2] Looking up the word theory in an English dictionary, The Free Dictionary, a theory is described as a set of statements devised to *predict* facts or phenomena. For instance, the pricing of the new product to be launched in a market characterised by perfect competition draws on the equilibrium between supply and demand. Bryman and Bell (2007:7) look upon theory as an explanation to observed regularities, by which a theory becomes a means to *explain* a phenomenon. An example is the employment of various economic or behavioural theoretical models to deduce the crux of the present recession. By comparing these two rather instrumental definitions, theory is considered as a tool to *predict* and/or *explain* an empirical phenomenon. This indicates the presence of a time dimension; a theory has an ex post and/or an ex ante function. Furthermore, a theory can be *prescriptive*; e.g. the establishment of an organisational structure facilitating a learning organisation as proposed by Senge (1990), or it can be *descriptive*; e.g. vocational learning when getting access to the community of practice through Legitimate Peripheral Participation (Lave and Wenger, 1991). As to the former, the theory becomes a cookbook for consultants when creating a learning organisation. As to the latter, the intention is to understand, interpret and thereby add new elements to the existing theories.

The above individual knowledge acquisition (psychological orientation) draws on a cognitive learning theory. This orientation can be traced back to 1929 when Bode, a German gestalt psychologist, challenged the behaviourist learning orientation. The Gestalt view of learning is labelled "cognitive or information-processing" and it draws on two assumptions: First, the memory system is an active organising processor of information and second, prior knowledge plays an important role in learning (Merriam et al., 2007:285). The individual is at the cornerstone of this orientation. This viewpoint sheds light on *individual learning mechanisms*.

Fenwick's (2008) analysis of the learning literature labelled community-of-practice considers learning as:

> *"people's participation in CoPs, which in turn shape their identities."…"The view is cultural."* (ibid. p.235).

The central point within this sociological learning orientation is to bring the contextual setting to the fore in order to understand the learning process. It is a viewpoint drawing on *institutional learning mechanisms*. In other words, rules, cultures and/or structures enable learning. This learning orientation can be traced back to Vygotsky (1896-1934), who is credited for developing the foundation of this view indicating that:

> *"learning is socially mediated through a culture's symbols and language, which are constructed in interaction with others in the culture."* (Merriam et al., 2007:292).

### 4.2.1. The two extremes on the continuum

Given that the intention is to identify the learning continuum, the above-mentioned taxonomy proposed by Fenwick (2008) is challenged. The co-participation or co-emerge orientation does not represent an extreme. It is a learning orientation aiming to bridge the two extreme epistemologically constructivist stances.

By way of example, Pentland (1992:527) draws on pragmatism to build a bridge between the "Ghost and the Machine". The ghost represents the cognitive learning orientation (individual learning mechanisms), while the machine is a metaphor for the institutional learning mechanisms. Likewise, Fenwick (2008:236) describes this understanding of learning as knowledge creation through social participation. It is a reciprocal interaction between the individual – its upbringing from child to present – and the collective consisting of social structures, cultural factors and other individuals. Thus, this co-emergent learning orientation focuses on a reciprocal interaction between endogenous learning mechanisms and exogenous learning mechanisms.

Elkjær (2004 and 2005) is credited for developing the "third way of learning"; a learning orientation in line with the above-mentioned co-emergent perspective as well as the "Ghost and Machine" metaphor. Elkjær (2004 and 2005) as well as Elkjær et al. (2007:22) illustrate a similar taxonomy among the learning theories and identify three different ways of learning. However, only the first and second way of learning will be explained[3] below.

A group of learning theories compares the individual's mind to a container. This first way of learning is in line with Fenwick's (2008) "individual knowledge acquisition". Knowledge is understood as a substance (*what* is learned) and the learning theories describe *how* the substance is transferred and added to the individual's mind (*who* learns). Indeed, Elkjær (2004) also denominates the "first way of learning" the acquisition metaphor. Learning theories drawing on this stance consider the organisation as a system divided into at least two subsystems; the individual and the organisation (the context). These subsystems can be studied separately. Learning theories adopting this cognitive/psychological orientation focus on the individual in the effort to understand the learning process.

The other extreme, the social and cultural learning theories, uses social processes and the social environment as facilitators for learning; in Fenwick's (2008) terminology, the community-of-practice learning theories. Elkjær (2004) designates this learning orientation the second way of learning – or the participation metaphor. This understanding of learning is a backlash to the cognitive/psychological learning orientation and, last but not least, to the concept of regarding the individual as the focal point for the learning process.

Learning is the process of developing from being a newcomer to becoming an oldtimer. In other words, learning and socialisation are joined together and the organisation or the place where learning activities take place is the community of practice. However, referring to Elkjær (2004:420), the *how* and the *what* of learning disappear within the broader concept of learning as participation. Learning within this understanding is to get legitimated peripheral access to the community of practice (Lave and Wenger, 1991); a kind of apprenticeship. Accordingly, the learning processes are transferred from the individual's mind to the contextual setting.

### 4.2.2. The learning mechanisms

In his analysis of the many faces of epistemological constructivism, Philips (1995) is in congruence with the above taxonomy. He identifies six different versions of constructivism and he discusses these from three different perspectives. One of the perspectives discusses the learning mechanism being applied. Philips' analysis points out that despite having a constructivists approach to learning, the different versions of epistemological constructivism diverge with respect to the mechanisms facilitating learning. The one extreme is the individual's creation of knowledge, while the other extreme is a socio-political construction (ibid. p.8).

> *"Piaget and Vygotsky, for example, gave quite different accounts of this matter; one stressed the biological/psychological mechanisms to be found in the individual learner, whereas the other focussed on the social factors that influenced learning."* (Philips, 1995:7).

[3] As Elkjær's third way of learning draws on Dewey's pragmatic understanding of learning discussed in chapter 6, the third way of learning will not be explained in this chapter. In addition, the objective of this section is to identify the extremes – and that objective is achieved by focusing on the first and second way of learning.

Jarvis (2007),[4] an English sociologist and learning researcher, takes up a discussion of different psychological learning models. A psychological approach to understanding the learning process takes its starting point endogenously in the individual person to the environment. These learning theories address analyses dealing with the individual's learning mechanisms and focus on how these factors influence the learning process.

Conversely, a sociological orientation considers learning to be initiated exogenously (outside the individual). The building blocks of these learning theories are the social mechanisms; in particular how these factors influence the individual.

Concluding on the above, the two extremes within the learning theories are a psychological orientation and a sociological orientation. The two perspectives address rather different learning mechanisms and in doing so, they seem to encircle the domain of learning.

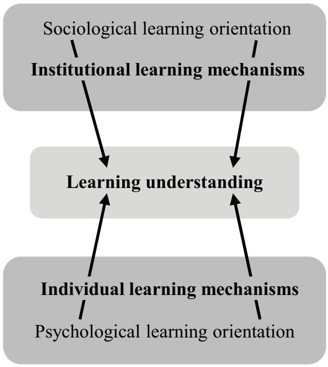


Figure 4.2. Two perspectives on the learning phenomenon. Inspired by Jarvis (2007:58).

As it appears from figure 4.2, the learning orientation drawing on a psychological stance describes the learning phenomenon as endogenous, individual processes. Each individual has its own cognitive structure and new knowledge is acquired when it is added to this structure. This stance addresses *individual learning mechanisms*.

The sociological learning orientation focuses on exogenous learning mechanisms such as culture, social factors and/or organisational structures. The focal point is to understand how these *institutional learning mechanisms* influence learning.

This categorisation makes it possible to identify the learning understanding in an article, regardless of whether the applied unit of analysis is at a group, cross-functional, organisational, interorganisational or network level. For instance, if the focal point of a study is an organisation, the learning orientation can be based on individual or institutional learning mechanisms to demonstrate the learning understanding applied in the article.

[4] Jarvis (2007:58) concludes that a learning theory has to take a psychological as well as a sociological perspective in order to explain this complex phenomenon. The point of departure, however, has to be the individual learner.

## 4.3. The PD continuum

Although the theories dealing with PD are multifaceted, two rather different stances permeate the construction of these theories. One stance is to analyse and understand the PD as a progression through a number of well-organised stages (Baxter, 1999). It starts with an idea and ends with a sellable product that impacts society, the work organisation, the production systems and so on. The other stance considers the social and technical elements as inseparable in the PD. This group of researchers calls *"into question the artificial gulf between the "social" and the "technical" - and thus between the social sciences and natural science and engineering."* (Williams and Edge, 1996:893).

In the same vein, Hutchby (2001:444) argues *"that a new empirical perspective is possible on the nature of the relationship between technological artefacts and human practices."*. In doing so, Hutchby rejects both extremes; instead, he proposes a "third way" bridging the two opposite stances; i.e. realism causing technological determinism and anti-essentialism resulting in social determinism.

Inspired by reading various PD articles/books and the above quotes, the two stances to PD are termed an *engineering view* and a *sociotechnical view*, respectively. The discussions of PD are divided into these two views.

### 4.3.1. The engineering view

A branch within the engineering orientation focuses on how to coordinate and carry out PD activities through well-organised "stages", whereupon a go or no-go decision is made at the "gate". Yet, the stages and gates have to overlap (Cooper, 1994:5); it is like a rugby match (Takeuchi and Nonaka, 1986:138). By following this funnel analogy (Baxter, 1999:17), the organisational risk can be minimised. Basically, the stage/gate models follow these ground rules: *"when uncertainties are high, keep the investment (stake) low; as the uncertainties are reduced, increase the investment"* – a rather rational behaviour and world view.

The gradual development of a new product starts with a sketch and it ends with a final and sellable product. It is a chain of PD activities where the physical artefact is subject to certain forms of action. During the PD process, the gradual development of product specifications causes a gradual restriction on the engineer's degree of freedom. In other words, the constitutive effect of a physical artefact varies during the PD process; an example of technological determinism at the micro level.[5]

Notwithstanding the fact that this extreme position constitutes a considerable part of the research, a literature review conducted by Cunha and Gomes (2003) sheds light on a co-evolution of theories dealing with organisation and PD processes. This review spans a continuum from control to disciplined autonomy when conducting the PD activities. Another literature review performed by Krishnan and Ulrich (2001) focuses on the decision-making process. They divide the activities into two main groups; setting up the PD project and PD

[5]Technology determinism as a meso-level phenomenon is visible in Henderson and Clark's (1990) discussion on how a radical or architectural product innovation changes the established structures and procedures within an organisation.

activities in relation to the project in question. The former spotlights decision-making issues, while the latter focuses mainly on technical PD activities within each of the PD stages. Similarly, Brown and Eisenhardt's (1995) organisational perspective on PD facilitates an understanding of a gradual movement from considering PD as a rational plan, followed by regarding PD as a communication web among activities and finally, understanding PD as disciplined problem solving.

Accordingly, the contribution from the above reviews of the PD literature is a gradual movement away from pure technological determinism towards organisational and managerial issues.

### 4.3.2. The sociotechnical view

The sociotechnical understanding becomes visible when studying the literature under the umbrella of Science and Technology Studies[6] (STS), a research tradition analysing the relationship between technology and society. The STS calls in question technological determinism. For instance, Williams and Edge (1996:892) shed light on how researchers with different backgrounds question the traditional understanding of the PD process as a "linear model"; a model similar to the rational stage/gate model presented in the engineering view.

Drawing on Law and Bijker (1992:305), the majority of the STS researchers considers technology to be *"never purely technological: it is also social. The social is never purely social: it is also technological."*. Hence, non-technical elements are central for understanding PD (Bijker, 2010:67). The PD of a product is neither the outcome of purely social nor purely technical elements; instead a product is the result of sociotechnical elements.

Accordingly, this view challenges the taken-for-granted by applying a sceptical and pluralistic approach to technology, resulting in the boundary between social and technological elements being penetrated; socio and technical fuse into sociotechnical.

Referring to Grint and Woolgar (1997:17-38), the research within STS can be categorised into two streams, namely an interactional and a network approach. The former considers technological and social elements as two separate but rather complex entities, within which continuous interaction takes place. The latter understands the interplay as a heterogeneous network of social and technical actors (actants).

Technological determinism is rejected, but according to Grint and Woolgar (1997), the majority of researchers operating under the umbrella of STS maintain the "residual technism" of a technology; that is, the material properties of a product. Grint and Woolgar, however, position themselves at the extreme as they disagree with the viewpoint that a product can have material properties. They dismiss the idea that a product/component has the capacity to exert influence on the social context; they reject that the material properties are predetermined (Hutchby, 2001:446).

Instead, Grint and Woolgar (1997:70) consider technology as text. Their suggestion to understand "technology as text" may be seen as an alternative to the PD stage/gate model or

[6] Within the umbrella of the STS theories, the Actor Network Theory (ANT) and the Social Construction of Technology (SCOT) emerge.

the understanding of the PD process as a string of problem-solving PD activities. Drawing on the "technology as text" analogy, the PD process is made up of the acts of reading and writing text. The development of a technology is writing text. Correspondingly, consumption of the technology is reading text.

Grint and Woolgar claim that everything is interpretation. This implies that the constitutive effect or the capacity of a technology will never be settled and, ultimately, that the effect of a technology is not transparent. The effect depends on the interpretation of the technology; according to the two authors, it is "thoroughgoing interpretivism".

Fallan (2008:63) draws upon the Actor Network Theory (ANT) when introducing the Script Analysis as the key to understand what takes place between the sphere of production and the sphere of consumption; i.e., the PD process. There is a constant movement between the substance inscribed into the artefact and its description. Although Fallan's Script Analysis has much in common with Grint and Woolgar's (1997) "technology as text", there are a number of differences between the two concepts. Briefly, two of these are: ANT acknowledges the above-mentioned "material properties of a product" and ANT gives non-human factors, like for instance technology, a kind of agency.

Accordingly, Grint and Woolgar's (1997) "thoroughgoing interpretivism" is the extreme position; however, the majority of the STS theories seem to acknowledge a less radical position.

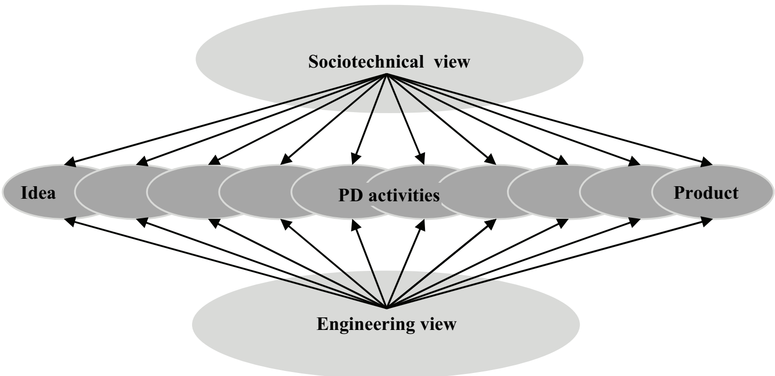


Figure 4.3. Two stances in relation to Product Development.

As it appears from figure 4.3, the PD starts with an idea, which is followed by a chain of PD activities, the end result of which is a physical product. The conceptualisation of each single PD activity as well as the overall chain of PD activities depends on the applied view. Drawing on the engineering view extreme, the product being developed shapes the PD context. The extreme of the sociotechnical view is the "thoroughgoing interpretivism" of the PD context.

The next section combines the learning and PD continuums discussed in the previous two sections to create a framework for categorising the literature being reviewed in chapter 5.

## 4.4. The categorisation of the literature

The learning continuum spans the two extremes, *individual learning mechanisms* and *institutional learning mechanisms*. The former draws on a psychological orientation to understand the learning process in a PD context, while the latter makes use of a sociological orientation to understand the learning process in a PD context.

The PD continuum spans an *engineering view* and a *sociotechnical view*. Regarding the former, an extreme stance gives rise to technological determinism, by which the product being developed shapes the PD context. Addressing the latter, both the social and the technical elements constitute the PD context; yet, an extreme position implies that the constitutive effect of the technology is subject to "thoroughgoing interpretivism".

Using the term continuum to explain the two extremes is a very conscious choice. We are rarely dealing with a purely engineering or purely sociotechnical view, but rather a view somewhere between the two. Similarly, learning is seldom considered to be purely individual learning mechanisms or strictly institutional learning mechanisms (structures or processes); again, the answer lies somewhere between the two extremes.

The learning and PD continuums imply a categorisation, which is applied to organise the review of the literature. The four categories used to pinpoint the underlying perspectives as regards learning in a PD context are:

- Individual learning mechanisms in a PD context in the light of an engineering view.
- Individual learning mechanisms in a PD context in the light of a sociotechnical view.
- Institutional learning mechanisms in a PD context in the light of an engineering view.
- Institutional learning mechanisms in a PD context in the light of a sociotechnical view.

The next section explicates the process of selecting a theoretical contribution to be included in the review.

## 4.5. Including a theoretical contribution in the review: the selection process

Referring to section 4.1 dealing with the guiding principles for the review, the purpose is to gain an overview of the literature in a broad sense; for this reason, it is not appropriate to structure the selection process too much (Bryman and Bell, 2007:105). In addition, the theoretical domain is not narrowed down; that is, the literature being reviewed includes research employing various methodological approaches as well as research having different purposes, e.g. to prescribe, to describe, to predict or to explain.

Given that the intention is to achieve an understanding of how learning takes place in a PD context, the two phenomena are linked. It limits the literature available for the review process and increases pluralism. Mainly due to the latter, the screening of the literature to be included in the review proves to be problematic. There are two reasons for this: First, a search in various databases and journals indicates a lack of common/agreed syntax with regard to the terms "learning" and "PD".[7] Second, an inquiry in, for instance, the Business Source Complete[8] database sheds light on another problematic aspect. When searching for *"author-supplied keywords = learning and product development"*, this database finds 33 articles in different journals. If using *"article title"* as a criterion for selecting *"learning and product development"*, 15 articles are found. When examining the contents of these articles, a lack of coherence between the substance of the article and the *"author-supplied keywords"* or *"article title"* is often identified.[9]

MacLure (2005:400) indicates to have had similar problems when using the abstract of an article to decide whether an article meets the selection criteria. Consequently, the articles rather than the abstracts are scrutinised, which eliminates the risk of rejecting a theoretical contribution on a wrong basis.

Various databases[10] have been used to retrieve the articles. However, referring to Randolph (2009:7), electronic searches in databases will produce only about 10 percent of the articles needed for an exhaustive review. Randolph considers the reference lists of the articles to be an effective method for identifying and selecting articles for the review. Thus, the reference lists of the articles are scrutinised; this snowball sampling (Bryman and Bell, 2007:200) has been useful for identifying interesting theoretical contributions to be included in the review. Besides this iterative selection process, dialogues with my supervisors, colleagues and the participation in PhD courses have paved the way for including articles.

Accordingly, learning and PD are the focal points for the selection process. To be more specific, focus is on the *how, what, who* and the *enabler* from the working hypothesis presented in section 4.1. To be included in the review, the article has to deal with learning, either the *how*, *who* or *what*, and PD, the *enabler*. In line with the snowball sampling, a part of the selection process has been an iterative process alternating between searching and

[7] To illustrate this lack of agreed syntax as regards learning, Nonaka et al. (2000) and Peltokorpi et al. (2007) describe learning as *knowledge creation*, while Dyer and Nobeoka (2000) and Hansen (1999) interpret it as *knowledge sharing*. Hutchins (1995) applies *distributed cognition* and Gorman and Carlson (1990) consider it as *mental processes*. Gooding (1990), Lane and Lubatkin (1998), Ruy and Alliprandini (2008), Edmondson and Nembhard (2009) and others use the word *learning*, whereas Brown and Duguid (1991) and Garrety et al. (2004) see it as *community of practice*. Under the STS umbrella, an *"artefact enables interpretive flexible thinking and action."* (Bijker, 1993), Suchman (2000) understands it as *socially constituted practice* and in the same vein, Law (1989) describes it as *heterogeneous engineering*, while Gherardi and Nicolini (2000) focus on an *ongoing translation of situated knowledge*.

[8] www.cbs.dk, CBS Library, 15 December 2009.

[9] Gil and González (1999), for instance, analyse how a strategic alliance makes it possible to share risk and cost when developing a new product; it calls for a choice to organise the specific new product development project(s) (Gerwin and Ferris, 2004). Riley (2007) discusses competitive strategies for firms; Salo and Kakola (2005) continues in the same vein and emphasises that a high-technological firm has to reduce its Time To Market (TTM). A number of articles focus on customer integration, for instance, Enkel et al. (2005) apply the lead-user approach to reduce market risk; Hoffmann (2007) analyses how consumers contribute to sustainable products and services; Bowonder (2004) discusses concurrent engineering; Vickers and Ellis (2004) include simulations in the analysis. Janz and Prasarnphanich (2009) focus on knowledge sharing and integration in relation to information systems and development teams; Ottosson (2003) spotlights how a new intranet platform makes the PD dynamic. Anderson and Parker (2002) develop an engineering-based model of outsourcing based on accumulated learning within production.

[10] Among others: www.statsbiblioteket.dk, Business Source Complete, Sage Journals Online, ScienceDirect, JSTOR, EBSCOhost, ABI/INFORM Global, ProQuest and Academic Search Elite.

reading articles; an approach with much in common with the abductive research strategy. One becomes gradually wiser during the literature review.

## 4.6. Summary

The objectives of the chapter were to create a framework for a categorisation of the literature being reviewed in the next chapter and to explicate the selection process.

To achieve an understanding of the underlying perspectives in the literature dealing with learning in a PD context, a categorisation is introduced. Two continuums pave the way for this categorisation: The learning continuum spans individual learning mechanisms and institutional learning mechanisms, while the PD continuum spans an engineering and a sociotechnical view.

This categorisation is an instrument for taking one's bearings when reading an article. This way of thinking is applied during the literature review. Accordingly, the analytical instrument consists of a learning and a PD continuum and is arranged in the following categories: "Individual learning mechanisms in a PD context in the light of an engineering view", "Individual learning mechanisms in a PD context in the light of a sociotechnical view", "Institutional learning mechanisms in a PD context in the light of an engineering view" and finally, "Institutional learning mechanisms in a PD context in the light of a sociotechnical view".

The process of selecting a theoretical contribution to be included in the literature review originates from the working hypothesis. The *how* refers to the learning process, the *what* addresses the outcome of the learning process, while the *who* sheds light on the learner (the learning entity). The *enabler* is related to PD. For an article to be included in the review, both learning and PD must be discussed. The content of the article, rather than the abstract, is examined in order to clarify whether it should be included or not.

Various databases have been used to retrieve the articles. However, snowball sampling has been useful for identifying the articles as well; be it reference lists, dialogues with supervisors and colleagues or participation in PhD courses.

Chapter 5 presents the outcome of the literature review. It starts with an introduction to the review process in an attempt to link the analysis and the presentation of the literature review to the discussions put forward in this chapter 4.

# Chapter 5. Literature review of learning and PD

Chapter 5 is a direct continuation of chapter 4. In chapter 5, the purpose is to present the review and thereby answer the research question addressing the literature review. A second purpose is to identify a theoretical perspective to be applied for studying learning when conducting Product Development (PD) in collaboration with a customer.

Chapter 5 starts with a brief introduction to the review process, following which each of the four categories presented in section 4.4 is subjected to a review. Section 5.2 addresses individual learning mechanisms/PD in an engineering perspective. Section 5.3 focuses on individual learning mechanisms/PD in a sociotechnical perspective, while section 5.4 sheds light on institutional learning mechanisms/PD in an engineering perspective. Section 5.5 discusses the institutional learning mechanisms/PD in a sociotechnical perspective, section 5.6 wraps up the review, and section 5.7 establishes the theoretical position to be applied in the research. Section 5.8 summarises the chapter.

## 5.1. The review process

Concurrently with reviewing the articles, an IT application (Mindjet Pro) is employed to create a mind map. This makes it possible to sustain the understanding of a reviewed article and, last but not least, to gradually achieve an overview of the literature.

The underlying basis for the development of the mind map is the working hypothesis presented in section 4.1. The applied learning understanding is examined; first, the *how* triggers a focus on identifying whether the article draws on individual or institutional learning mechanisms to describe the learning process in, for instance, a group or in an organisation. Subsequently, the *who*, dealing with the learning entity, as well as the *what*, addressing the outcome of the learning process, will be scrutinised. Focusing on the *enabler* makes it possible to grasp the PD context; is the PD context portrayed as an engineering or as a sociotechnical setting?

The classification of learning into individual/institutional learning mechanisms and PD into an engineering/sociotechnical view presented in sections 4.2-4.4 constitutes four extremes of two continuums. This classification is a means for guiding my thought and interpretation process when reviewing a theoretical contribution, making it possible to classify a contribution as belonging to one of the four categories. Yet, this classification is not value-neutral as it is an interpretation. Thus, the classification of a theoretical contribution to one of the four perspectives can be called in question.

## 5.2. Individual learning mechanisms/PD in an engineering view

The common denominator of the literature within this category can be traced back to March and Simon's (1958) classical work on organisational behaviour.[1] This decision-making theory is considered as a break with the traditional classical organisational theories of the time. The previous conception of employees as instruments devoid of biological factors was superseded

[1] This classical work does not form part of the literature review, but it is mentioned because it lies at the root of the majority of the contributions within this category.

by a conception of employees as human beings with feelings, wants and motives. Still, however, the individuals are believed to hold only a limited level of knowledge and therefore lack the capabilities to solve problems (March and Simon, 1958:136).

Decision-making is not rational. Instead, it is characterised by a certain level of bounded rationality, as it is not possible to achieve complete information about all the consequences a decision might have. Referring to March and Simon (1958:152), three mechanisms cause these cognitive limitations on rationality. First, the individual decision-maker is subject to endogenous cognitive constraints; second, an organisation has a number of channels facilitating/constraining communication; third, owing to of the fact that an organisation is divided into different functions, all employees do not receive the same information. As it will appear in the below, one or more of these three cognitive mechanisms often constitute the focal point of an article.

### 5.2.1. The learning process (How)

The balanced approach between exploitation and exploration as a learning phenomenon proposed by March (1991:72) is applied by Tsai and Huang (2008:84) to establish an analytical framework. Nevertheless, the authors focus solely on exploration as they interpret it to be the most important issue seen in a long-term perspective. The learning process is purely endogenous cognition and it is discussed with respect to individual learning mechanisms.

Besides focusing on endogenous cognitive constraints, Meyers and Wilemon (1989), Lane and Lubatkin (1998), Ruy and Alliprandini (2008) and Liepè and Sakalas (2008) make a point of discussing cognitive mechanisms on the organisational level and/or in the environment. Liepè and Sakalas' (2008:73) constructivist epistemology asserts that learning in an organisation requires two transformation processes. First, an individual's knowledge has to be transformed into information and made available for other employees in the organisation; second, these individuals must internalise the information and accumulate it into their knowledge stock. The organisational cognitive mechanisms are the means to facilitate the information transfer among the employees. Meyers and Wilemon (1989:82) describe the learning process as being time-dependent. At time T1, a team consists of all knowledge embedded within its members and other available inputs. As a result of performing activities in relation to error detections and corrections, the accumulated knowledge increases within the team, which gives rise to a higher level of knowledge at time T2. The facilitator ensuring the intra-team learning is an effective communication network within the team/organisation and to the surrounding environment. Hence, the contribution from Meyers and Wilemon (1989) draws on all three above-mentioned cognitive mechanisms suggested by March and Simon (1958). Lynn (1998:90) takes another approach and proposes three different learning processes dependent on technological as well as market uncertainties. Akgün et al. (2006:219) continue in the same vein and propound that technical and market knowledge is socially distributed among cross-functional PD teams.

5.2.1.1. Originating from Argyris' learning theory

Meyers and Wilemon (1989), Liepè and Sakalas (2008) and Ruy and Alliprandini (2008) draw upon Argyris' learning theory. Argyris' (1976:365) learning model focuses on the detection and correction of errors; an error makes action ineffective. Argyris' learning theory is action-oriented and it differentiates between espoused theories of action and theories-in-use. While the espoused theories of action represent what the individual says he/she will do, the theories-in-use are the de facto action performed by the individual. The former are rather perceptible as they are expressed by language. The latter can only be identified by observations – they are embedded in the individual's action. In order to achieve double learning, the individual has to modify its current theories-in-use (Argyris, 1976:371), entailing that the distance between espoused theories and theories-in-used are minimised. That is, double learning will only take place if and when the individual changes its individual learning mechanisms; a change in organisational structures, routines, etc. will not automatically instigate learning.

#### 5.2.1.2. Originating from absorptive capacity

Lane and Lubatkin (1998:462) use the theory of absorptive capacity to develop an interorganisational learning theory termed relative absorptive capacity. This learning orientation can be traced back to Cohen and Levinthal's (1990) bridge-building between learning and innovation. The theory of absorptive capacity emphasises that information external to the boundaries of the organisation is assimilated by individuals if they have a sufficient level of related knowledge.

Cohen and Levinthal (1990:129) take as their point of departure the cognitive theory at the individual level. The individual's current level of knowledge is applied to understand the available information. If it is considered valuable for the firm to improve its competitive position, the information is assimilated. The process of assimilation requires that there be a limited gap between the information available to be assimilated and the current cognitive level. That is, new knowledge is endogenously accumulated in the individual if, and only if, it fits with existing cognitive structures (individual learning mechanisms). Thus, Cohen and Levinthal's learning orientation has a subjective epistemology.

As mentioned elsewhere, the learning theory developed by Lane and Lubatkin (1998) is termed "relative absorptive capacity" as the authors argue against the notion that an organisation can learn from all industries. Instead, the "student-firm" and the "teacher-firm" must be in proximity to each other. Referring to Lane and Lubatkin, to be able to assimilate new knowledge, the organisation has to have some abilities relatively close to the available knowledge. First, the knowledge exogenous to the organisation has to be understandable and perceived as valuable. This stance corresponds to March and Simon's (1958) "cognitive mechanisms in the environment". Second, the internalisation of the available information depends on the similarities between the two knowledge processing systems. Lane and Lubatkin (1998:464) draw an analogy to a computer system in order to explain the organisational processing system; much like a computer system, the organisations must establish ground rules for how knowledge is acquired, stored and transferred. Using such an analogy to explain the learning process is common for researchers drawing on the cognitive learning orientation. Third, the absorptive capacity is influenced by the ability to interpret the business potential of the available knowledge; that is, will the knowledge result in competitive advantages?

### 5.2.1.3. Originating from behaviourism

Lynn (1998:75) describes three different learning processes dependent on market and technological uncertainties. The first learning model builds on the experience curve, the second model focuses on the transfer of experience from one cross-functional team to another, while the third model explains how knowledge is acquired from competitors, suppliers and customers. The learning orientation applied to explain the concept diverges. Actually, the learning orientation in the last two models is not immediately evident in the article; the models simply describe how experience or knowledge is transferred from one contextual setting to another. In any case, the first learning model, denoted "within-team learning", is applied to analyse how learning influences the PD process with regard to Time to Market (TTM) and product success rate (Lynn et al., 1999:441). Given that the learning model draws on the learning curve effect, the learning orientation is behaviourism.

Behaviourism[2] has three underlying assumptions. First, the focus is on observable behaviour rather than on internal thought processes, resulting in learning being perceived as changes in behaviour. Second, as the environment constitutes behaviour, the individual learning is constituted by elements in the environment. Third, the principles of contiguity and reinforcement influence the learning process; the former sheds light on the temporal distance between two events, while the second focuses on the necessity of repeating an event. That is, the relationship between the individual and the context is characterised by the fact that the environment determines the individual's response.

Behaviourism was developed by John B. Watson in the beginning of the twentieth century, while B. F. Skinner is credited for developing behaviourism as a theory of learning.

### 5.2.1.4. Originating from humanistic learning orientation

Akgün et al. (2007:503) analyse how emotional capability influences learning capability and how these two factors affect product innovativeness. The innovativeness of an organisation is improved if the emotions of its employees are aligned with organisational routines (ibid. p.510). As this article discusses how emotion influences the learning process, it draws on a humanistic orientation to learning.

Humanistic theories view learning from the perspective of motivation and growth potential. It puts emphasis on the cognitive as well as the affective dimension of learning (Merriam et al., 2007:282). This learning orientation refuses to accept that behaviour is predetermined by the environment or one's subconscious, and in doing so, it rejects pure behaviourism as well as pure cognitivism as learning theories. Instead, humans can control their own destiny and they possess unlimited potential for growth and development. In his theory of human motivation, which draws on a hierarchy of needs, Maslow[3] has contributed to this learning perspective. Maslow considers the highest level of need, self-actualisation, to be the goal of learning and in this regard, learning contributes to the psychological health of the individual.

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[2] The decision to categorise Lynn's behavioural contribution within this category might be a cause for wonder. On the one hand, exogenous stimuli determine the individual's behaviour, indicating a certain level of institutional learning mechanisms. On the other hand, however, the individual is the learning entity and the focus is on the individual's ability to carry out activities more "appropriately".

[3] See Maslow, A. H. (1943) "A Theory of Human Motivation", *Psychological Review*, 50. 4, pp. 370-396.

5.2.1.5. Originating from social-cognitive learning orientation

In another article, Akgün et al. (2006:211) combine a social cognitive perspective with organisational learning literature to develop a framework dealing with learning processes within PD teams. In this article, the relationship between a team's cognitive capabilities and eight socio-cognitive[4] factors is analysed. In doing so, a team's learning mechanisms are considered the driving force behind the eight socio-cognitive factors resulting in a successful outcome of learning (ibid. p.221).

The social-cognitive orientation to learning emphasises that the individuals learn from observations. Until the 1960s, it was more or less ranked alongside behaviourism, but with the work of Bandura focusing more on cognitive processes, the social-cognitive learning theory breaks away from a purely behaviourist orientation of learning. A key feature of Bandura's learning theory is the separation of observations from the acts of imitations (Merriam et al., (2007:288), suggesting that learning does not necessitate action or experimental activities. Instead, observations of factors within the social context can initiate learning endogenously to the individual; i.e., within the individual learning mechanisms.

Bandura has developed a learning model of triadic reciprocality.[5] This understanding of learning draws on a dynamic system perspective in which the individual's behaviour is a function of the interactions within the social context. The individual influences the environment and, at the same time, the environment influences the individual's behaviour. It is a triadic reciprocal relationship between a social contextual setting, the learner's internal cognition as well as other endogenous factors (individual learning mechanisms) and all individuals' actions as well as behaviour within this context.

The social dimension of this learning theory acknowledges the social origins of the individual's thoughts and actions, while the cognitive dimension recognises the influential causal contribution of thought processes to human motivation and action. Thus, learning becomes more situational and responsive to the individual's interaction – it is not a function of stimuli responses or cognitive abilities, but depends instead on social actions/dialogue and reflection.

### 5.2.2. Who learns[6]

Tsai and Huang (2008:87) uses the PD project as the unit of analysis without, however, specifying whether the focus is on activities or on an organisational unit. As the focus of the research is to shed light on the necessity of having different cognitive skills represented within the team, the learners seem to be the individual members of the team. Likewise, Ruy and Alliprandini (2008:447) take the PD process as the unit of analysis in combination with a cognitive orientation. The learner is the individual as well as archives, drawings, etc.

[4] The applied socio-cognitive factors are: information acquisition, information implementation, information dissemination, unlearning, thinking, improvisation, sense-making and memory (Akgün et al., 2006:212)

[5] The explanation of the triadic reciprocality model draws mainly on the work in Merriam et al. (2007:287-291).

[6] All things being equal, the unit of analysis in a research project in combination with the applied learning orientation frames the learning entity; that is, who learns. Thus, the chosen unit of analysis establishes the scope of the learning process, while the researcher's interpretation of the learning process pinpoints the element(s) being influenced by the learning activities. For instance, if choosing an interorganisational setting as the unit of analysis and using a cognitive learning theory, the learner will be an individual and usually some of the elements within the boundaries of the dyadic relationship.

Liepè and Sakalas (2008:78) seem to be rather true to the applied subjective epistemology as *"Learning and all knowledge is achieved and possessed by individuals."*. The container of knowledge is the individual's cognitive structure and only information can therefore be transferred within organisational cognitive mechanisms. Nevertheless, the triple loop learning model (ibid. p.77) implicitly acknowledges that changes take place in routines and taken-for-granted assumptions. Meyers and Wilemon (1989:80) take a slightly different view. They consider team knowledge to consist of all knowledge embedded endogenously in its members and other available sources of knowledge. Despite the fact that the outcome of the learning process is described as being new knowledge, the authors do not explain where this new knowledge is accumulated in the team.

Drawing attention to Lane and Lubatkin (1998), the dyadic relationship between the student-firm and the teacher-firm is the unit of analysis, while the applied learning orientation is cognitive. The direction of the learning content is triadic in that it consists of the student-firm's knowledge base, the firm's knowledge processing system and finally, the commercial objectives (ibid. p.473). Despite employing a cognitive learning orientation, the individuals are no longer held to be the learning entity; the learner is one of the actors in the dyadic relation between the student-firm and the teacher-firm.

### 5.2.3. What is learned

The learning content (what is learned) within this perspective addresses uncertainty reduction. Referring to Tsai and Huang (2008), exploration is considered an advantage when the level of uncertainty is high. Therefore, these authors argue for the necessity of creating knowledge in order to handle uncertainties. The learning outcome improves the ability to understand technological as well as market uncertainties. It makes it possible to gain the understanding crucial for enhancing the PD performance as well as for achieving a successful product design. In the same way, Lynn (1998:86) explains that the outcome of the learning process depends on a combination of uncertainties in relation to the market and the technology. Lynn seems to be more specific, as the learning content addresses the team's ability to conduct an activity. Akgün et al. (2006:217) agree that new knowledge results in a better understanding of technical and/or marketing shortcomings of a new product. Meyers and Wilemon (1989:82) do not distinguish between information, knowledge or learning; instead, they use the words interchangeably. Nevertheless, inter-team learning improves intra-team error detection and correction, resulting in a team more knowledgeable at time T2 than at time T1. It enhances the team's ability to handle problems, challenges, crises and events.

The distinction between information and knowledge or various types of knowledge is more prevalent in another group of articles. The epistemological approach taken by Liepè and Sakalas (2008:74) indicates that the learning process consists of endogenous changes in the individual's mind. Due to this, the authors consider single, double-loop and meta-learning as purely individual cognitive processes; learning does not change organisational routines, taken-for-granted or contextual factors. Hence, routines, taken-for-granted and contextual factors only facilitate information transfer in order to optimise business processes as well as new product development. Instead of distinguishing between information and knowledge, Ruy and Alliprandini (2008:461) makes a distinction between tacit and explicit knowledge.

The outcome of a PD project is new tacit knowledge and explicit knowledge improving the PD process, including sketches, drawings, and test reports. The learning content improves the student-firm's knowledge base and thereby the competitive position (Lane and Lubatkin, 1998). The nature of knowledge deals with an improvement of "know-what", "know-how" and "know-why". The former makes it possible to understand knowledge in the environment, while the know-how is the internal knowledge processing system of the organisation. The latter sheds light on the student-firm's ability to commercialise the assimilated knowledge.

#### 5.2.4. PD as an enabler

Ruy and Alliprandini (2008:478) perceive learning as a crucial element in managing PD activities, while Tsai and Huang (2008) employ learning as a means to grasp market as well as technological uncertainties and thereby become more effective in relation to PD. The market and technological uncertainties necessitate team-learning dealing with technical, manufacturing and marketing problems during the PD process (Akgün et al., 2006:218). In the same vein, Lynn (1998:86) links three learning strategies to four different PD strategies. The latter depend on a combination of market and technological uncertainties. So saying, PD calls for an appropriate learning strategy in order to be able to launch a successful product. Similarly, to successfully conduct the PD process, the organisation has to learn faster than their competitors (Liepè and Sakalas, 2008:73). Instead of interpreting it as a learning race to handle uncertainties, Meyers and Wilemon (1989:80) exemplify how a new "technological wave" affects the business. For instance, the introduction of microprocessors brings in its wake new products to be developed, new business processes, new industries and new user needs. This new technology changes the rules of the game; learning is thus mandatory.

Taking the dyadic relationship as the unit of analysis, the focus of the empirical work in Lane and Lubatkin (1998) naturally addresses these phenomena, making it problematic to identify the PD understanding. However, the quotations applied in the article indicate that technological uncertainties and risk-sharing alliances are central issues. Furthermore, the findings in the article stress the importance of the R&D alliance as a means to reduce the gap between the student-firm and the teacher-firm in terms of know-what, know-how and know-why.

The next subsection presents an overview of the literature in this perspective.

#### 5.2.5. The rationalising perspective

| **Rationalising perspective** | Learning process (How) Section 5.2.1 | Who learns Section 5.2.2 | What is learned Section 5.2.3 | PD as enabler Section 5.2.4 |
|---|---|---|---|---|
| Individual learning/ engineering view | The focal point of the learning process is cognitive limitations on rationality. It addresses the individual learning mechanisms and information channels. | Learning takes place primarily in the individuals. Individuals are connected through organisational systems. | How to handle the decision-making processes during uncertain conditions; technological/market uncertainties. | Learning enables PD and becomes the means to improve the competitive position of the firm. |

Table 5.1. The rationalising perspective.

The organisational decision-making theory is the underlying basis for the literature in this category; hence, it is termed a "**rationalising**" perspective. The cognitive limitations on rationality (often denoted bounded rationality) are the focal point for the learning process. It addresses the individual learning mechanisms, organisational constraints (unsuitable channels to facilitate communication) and finally, drawbacks of having different information available. This partitioning of the organisation into subsystems is a general methodological approach taken within this category. In general, as the literature draws on a subjective and constructivist epistemology, the learner is mainly identified as the individual. The learning content focuses on handling decision-making under conditions of uncertainty, that is, technological and market uncertainty, in order to improve the PD process and thereby achieve competitive advantages. By taking this position, learning becomes an instrument for improving the competitive position of the firm. Thus, this understanding does not consider PD to enable learning.

## 5.3. Individual learning mechanisms/PD in a sociotechnical view

In contrast to the discussion of the literature in section 5.2, the individuals' interactions with artefacts become a central issue within this perspective, for instance as interplay between cognitive structures and artefacts. Thus, the PD process is interpreted as interplay between an inquiry paradigm and an application paradigm (Beckman and Barry, 2007:27), or as bridging mental models with physical configuration of the apparatus (Gooding, 1990:187), or combining mental models with mechanical representations (Gorman and Carlson, 1990:133), or as conscription devices enabling group participation (Henderson, 1991:456).

### 5.3.1. The learning process (How)

Different variants of the cognitive learning orientation are applied in these contributions to focus attention on the individual learning mechanisms. Beckman and Barry (2007) draw on Kolb's cognitive learning model and Gorman and Carlson (1990) analyse invention as a cognitive process. Gooding (1990) makes use of situated cognition to emphasise the necessity to include personal aspects of cognition to the social, institutional and ideological factors. Finally, Henderson (1991) perceives sketches as group thinking instruments for distributed cognition. Below, these three variants of the cognitive orientation are elaborated.

<u>5.3.1.1. Originating from Kolb's cognitive learning model</u>

Beckman and Barry (2007:27) combine Owen's PD model with Kolb's cognitive learning model. The latter is the main building block for the construction of a four-stage problem-solving innovation/learning model, by which Kolb's experiential learning theory becomes the focal subject.

Kolb's learning model is among one of the most quoted within pedagogical as well as organisational learning literature (Elkjær, 2005:113). Kolb (1976) denotes his learning model "the experiential learning model" and details the process as a four-stage learning cycle/spiral consisting of experiencing, reflecting, thinking and action (Kolb and Kolb, 2005:194). The learning model consists of a perception and a transformation dimension. The perception dimension sheds light on how to grasp an event and it sets up a tension field between abstract conceptualisation and concrete experience. The transformation dimension focuses on how the individual handles a situation and the tension field consists of active experience at one extreme and reflective observation at the other.

Turning to Beckman and Barry's (2007) innovation/learning model, the reflective observation and active experience are replaced by Owen's interplay between understanding within the theoretical domain and experimentation within the practical domain. That is, the transformation dimension in Kolb's learning model is replaced by Beckman and Barry substituting "reflective observation" and "active experimentation" with "the realm of theory" and "realm of practice", respectively. This replacement is combined with the aforementioned perception dimension, as Beckman and Barry maintain this part of Kolb's learning model.

There is a close relationship between Gorman and Carlson's (1990) analytical framework and the above-mentioned perception dimension in Kolb's learning model; that is, the abstract conceptualisation versus concrete experience continuum. Thus, cognition is the means to grasp an event by combining abstract conceptualisations with concrete experimentations conducted on the artefact; in other words, this process of cognition consists of a merger between a mental model and a mechanical representation. Gorman and Carlson's (1990) learning understanding separates the individual's mental model from the problem-solving strategy applied by the individual. The latter is the means to merge the mental model with the mechanical representation of the artefact. So saying, between the individual's mental model and the artefact (mechanical representation) lie the rules of thumb for conducting problem-solving activities. In addition to using these rules of thumb, an individual borrows mechanical representation(s) from one or other artefacts and applies these mental representations as means in the PD process. This strict division into these three elements – mental model, heuristics[7] and mechanical representation of the artefact – gives rise to a purely cognitive interpretation. This viewpoint is underpinned by the focus on the individual learning mechanisms, a distinctive feature of the cognitive[8] learning theories (Merriam et al., 2007:285). Nevertheless, the conclusion of the article emphasises that mental models are not context-free, but are shaped by personal preferences and social and economical pressures.

5.3.1.2. Originating from situated cognition

The contribution by Gooding (1990) is another variant of the cognitive orientation, as he describes the cognitive phenomenon to be situated. The ability to manipulate a material object depends on personal knowledge and human agency in the material world (ibid. p.166). It is an ongoing process that draws on the present state of endogenous cognitive structures and situated conditions. Gooding suggests that every action is initiated by a problem and concluded by a decision; every outcome is embedded in a sequence of actions (ibid. p.178). As social and institutional factors influence the individuals, the learning orientation adopted by Gooding is not purely cognitive.

[7] Gorman and Carlson (1990:147) describe the problem-solving strategy as "heuristics". This term is borrowed from cognitive science and means "rules of thumb for problem-solving".

[8] The common denominator of cognitive learning theories is the focus on mental processes that are controlled by the individual (Merriam et al., 2007:287). Later on the same page, Merriam et al. emphasise that the cognitive theories of learning cover a spectrum of theories directed toward miniature models of specific facets of cognition.

Elsbach et al. (2005:423) describe situated cognition as *"thinking that is embedded in the context in which it occurs."*. However, situated cognition and situated learning are used interchangeably (Evans et al., 2007), making Lave and Wenger's (1991) "Situated Learning: Legitimate Peripheral Participation" and Brown et al.'s (1989) "Situated Cognition and the Cultural of Learning" examples of this theoretical position. Furthermore, in their analysis of occupational safety within the building industry, Gherardi and Nicolini (2000) engage in a discussion of a cognitive perception of situated knowledge versus a sociotechnical approach. The latter is described as:

> *"a socio-material* (sociotechnical, author) *constructionist approach conceives knowledge and knowing as inextricably bound up with the material and social circumstances in which they are acquired."* (Gherardi and Nicolini, 2000:331).

This quotation embeds knowledge *within* the sociotechnical system and not *between* artefacts and mental models. Hence, a mismatch is apparent if comparing Gooding's (1990) approach with the interpretations of situated learning of Lave and Wenger, Brown et al., and Gherardi and Nicolini. Placing these four viewpoints on a continuum spanning individual and institutional learning mechanisms, Gooding would be positioned on the "individual" part of the continuum. Conversely, the other three contributions would be placed somewhere on the "institutional" part of the continuum. Accordingly, the tendency to regard situated cognition and situated learning as interchangeable concepts are problematic. Although both concepts draw on a situational context, the learning orientation diverges.

In any event, the argument behind placing situated cognition in this subsection is dual. First, Gooding's (1990) focus on manipulation of mental models addresses the individual learning mechanisms. Second, Elkjær (2005:52) problematises the fact that the practice-based learning orientation, for instance Lave and Wenger's (1991) community of practice, ignores thinking and reflection.

#### 5.3.1.3. Originating from distributed cognition

Henderson (1991) makes use of a third variant of the cognitive learning orientation, which is the distributed cognitive theory. Drawing on Latour's concept of inscriptions, Henderson introduces conscription devices[9] as a subgroup of inscriptions. While inscriptions are immutable (ibid. p.454), the conscription devices are considered to be changeable. Therefore, when engineers carry out activities, they alter the conscription devices; it is an ongoing transformation which starts with a rough sketch and ends with a final product. Besides facilitating the final design of a product, the visual representations, like for instance sketches and drawings, prepare the ground for collective learning as well as social interaction among the engineers.

The function of a conscription device is threefold: first, it is an organising device;[10] second, it is a thinking tool and third, it is a boundary object. Obviously, the last two mentioned functions – thinking tool and boundary object – have a cognitive role in Henderson's (1991)

[9] An inscription contains verbal as well as visual representations, while the conscription device only addresses the visual representations (Henderson, 1991:452).

[10] As an organising device, it shapes the structure of the work processes and indicates who may participate in the work. Besides, sketches and drawings are the means for coordination as well as for handling conflict.

contribution. Describing a conscription device as a thinking tool draws on cognition. It is an instrument for thinking, which is illustrated by the quotes *"I can't think without my drafting board."…"As soon as you start drawing it, you have ideas and changes."* (ibid. p.460). As a boundary object, the conscription device allows interacting engineers belonging to different functions/groups to read different meanings from sketches or drawings depending on their actual needs. It prompts distributed cognition among interacting participants.

Rasmussen (2001:579) credits Edwin Hutchins for having developed the theory of distributed cognition. Hutchins (1995) describes the successful flight of a commercial airliner as the result of a sociotechnical system rather than individual cognitive processes. Thus, instead of employing the individual learning mechanisms as the unit of analysis, the sociotechnical system takes centre stage. The sociotechnical system is the cockpit. It consists of the pilots, their social interactions and the many technical devices. As opposed to the pure cognitive focus on the individual learning mechanisms, the approach proposed by Hutchins (1995:284) sheds light on memories *"which transcend the boundaries of the individual actor."*.

Landing an airplane requires the pilots to adjust the landing speed to the calculated gross weight when touching the ground. Procedural descriptions of memories available in flight manuals combined with various instruments – visual as well as spoken representations – make up exogenous memories. Despite the fact that the cockpit system has a lot of redundant information, *"the memory process emerges from the activity of the pilots."* (ibid. p.286). That is, notwithstanding that the memories are distributed between procedural descriptions in flight manuals and electronic devices, the pilots are the key elements. This indicates a cognitive learning orientation – distributed cognition.

### 5.3.2. Who learns

The learning approach taken by Beckman and Barry (2007) and Gorman and Carlson (1990) considers the individual to be the learner. However, the figure depicted in Beckman and Barry's (2007:27) article assigns to knowledge the role of a bridge spanning the realm of theory and realm of practice; it is the linchpin between the mental model and the PD activities. This figure in combination with the application of Owen's PD process model indicates knowledge to be embedded endogenously in the individual as well as in the four-staged learning/innovations model. Likewise, from the perspective of Gorman and Carlson, the tripartition of the individual's mental model, problem solving by using rules of thumb and mechanical representation of the artefact set the scope for identifying the learner. Gorman and Carlson emphasise that the challenges lie in merging the mental model and the mechanical representation, suggesting that the artefact (mechanical representation) also becomes an end point for the learning process.

Gooding (1990:178) emphasises that *"every outcome is embedded in a sequence of actions."*, which results in a manipulation of the mental model (cognitive structure) and/or the artefact (material object). So saying, it triggers changes to the artefact, to the individual learning as well as to the context in which the sequence of actions takes place. Henderson's (1991) employment of distributed cognition illustrates that learning takes place by changing the artefacts (conscription devices) and the individuals' perception of these.

### 5.3.3. What is learned

Referring to Gorman and Carlson (1990), the ongoing interaction with an artefact enables the individual to modify its mental model as well as the rules of thumb; both the mental model and rules of thumb are endogenous processes. While a mental model is considered as being unstable, incomplete and without boundaries, the mechanical representation of the artefact is regarded to be clear and precise. It is an actual artefact, yet also an image which is retained within the individual to be used for future inventions (ibid. p.141). Gooding (1990) continues partially in the same way. He considers the learning content to be successive manipulations of an old outcome to produce a new outcome; a process in which tacit knowledge and procedural skill are crucial elements. This outcome is the result of agency (ibid. p.179), whereby each action depends up on the specific situation. Just like Gorman and Carlson, Gooding considers a material model to be more stable as compared with a mental model (ibid. p.189).

According to Beckman and Barry (2007), the problem/solving cycle deals with finding and selecting problems and subsequently finding and selecting solutions. The outcome of this four-staged innovation/learning model results in an improvement of the abilities to accomplish each of the four stages. In addition, the learning content addresses the individuals' capabilities to generate ideas/proposals within the "realm of theory" and translate these ideas/proposals to the "realm of practice" by creating artefacts. Likewise, Henderson (1991) sheds light on improving the PD process as an outcome; hence, the learning content is more than changes occurring endogenously in the individuals' cognitive structures. The focal point is the successive creation of the conscription devices. This ongoing creation of the conscription devices facilitates changes as for the structure of the work processes, coordination among the engineers, conflict management as well as human perception.

### 5.3.4. PD as an enabler

Beckman and Barry (2007) describe the four-staged innovation/learning model as a method to enable social interaction among individuals. Given that Beckman and Barry draw on Kolb's experiential learning theory, PD enables a continuous movement around the innovation/learning cycle. It is a step-by-step movement among the four categories that emerge when combining the two dimensions in Kolb's learning model. As mentioned elsewhere, Beckman and Barry reject the transformation dimension and substitute their own, but retain the perception dimension; that is, the abstract conceptualisation versus concrete experience continuum. In this regard, Gorman and Carlson (1990) as well as Gooding (1990) make use of Kolb's perception dimension as a central concept in their analyses. Henderson (1991:451) only touches on the perception dimension in her brief account of two different kinds of tacit knowledge; visual and kinesthetic knowledge. The kinesthetic learning style is an action-oriented learning process rather than a process of listening or thinking (Merriam et al., 2007:194); a viewpoint which is in line with Kolb's perception dimension.

Referring to Kolb's experiential learning model (1976), the perception dimension sets up a dialectic tension field addressing how an individual grasps an event. However, Elkjær (2005:116) points out that there is a lack of dialectics in Kolb's learning model, even though Kolb describes it as a dialectic tension field between extremes. The dialectic tension field disappears into thin air because Kolb makes use of the extremes to construct the four different sequential stages in his learning model.

Accordingly, as an enabler for learning, PD may instead be viewed from two opposing perspectives. Is the focus on abstract conceptualisation (creating a theoretical and comprehensive model before initiating the design of a new product)? Or is the starting point the concrete experience (combining experience and design during the creation of the product)? Frankly speaking, does PD enable a top-down or bottom-up approach?

Gorman and Carlson (1990) draw on the perception dimension to illustrate Bell's and Edison's approach to PD (inventors of the telephone), by which the bottom-up/top-down PD principles become apparent. The analysis indicates that Bell mostly developed abstract ideas of the telephone endogenously in his mind (top-down approach). Conversely, Edison worked very closely with the physical telephone and thereby got new ideas. Hence, for Bell, the starting point and the problem-solving process were abstract conceptualisation, while Edison engaged in a bottom-up approach, by which his problem-solving process focused on the creation of the artefact – concrete experience. Gooding (1990:166) follows in the same vein. He claims that an invention necessitates the carrying out of concrete experimentations on the artefact (material object), which results in a manipulation of *"the world as well as talk and thought about the world."*. Gooding introduces an "experimental map". This method ranks alongside personal aspects of cognition and communication with social, institutional and ideological bases of knowledge. PD is thus considered a method enabling bridge-building between mental models, the artefact and institutional factors.

Henderson (1991:451) considers *"technology as a social process, simultaneously socially shaped and society shaping."*. A conscription device is the seed to collective knowledge creation and social interaction among engineers; it is the *"social glue both between individuals and between groups."* (ibid. p.448). Hence, PD enables human interaction and the use of conscription devices to establish different sociotechnical contexts. It allows members belonging to different groups to read different meanings and thereby create new designs collectively.

The next subsection presents an overview of the literature in this perspective.

### 5.3.5. The perceiving perspective

| **Perceiving perspective** | Learning process (How) Section 5.3.1 | Who learns Section 5.3.2 | What is learned Section 5.3.3 | PD as enabler Section 5.3.4 |
|---|---|---|---|---|
| Individual learning/ sociotechnical view | Addresses how individuals grasp and handle events. It is a merger between mental models and artefacts in a socio-technical context. | Individuals and artefacts; articles include the sociotechnical context as an end point for learning. | To improve PD capabilities, including the sociotechnical context. Stabilisation ranks alongside knowledge. | PD enables learning in a sociotechnical context; either a top-down or a bottom-up PD context for learning. |

Table 5.2. The perceiving perspective.

The learning process is considered a merger between individual learning mechanisms and artefact(s). Kolb's (1976) perception dimension is prevailing in this group of contributions explaining this merger, for which reason this category is termed "**perceiving**". The learning process addresses how an individual grasps and handles an event or situation. Although three different cognitive theories emerged during the review, the individual learning mechanisms remain at the centre of the learning process. The sociotechnical context, however, constitutes and is constituted by the thinking and actions of the individuals. Hence, the individuals and the artefacts are considered to be the learning entity; however, the articles include the sociotechnical context as an end point for learning. The terms knowledge and information are eclipsed by the term stabilisation, which has two dimensions. First, the mental model becomes stabilised, and second, the artefact becomes increasingly stable in course of the PD process. Both subject matters are held to be learning content. PD enables learning. A top-down approach to PD enables learning as abstract conceptualisation, while the opposite is true for a bottom-up approach, as PD enables the application of concrete experience.

## 5.4. Institutional learning mechanisms/PD in an engineering view

As it appears from the review in section 5.2 dealing with individual learning mechanisms in an engineering perspective, these contributions draw on decision-making theories in an effort to improve PD and thereby achieve competitive advantages. The theoretical contributions in this section focus on communities and on how structures, processes and routines are developed in order to improve the competitive advantages of the firm. Hence, an improvement of the competitive position is a common denominator for the two different perspectives.

The differences between the learning orientation in section 5.2.1 and the one being analysed in this section can be traced back to the intense discussions among researchers/consultants with regard to **organisational learning** and **learning organisation**; two distinct stances to the learning phenomenon.

> *"The literature on organizational learning has concentrated on the detached observation and analysis of the processes involved in individual and collective learning inside organizations; whereas the learning organization literature has an action orientation, and is geared toward using specific diagnostic and evaluative methodological tools which can help to identify, promote and evaluate the quality of learning processes inside organizations."* (Easterby-Smith and Araujo, 1999:2).

The above quotation exposes two research streams in relation to the development of organisational knowledge. The purpose of the research as well as the target group diverges. **Organisational learning** (OL) is descriptive. The academics conduct research in order to enhance the understanding of learning processes and/or learning content within an organisational context. **Learning organisation** (LO), on the other hand, is prescriptive. It focuses on explaining practicians how to optimise knowledge transfer as a means to improve the competitive position of the organisation. In the words of Vera and Crossan (2003), the research addressing the LO perspective focuses on the alignment between strategies, structures, cultures, processes and systems; the challenge is to understand the systems and the infrastructures of the organisation, whereupon the proposals are presented.

The academic gap between the two learning stances differs. Illeris (2003), a researcher from a pedagogical university, applies a social-cognitive learning orientation to describe workplace learning. Illeris takes the following stance to the LO stream literature.

> *"The expression, "learning organisation", is thus a misnomer, a kind of verbal theft, as organisations do not have and cannot develop such qualities."* (ibid. p.168).

Dodgson (1993:377) agrees and considers the individuals to be the primary learning entity in the organisation; however, the individuals create an appropriate infrastructure that underpins learning. Thus, Dodgson orchestrates a learning orientation in which the structural dimension influences the learning context; that is, organisational infrastructure enables and/or constrains the individual learner. An even greater focus on the structural dimension is perceptible in Senge's (1990) contribution to the theory of LO. He considers an LO to be an organisation that creates structures and strategies; e.g., the five disciplines that enable learning among all employees in the organisation.

The above indicates a gradually growing constitutive effect of various elements within the contextual settings at the expense of the individual. This shift in focus from the individual to the organisation seems to have some consequences. As Elkjær (2005:36) briefly points out, it is rather difficult to identify the theoretical concept of learning these contributions make use of. Therefore, in contradistinction to sections 5.2.1/5.3.1, the review of the learning process in section 5.4.1 does not include a discussion of the underlying learning orientations applied by these contributions.

### 5.4.1. The learning process (How)

Studying the learning processes at Toyota, Fuchs (2007:29) considers the learning groups to be heterogeneous as their members belong to different professional practices, functions and organisations. Correspondingly, the development of Toyota's knowledge sharing network is the result of a deliberate, gradual evolution of three shared social communities (Dyer and Nobeoka, 2000:352). The members of each of the three social communities belong to different hierarchical levels in the interacting organisations; moreover, all three communities include members from various organisations. In line with this, Powell et al.'s (1996:142) analysis of learning in networks focuses on a community made up of different organisations and organisational practices. Holmqvist (2003:96), however, challenges the approach of separating intraorganisational learning from interorganisational learning as the continuous interactions initiate an adaptation of behaviour, rules and routines within the interacting units.

Articles applying a meso-perspective on the learning entity address the learning processes taking place when a project team conducts post-project reviews (Koners and Goffin, 2007) or when the PD team develops complex technology (Garrety et al., 2004) in various kinds of Communities Of Practice (COP) when developing a high-modularised product (Hildrum, 2007). However, the definition of a COP diverges. Garrety et al. (2004:352) address the differences between a COP and a PD project team. While the latter is more ad hoc in nature and more instrumental, the COP develops its own routines and rules and has an inventory of shared assumptions and knowledge. Hildrum (2007:468) agrees and emphasises that an ongoing development of knowledge and expertise takes place when a group of people are carrying out activities. Koners and Goffin (2007:245) compare a project team with an embryonic form of a COP.

Just as the interpretations of the learning entities differ, so does the understanding of the interaction. For instance, the interaction within and between heterogeneous learning groups is a three-phase structured process, which Fuchs (2007) denotes action learning. She compares it to the "lean thinking" concept (ibid. p.28). The first phase is to analyse and describe the problem; then, in the second phase, the learning group revises existing knowledge in order to come up with a solution. Finally, the third phase involves reflection on the process. While the first two phases address knowledge sharing within the heterogeneous learning group, the third phase includes the learning activities between interacting groups as well.

The learning model introduced by Powell et al. (1996:138) is labelled cycles of learning. This learning model is a network analogous to Cohen and Levinthal's (1990) theory of absorptive capacity indicating that a firm's capacity for learning depends on its internal as well as external R&D capabilities (ibid. p.119). Thus, learning activities take place within as well as between interacting firms. In this regard, the R&D ties are the open sesame to the learning network, whereas the main drivers of the dynamic learning system are network experience, diversity of ties and network centrality. Accessing this learning network makes it possible to keep pace in the high-speed learning race taking place within biotechnology.

The development of a knowledge-sharing network at Toyota has much in common with Powell et al.'s network learning within biotechnology. By gradually developing and strengthening its ties, Toyota manages to establish bilateral as well as multilateral ties within its supply network (Dyer and Nobeoka, 2000:360). In the social community termed Supplier Association, top managers share explicit knowledge with respect to Toyota's policies and best practice. This results in a development of bilateral ties between Toyota and each supplier as well as weak social ties among the suppliers. Joint problem solving activities at the suppliers' location take place in Consulting Problem Solving communities. These activities include workshops and seminars by which tacit knowledge is shared in multilateral relationships. The third social community is Voluntary Learning teams, which consist of 6-12 suppliers and a number of Toyota consultants. The focus is to create strong multilateral ties in the supply network and thereby be able to share tacit knowledge. Thus, by creating a network identity, members of the social communities feel a shared sense of purpose with the collective; it dictates who is and who is not a member of the network.

Likewise, Hansen (1999) applies social network theory to describe the search activities applied to identify new knowledge, while the PD theory is used to describe the knowledge transfer activities; that is, the movement and incorporation of knowledge. By combining the search and transfer activities, the findings indicate that weak ties facilitate the search for new knowledge, but hamper the transfer of complex knowledge (ibid. p.82). This viewpoint is in keeping with the above discussions that suggested that weak and strong ties crossing organisational boundaries[11] each have their strengths and weaknesses with respect to searching for and transferring new knowledge.

[11] The research contribution of Hansen is intraorganisational as it focuses on subunits in a multiunit organisation. The reason for including the contribution of Hansen in an interorganisational argumentation is the size of the focal organisation (a large electronic company), which consists of 41 divisions.

Turning to the contributions with a more narrow learning entity scope, the means to transfer tacit as well as explicit knowledge become more micro-oriented compared with the above focus on ties and network. Koners and Goffin (2007:245) focus solely on tacit knowledge and argue for the necessity of establishing social interaction as a means to transfer knowledge. Metaphors and stories being told facilitate knowledge transfer within the community as well as facilitate learning to be applied in future PD projects. Garrety et al. (2004) and Hildrum (2007) discuss the roles of brokers and boundary objects[12] in transferring knowledge within and between interacting COPs. To become a broker, it is necessary to be a member of several COPs (Hildrum, 2007:470). However, on the back of increasing technical modularity, the face-to-face interaction between brokers can be substituted by Information and Communication Technologies (ibid. p.482). Hence, the role of a broker can be replaced by a boundary object. Hildrum's viewpoint is contrary to that of Koners and Goffin (2007) who focus on establishing social interaction as the means to share knowledge. Garrety et al. (2004:356) make use of both concepts to discuss a balancing between autonomy and integration among COPs. In doing so, brokers as well as boundary objects facilitate an appropriate alignment of interests among all COPs involved. Social interaction among brokers transfers knowledge into the community, while a technological artefact acts as a boundary object and thereby constitutes the integration of knowledge within the community.

### 5.4.2. Who learns

The individuals are mentioned as community members who may possess important knowledge from similar communities (Garrety et al., 2004), members of a project team who manage, combine and co-create new technological knowledge (Hildrum, 2007) or members of an action learning group using lean thinking (Fuchs, 2007). Despite this scattered focus, the individuals are not considered to be the learning entity. Explicitly, Hildrum and Garrety et al. regard the COP to be the learner, while Koners and Goffin (2007) emphasise that knowledge has to be widely shared within the organisation as well.

Literature addressing knowledge sharing across the boundaries of an organisation suggests that the learner is to be found at a generic organisational level. For instance, Powell et al. (1996) describe the learner to be at firm level. They regard the knowledge base of an industry to be complex and expanding and add that the sources of expertise are widely dispersed. Consequently, the locus of innovation is in the network rather than within the individual firm. Thus, in addition to the fact that the individual firm learns, new knowledge will also be embedded within the industrial network. Likewise, the three social communities within Toyota's supply network constitute the means to transfer knowledge (Dyer and Hatch, 2004). This community knowledge is embedded in the network, resulting in new knowledge becoming available for either Toyota or one of its suppliers (Dyer and Nobeoka, 2000:364). Hence, just like in the findings of Powell et al. in relation to biotechnology, the learner is Toyota's supply network as well as each participating organisation. Fuchs (2007) agrees and considers the interacting organisations the learning entity.

[12] Hildrum does not use the term "boundary objects". Nevertheless, the argumentation applied to explain the role of face-to-face interaction and "Information and Communication Technologies" has much in common with the function of a boundary object.

### 5.4.3. What is learned

Tacit knowledge is difficult to transfer, but the obstacles become more surmountable when knowledge is formal (Garrety et al., 2004), explicit (Dyer and Nobeoka, 2000; Koners and Goffin, 2007; Fuchs, 2007) or highly codified and independent (Hansen, 1999). Hence, the learning content consists of tacit as well as explicit knowledge.

Despite its diverse nature, knowledge is transferred and shared within and/or among a network of communities, in which it becomes embedded in the shape of a new saleable product (Hildrum, 2007), is used to introduce changes in future PD processes (Koners and Goffin, 2007), aligns interests and develops social relationships among interacting COPs (Garrety et al., 2004). This group of contributions focuses mainly on improving the stock of knowledge in terms of routines, procedures and the patterns of interaction. The content of the learning process finds expression in an improvement of one or more business processes and it is most often rather specific.

Drawing attention to the articles focusing on the network level, Dyer and Nobeoka (2000) discuss the differences between network and organisational learning. They consider the outcome of the learning process to be network specific and accordingly embedded within the particular network. This knowledge storage mechanism contains best practice as well as an understanding of how to coordinate with other companies. As the three social communities store knowledge at the network level, the knowledge becomes available for the individual firm, on the basis of which it is able to initiate changes within business processes and/or routines. Fuchs (2007) considers changes to take place in a seven-step problem-solving model or in the patterns of collaboration with the customers. Powell et al. (1996) shed light on an improvement of the firm's reputation and ability to collaborate with external partners.

Thus, the changes at the network level are rather generic. They address an improvement of the working processes by internalising best practice as well as the ability to coordinate/collaborate with other organisations. At the organisational level, the learning outcome results in changes within various business processes and routines.

### 5.4.4. PD as an enabler

Given that the locus of innovation is embedded within the network of learning, it is crucial to access this learning community. R&D ties (the admission ticket) provide the access to the interorganisational learning communities (Powell et al., 1996). Correspondingly, Dyer and Hatch (2004) stress the necessity of becoming a member of the Toyota Group in order to stay in business in today's world of competition. To establish an appropriate network structure enabling knowledge sharing, Toyota gradually develops ties among members of the supply network. This development takes place during meetings as well as when conducting activities. Likewise, Hansen (1999) interprets the inter-unit ties as instrumental in searching for and transferring knowledge in PD projects. Thus, these contributions consider PD as an enabler for accessing a network of learning actors as well as an appropriate infrastructure facilitating knowledge sharing and utilisation.

Fuchs (2007) focuses on learning processes within Toyota's network and she is rather specific when explaining the relation between learning and PD. She regards PD as an enabler for action learning, resulting in continuous changes. These changes are illustrated as an ongoing evolution of "the seven-step problem-solving model" used for conducting PD activities.

As PD necessitates coordination among human, social and material factors across functional or organisational boundaries, a PD project is suitable for studying the learning process (Holmqvist, 2003:447). Agreeing with this statement, Garrety et al. (2004) introduce the concepts of brokers and boundary objects as enabling determinants. Hildrum (2007) continues the discussion, indicating that brokers, and in part boundary objects, facilitate new technological knowledge. Similarly, sharing knowledge, Koners and Goffin (2007) emphasise the enabling role of metaphors and stories in post-project reviews. In contradistinction to Powell et al., (1996), Hansen (1999) and Dyer and Hatch (2004), this group of contributions does not consider PD as an enabling determinant of access to a suitable knowledge-sharing infrastructure. Instead, PD is considered suitable for studying the learning phenomenon; consequently, PD is regarded as an appropriate instrument for studying the learning processes.

The next subsection presents an overview of the literature in this perspective.

### 5.4.5. The accessing perspective

| **Accessing perspective** | Learning process (How) Section 5.4.1 | Who learns Section 5.4.2 | What is learned Section 5.4.3 | PD as enabler Section 5.4.4 |
|---|---|---|---|---|
| Institutional learning/ engineering view | Focus on institutional learning mechanisms to access external/valuable knowledge. Individuals disappear and, instead, knowledge flows between organisational entities. | Organisational entities and industrial network. Individuals are considered a homogenous crowd and become institutionalised. | Improving competitive position by implementing best practice as regards PD and collaboration. | Generally speaking, PD is regarded as a suitable business process for studying the learning phenomenon. |

Table 5.3. The accessing perspective.

The learning process consists in accessing valuable knowledge; thus, this category is denoted "**accessing**". The shift in focus away from the individual to institutional learning mechanisms causes the individual persons to be regarded as a homogenous crowd. The learning process sheds light on the appropriate institutional learning mechanisms for accessing the network, organisation, COP or PD team, after which knowledge flows from one organisational entity to another entity. The institutional learning mechanisms used for accessing the source of knowledge, the admission tickets, so to speak, range from R&D ties to social interaction. The learning process implies changes in the institutional learning mechanisms, such as procedures, structures, routines or the patterns of interaction. Endogenous structures, i.e., the individual learning mechanisms, are not directly affected as changes are described to take place within the COP, organisation and/or at network level. In general, the learning outcome is a means to improve business processes and thereby achieve competitive advantages. With the exception of the article by Fuchs (2007), the contributions within this perspective do not consider PD as being a learning enabler. Either the focus is on accessing a learning community to facilitate knowledge sharing or on applying PD activities in an effort to study the learning phenomenon.

## 5.5. Institutional learning mechanisms/PD in a sociotechnical view

Rather than discussing structures and/or organisational routines as a means to transfer knowledge as done in the previous section, the focus of this category is, among other things, to understand how the capacity of a boundary object makes it possible to transform situational knowledge. Another group of articles considers learning to be situated in practice or in activities.

### 5.5.1. The learning process (How)

Just as the contributions reviewed in section 5.4.1, the learning theories within this perspective have a tendency to bring the contextual setting to the fore in the analyses and contributions. This complicates the identification of the learning processes.

Howbeit, the analysis in this section addresses two groups of contributions. First, the learning process is considered as the handing over of "situated knowledge" of various kinds. Second, different "situated learning" theories become the subject matter; practice-based learning, learning as knowledge creation and finally, learning as a path-dependent activity embedded in practice.

<u>5.5.1.1. Learning process as the transfer, translation or transformation of knowledge</u>

The framework applied by Carlile (2004:558) divides knowledge into the categories of specific property or relational property. The knowledge falling within the specific property category consists of a different and a dependent nature, respectively. While the different nature of knowledge arises because of cross-functional collaboration, the dependencies emerge due to technical and coordinative issues. If the differences and dependencies between interacting domains are unknown, knowledge becomes novel;[13] novelty is a third dimension in relation to specific properties. The relational property category describes knowledge as being either common or domain-specific.

The learning process is to transfer, translate and transform the relational domain-specific knowledge from one engineering group to another by applying common knowledge. Thus, Carlile regards common knowledge as an enabler. Common knowledge can be a lexicon, a tool or a clay model (a mock-up of the physical artefact, author). Obviously, the concept of "common knowledge" applied in this 2004 article has much in common with the concept of "boundary object", which Carlile makes use of in his article from 2002. That is, a boundary object establishes a shared syntax or language facilitating knowledge transfer crossing a syntactic knowledge boundary. A semantic boundary necessitates an interpretative approach. It calls for a concrete means to specify and learn about the differences and dependencies dealing with the knowledge to be translated when crossing a boundary. The boundary object

[13] Carlile (2004:557) deliberately uses the word novelty instead of uncertainty. Uncertainty is described as an external feature indicating that all is not known in a given environment. Novelty does not indicate an external advantageous object. Novelty emphasises what an actor needs to share and assess when all is not known.

has “semantic capacity”. The highest novelty indicates a pragmatic boundary, which results in a political approach to transform knowledge. In this situation, the boundary object has to have pragmatic capacity.

Sole and Edmondson (2002:S30) throw light on the complications arising when knowledge is situated within a COP. Especially the team’s awareness as well as the appropriability of the situated knowledge influence team learning. However, the individuals are viewed upon as a homogeneous crowd, for which reason the individual disappears in the definition of situated knowledge; it is defined as *“shared by those who are co-located – despite role or task-based differences.”* (ibid. p.S20). Likewise, individuals outside the practice do not possess this situated knowledge although they assume similar roles or carry out similar tasks. That is, the specific situation in a contextual setting constitutes learning.

5.5.1.2. Practice-based learning

Instead of describing learning as a process by which explicit and/or abstract knowledge is transmitted from the mind of someone who knows to the mind of someone who does not know, learning bestows the individuals with an *“ability to behave as community members.”* (Brown and Duguid, 1991:48). The central aspect of the learning activities is to work in practice and thereby become a practitioner.

Brown and Duguid (1991) draw on Lave and Wenger’s (1991) “Legitimate Peripheral Participation” and Orr’s (1987 and 1990) analysis of the service technicians to view learning as a bridge between working and innovation. This practice approach to learning is combined with Daft and Weick’s (1984) “enacting organisation” (Brown and Duguid, 1991:41) to be able to explain the importance of having a community of interpretation enabling learning.

In Legitimate Peripheral Participation, Lave and Wenger (1991) point out a major difference between a learning understanding that includes practice in the learning process and a learning understanding that considers learning to be contextually embedded within practice. To emphasise an unequivocal distinction between these two perspectives, Lave and Wenger change the title of their learning theory from situated learning to Legitimate Peripheral Participation. In doing so, they draw on Vygotsky’s “zone of proximal development” theory to emphasise learning as being *“the changing relations between newcomers and old-timers in the context of a shared practice.”* (ibid. p.49). Thus, Lave and Wenger’s social practice theory of learning is an analytical tool for interpreting and understanding learning activities in a situation where a newcomer gets access to peripheral participation within the COP; the COP is not a static unit, but *“The practice itself is in motion.”* (ibid. p.116).

Another important contribution to the practice-based understanding of learning is Brown et al.’s (1989) analysis of situated cognition. They emphasise that *“concepts are both situated and progressively developed through activity…”* (ibid. p.33). That is, an activity applies knowledge and, at the same time, it produces new knowledge. This results in a stance in which an activity is seen as situational and inseparable from learning and cognition.

Brown et al. (1989) make use of an analogy between situated learning and tools[14] to illustrate that the application/understanding of both is contextually embedded. Likewise, the situated learning focuses on an ongoing adaptation to contextually embedded activities. Everything is situated in the activity. It is not possible to separate learning from the specific situation.

Hence, the individual is embedded in a social as well as a physical practice. The experience with the specific situation and the tools being applied are an integral part of the practice-based learning process.

5.5.1.3. Learning as knowledge creation

Peltokorpi et al.[15] (2007:55) concur with the practice-based learning orientation regarding a contextually situated knowledge creation process; in this connection, please note that instead of using the term learning process, Peltokorpi et al. describe it as a knowledge creation process. Just as in the practice-based learning perspective, PD and knowledge creation proceed concurrently. These activities take place in a Ba, which is *"a shared context in motion."* (ibid. p.53), and the activities are performed by *"contextually situated actors."*. A context does not exist in a vacuum, but is the result of individuals' interactions and interpretations. Despite this approach to the contextual setting, Peltokorpi et al. (2007:53) describe Ba to be deliberately designed as a means to enable knowledge creation. Hence, the management of innovation and knowledge creation is attributed to organising an appropriate Ba. In any case, an ongoing conversion between tacit and explicit knowledge within different Bas enables knowledge creation.

The contribution from Peltokorpi et al. draws mainly on Nonaka's (1994:15) knowledge creation model, which consists of two dimensions, an ontological and an epistemological dimension. The latter dimension sheds light on a continual reciprocal transformation between tacit and explicit knowledge. This transformation consists of four phases and the model is termed SECI; socialisation, externalisation, combination and internalisation. The ontological dimension deals with the community of interaction, which spans individuals, groups, departments and organisations. That is, the community in which interaction takes place can be cross-functional as well as interorganisational.

In an article from 1998, Nonaka and Konno introduce the aforementioned concept of Ba to describe the community of interaction as being a forum for interaction among individuals, working groups, project teams and front-line contact to customers (ibid. p.41). Just as the SECI knowledge creation model consists of four phases, Ba is divided into four phases, an originating Ba, an interacting Ba, a cyber Ba and finally, an exercising Ba.

An extension of Nonaka's knowledge creation model emerges in an article from 2000 which introduces a knowledge management element. Just as the SECI spiral and the Ba

[14] A more updated example illustrates the analogy between situated learning and tools. *"At the end of December 2009, just after the United Nations Climate Change Conference in Copenhagen, we are all concerned with how to reduce the emission of $CO_2$. Therefore, we ask our car dealer to adjust the engine in our car in order to reduce the $CO_2$ emission. In this specific situation, the specific highly skilled motor mechanic uses specific electronic tools to reduce the $CO_2$ emission. He checks the type of the specific engine, what kind of software is downloaded in the computer system of this specific engine, etc., and then he uses his skills in combination with the tools to adjust it."*. All are situated; the Climate Change Conference has just ended without being successful, it is a specific car, it has a specific version of software and it is a specific motor mechanic, who has learned to apply the specific tools when conducting similar activities.

[15] Please notice that Ikujiro Nonaka is one of the co-authors of this contribution.

contextual setting, the managerial element to manage the knowledge creation process consists of four different knowledge assets; these are experiential knowledge assets, conceptual knowledge assets, systemic knowledge assets and routine knowledge assets. Accordingly, Nonaka et al.'s (2000) model consists of three inseparable elements; a SECI process, an appropriate Ba and knowledge assets. The latter is simultaneously the input to the SECI spiral, the outcome of this process and a moderator facilitating an appropriate Ba and SECI process.

The applied learning orientation diverges among the four phases. The socialisation phase focuses on sharing mental models and technical skills by creating an "originating Ba" consisting of shared feelings, emotions and experience. Similarities to the learning orientation drawing on humanism are striking, as words such as "care, love, trust and security, energy, passion, and tension" are used to describe this part of the knowledge creation process. The pivotal point in the following externalisation phase is to apply metaphors and/or analogies to create an artefact, for instance a mock-up. Articulation of tacit knowledge embedded endogenously in the members of the "dialoguing Ba" results in conceptual knowledge as for instance a product concept. The description of the externalisation phase could indicate a socio-cognitive learning orientation. However, it is clearly emphasised in the explanation of the Ba concept that knowledge is contextually embedded in practice. Therefore, drawing on this argumentation, some similarities to the practice-based learning theory emerges, for instance Brown and Duguid (1991). In the combination phase, the interacting actors transfer explicit knowledge within the "systemising Ba". It deals with systemised and packaged explicit knowledge; for instance documents, product specifications, manuals or knowledge to be transferred between databases. Thereby, knowledge is transferred from one system/actor to another system/actor like water flows in a tube. Hence, it is impossible to identify a learning orientation in relation to the combination phase. Instead, there are some similarities to Information and Communication Technology. Internalisation, the fourth phase, sheds light on applying storytelling to share mental models as well as learning as the means to ensure an embodiment of the explicit knowledge. The "exercising Ba" is the contextual setting for the internalisation, which facilitates learning by doing; however, knowledge is also embodied through simulations and experiments. In this regard, the individual is visible in the explanations, indicating a cognitive learning orientation. However, as mentioned in relation to the interpretation of the externalisation phase, knowledge is deeply embedded in a shared context in motion. That is, the learning orientation bears similarities to the practice-based approach to learning.

#### 5.5.1.4. Learning as a path-dependent activity embedded in practice

Like Brown and Duguid's (1991) practice-based learning and Nonaka et al.'s (2000) knowledge creation approach, Miettinen et al. (2008) emphasise the necessity of being grounded in practice. The accomplishment of PD activities results in learning and thereby co-evolution of an artefact, acquisition of new competencies and ability to collaborate in a network. These developments are not discrete events, but path-dependent. Hence, PD is not a single event taking place in isolation from previous PD projects. Instead, it follows a path embedded in prior physical artefacts and the company's network collaboration, which consists of *"a constellation of material entities and artefacts, human competencies and social relationships between partners."* (Miettinen et al., 2008:215).

Miettinen et al. (2008:216) address two types of learning to ensure the ongoing development of products, competences and networking. The two learning activities (the term "learning process" is not used in the article, author) are experimental learning and collaborative learning. The experimental learning activity takes place when the individual works and conducts experiments with instruments and artefacts. The outcome of this learning activity is cumulative as it is an ongoing enhancement of the competences embedded within the PD activities. The collaborative learning activity is the means to search for and encounter a partner within the biotechnological network who possesses complementary knowledge, skills and competences. This learning activity adds to the competences.

The applied learning theory is a combination of cultural-historical activity theory and the epistemology of things and effects (Miettinen et al., 2008:203). As with the Legitimate Peripheral Participation theory (Lave and Wenger, 1991), the cultural-historical activity theory can be traced back to the work of Vygotsky. Referring to Merriam et al. (2007:277), Vygotsky's sociohistorical theory cannot be categorised as a learning theory, but it has important implications for the understanding of practice. In this light, Vygotsky's theory has been an important platform for learning theories taking a practical approach. Vygotsky's contributions have been used to understand the social dimension of learning with respect to the construction of language, symbols and culture.

In light of the fact that Miettinen et al. (2008) apply the epistemology of things to interpret the effects arising from experimentations and artefacts, there are similarities between their work and that of Gibson (1979). [16] Yet, the work of Gibson is not used in the contribution. Instead, the authors include the STS theories as well as the philosophy of science (ibid. p.205) in order to explain this phenomenon. By doing so, the individual disappears.

Concluding on Miettinen et al., the embeddedness of activities in a path-dependent practice draws on a view dealing with an inseparable relationship between history, activities, PD and learning.

### 5.5.2. Who learns

Carlile (2004:561) selects participants from four different groups involved in a specific PD project to analyse the utilisation of knowledge embedded in an intraorganisational context. The framework of the analysis addresses the functional level within an organisation and it sheds light on the capability to hand over syntactic, semantic and political knowledge. Thus, Carlile regards a group to be the learner. Correspondingly, Sole and Edmondson (2002:S17) identify the team as the learning entity.

Referring to Brown and Duguid (1991:49), a "community of interpretation" is not formally established to carry out a specific task; it gradually emerges in shape as well as in membership. This worldview challenges the use of, for instance, an organisation/team as the

[16] An ecological object offers what it does because it is what it is. However, the perception of an ecological object is not value-free; rather, it arises from an inseparable interplay between endogenous perception and exogenous stimuli. Given that Gibson's (1979:141) theory *"is wholly inconsistent with dualism in any form, either mind-matter dualism or mind-body dualism."*, the perception of an artefact is situational.

unit of analysis in a piece of research. Instead, the activities must be chosen as the unit of analysis. Thereby, within the situated learning approach, the learner is the members of the community when conducting activities (ibid. p.48).

Peltokorpi et al. (2007:56) describe the knowledge SECI spiral to become larger in scope as it moves from endogenous cognitive processes to the crossing of organisational boundaries. In line with Brown and Duguid (1991), the unit of analysis chosen is the chain of activities in relation to a PD project starting from concept creation to product launch. Hence, functional or organisational boundaries will not limit the scope of the knowledge creation. Peltokorpi et al. (2007) consider the individuals as the learner; however, these individuals are contextually situated and as Nonaka and Konno (1998:40) describe it: *"knowledge is embedded in Ba..."*. Thus, the situational and contextual Ba with all its members is the learner and this Ba can be multilayered and partly overlapping.

The unit of analysis chosen by Miettinen et al. (2008:205) is the path, which is the result of successive PD activities. The focus is to understand the ongoing formation of material artefacts and the human ability to carry out activities and to interact with internal as well as external partners. Thus, the learner is the artefacts and the inseparable relation between human(s) and activities.

### 5.5.3. What is learned

If the domain-specific knowledge between two interacting cross-functional groups is unknown, the knowledge novelty increases (Carlile, 2004:557). To be able to transfer this domain-specific knowledge, it is necessary to improve the common knowledge by modifying the boundary object, for instance the knowledge database, drawings or mock-ups. Thus, learning increases the cross-functional group's ability to transfer, translate and transform the domain-specific knowledge embedded within the interacting groups. In the same way, the learning content is application-oriented within the practice as it enables the team to carry out problem-solving activities (Sole and Edmondson, 2002:S18).

Rather than abstract knowledge decoupled from practice, the situated learning orientation considers the learning content to be embedded in practice. The members of the "community of interpretation" increase their own knowledge and, at the same time, they add to the collective knowledge within the community (Brown and Duguid, 1991:44). Thus, the community's ability to apply knowledge, when working, learning and innovating, results in new knowledge embedded in situational activities. Given that the Legitimate Peripheral Participation learning orientation emphasises that the generalisability of knowledge depends on the ability to (re)negotiate the meaning of a specific event, knowledge is considered as being temporary within this learning orientation.

Peltokorpi et al. (2007:55-56) address the outcome in relation to each of the four phases in the SECI spiral. Among other things, the outcome includes tacit knowledge, as for instance shared experience and routines, as well as explicit knowledge, like a tangible end product. However, returning to Nonaka et al. (2000), knowledge transcends this tacit-explicit taxonomy. Knowledge is "justified true belief'" and Nonaka (1994:15) emphasises the "justified" rather than the "true" aspect of belief. Knowledge is not static, but dynamic, contextual and humanistic. Thereby, in concordance with the approach taken by Lave and

Wenger (1991), knowledge becomes temporary and due to its context-specific embeddedness, it is dependent on a particular time and space. In addition, without being embedded in a practice, it is merely information and, accordingly, not knowledge (Nonaka et al., 2000:7). Just as the practice-based learning (Gherardi and Nicolini, 2000:332; Lave and Wenger, 1991:32), the creation of new knowledge is like a journey from "being" to "becoming".

As Miettinen et al. (2008) emphasise the embeddedness of activities in a path-dependent practice, they seem to be in line with the above. However, instead of focusing on the individual's journey from "being" to "becoming", their stance emphasises that PD activities follow a trajectory. As a direct outcome of experimentations and collaborations, the organisation enhances its PD trajectory. This results in a strengthening of its competencies in searching for and encountering complementary knowledge as well as in conducting experimentations on new product and business activities.

### 5.5.4. PD as an enabler

As PD necessitates cross-functional collaboration, Carlile (2004:563) considers this to be an appropriate context for studying knowledge transfer, translation and transformation. By doing so, Carlile regards PD as a phenomenon that renders it possible to study how knowledge is handed over boundaries. The contrary approach is taken by Sole and Edmondson (2002) who consider PD to facilitate a community of shared practice and site-specific knowledge. This gives rise to an understanding of PD as enabling *"common work practices, common interpretations of joint endeavours and shared epistemic perspectives…"* (ibid. p.S18).

Brown and Duguid (1991) consider the situational activities to enable a gradual establishment of a COP. In this regard, learning is interpreted *"as the bridge between working and innovating."* (ibid. p.41). The definition of a COP conjures up an image of an interpretive unit that has fluid boundaries regarding membership as well as shapes. It is a community of interpretation *"often crossing the restrictive boundaries of the organization to incorporate people from outside."* (ibid. p.49). In agreement with the practice-based learning theory, Peltokorpi et al. (2007) regard the PD process, the knowledge creation process and the Ba to be situated in practice. In other words, learning and PD are embedded in the concept of Ba. Ba is not just a physical space, but a shared context in motion depending on time (the history) as well as space (the place). Hence, PD enables a situational context. It is a holistic understanding, which synthesises *"micro and macro, tacit and explicit knowledge, and agents and context…"* (Peltokorpi et al., 2007:50). The work of Miettinen et al. (2008) follows the same track as proposed by Brown and Duguid (1991) and Peltokorpi et al. (2007). Thus, PD, network collaboration, learning and acquisition of new competencies develop simultaneously with individuals conducting PD activities; it follows a path cleared by the outcome of prior PD activities. That is, PD enables a sustained development of the "path", and based on the work of Garud and Karnøe (2001), Miettinen et al. (2008:206) point out:

> *"that path construction takes place in a "technological field"."…"This field is also in motion, one in which different courses of events and developmental trajectories (of technologies, institutions and markets, for examples) constantly create new possibilities and constraints. Path construction navigates through the evolving field of opportunities and constraints."*.

The next subsection presents an overview of the literature in this perspective.

### 5.5.5. The practising perspective

| **Practising perspective** | Learning process (How) Section 5.5.1 | Who learns Section 5.5.2 | What is learned Section 5.5.3 | PD as enabler Section 5.5.4 |
|---|---|---|---|---|
| Institutional learning/ sociotechnical view | Individuals are a homogenous crowd with similar learning mechanisms and motivation to act. Hence, being a member of the practice enables learning per se. | PD activities and learning are inseparable and embedded in the practice. I.e., the practice with all its members is the learner. | The individuals are evolving into being practitioners improving the ability to carry out PD activities. | Practising PD enables learning in a situated practice. This practice is in motion; it has a time/space dimension. |

Table 5.4. The practising perspective.

This category is termed "**practising**" due to the fact that knowledge and learning are embedded in the practice; a practice that emerges when practising. Two subject matters are presented; handover of knowledge and practice-based learning theories. The former explains why different kinds of knowledge make it necessary to transfer, to translate or to transform knowledge. The latter addresses the fact that learning is situated in the practice; be it a COP of interpretation, a Ba in motion or a path-dependent practice. In other words, PD activities and learning are inseparable and take place within an emerging situated practice. The general view is to regard the situated practice with all its members as the learner. Thus, the practising perspective regards the individuals as being able to learn. However, the individuals are considered a homogenous crowd with similar learning mechanisms and motivation for action; being a member of the practice enables learning per se. The individuals are evolving from being newcomers to becoming old-timers; thus, they improve the ability to conduct PD activities when working. The carrying out of a PD activity enables learning in a situated practice. This situated practice is in a state of flux, and it has a time as well as a space dimension.

The literature review is wrap-up in the next section, while the following section draws on the review to pinpoint a theoretical perspective to be applied in this thesis.

## 5.6. The wrap-up of the literature review

This section sheds light on the drawbacks of the categorisation applied to carry out the review, after which four underlying perspectives of the reviewed literature are presented.

### 5.6.1. Drawbacks of the literature review

The above categorisation of the literature is likely to give rise to wonder as well as criticism. I acknowledge this as some of the contributions are rather difficult to place; especially Henderson (1991) and Beckman and Barry (2007).

Obviously, the former draws on a sociotechnical view, but the continuum spanning individual/institutional learning mechanisms makes the categorisation problematic. Henderson (1991) emphasises that artefacts (denoted conscription devices) are the social glue holding together the engineers' interactions within the sociotechnical context. She describes the artefact as being the *"thinking tools of distributed cognition."* (ibid. p.459). Drawing on distributed cognition, the individual's cognition is not the focal point; rather, the practice becomes the pivotal point. Within this practice, cognition is distributed among various representations, while social interactions between engineers enable action and learning. Accordingly, Henderson's contribution "belongs to" the sociotechnical category and in the middle between individual and institutional learning mechanisms.

Drawing attention to Beckman and Barry (2007), the application of Kolb's experimental learning model clearly identifies individual learning mechanisms as the focal point. Therefore, the problem arises from the rationalising and perceiving view categorisation. On the one hand, the problem/solving learning model proposed is rather rational as it is a sequential step-by-step process starting with problem identification/selection and ending with solution identification/selection. The focus is to obtain the necessary information before continuing on to the next step. On the other hand, the application of Owen's PD process model indicates a good deal of focus on social interactions, in which the individuals apply tools and language to develop the artefact and the social context (Beckman and Barry, 2007:27). Hence, an optimal categorisation would be somewhere between the rationalising and perceiving view.

### 5.6.2. Four underlying perspectives on learning in a PD context

The literature review identifies four underlying perspectives on learning in a PD context; these are termed rationalising, practising, accessing and perceiving.

The rationalising category addresses cognitive limitations on rationality. It focuses on the individual learning mechanisms and organisational constraints imposed by channels unsuitable for facilitating communication. The outcome of the learning process is abstract and context-independent knowledge and, additionally, PD is not regarded as an enabler for learning. Instead, learning enables PD and thereby improves the competitive position.

The practising category is highly contextually dependent, a viewpoint contrary to the rationalising perspective. PD activities, learning and knowledge are thereby embedded in the context; a context being considered as a situated practice. Knowledge cannot be context-independent; in such a situation, it is "merely information". As in the rationalising and perceiving perspectives, the individuals are regarded as being the learner within the practising approach. However, these practising theories perceive the individuals to be a homogenous crowd with similar learning mechanisms; hence, being a member of the situated practice enables learning per se.

The accessing theories improve the understanding of institutional learning mechanisms, as for instance structures and elements instrumental in gaining access to valuable external knowledge. The institutional learning mechanisms used to access this source of knowledge, the admission tickets, so to speak, range from R&D ties to social interaction. This shift in focus from individual to institutional learning mechanisms causes the individual persons to be regarded as a homogenous crowd. Just as the rationalising category, the contributions in the accessing perspective do not consider PD to be a learning enabler.

In contrast, the perceiving view brings the employees to the fore, as the facilitator for actions is the interplay between the individual learning mechanisms and the artefacts in a sociotechnical context. Besides, PD is regarded as an enabler for learning. These contributions help us to understand the role of artefacts and the sociotechnical context. In opposition to the rationalising and accessing perspectives, the learning content is not abstract and context-independent; instead it addresses concrete changes of the individual learning mechanisms, artefacts and the sociotechnical context.

Based on the above understanding of the literature and the preliminary analysis in chapter 2, the theoretical perspective to be applied in this thesis is presented in the next section. It establishes a link to the second part of the theoretical discussions presented in chapters 6 and 7.

## 5.7. A theoretical perspective to study learning within PD working practices

Referring to the preliminary analysis, the PD of a Wind Turbine Control (WTC) is performed in different locations, be it in a meeting room, in the production area or in an open-plan office. These locations have different facilities, which the employees make use of to conduct a specific PD activity. The employees, however, employ these facilities differently. In addition, each of the employees has different levels of experience in relation to the development of WTCs and display different degrees of commitment to the performance of a PD activity. Hence, the employees are not a homogenous crowd; each individual has its own ability to understand and carry out PD activities. In other words, neither the employees nor the working practices are homogeneous.

This empirical understanding illustrates that both the working practices and the employees involved are heterogeneous. With reference to the literature review, this "dual heterogeneity" has not previously been applied to the study of learning within PD working practices. Therefore, Dewey's learning understanding originating in American pragmatism is brought to the fore. By drawing on this learning orientation, I expect that it will be possible to study and reflect on the working practices during the PD of a WTC, and thereby contribute to the extant understanding of learning when conducting PD in collaboration with a customer.

In line with the discussions in section 4.2.1, this learning orientation lies between the "first way and second way of learning" (Elkjær, 2004/2005) or between the "Ghost and the Machine" (Pentland, 1992). It draws on a stance that considers the context (the working practice), interpretation and action to be inseparable. For instance, the ISO 9000 procedures describe some rules to be followed when conducting PD activities, but these rules do not determine actions. Instead, action is the result of the individual's interpretation(s) of the rules within a situational working practice.

Accordingly, chapter 6 deals with this learning orientation. Given that this understanding of learning does not explicitly address workplace learning, it is necessary to give careful consideration to this issue. The literature review of the articles categorised in the practising and perceiving perspectives suggests that PD is an enabler for learning; both perspectives draw on a sociotechnical view on PD. Therefore, the first part of chapter 7 engages in a discussion focusing on the sociotechnical phenomenon. In this part of chapter 7, the pragmatic learning understanding forms the basis for applying sociotechnical theories in an attempt to conceptualise this PD working practice. Next, the analytical framework is constructed in the sections 7.6-7.9 by combining chapter 6 with the first part of chapter 7. Figure 5.1 illustrates the approach applied in the following two theoretical chapters.

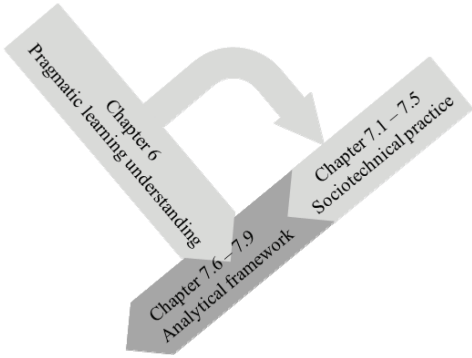


Figure 5.1. The overall structure of chapters 6 and 7.

## Section 5.8. Summary

The purpose was to present the review and thereby answer the research question addressing the literature review. A second purpose was to identify a theoretical perspective to be applied for studying learning when conducting PD in collaboration with a customer.

The literature review is guided by the research question *"which underlying perspectives are prevalent in the literature dealing with learning in a product development context"*. To obtain this understanding, a categorisation of the literature is introduced. The categorisation draws on, as the two extremes on the learning continuum, a psychological orientation addressing individual learning mechanisms and a sociological viewpoint focusing on institutional learning mechanisms. In addition, two different stances are used to understand the PD continuum; an engineering and a sociotechnical view. These two continuums pave the way for identifying four underlying perspectives on learning in a PD context; these are termed accessing, rationalising, perceiving and practising.

The accessing perspective sheds light on gaining access to external sources of knowledge. The institutional learning mechanisms employed to access the sources of knowledge range from R&D ties to social interaction. As it mainly addresses managerial considerations, the employees' actions are pushed to the rear, implying that the individual persons are regarded as a homogenous crowd. The rationalising category addresses bounded rationality, which focuses on the cognitive constraints on the individuals and/or organisational levels. The learning content is abstract and context-independent knowledge. Common to the accessing and rationalising perspectives is to consider learning as an enabler for PD; i.e., to improve the competitive position of the firm. Thus, these two perspectives do not regard PD as an enabler for learning.

In contrast to this, both the perceiving and practising perspectives consider PD as an enabler for learning. The perceiving view brings the employees to the fore, as learning deals with interplay between the individual learning mechanisms and artefacts in a sociotechnical context. The learning content sheds light on concrete changes of individual learning mechanisms, artefacts and the sociotechnical context. The perceiving perspective helps us to understand the role of artefacts in enabling a sociotechnical context. The practising category is highly contextually dependent. Activities, PD, learning and knowledge are thereby embedded in the context; i.e., in a situated practice. Like the rationalising and perceiving perspectives, the individuals are regarded as a learning entity; however, the practising theories perceive the employees as a homogenous crowd.

The empirical understanding derived from the preliminary analysis illustrates that both the working practices and the employees involved are heterogeneous. This "dual heterogeneity" has not been a theoretical perspective applied to the study of learning within PD working practices before. Hence, American pragmatism is brought to the fore to study learning when conducting PD in collaboration with a customer. As this learning position does not explicitly address workplace learning, PD theories considering the working practice as a sociotechnical phenomenon pave the way for elaborating on the PD working practice.

# Chapter 6. The pragmatic learning understanding

A person is neither a passive individual being institutionalised by the contextual setting nor an individual free to act on its own judgement. For instance, the Road Traffic Act prescribes some rules to be followed when riding a racing bike; these rules, however, are sidelined when riding a racing bike uphill the Stelvio Pass. When starting the 25 kilometres long ascent, the gradient is not a problem, but you are passing towns with traffic lights etc. In this situation, the rules have to be followed to avoid a crash. Halfway the ascent, the rules are still the same, but you are not thinking about the rules anymore. The contextual conditions have changed; now, the traffic is moderate, but the gradient is very high. Action, thinking and emotion are wholly focused on the next hairpin bend. Hence, it is a situational interpretation of the context that enables action; i.e., context, interpretations and actions are inseparable. To improve the understanding of this phenomenon, a learning understanding drawing upon American pragmatism is the focal point of this chapter.

The objective of this chapter is to improve the understanding of pragmatic learning. The analysis of pragmatism identifies some key concepts that will form the building blocks for the construction of the analytical framework in chapter 7. Hence, chapters 6 and 7 are interlinked; the former orchestrates a theoretical platform for the discussion in chapter 7.

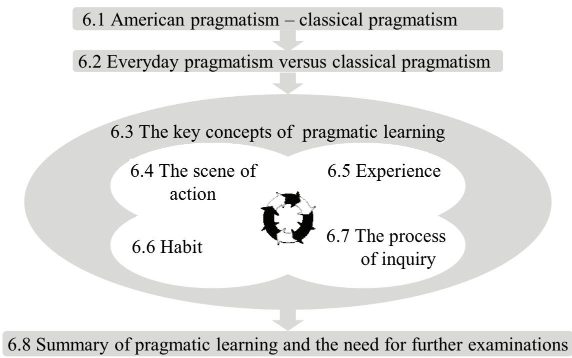


Figure 6.1. The structure of chapter 6.

The structuring of the chapter appears from figure 6.1. By way of introduction, the root of pragmatism is described to illustrate the social conditions from which this philosophy originates. Because the term pragmatism is applied differently, the following section 6.2 will discuss the matter in this regard, thereby identifying key concepts of the pragmatic learning understanding. The section identifies the existence of a complex and inseparable interplay among four concepts, which are discussed in the following sections, 6.4-6.7. Accordingly, the focal point of section 6.3 is to provide an overview of the interplay among the four concepts before each of these is discussed separately. Finally, a summary is presented, including a discussion of the necessity of further examinations into the contextual setting.

Seeing that several terms are presented and discussed, table 6.1 at the end of the chapter is intended to give an overview of these terms; in general, words in *italics* are included.

## 6.1. American pragmatism – classical pragmatism

American pragmatism (from time to time denoted classical pragmatism) has it roots in the late 19th century; it was formed in the aftermath of the American Civil War. Some of the great thinkers at that time formed the Metaphysical Club in Cambridge, Massachusetts, at the beginning of the 1870s in an attempt to facilitate informal philosophical discussions. One of the outcomes of these discussions resulted in a stance on contextual embeddedness. Thus, an interpretation originates within the social context rather than being a pure product of individual cognitive processes. Actually, it laid the foundation for the classical pragmatism.

As the American pragmatism gradually evolved as a dialogue among philosophers at the end of the 19th and the beginning of the 20th century, a number of contradictions in the American society influenced their thinking. The era was characterised by a sense of new beginnings, and it was thus crucial for the majority of the people in the US society to be action oriented. It was necessary to take advantage of all opportunities facilitated by the social context. Finally, the rapid industrialisation had a huge impact on the development of the society, particularly on the workers' everyday life.

### 6.1.1. Pragmatism – empirically rooted natural science

Peirce (1839-1914) read philosophical literature, especially Kant and scholastic philosophy (Webb, 2007:1066). His intention was to develop a logical and systematic method for philosophy – he entertained the hope that logic and science could teach men and women to see "the particulars" from the point of view of a universal community of observers (Bertilsson, 2004:373).

Peirce's intellectual background within physics, mathematics and experimental science was rooted in empirical research (Elkjær, 2005:73) and it was combined with Darwin's theory of evolution of the species (Webb, 2007:1066). It inspired Peirce to develop a theory of scientific thoughts as an evolutionary process and, as mentioned in chapter 3, Peirce is credited for developing the process of abduction. This logical inference[1] proposed by Peirce

[1] Just as this logical inference, the semiotics can be traced back to the work of Peirce and, as it will appear, there is a close relationship with the pragmatic learning understanding later developed by John Dewey. Semiotics addresses a categorisation of signs – icon, index, symbol – in a triadic structure to be the pivot for the interpretation of an indeterminate situation. It consists of three steps. The first step consists of an "icon". For instance, if noticing an unknown object in the empirical sphere, this icon prompts a kind of a "vague experience" or a feeling; something disturbs our thinking or feeling, but at the time, we do not know what it is. This vague experience, maybe a comfortable "soft song" or an unpleasant feeling, arouses our organism and we – as human beings – are induced to follow an instinct to conceptualise, "what is going on?". The vague experience has to reach a certain level, as it must arouse emotion in order to continue to the next step. The second step in the triadic structure of signs is "index". It consists of empirical observations. Observing something, for instance that the beautiful loudspeakers from Bang & Olufsen also transmit an outstanding sound, necessitates that what I perceive as being "a good sound" corresponds to something out there. The vague experience from the first step in the triadic structure, "I hear a beautiful soft song", has now been connected to an object to which it can be related. In a way, the consequences of the second step are that the possible causes to the vague experience are narrowed down. Finally, the third step is an interpretive process where the symbol is set in motion. It is an ongoing and reciprocal interchange between the vague experience and the empirical observations. The process is regarded as a kind of sign transfer; the "sign vehicle" points to an object by invoking the interpretant (the symbol) into the head of the interpreter. It focuses on identifying a match between the sign transferred and the available symbols. Hence, the triadic structure of signs becomes an instrument for imparting meaning to the situation in question; and the understanding imparted will make it possible to construct new ideas.

applies physics/mathematics formulae rather than everlasting propositions as a means to achieve a result.

Despite the fact that Peirce's intellectual background within physics and mathematics permeates his development of a logical and rather scientific version of pragmatism, there are no individual interpreters to be found in his philosophy (Bertilsson, 2004:374). Nevertheless, the social dimension seems to have a certain influence on Peirce's understanding of the analytical generalisation, and thereby the quality and validity of the research, because his understanding of truth focuses on the possibilities to achieve a common agreement within the community dealing with the interpretation of a phenomenon that exceeds a time as well as a space dimension.

### 6.1.2. Pragmatism – development of the society

William James (1842-1910) addresses the individuals in his conceptualisation of meaning and truth. Thereby, the individuals' interpretations of the vague experience in the attempt to make sense of "what is going on" become a subject matter.

The work of James was characterised by a religious understanding of the world and an academic career within medicine; later on, his interest in psychology and philosophy had an impact on his interpretation of truth. In addition, just like Peirce, Darwinism influenced James' thinking. Thus, the human organism adapts to the environment through biological functions and processes (Barbalet, 2004:341). This is considered to be the reason why the evolution of human actions combined with emotional and ethical aspects was so important in James' conceptualisation of meanings.

John Dewey (1859-1952) is another key contributor to classical pragmatism (Elkjær, 2005:72; Cohen, 2007:773). Dewey is credited for transferring classical pragmatism (from Peirce's logical pragmatism via James' religious and humanistic understanding) to apply to problems in relation to social and political issues. He regarded philosophy to be a useful tool or method for people to understand real life problems. Especially Dewey's contribution to a pragmatic learning understanding is widely recognised.

### 6.1.3. The underlying basis for the pragmatic learning understanding

Starting at the beginning of the 20th century and continuing until his death in 1952, Dewey's development of the pragmatic learning understanding proved to be a long journey. The learning theory is mainly inspired by three sources, namely experimental (functional) psychology, Darwin's theory of evolution and finally, Dewey's philosophical stance.

Dewey (1938:107) advocated the experimental psychology at the expense of the contemporary approach to understand humans' consciousness. At the time, human behaviour was regarded as being divided into three mechanical sequences: a triggering stimulus, subsequent an idea and finally, a motor response (Elkjær, 2004:423). This reflex arc concept formed the basis for Dewey's critique, as it perceives the relationship between doing and thinking to be dualistic; in other words, doing and thinking are regarded as two separate processes (Elkjær, 2005:93). This viewpoint is rejected by Dewey (1938:chapter 6) who instead regards thinking and doing as being inseparable and situation-dependent and coins the term "thinking-in-doing process" to describe the phenomenon.[2]

The second source of inspiration was Darwinism. Dewey (1938:26) employed this evolutionary approach to point out that humans live on Mother Earth and make use of different biological faculties to grasp "what is going on" and act accordingly. To survive, a person has to be socialised; that is, engage in continuous adaptation to changes in the world and thus develop habits. It emphasises that the faculties of feeling, seeing, tasting, hearing and touching exclusively exist in active connection with their environment. Hence, the biological faculties are not passive, but instead actively used by the human to ensure an ongoing evolution and thereby adaptation to the society.

The third source was Hegel's contribution to Dewey's philosophical understanding (Elkjær, 2005:63-67) and he remained the chief source of Dewey's logic (Huber, 1973). This Hegelian view orchestrated a number of key concepts in terms of his work.

> *"Hegel wanted to know if history had any meaning and posited the dialectic as a formal device to enable him to explain social change. In dialectical form, knowledge moves in stages from thesis, to antithesis, to synthesis; history obligingly repeats these stages empirically. "Process" and "emergent" are key words."* (Huber, 1973:277).

Referring to Dewey (1938), this "dialectic" approach between thesis and antithesis starts in the observable sphere, as knowledge cannot be prior to observation. It entails that it is not possible to reflect without a preceding empirical observation. Accordingly, reflective thinking is "guided" by observations and the human's experience with the situation as well; that is, thinking is not an a priori phenomenon to empirical observation.

As the concept of pragmatism can mean different things, it is necessary to clarify the interpretation of this term before resuming the examination of the pragmatic learning understanding.

## 6.2. Everyday pragmatism versus classical pragmatism

Regarding the everyday pragmatism depicted in the top part of figure 6.2, a pragmatic solution to a task or a problem is an act conducted by an action-oriented person (Elkjær, 2005:70). He/she "simply" finds a workable solution to a problem and subsequently, the solution is implemented. This exemplification is the common perception of pragmatism. Seen from a learning perspective, the problem/solution doings do not comprise reflective thinking.

[2] *"The moral of Dewey's critique of mechanistic psychology is that perception and behavior are contextually dependent."* (Webb, 2007:1067).

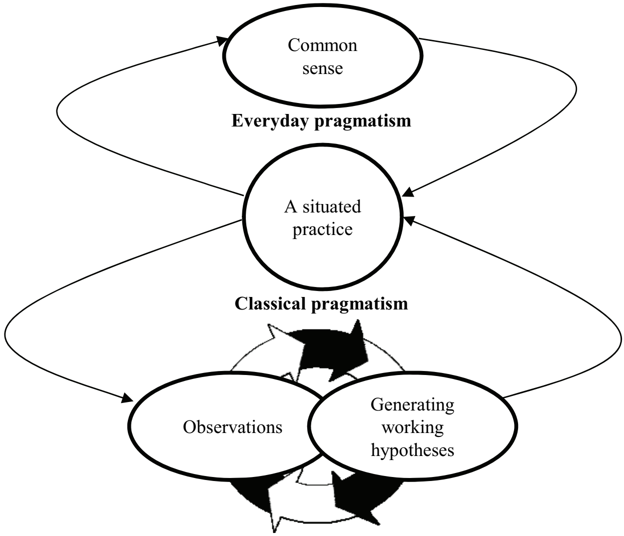


Figure 6.2. Everyday pragmatism versus classical pragmatism.

Turning to classical pragmatism, the opposite holds true. It is depicted in the bottom part of figure 6.2. To find a way to handle an *indeterminate situation* (the aforementioned vague experience), one starts with an observation followed by a reflection (generating a working hypothesis). This interchange between observations and reflections continues until the *indeterminate situation* has been transformed into a *determinate situation*. Referring to Dewey (1938), it is a controlled and managed *process of inquiry*.

### 6.2.1. Different means-consequence relations

Both kinds of pragmatism take as their point of departure a situated practice in order to find a workable solution. That is, the two viewpoints agree upon the starting point and the outcome (the consequence), as the intention is to solve a practical and existential problem. The similarities, however, seem to stop there, as the problem/solving doings enter into different *means-consequence relations*. The most conspicuous distinction is the quality criteria addressing the validity of the achieved consequence and the applied means to achieve the consequences – to identify a solution.

With regard to the "quality criteria", the everyday pragmatist does not take into consideration other (theoretical) perspectives, nor does he/she try to establish a connection between a proposed solution and well-established theories. In other words, the means being applied is common sense. By doing so, it becomes difficult for other individuals to challenge the conclusion – the consequence. While the means to arrive at a solution applied by the everyday pragmatist is common sense considerations, the classical pragmatist brings into focus a controlled and managed *process of inquiry* as the logic for finding a testable solution.

The classical pragmatist makes use of agreed terms, concepts and theories in order to achieve a proper evaluation of the consequence.

The next section focuses on the key concepts of pragmatic learning – classical pragmatism.

## 6.3. The key concepts of pragmatic learning

As stated in the quotation below, the individual exists by means of the environment.

> *"Whatever else organic life is or is not, it is a process of activity that involves an environment. It is a transaction extending beyond the spatial limits of the organism. An organism does not live in an environment; it lives by means of the environment."…"every organic function is an interaction of intra-organic and extra-organic energies, either directly or indirectly."* (Dewey, 1938:32).

This viewpoint is essential for the pragmatic learning understanding. It entails that there is an inseparable interaction between "the organism (the man) and the environment". Hence, "who learns" and "what is learned" are embedded in the man-environment; it is a transactional relationship between the individual and the environment (Elkjær, 2004:42). Given that a great many combinations of "who" and "what" are perceptible in this learning understanding, the explanation of the pragmatic learning understanding does not make use of a categorisation similar to that being applied to conduct the literature review in chapter 5.

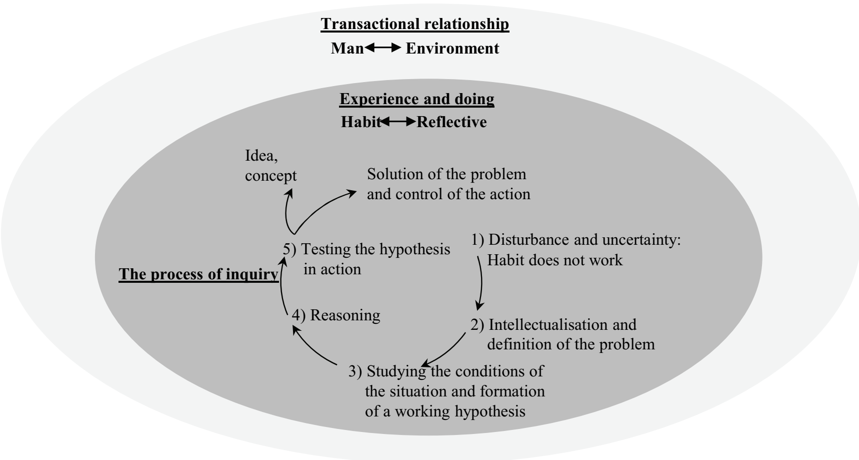


Figure 6.3. Overview of the pragmatic learning understanding.[3]

Figure 6.3 presents an overview of the pragmatic learning understanding. *Experience* is embedded in a transactional relationship between the man and environment, and it consists of

[3] The process of inquiry depicted at the centre of figure 6.3 makes use of Miettinen's (2000) headlines and illustrations. Dewey (1938) applies other headlines for the five phases in relation to the process of inquiry. These are: 1) The antecedent condition of inquiry, i.e. the indeterminate situation, 2) Institution of a problem, 3) The determination of a problem solution, 4) Reasoning and 5) The operational character of facts-meanings.

both *habitual* and *reflective experience*. The starting point for the *process of inquiry* (the learning process) is the current level of *experience*, and a *successful process of inquiry* implies the creation of new *experience*.

The above-mentioned transactional relationship calls in question where to start the examination and explanation. However, as the learning understanding draws on Peirce's logical inference, the explanation will, just as the process of abduction, make use of the "vague experience" as the starting point – something disturbs our habits, causing an *indeterminate situation* to arise.

### 6.3.1. Disturbances in the habitual experience triggering an indeterminate situation

The continuous maintenance of habits becomes the routine way of doing things. That is, the individual has or develops standard procedures for handling events; referring to figure 6.3, it is the individual's *habitual experience* for doing. As pointed out elsewhere, the notions of *experience* and doing are inseparable. Usually, this habitual doing functions well, but from time to time, an unexpected event occurs. This disturbance in the *habitual experience* triggers an *indeterminate situation*.

### 6.3.2. Indeterminacy embedded in a transactional relationship

It is not just an *indeterminate situation*, but **the *indeterminate situation*** takes place in the "man-environment" relationship. It is the outer shell of figure 6.3. This contextually embedded situation might have one or more of the following traits: disturbed, troubled, ambiguous, confused, full of conflict etc. (Dewey, 1938:109). Thus, the uncertainty is anchored in traits of the *indeterminate situation* and is not purely personal states of doubt. Purely personal doubt is regarded as a mental illness and thus cannot initiate a *process of inquiry*.

Referring to Dewey (1938:38), disturbances in the *habitual experience* form the basis of organic learning, while the *process of inquiry* is the means to transform the *indeterminate situation*. Accordingly, in the attempt to grasp "what is going on" and thereby gradually transform the *indeterminate situation* into a *determinate situation*, the individual constructs an inquiry.

> *"The original indeterminate situation is not only "open" to inquiry, but it is open in the sense that its constituents do not hang together. The determinate situation on the other hand, qua outcome of inquiry, is a closed and, as it were, finished situation or "universe of experience"."* (Dewey, 1938:109).

### 6.3.3. Process of inquiry transforms indeterminacy into determinacy

The transformation of the *indeterminate situation* into a *determinate situation* includes a modification of the existing conditions in the environment as well as individual learning. In other words, the outcome of the five-phased *process of inquiry* depicted in figure 6.3 is new *experience* embedded in the transactional relationship – within the man-environment relationship.

Referring mainly to Dewey's "Logic: The Theory of Inquiry", (1938:chapter 6), the five-phased learning model is an iterative process. The model uses inquiry/reflection to transform the *indeterminate situation* into a *determinate situation* (inquiry and reflection are interchangeable for Dewey). The inquiry is divided into two different operations: observations of social/material factors within the transactional relationship and the generation of ideas/working hypotheses to suggest a solution to the indeterminacy.

Briefly, the first phases of the *process of inquiry* are characterised by being precognitive, as these draw mainly on *habitual experience*, while the latter phases become increasingly reflective; these draw on *reflective experience*. Drawing attention to each of the five phases, the first phase addresses the subject matters explained in subsections 6.3.1 and 6.3.2. That is, something in the "transactional relationship" initiates an *indeterminate situation*, because our habitual way of doing things does not work sufficiently anymore. The next phase focuses on defining the root cause of the *indeterminate situation* or conceptualising a "well-defined problem". The conceptualisation of the problem is still precognitive. The very first ideas or working hypotheses for handling the indeterminacy are the focal point of the third phase; these are only suggestions flashing up. The fourth phase applies reflective thinking (*reflective experience*) as a means to come up with a solution. Regarding the third and fourth phase, the key word for Dewey is continuation of the *process of inquiry*. The pragmatic stance emphasises the necessity to prove the worth and validity of a working hypothesis/solution within an empirical setting. The fifth phase addresses this issue.

### 6.3.4. Experience is the starting and the ending point

As illustrated in figure 6.3, the starting point for the *process of inquiry* is the current level of *experience* embedded in the transactional relationship. In addition, a *successful process of inquiry* produces new/modified *experience*, which becomes embedded in the transactional relationship.

*Experience* is considered the result of ongoing inquiries taking place within various transactional relationships. For Dewey (1933:86-89), knowledge is a subset of experience. In this regard, he attempts to make use of insights derived from *reflective experience* as a means to understand practical problems of the society. However, due to the fact that most of the individuals' doings are guided by *habitual experience* rather than *reflective* (deliberated) *experience*, Dewey found it necessary to make a functional distinction between *habitual experience* and *reflective experience*.

In sum, disturbance in the *habitual experience* is the trigger for the *process of inquiry*, and the ongoing interchanges between observations and generation of working hypotheses will gradually activate the *reflective experience* that enables reflective thinking and new *experience*.

The introduction indicates four key concepts. Although extremely interrelated, the four concepts will be discussed below in order to present them in a readable way. The transactional relationship unfolds within a *scene of action*, which is the first concept to be presented in section 6.4, whereupon *experience* is discussed in section 6.5. Habit is addressed in section

6.6 and finally, section 6.7 sheds light on the *process of inquiry*. The presentation is thus in line with the structure indicated in figure 6.3.

## 6.4. The scene of action

The environment consists of various objects; however, the interpretation of the meaning contents of these objects is only possible within the context of the individual's perceived environment (Dewey, 1938:73). The constitution of this perceived environment is the result of the interactions between objects, as for instance artefacts (things), and the individual (a living creature). As a result, the transactional relationship between the "man and environment" can be located to a contextual setting; that is the *scene of action*.

> *"An environment is constituted by the interactions between things and a living creature. It is primarily the scene of actions performed and of consequences undergone in processes of interaction;…"* (Dewey, 1938:152).

The interpretation of an *indeterminate situation* only takes into consideration that part of the environment that enters directly into the perceived environment. In other words, when interpreting an *indeterminate situation*, the interpretation draws on all material and social factors existing within the *scene of action*. Likewise, the individual lives on the planet earth and has a number of biological senses, for instance feeling, seeing, tasting, hearing and touching, but the "functionality" of these senses only exists in active connection with the *scene of action*.

Ascribing the transactional relationship to be the *scene of action*, in which the individual "lives by" endogenous as well as exogenous energy to carry out doings, addresses a fundamental principle.

> *"There is, of course, a natural world that exists independently of the organism, but this world is the environment only as it enters directly and indirectly into life-functions. This organism is itself a part of the larger natural world and exists as organism only in active connections with its environment."* (Dewey, 1938:40).

Ontologically, this quotation acknowledges the existence of an external world beyond the individual's immediate perception sphere. It considers the environment to be a subset of the world; a subset that becomes a part of the individual's life functions from childhood to maturity. As mentioned elsewhere, the individual lives by means embedded within the *scene of action*, which facilitates an active and continued adaptation to the world.

These viewpoints indicate that the concept of science merges with the concept of reality. Thus, Dewey's learning theory is not just an epistemological discussion of how the individual constructs *experience* about the world. It is ontological as well, seeing that the "reality" gradually evolves. Decoupling the processes of knowledge generation from the concept of reality does not make any sense; it is a theory of becoming (Elkjær and Simpson, 2006:9).

### 6.4.1. The scene of action evolves gradually – it is a historical being

Elkjær (2004/2005) draws attention to the fact that the *scene of action* forms gradually due to the existence of a time dimension (also denoted a history dimension). Webb (2007:1070) and Elkjær (ibid.), among others, link this history dimension to the concept of *experience*. In other words, the *scene of action* is a historical being (Cohen, 2007:777) and *"Each particular activity prepares the way for the activity that follows."* (Dewey, 1938:33). Thus, activities conducted in the past influence the *scene of action*.

*Experience* evolves gradually and becomes embedded within the *scene of action* consisting of environing circumstances (Webb, 2007:1070) and sentient, cognitive and emotional humans (Cohen, 2007). Cognition (thoughts) and emotions (feelings) originate from this embedded *experience* within the *scene of action*. The individual is neither a passive person being institutionalised by the *scene of action* nor is it unrestricted to act on its own free will. To understand this reciprocal interaction between the individual and the *scene of action*, Elkjær (2004:429) suggests mapping the conditions for the interaction and the *trajectory* of the project.

> *"Trajectory is a concept that can be used to identify a phenomenon in time in such a way that it can be understood as an historic course of events."* (Elkjær, 2004:428).

Drawing on Elkjær (2004), a *trajectory* is the "life story" of a project, as for instance the Product Development (PD) of a breaker panel to be built into a wind turbine control. The *trajectory* influences the *scene of action* and, in doing so, the *trajectory* influences the individuals' doings. Simultaneously, the individuals' doings will constitute the *trajectory*.

### 6.4.2. Heterogeneity within the scene of action

Referring to Webb (2007), and other pragmatists as well, data are never given, quite the reverse, they are taken seeing that the interpreter has his/her own "interpretative system". This interpretative system is embedded within the *scene of action* and it is situational.

> *"The human retina is not engaged in passive photography of incoming sense data but is more nearly analogous to a computer algorithm selecting templates to shape transmissions from sensory organs into mental images. These sensory organs themselves are highly selective in excluding the bulk of possible "sense data" from the enormous quantity and complexity of events occurring in the organism's environment."* (Webb, 2007:1067).

Thus, the endogenously cognitive faculties vary among individuals when interpreting an *indeterminate situation*. Likewise, Elkjær's "Third way of learning" (2004 and 2005) sheds light on other crucial biological faculties being applied to handle indeterminacy; these are commitment, intuition and emotion. She points out that individuals and groups of individuals are not homogeneous. They demonstrate different levels of commitment, intuition and emotion.

*"It is also an attempt to recognize individual and group differences in organizations rather than levelling them out and not attach any meaning to the fact that individuals and groups have different gender, power, values and ideas, etc."* (Elkjær, 2004:430).

Just as individuals and groups of individuals are not homogeneous, neither are the *scenes of action*; the history and context are continuously mutable. Consequently, the *indeterminate situation* or the PD activity to be conducted within the *scene of action* will always be situational.

In sum, the *scene of action* forms the basis for the individual to make sense of "what is going on". Without a *scene of action*, indeterminacy cannot occur. Purely personal doubts are regarded as mental illness and consequently, they will not be able to initiate a *process of inquiry*. That is, it is only possible to understand the real-life consequences of the concepts of *experience*, the concept of habit and *the process of inquiry* within the *scene of action*.[4] Therefore, these three concepts are in focus below.

## 6.5. Experience

Dewey's interpretation of *experience* draws on his critique of the structuralistic approach in psychology (Webb, 2007:1067); in particular the reflex arc concept, which considers thinking and doing to be two separate processes (Elkjær, 2005:93). In accordance with the structuralistic research tradition, the consciousness consists of various elements, such as sensory perception, feelings, etc. The mental processes are divided into the most basic elements, and a synthesis process involving all these elements is what creates the mindfulness of the individual.

An opposite view is applied within functional psychology research. It addresses various functions of the consciousness in order to comprehend the mental processes. The functional approach to consciousness is regarded as a means to understand the continuous adaption of the individual to the *scene of action*.

The distinction between perception (sensing and thinking, author) and behaviour (doing, author) is another criticism put forward by Dewey (1933:93), as he sees it as a repetition of the old dualism between soul and body (Elkjær, 2004:423). This viewpoint indicates that sensing and thinking take place in the brain, while a doing is carried out by arms, legs, mouth, etc. Rather than being this step-by-step thinking and doing process, Dewey regards it to be a thinking-in-doing process.

### 6.5.1. Experience embedded within the scene of action

The rejection of the above structuralistic understanding prepares the ground for an empirical and action-oriented approach to *experience*. *Experience* is the ongoing formation of the

[4] The concepts are not listed according to priority, implying that the scene of action should be the most important of the four key concepts. Equality among the concepts seems to be more appropriate as the concept of *experience* in connection with the indeterminate situation localised within the scene of action is the fundamental point of departure for Dewey's learning theory (Webb, 2007:1070) and the key to understand his philosophy (Elkjær, 2005:92).

individual and the *scene of action*, as these are evolving in a reciprocal interaction. Disturbance in the *experience* causes an *indeterminate situation*. The interpretation as well as the reaction to the *indeterminate situation* depends on the *experience* within the *scene of action*. This *experience* embedded within the *scene of action* enables the individual's thinking-in-doing process.

> *"This means that the environment or the context is part of the interpretation. Neither is the interpretation an autonomous action independent of time and space, but takes place as a historical and contextual action. Nor is the response an independent event, which follows a stimulus."* (Elkjær, 2004:424).

The individuals do not possess the same level of *experience* and they employ different degrees of energy when acting in the attempt to handle the *indeterminate situation*[5]; the aforementioned heterogeneity.

### 6.5.2. Two kinds of experiences

The concept of *experience* consists of non-reflective *experience* based on habits as well as *reflective experience* mediated by intelligence and knowledge (Miettinen, 2000:61). The former is the dominant form of *experience* and it is a kind of non-cognitive *experience* (Webb, 2002:989) also denoted primary *experience* or *habitual experience*. The *reflective experience* is a cognitive *experience*; from time to time termed secondary *experience.*[6] However, referring to Dewey, it is difficult to separate/distinguish between these two kinds of *experience*, as they are rather expressions of two extremes on a continuum.

Knowledge is considered a subset of *experience*. The knowledge content embedded in the *experience* is the argumentation being applied by Dewey to distinguish between the two kinds of *experience*. Elkjær (2005:96) considers the non-cognitive (*habitual experience*) to be all kinds of *experience*, of which knowledge is not the primary substance. As the *habitual experience* represents the majority of the accumulated *experience*, most of the *experience* is not considered to be knowledge (Webb, 2007:1070).

[5] If you walk alone in a very dark and desolate forest at midnight and you hear a vague noise just as if someone is following you, your thinking and doing will be completely different than if hearing exactly the same noise when taking a walk downtown Copenhagen at midday. That is to say, the interpretation of an event or indeterminate situation depends on contextual factors in the surroundings. If you walk in the same dark forest and the awful noise occurs, your thinking and doing will moreover depend on whether you are a city dweller who never walks in a dark forest or you are a highly skilled Special Forces soldier who is accustomed to carrying out necessary activities behind enemy lines. If the first-mentioned person – who became scared when he heard the awful noise in the dark forest – is accustomed to conducting an improvised speech, his perception of the indeterminate situation, thinking and doing will be different compared to the last-mentioned Special Forces soldier if he has never tried to speak without notes. Those examples indicate that an individual's *experience* is contextual, affects the perception of an indeterminate situation and thus the interplay between thinking and doing. Accordingly, separating individual *experience* and *experience* of the surroundings does not make any sense; the level of *experience* is socially situated at the "scene of action".

[6] The function of the primary *experience* is to make the very first and immediate interpretation of the indeterminacy. That is, it is applied to make sense of "what is going on within the scene of action". The secondary *experience* consists of reflective thoughts and these become activated due to a vague experience in the primary *experience*. Thus, when the individual faces an indeterminate situation within the scene of action, working hypotheses are generated. The *reflective experience* is the means to achieve a determinate situation, which forms the basis of new *experience*.

Drawing on Dewey's "How we think" (1933), Miettinen (2000) engages in a discussion of the dual nature of *experience*; that is to say, an empirical or experimental attitude of mind. The former empirical attitude of mind[7] addresses empirical thinking of ordinary phenomena. For instance, for the majority of the citizens in Denmark, riding a bike is second nature. Contrarily, the experimental attitude of mind activates thoughts and reflections and thereby *"liberates us from intellectual laziness and from the tyranny of tradition."* (Miettinen, 2000:68).

This dual nature of the mind sheds light on the need for initiating an experimental attitude of mind if the individual is going to generate new *experience*. *Experience* enables a connection between the past, the present and the future. This bridge building between the present and the future is possible due to the human's ability to make use of present *experience* as the underlying basis for forecasting the future.

> *"we live life forwards by bringing our past experiences to bear on how we can anticipate the future."* (Elkjær and Simpson, 2006:6).

Dewey (1933) points out that if the applied *experience*s are dominated by the past and/or habits, the experimental process might be obstructed. Dewey (1933:269) describes three crucial disadvantages in this regard "1) its tendency to lead to false beliefs,[8] 2) its inability to cope with the novel[9] and 3) its tendency to engender mental inertia and dogmatism".[10]

The drawbacks of an empirical attitude of mind entirely drawing on *habitual experience* seem to be far-reaching. Therefore, the challenge is to find a way to break out of this "empirical attitude of mind" – when or if suitable!

> *"The central issue in Dewey's conception of experiment is whether an authority-bond and routine ways of thinking and action can be replaced by a "reconstructive" and reflective way."* (Miettinen, 2000:65).

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[7] Miettinen (2000:68) considers this empirical attitude of mind the great flywheel of our society.

[8] Many empirical conclusions are very practicable in everyday life. From time to time, these are more accurate compared with predictions based on scientific methods. For instance, sometimes an old man is able to forecast the weather more precisely than a meteorologist using scientific models and tools. However, these empirical conclusions are not trustworthy. Normally, an empirical conclusion draws on a commonsense stance; e.g. this event will result in another predictable event. In other words, the method of prediction draws on a narrow-minded causal relationship between/among events. That is, the applied method for arriving at a conclusion does not make use of other criteria to predict alternative outcomes. Hence, it calls into question the (missing) evaluation of alternative predictions as well as the conclusion. It might be right or wrong and consequently, it easily leads to false beliefs.

[9] As the nature of the *habitual experience* is past homogeneities, the inference of an indeterminate situation follows the *"grooves and ruts that custom wears and has no track to follow when the groove disappears."* (Dewey, 1933:270). That is, the individual's inference follows a track just like a train. However, if the track gets outdated due to a change or novelty, there is no longer a track to guide the perception.

[10] According to Dewey (1933), the third disadvantage is extremely problematic, as it constitutes a very harmful feature of the empirical *experience* that might have a huge impact on the individual's mental attitude. Naturally, the mind requires a certain level of coherence among the perceived facts and their root causes. If this coherence is not achieved to an acceptable level, the individual has a tendency to create its own coherence. As Dewey (1933:271) points out, it has serious consequences when *"Fantastic and mythological explanations are resorted to in order to supply missing links"*. In such circumstances, the empirical approach is characterised by laziness, conformism and slave-like dependence on authority (Miettinen, 2000:68).

### 6.5.3. Empirical versus experimental attitude of mind

Referring to Dewey (1933), new *experience* is only achievable if the individual within the *scene of action* has the ability to set in motion an experimental attitude of mind. This experimental approach makes use of the perceived social and material factors to initiate reflection, which might result in new *experience*. Dewey (1916) interprets a learning outcome to be achievable if the individual has the ability to link a doing to the subsequent consequences.

> *"It is not experience when a child merely sticks his finger into a flame; it is experience when the movement is connected with the pain which he undergoes in consequence. Henceforth the sticking of the finger into flame means a burn. Being burned is a mere physical change, like the burning of a stick of wood, if it is not perceived as a consequence of some other action."* (Dewey, 1916:139).

However, according to Dewey (1933:chapter 13), the majority of the individual's life, and thereby doings, draws on *habitual experience*; the empirical attitude of mind. I.e., the *habitual experience* plays an essential role in relation to the individual's becoming. It indicates that this learning understanding does not simply address the creation of new knowledge by applying and creating *reflective experience*; it implies an ongoing adaption of the non-cognitive (*habitual experience*) and emotional factors as well. Accordingly, neither *reflective* nor *habitual experience* is a rigid or static concept; referring to Dewey (1933:277), both are vital and hence growing. They form the basis of all human doings; as Cohen (2007:777) emphasises *"All experience is in some sense educational."*, thus enabling the continuous development of the individual and the environment (Elkjær, 2004:424).

The question is when and how the "authority bond and routine ways of thinking" as proposed by Miettinen (2000) should be replaced in an attempt to enable the experimental attitude of mind. The *process of inquiry* seems to be a crucial concept for identifying a suitable way to enable an experimental attitude of mind. However, before engaging in the discussion of the *process of inquiry*, it is necessary to shed light on the concept of habit.

## 6.6. Habit

In everyday speech, a habit is interpreted as a routine way of doing things, finding expression in "status quo", "pure repetition" and "we have tried this before, it does not work or it is difficult to change these habits". Likewise, this view on habit is from time to time attributed to "mindless action", by which less skilful workers carry out assembly work divided into simple activities according to Taylor's scientific ideals, "mundane activities" regarded as not very important and finally, the stance that the habit is "explicitly stored" in standard procedures etc.

Cohen (2007) regards the above-mentioned interpretations of habit as being the main obstacle to the theoretical development of the study of routine. Therefore, in an effort to expand our understanding of organisational routine, he proposes to perceive habits as:

> *"effective action, individual or collective, always occurs through the operation of a biological system in which habit is integral. You can choose to eat a piece of cake, but only your arms, mouth, and intestines can accomplish the deed."* (Cohen, 2007:777).

The discussions in Cohen's article draw upon two opposite views – "the Simon view" and "the Dewey view". Owing to the fact that the majority of research addressing organisational routines draws on the former, Cohen's contribution makes for a contrast, as it takes a pragmatic stance. Two subject matters come to mind. First, compared with the traditional "Simon view", Cohen's approach is much more action-oriented and second, it rejects a system view of cognition, emotion and routine (habit). Instead, these are closely interrelated and inseparable.

In Dewey's "Experience and Education" (1939), he defines/interprets habit from a biological perspective:

> *"The basic characteristic of habit is that every experience enacted and undergone modifies the one who acts and undergoes, while this modification affects, whether we wish it or not, the quality of subsequent experiences. For it is a somewhat different person who enters into them. The principle of habit so understood obviously goes deeper than the ordinary conception of a habit as a more or less fixed way of doing things, although it includes the latter as one of its special cases. It covers the formation of attitudes, attitudes that are emotional and intellectual; it covers our basic sensitivities and ways of meeting and responding to all the conditions which we meet in living."* (ibid. p.18).

Dewey does not consider habits as "rigid, mindless, mundane or explicitly stored in standard procedures". Instead, habits are the building blocks of all human doings. They shape and empower the cognitive and emotional processes inherent in the individual – as Dewey often denotes it, "man is a creature of habit".

The above quotation explicitly indicates a time dimension and implicitly a space dimension of habit. Before engaging in this time and space discussion, two different roles of habits are introduced.

### 6.6.1. Two different roles of habit

> *"Any habit is a way or manner of action, not a particular act or deed. When it is formulated it becomes, as far as it is accepted, a rule, or more generally, a principle or "law" of action. It can hardly be denied that there are habits of inference and that they may be formulated as rules or principles."* (Dewey, 1938:21).

The quotation points out two different roles of habit: (1) a stabilising factor for living in present-day society as well as (2) a standard way of drawing inferences.

First, habit is considered as being a stabilising factor in society; it is *"the great flywheel of society."* (Miettinen, 2000:68). For instance, when the skilled prototype worker assembles a breaker panel to control the operation of a wind turbine, he/she knows the best practice regarding the wiring of all the components; best practice is simply familiar to them.

Additionally, when two highly skilled engineers work together to design an electrical circuit to a breaker panel, they are fully versed in the causal relationships between ampere, voltages, ohms, etc. They know the legal regulations like the back of their hand. Likewise, when using the computer, I do not pay attention to programmes and the operative system. Or when driving a car or riding the racing bike uphill the Stelvio pass, it is done without much thought; otherwise it would be too clumsy. This empirical attitude of mind devoid of in-depth reflection is a precondition for living in present-day society.

Second, besides being a stabilising factor, the Dewey quotation above addresses the individual's tendency to build up its own habitual way of drawing inferences; a kind of standard procedure for handling an *indeterminate situation*. The use of standard inference is efficient if the problematic situation deals with events rooted to "the great flywheel of society". However, if the root cause of an *indeterminate situation* diverges, the habitual way of inferring might still be efficient, but it is not an effective manner of doing. In other words, if the individual perceives an event as being rooted to "the great flywheel of society", the habitual way of making inferences is not challenged. Consequently, only the *habitual experience* is activated.

### 6.6.2. Habit in a time and space perspective

Dewey (1933) underlines the imperative of having a certain level of "mental habits" in order to avoid disruptive behaviour. The formation of these mental habits starts in the childhood and constitutes a lifelong personal development.

The individual is living in a world in which doing is unavoidable (Dewey, 1933:86) and referring to the introduction in Dewey's "Logic; The Theory of Inquiry (1938)", a doing is guided by the consequences of priori doings. A consequence is the result of different means being applied by the individual to transform an *indeterminate situation* into a *determinate situation*; habit is one of the means being applied to guide the doings in the *means-consequence relation*. In this understanding, habits are both "today's consumption" and "tomorrow's skilled capabilities"; past doings are embedded in the habits. In other words, the individual is continuously modifying its endogenous predisposition of doing; habits are a historical being.

In his "Experience and Nature", Dewey (1925) draws a biological analogy between animals and human beings in relation to the continuous formation of habit.

> *"In contrast with lower organisms, the more complex forms have distance receptors[11] and a structure in which activators[12] and effectors[13] are allied to distance even more extensively than to contact receptors. What is done in response to things near-by is so tied to what is done in response to what is far away, that a higher organism acts with reference to a spread-out environment as a single situation."* (1925:213).

[11] A specialised cell or group of nerve endings that responds to sensory stimuli.

[12] Any agency bringing about activation; a molecule that increases the activity of an enzyme, or a protein that increases the production of a gene product in DNA transcription.

[13] A muscle, gland or organ capable of responding to a stimulus, especially a nerve impulse.

Just as the discussion dealing with the habitual way of responding to an *indeterminate situation* depends on priori doings – the time distance – the above quotation sheds light on an interpretive dependency with regard to the "spread-out environment" – a space distance.

Referring to Dewey's analogy between lower organisms and higher organisms, the former are "connected" with each other within the *scene of action*. These lower organisms apply signalling acts, a kind of "schemes of behaviour", to coordinate their doings. The signalling among the animals continues until a joint action is possible or status quo in the hierarchy has been restored. Regarding the latter, the humans, the "signalling acts" encompass for instance dialogues – language, body language and communication. The behaviour of an individual or a group of individuals affects the behaviour of others. Two aspects emerge in this regard. First, languages and communication are the enablers for modifying other people's *experience*; qualities unique to human beings.

> *"Human learning and habit-forming present thereby an integration of organic-environmental connections…"* (Dewey, 1925:214).

Second, the space and time distance challenges posed by the above-mentioned "spread-out environment" are, or can be, handled by *"the development of recorded speech,…"* (Dewey, 1925:213). The application of "record speech" as a means to guide other individuals' doings paves the way for a constitutive effect beyond the *scene of action*. Please note that Dewey's "Experience and Nature" was published in 1925, which might be the reason why he uses the "development of recorded speech" as the enabler for handling the space distance among interacting individuals embedded in different *scenes of action*.

The application of today's IT[14] systems makes it possible to transfer "the recorded speech" from one *scene of action* to a number of other scenes of action. This received or retrieved "recorded speech" will not automatically result in a change; however, it is a means to guide the doings in relation to the situationally *indeterminate situation* within the *scene of action* in question. It has a constitutive effect on the doings.

So far, three key concepts have been examined. From time to time, it has been necessary to refer to the *process of inquiry* in the endeavour to put forward an explanation. The next section addresses this and hopefully, the examination of the *process of inquiry* will close the loop and thereby improve the understanding of pragmatic learning.

## 6.7. The process of inquiry – the learning process

Dewey's (1938) logic addresses subject matters dealing with personal development in a social world; the *process of inquiry* sheds light on how we as human beings learn.

> *"Inquiry cannot be reduced to a response to purely abstract thoughts as it is anchored in everyday situations. It is part of life to inquire, mull things over, come to conclusions and make evaluations. We do it all the time whether we are aware of it or not. This is how we learn and become cognizant of our world and who we are in this world."* (Elkjær and Simpson, 2006:7).

[14] Information Technology, for instance e-mail, Computer Added Design/Manufacturing, video conference, etc.

Dewey's empirically based inquiry[15] addresses everyday situations. This logic has its origin in the "social world" in which human beings live and become; they make use of the accumulated *experience* to reflect on "what is going on" when handling indeterminacies; in other words, they learn.

A *successful process of inquiry* results in learning. The outcome of this learning process is defined as knowledge or *reflective experience*. Actually, Dewey (1938:15-16) prefers to denote it "warranted assertions". In this regard, he sheds light on the control aspect, as the warranted assertions have to be testable for public inquiries.

> *"If sheer dogmatism is to be avoided, any hypothesis, no matter how unfamiliar, should have a fair chance and be judged by its results. The other point is that inquiries, numerous in variety and comprehensive in scope, do exist and are open to public examination. Inquiry is the life-blood of every science and is constantly employed in every art, craft and profession."* (Dewey, 1938:12).

The quotation addresses the credibility and validity of the consequence (the outcome) of the *process of inquiry*. Looked upon from the perspective of this thesis, the quotation pinpoints some of the issues dealing with the quality of the research discussed in the methodological chapter 3.

### 6.7.1. The means-consequence relation as a means to control the process of inquiry

Additional to controlling the consequence (the outcome of the *process of inquiry*) as mentioned above, the *process of inquiry* has to be controlled as well. However, this is another kind of control. While the outcome is subject to retrospective control, the control of the *process of inquiry* needs to be more proactive. The control of the *process of inquiry* consists in managing the relation between the <u>means</u> applied and the <u>consequences</u> in this regard.

> *"all logical forms, such as are represented by what has been called proximate logical subject-matter, are instances of a relation between means and consequences in properly controlled inquiry, the word "controlled" in this statement standing for the methods of inquiry that are developed and perfected in the processes of continuous inquiry."* (Dewey, 1938:19).

Dewey regards thinking to be a pivotal instrument for controlling the *process of inquiry*. Thinking is an enabler in the *means-consequence relation* and it ensures continuous experimentation until the *indeterminate situation* has been transformed into a *determinate situation*. Referring to Dewey (1938:115), if/when a working hypothesis is accepted as a solution to the indeterminacy, the *process of inquiry* is immediately cut short. That is, regardless of whether the working hypothesis for handling the indeterminacy is appropriate or not, the process of thinking becomes blocked if/when a working hypothesis is accepted. That is, to prevent that the *process of inquiry* results in a premature solution or cessation of the experimentation with thoughts, the process of thinking calls for a certain structure and persistence.

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[15] Dewey (1938:108) defines an inquiry as *"Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole."*.

Dewey (1933 and 1938:chapter 2) regards the thought processes[16] as endogenous mental processes[17] that have to be managed if possible; referring to section 6.5, the *habitual/reflective experience* forms the basis of these endogenous mental processes.

> *"Unless the pertinence and force of each seemingly evidential fact and seemingly explanatory idea is judged, appraised, the mind goes on a wild-goose chase."* (Dewey, 1933:215).

To avoid that the *process of inquiry* takes the wrong track, both the observations of facts and the creation of working hypotheses have to be judged. The individual makes use of each single observation of social/material factors within the *scene of action* as the <u>means</u> to guide his/her endogenous mental processes. The individual draws on the *habitual/reflective experience* to judge each observed means, which paves the way for creating a working hypothesis in line with the *habitual/reflective experience*. This interchanges continues until the *indeterminate situation* has been transformed into a *determinate situation*; the <u>consequence</u> part of the means-consequence relation.

### 6.7.2. The end-in-view as a means to guide the mental process

A means to guide the mental processes is the desired outcome of the *means-consequence relation*; in Dewey's terminology, the consequence or the *end-in-view*. To establish an *end-in-view*, it is necessary to take into consideration the condition of the *means-consequence relation* (Dewey, 1933:84); that is, the enabling and constraining means within the *scene of action*.

Referring to Dewey, the relation between the means and the consequence, especially "the *end-in-view*", is the focal point for understanding PD.

> *"The operations by which things become understood as chairs, tables, shoes, hats, food, illustrate the means-consequence relation from the "means" side. The relation beginning with the "consequence", or result-sought, side is illustrated in any invention."* (Dewey, 1933:233).

Dewey (1933:233) exemplifies this viewpoint be referring to Edison's thoughts of producing light by the use of electricity as well as the Wright brothers' intention to construct "a machine to fly in the air" (Dewey terms it an invention). Both inventions[18] start at the "result-sought" side, the desired *end-in-view*, whereupon the conditions of the *means-consequence relation* are discovered.

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[16] Cohen (2007) emphasises the embeddedness of habit in the doing, which shapes and empowers the two biological faculties – cognition (thinking) and emotion (feelings); i.e., the term "thinking" should be read as an endogenous mental process consisting of cognition as well as emotion.
[17] Actually, Dewey (1938:22) uses the term "mental elements" to describe the process.
[18] Two more up-to-date examples come to mind. They are taken from my employment at Bang & Olufsen as Senior Supply Chain Manager. The conceptual designers' ideas were the "law" to be abided by. From time to time, employees from other departments regarded the designers' ideas for certain features as being impossible to realise. E.g., the shape of the new loudspeakers had to look like a swan standing in a lake and the surface of the back cover of the new television had to be as soft as the inside of a lady's thigh. The employees involved in these PD activities were very aware of not "breaking the law".

In other words, if the *process of inquiry* is dedicated to PD, the involved employees' mental processes have to be guided in the direction of something needful or desirable; an *end-in-view* of the PD. Afterwards, the means to make it a successful PD, for instance artefacts and methods, have to be identified.

Referring to Dewey (1933:233), every time a problem of this kind is meant to be solved (a PD activity, author), the doings enter into the *means-consequence relation* and, in doing so, they take on added meaning. Accordingly, if the employees successfully handle a PD activity, they transform an *indeterminate situation* into a *determinate situation*, implying that learning occurs.

### 6.7.3. Framing the end-in-view

Dewey (1938:17) discusses some challenges of how to frame the *end-in-view*. According to this discussion, the framing of the *end-in-view* calls for establishing coherence between the *end-in-view* and the enabling means. The *end-in-view* discussion indicates that the *experience* gap has to be manageable. This issue addresses a potential gap between "available *experience*" and "necessary *experience*". For instance, if a ten-year-old of average intelligence is going to solve a very complex integral, there is an unmanageable knowledge[19] gap. Or when a prototype worker assembles a breaker panel to a wind turbine control, he/she has to be able to read the electrical drawings and compare these with the physical breaker panel being assembled.

Hence, in order to ensure a controlled *process of inquiry*, any *experience* gap that may exist between necessary *experience* and available *experience* has to be manageable. An *end-in-view* far from the available *experience* constrains a controlled *process of inquiry*.

The next section sheds light on the five phases in Dewey's logic – the process of inquiry.

### 6.7.4. The pattern of the process of inquiry[20]

The interpretation of Dewey's five-phased learning model draws on a number of sources: Mainly Elkjær (2005:chapter 9), Miettinen's (2000:64-67) visualisation of Dewey's learning model, Dewey's "How we think" (1933:chapter 7) and finally, his "Logic: The theory of inquiry (1938:chapter 6). The headlines applied in relation to the five phases draw on Miettinen's contribution, while Dewey's headlines are indicated in the footnotes. As pointed out elsewhere, the five-phased learning model is an iterative process and not a sequential process model as indicated below.

#### 6.7.4.1. Disturbance and uncertainty: Habit does not work[21]

When/if the habitual manner of working becomes ambiguous, disturbed, troubled, confused, obscured or conflicting, an *indeterminate situation* emerges. This growing indeterminacy in

[19] When using the term knowledge, I refer to Dewey's (1938) understanding of knowledge as being warranted assertions. Only part of the individual's *experience* is knowledge; in other words, the use of knowledge in the text is problematic. The term *experience* might be more appropriate.

[20] Dewey (1938) operates with two different processes of inquiries – common sense and scientific inquiries, which he elaborates on in his 1938 book, chapter 4. Referring to Dewey (1938:105), the logic applied in the two inquiries is identical. Accordingly, section 6.7.4 does not distinguish between the two types of inquiries.

[21] Dewey (1938) denotes this first phase "the antecedent condition of inquiry: the indeterminate situation".

the *habitual experience* results in an increased uncertainty; it provides the breeding ground for an inquiry. The precondition for inquiring is not a pure endogenous disturbance, neither is it an uncertainty in the environment decoupled the individual.

> *"The starting point of the experience is not experience understood as an internal representation or recollection of an individual but as a disturbance in the human, material activity or in the man-environment system."* (Miettinen, 2000:66).

Given that the indeterminacy cannot be the result of a purely endogenous disturbance, the *indeterminate situation* emerges within the *scene of action*.

> *"It is the situation that has these traits. We are doubtful because the situation is inherently doubtful. Personal states of doubt that are not evoked by and are not relative to some existential situation are pathological; when they are extreme they constitute the mania of doubting. Consequently, situations that are disturbed and troubled, confused or obscure, cannot be straightened out, cleared up and put into order, by manipulation of our personal states of mind."* (Dewey, 1938:109).

The pivotal focal point is the situation, for which reason the *indeterminate situation* depends on the subject matter causing the disturbance in the *habitual experience*.

#### 6.7.4.2. Intellectualisation and definition of the problem[22]

The second phase focuses on grasping the disorder – the *indeterminate situation*. It is a sensing process in which the indeterminacy is subjected to a "preliminary reflection"; that is, the individual attempts to understand "what is going on around me?", "what annoys me?" or "what makes me frustrated?". The individual "reflects" on the *indeterminate situation* to internalise the problem. But it is not an intentional reflection. Dewey stresses the absence of *reflective experience* during this phase, for which reason he considers the processes to be precognitive.

As pragmatism rejects any form of a priori conclusions/thinking, the precognitive processes draw on *habitual experience*. Actually, precognition is considered a necessary approach to defining a "real problem".

> *"to set up a problem that does not grow out of an actual situation is to start on a course of dead work, nonetheless dead because the work is "busy work". Problems that are self-set are mere excuses for seeming to do something intellectual, something that has the semblance but not the substance of scientific activity."* (Dewey, 1938:112).

Accordingly, a "ready-made problem" is not a real problem. It is just an assigned task to be solved. Practising without a well-defined and empirically anchored problem implies that the individual merely fumbles through the *process of inquiry*. Regarding the observations, without a well-defined problem, the individual will not be able to determine which data to select or which to reject. Likewise, the precognition will be aimless, entailing that the working hypotheses are accidental. That is, both operational dimensions of the inquiry will be indiscriminate.

[22] Dewey (1938) denotes this second phase "institution of a problem".

6.7.4.3. Studying the conditions of the situation and formation of a working hypothesis[23]

Pragmatism emphasises the old saying "well begun is half done"; that is, a proper understanding of the indeterminacy. Linking the problem and the solution is a gradual process – a progressive inquiry of the conditions.[24] The examination of the conditions involves empirical observations as well as mental processes drawing on *habitual experience* to identify potential solutions. The former is an interpretation of the social as well as the material factors within the *scene of action*.

> *"A possible relevant solution is then suggested by the determination of factual conditions which are secured by observation. The possible solution presents itself, therefore, as an idea, just as the terms of problem (which are facts) are instituted by observation. Ideas are anticipated consequences (forecasts) of what will happen when certain operations are executed under and with respect to observed conditions. Observation of facts and suggested meanings or ideas arise and develop in correspondence with each other."* (Dewey, 1938:113).

The working hypothesis for handling the indeterminacy is still rather vague; actually, in the beginning, it is only a suggestion flashing up. Some suggestions do not have the potential to become a working hypothesis. The suggestion can only become a working hypothesis if deemed to have the capacity to handle the indeterminacy. At this point, a working hypothesis is not present; it is not real, but rather made up of the individual's spontaneous responses. These responses constitute the foundation for continuing the *process of inquiry* and in this regard, they are crucial. If this ongoing "idea generation" is ceased, the *process of inquiry becomes blocked.*

6.7.4.4. Reasoning[25]

Retention of the inquiry is the pivotal element in this fourth phase. The challenges in this regard are twofold; if not met, both will result in the *process of inquiry* being cut short, implying that no learning will occur. First, it is crucial to apply *reflective experience* as a means to enable the continuous intellectual experiments. Second and simultaneously, one should shy away from accepting a meaning (or solution) too early.

The meaning/contents of various working hypotheses in relation to each other are the enabler for ensuring the continuation. That is, this phase deals with the interplay between creation and evaluation of the meaning/contents of a working hypothesis in relation to other created working hypotheses. Thought experiments operating with symbols continue until one of the working hypotheses seems to be a plausible proposition.

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[23] Dewey (1938) denotes this third phase "the determination of a problem-solution".

[24] Dewey (1938:112) illustrates this interchange between observations and precognition by describing the individual's reaction to a fire alarm in a crowded assembly hall. When noticing the sound of alarm, the individual considers which way to escape safely. The individual focuses on the material world or the structure within which the problem emerges. However, how does everybody else react in the crowed assembly hall, "will they use the same fire escape I have decided to use"? The social conditions in the hall represent a constitutive effect. Dewey explains this first step to be an observation of the factors constituting the problem or "the facts of the case". These constituted means are the foundation for a suggestion or an idea for how to escape from the crowed hall.

[25] Dewey (1938) also denotes this phase "reasoning".

*"The point made can be most readily appreciated in connection with scientific reasoning. An hypothesis, once suggested and entertained, is developed in relation to other conceptual structures until it receives a form in which it can instigate and direct an experiment that will disclose precisely those conditions which have the maximum possible force in determining whether the hypothesis should be accepted or rejected. Or it may be that the experiment will indicate what modifications are required in the hypothesis so that it may be applicable, i.e., suited to interpret and organize the facts of the case."* (Dewey, 1938:115).

According to pragmatism, only a practical testing of the working hypothesis can prove its worth as well as its validity. This practical rooting prompts Dewey to denote this fourth phase "reasoning"; a phase during which the individual creates a working hypothesis. It directs attention to the fifth phase – the operational dimension.

6.7.4.5. Testing the hypothesis in action[26]

The functional division of the *process of inquiry* initiated in the third phase is rather apparent in this fifth "operational" phase, which focuses on testing the working hypothesis in practice. The gradual refinement of observed facts and ideational solutions culminates in this fifth phase. The observed facts are derived from real life and they deal with an existential problem. Conversely, the ideational contents are non-existential as they are intellectual experiments.

However, the enabler of an intact interchange between observed facts and ideational solutions for resolving an existential *indeterminate situation* is an operational approach. As long as both the observed facts and ideational solutions are operational, the *process of inquiry* continues. Oppositely, if one of these becomes non-operational, the *process of inquiry becomes blocked.*

The ideational solution (the working hypothesis) is considered operational if it propounds one or more proposals for handling the indeterminacy and simultaneously prompts and outlines the need for further observations. The observed facts are operational if they are retrieved as a means to create or refine the working hypothesis formulated to handle the indeterminacy.

### 6.7.5. A successful inquiry implies a determinate situation and learning

A *successful inquiry* is apparent when the interchanges between observations of social/material factors and the individual *habitual/reflective experience* result in a transformation of an *indeterminate situation* into a *determinate situation* (Dewey, 1938:121).The observed social/material factors are thoroughly existential, they are real, and referring to Dewey (1938:27), every *process of inquiry "takes effect in greater or less modification of the conditions out of which it arises."*. Some of the modifications influence the social/material factors; e.g. an electrical diagram to a wind turbine control is reworked. In the same way, the interchanges between the observations and mental processes draw on *habitual/reflective experience*, e.g. fantasy, critical reflection, reflective thoughts and thought experiments. This implies an intellectual outcome of a *successful inquiry* consisting of new *experience*, which afterwards may be used as *experience* in future problematic situations.

[26] Dewey (1938) denotes this fifth phases "the operational character of facts-meanings".

Hence, a *successful inquiry* paves the way for changing the existential conditions within the *scene of action* as well as the creation of new *experience*; i.e., learning.

## 6.8. Summary of pragmatic learning and the need for further examinations

The objective of this chapter was to improve the understanding of pragmatic learning.

The scene of action is the contextual setting in which the process of inquiry takes place; for instance, a meeting room where PD engineers are developing a product. The understanding of the scene of action rejects any kind of dualism.

An individual is neither a passive individual being institutionalised by the scene of action nor is he/she unrestricted to act on his/her own free will. Instead, it is a situational interpretation within the scene of action that enables the doings.

A doing is an act. Due to the rejection of dualism, thinking is an inseparable element in a doing. Rather than being a step-by-step thinking and doing process, it is a thinking-in-doing process. This thinking-in-doing process takes place within the scene of action. The scene of action influences the thinking-in-doing and the scene of action is influenced by the individual's thinking-in-doing. That is, a doing is guided by the reciprocity between the social/material factors and the habitual/reflective experience.

The individuals do not have the same level of experience in conducting doings and likewise, the scene of action is continuously mutable. Thus, the individuals as well as the scene of actions are not homogeneous; instead both are heterogeneous.

Within this scene of action, the indeterminate situation emerges; it is the seed for the process of inquiry – the learning process. By conducting a process of inquiry, the indeterminate situation can be transformed into a determinate situation.

The means-consequence relation is a method for controlling the process of inquiry. It is a method for guiding the transformation of the indeterminate situation and thereby avoid that the process of inquiry takes the wrong track and becomes blocked before achieving a determinate situation.

Guiding the process of inquiry consists of handling the relation between the <u>means</u> being applied and the <u>consequence</u> in this regard. This way of thinking forms the basis of figure 6.4.

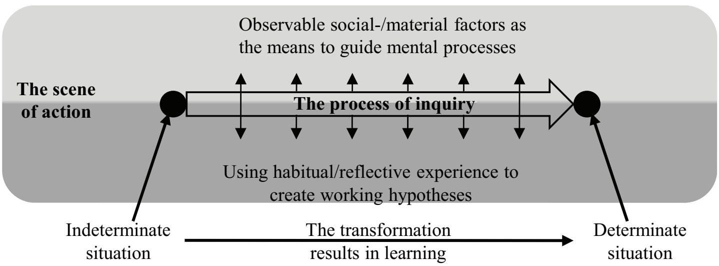


Figure 6.4. The process of inquiry transforms the situation to be determinate.

When conducting a process of inquiry, the doings enter into the means-consequence relation and in doing so, they take on added meaning; if the individuals successfully transform an indeterminate situation into a determinate situation, learning occurs. As depicted in figure 6.4, learning is defined as the transformation of an indeterminate situation into a determinate situation. This learning process results in the creation of new experience.

Referring to figure 6.4, the social/material factors are the means to guide the endogenous mental processes. The individuals draw on the habitual/reflective experience to judge each observed means, which paves the way for creating a working hypothesis in line with the habitual/reflective experience. This reciprocity continues until a determinate situation has been achieved.

Table 6.1 is an overview of various terms and concepts examined in chapter 6. The first column depicts the applied terms. The next column contains brief explanations and the last column refers to a section discussing the subject matter in question.

| Applied terms | Brief explanations | Refer to |
|---|---|---|
| Scene of action | The scene of action is the contextual setting in which the process of inquiry takes place; e.g., a meeting room where PD engineers are developing a product. | 6.4. |
| Indeterminate situation | Disturbance in the habitual way of doing things as habits do not work; something disturbs our thinking or feeling, but at the time, we do not know what it is. | 6.3. |
| Determinate situation | It is the outcome of a process of inquiry (see below). In contrast to the indeterminate situation, the constituents do now *"hang together"* (Dewey, 1938:109). I.e., achieving a determinate situation implies a modification of the existing conditions within the scene of action. | 6.3 |
| Process of inquiry | Continuous interchanges between observations of social/material factors and habitual/ reflective experience; it is a learning process initiated by an indeterminate situation and ending with restoration – a determinate situation. | 6.7. |
| Successful inquiry | A successful inquiry results in a restoration of the determinacy and creation of new experience; i.e., learning. | 6.7. |
| Blocked inquiry | The transformation of the indeterminate situation is terminated without a restoration of determinacy; as the inquiry is blocked, no experience is created. | 6.7. |
| Means-consequence relation | The means-consequence relation is a method for guiding the transformation of the indeterminate situation into a determinate situation; i.e., a method for guiding the process of inquiry. | 6.7. |
| Doing | A doing is an act conducted by an individual in the process of transforming an indeterminate situation into a determinate situation. | 6.4. |
| Experience | Experience unfolds in and because of the scene of action; experience is the continual transaction and reciprocal formation of the individual and the scene of action (Elkjær, 2004:423). Experience spans a continuum between habitual experience and reflective experience. | 6.5. |
| Habitual experience | Habitual experience is non-cognitive experience; our habits draw on habitual experience. Habitual experience is the stabilising factor – "the great flywheel of the society". | 6.5.<br>6.6. |
| Reflective experience | Reflective experience is cognitive. Reflective experience makes it possible to reflect on the root causes of an indeterminate situation and thereby transform it into a determinate situation. | 6.5. |
| End-in-view | The end-in-view is the desired/intended outcome of the process of inquiry. It is a means to guide the individual's reflection in a direction of something needful or desirable. | 6.7. |
| Trajectory | A trajectory is the life history of a project (Elkjær, 2004:428); e.g., the life history of the PD of a wind turbine control as *"Each particular activity prepares the way for the activity that follows."* (Dewey, 1938:33). | 6.4. |

Table 6.1. Overview of applied terms examined in chapter 6.

The next section addresses the application of pragmatism to understand learning within PD working practices; it will be instrumental in linking this chapter to chapter 7.

### 6.8.1. Application of pragmatism to understand learning within PD working practices

It is the individual's feeling of the indeterminate situation as well as understanding of when a determinate situation has been achieved, which initiates and ends the above learning process. However, in order to understand learning within a PD working practice, it is not appropriate to have the individual as the focal point as it precludes acknowledging that the individual and the PD working practice are evolving in reciprocal interaction (Elkjær, 2005:128). Instead, focusing on how a PD activity unfolds within a PD working practice makes it possible to appreciate this reciprocity.

Accordingly, if applying the pragmatic learning understanding in this thesis, it is necessary to combine pragmatism with a theory addressing PD working practices. In this regard, a suitable theory is in line with the fundamental principles of the scene of action being examined in section 6.4, the concept of experience being presented in section 6.5 and finally, the process of inquiry being discussed in section 6.7.

This viewpoint is in keeping with Elkjær (2004:426 and 2005:140). Elkjær combines the pragmatic learning understanding with Strauss's understanding of organisations as arenas consisting of social worlds. Strauss's organisational approach draws on two theories, both within the umbrella of pragmatism. Referring to Elkjær (2005:136), these two theories are Dewey's Human Nature and Conduct (1922) and the symbolic interactionism[27] developed at the University of Chicago.

Chapter 7 addresses a PD working practice as well as an analytical framework for studying learning within PD working practices.

[27] Blumer's (1969) conceptual interpretation of symbolic interactionism draws on George Herbert Mead (1863-1931) who, just like Dewey, is one of key contributors to the philosophy of American classical pragmatism. While Dewey sheds light on the learning processes, Mead focuses on the social interaction in which meaning is created. Human interaction is enabled by interpretation of symbols and ascertainment of the meaning of other individuals' actions. Drawing on Blumer (1969:72), action is the common denominator within the human society or "*the social world*"; the self, the act, social interaction, objects and joint action are embedded in action.
Both theoretical positions acknowledge that thinking cannot be prior to observations; action, thinking and emotion are inseparable. When an indeterminate situation emerges in society (the social world), each of the participants has to align their actions to one another. This action-oriented approach indicates a proactive human being adjusting self-action towards other people by interpreting their actions and making "signals" to others regarding how they ought to act. In addition, the proactive employees interpret other signs in the social world. Barley (1986 in Barley and Tolbert, 1997:98) considers day-to-day social interaction in an institution as being enacted through scripts and proposes to apply those scripts as analytical tools for studying how they influence human agency. Thus, social and material factors are means to determine an appropriate action.

# Chapter 7. Sociotechnical practice – creating the analytical framework

In this study, Product Development (PD) is the creation of a new Wind Turbine Control (WTC) and the focus is on the PD activity.

The main purpose of the chapter is to create an analytical framework for the study of a PD activity within a working practice, making it possible to analyse learning. Another purpose is to present an understanding of how a PD activity unfolds within a working practice.

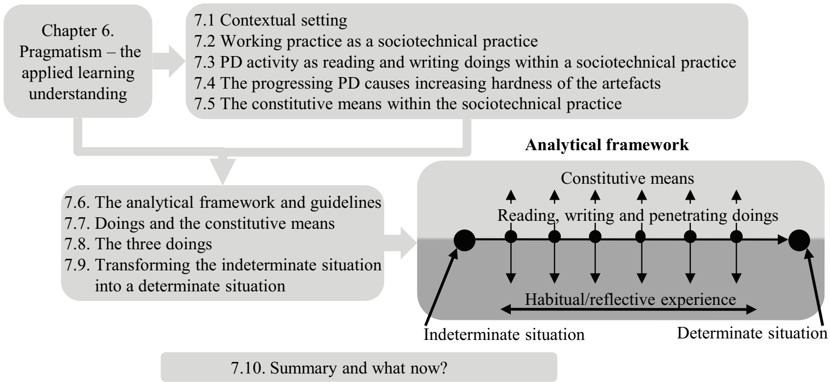


Figure 7.1. The structure of the chapter.

As illustrated in the topmost part of figure 7.1, the PD understanding draws on a sociotechnical perspective adapted to the pragmatic learning understanding. Based on a discussion of the contextual setting, the concept of SocioTechnical Practice (STP) is introduced. The building blocks of this concept draw on three subject matters which are examined in the following three sections. Section 7.3 addresses an interpretation of a PD activity through a reading and writing metaphor, while the next section focuses on a gradually increasing hardness of the artefacts. The third building block introduced in section 7.5 analyses the constitutive means within the STP. These analyses make up the first part of chapter 7.

The second part of the chapter depicted in the lowermost part of figure 7.1 addresses the construction of the analytical framework. In addition to the discussions in the first part of chapter 7, Goffman's (1974) frame analysis is brought to the fore. Three subject matters are discussed: Doings and constitutive means, the three doings and finally, the transformation of the indeterminate situation into a determinate situation. At the very end of the chapter, a link to the empirical part is briefly touched upon.

As in the discussion of pragmatic learning, the summary includes a table (table 7.1), which provides an overview of terms applied in this chapter. These terms are written in *italics* throughout the chapter. Underlined terms written in *italics* are discussed in chapter 6 and these appear from table 6.1.

## 7.1. Contextual setting

Referring to the pragmatic learning understanding, the *indeterminate situation* unfolds within the *scene of action*; disturbances cannot be purely endogenous, unless we are dealing with pathological conditions (Dewey, 1938:109). In other words, an *indeterminate situation* can only be interpreted in its contextual setting, as the disturbances are situational within the *scene of action*. Likewise, a *scene of action* can only be understood in relation to the doings being conducted. Thus, the *scene of action* unfolds a contextual setting (from now on a "working practice") in which thinking and emotion are involved in any doing. It makes no sense to separate doing, thinking and emotion from the working practice or, for that matter, the *indeterminate situation*.

A working practice is made up of a reciprocity between the individuals and the environment (Dewey, 1938:32-34), for instance between engineers conducting a PD activity within a meeting room or in the production area by the use of drawings, laptops and/or the physical product. The working practice is the setting in which learning takes place when the engineers are conducting a PD activity in the attempt to transform the indeterminate situation into a determinate situation.

## 7.2. Working practice as a sociotechnical practice

Henderson (1998:139) views the working practice as an *STP*[1] in which engineers apply sketches, drawings and prototypes as thinking tools and boundary objects. Sketches, drawings and prototypes are conscription devices and the visual representations of these become the social glue of the *STP*. Henderson (1991:451) emphasises that the creation of a technology within an *STP* is a social process, during which the technological creation is constituted by society while simultaneously constituting society.

Henderson (1991:457) refers to Hutchins' (1995) analysis involving the landing of a commercial airliner to illustrate that the conscription devices are the *"means for organizing the design to production process,…"* (ibid. p.448). Thus, the visual representations of the conscription devices are the thinking tools and boundary objects to facilitate communication and doings among the engineers.

Hutchins' (1995) analysis of the commercial airliner addresses the inseparable interaction between cognition, various representations and doings. The focal point for the analysis is the sociotechnical cockpit unfolding during descent and touch-down. This brings the pilots' doings to the forefront, as landing an airliner calls for ongoing doings; hence, the pilots' interactions become central in his analysis.

> *"a continual interaction with a world of meaningful structure. The pilots continually are reading and writing, reconstituting and reconstructing the meaning and the organization of both the internal and the external representations of the speed."* (Hutchins, 1995:284).

[1] Henderson applies the term "sociotechnological" rather than "sociotechnical". From now on, I use the latter.

The pilots' doings being conducted during descent and landing originate in social interaction between the two pilots. It is not a predetermined pattern of doings, but rather depends on recursive *reading* and *writing doings* of the available representations within the sociotechnical cockpit. That is, the representations are the means to guide the pilots' doings.

However, three issues have to be clarified. First, Henderson's (1991) analysis addresses mainly the two ends of the PD, the starting and the ending point; the former focuses on the role of a sketch, while the latter addresses the role of a fixed drawing. The intention is to establish an understanding of how a PD activity unfolds within an *STP* regardless of whether the analytical focus is the starting point, the ending point or somewhere between these two points of the PD. As it appears from the lowermost part of figure 7.2, section 7.3 discusses this subject matter by considering a PD activity as a series of *reading* and *writing doings*.

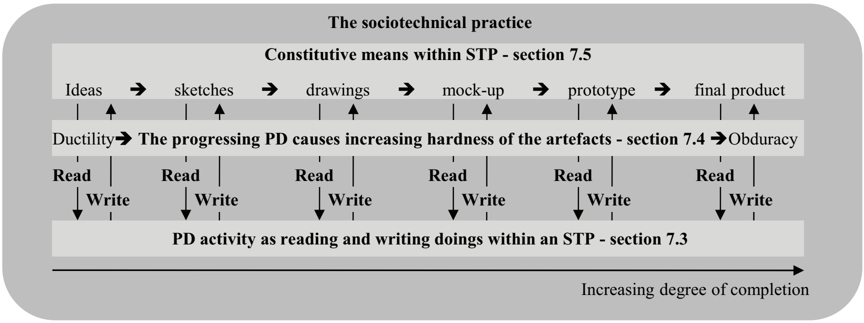


Figure 7.2 Overview of the next three sections addressing the PD understanding.

Second, Henderson considers a sketch to be flexible, while the final drawing is regarded as an inflexible conscription device. In doing so, she points out that an increasing hardness of the technical specifications (artefacts) prompts changes in the constitutive effect. Still, the question is how to understand hardness? Referring to the middle part of figure 7.2, section 7.4 addresses this subject matter; an increasing degree of completion causes an increasing hardness of the artefacts transforming from *ductile* at the beginning to *obdurate* at the end.

Third, Henderson spotlights conscription devises as being *constitutive means*; a thinking tool, a boundary object and social glue for the interaction. Drawing on the pragmatic learning understanding, the individual attempts to make sense of an <u>*indeterminate situation*</u> by observing all social as well as material factors. The question is how to understand this triadic and inseparable interplay between the three categories of *constitutive means*? As depicted in the uppermost part of figure 7.2, this subject matter is elaborated in section 7.5 dealing with *constitutive means* within the *STP*.

## 7.3. PD activity as reading and writing doings within an STP

Latour (1992) compares the creation of an artefact (Latour uses the term machine) with the creation of text. The engineers inscribe functionalities in the artefact just as authors inscribe text in a book. This inscription originates from a prescription of the qualities and behaviour of its users or readers. The users of the artefact or the readers of the book conduct a description, but *"Nothing in a given scene can prevent the inscribed user or reader from behaving differently…"* (Latour, 1992:237). As Akrich (1992) explains it, the gap between the prescription and the actual behaviour has to be analysed as a continuous interplay between the real user's description of the artefact and the inscription. In other words, the user's description of an artefact is only understandable if the relation between the form and the meaning of the artefact is analysed within an *STP*. Drawing an analogy to Hutchins' (1995) sociotechnical cockpit, the rules/procedures prescribed in various manuals are not the same as actually flying the commercial airliner. It is a not yet decided triadic relationship among *constitutive means* within the sociotechnical cockpit, interpretations and doings.

Referring to Akrich (1992), the theory of inscription is an appropriate method for understanding a PD activity when creating an artefact (Akrich uses the term technical object). It is a reciprocal action between the <u>consumption</u> and <u>production</u> of an artefact, which in Akrich's (1992:209) terminology is achieved by going:

> *"back and forth continually between the designer and the user, between the designer's projected user and the real user, between the world inscribed in the object and the world described by its displacement."*.

Grint and Woolgar (1997:70) propose to understand "technology as text". The "thoroughgoing interpretivism" (Grint and Woolgar, 1997) of technology has been problematised by Hutchby (2001:445) who refuses to acknowledge that everything is a matter of negotiation. However, referring to Grint and Woolgar (1997:73), the "technology as text" notion does not indicate an absolutely independent interpretation of a technology. As the two authors emphasise, the textual properties *"do not mean to suggest that any reading is possible (let alone that all readings are equally possible)…"*.

The textual metaphor is premised on a stance that holds the <u>production</u> (development) of a technology to be writing text. Likewise, the <u>consumption</u> (interpretation) of the technology is reading text. In doing so, Grint and Woolgar (1997) divide the nature of technology into two interconnected processes, namely those of *writing* and *reading doings*. The former establishes the functionality of the artefact, while the latter interprets the artefact.

Sketches, drawings and electrical diagrams are artificial representations of, for instance, the WTC being created. As Henderson (1991) states, it is like reading a map with codes, indexes, symbols, etc. Following Henderson's (1991:456) terminology, these conscription devices (from now on artefacts) are thinking tools for the *reading doings* of the engineers and they facilitate communication as well as interaction among the engineers. For instance, if artefacts are not brought along to a meeting, the engineers draw up a sketch on paper or on the blackboard, a *writing doing,* to enable thinking, communication and interaction among the participants.

With reference to pragmatism, artefacts do not cause thinking and interaction per se, but when the individual conducts *reading doings* and interprets the artefacts, the sketches and/or drawings become *constitutive means*. For instance, drawing on Hutchins' (1995) description of bringing down the commercial airliner, the manual to determine the appropriate landing speed does not have a constitutive effect during take-off or when flying at cruise altitude. However, during the descent, the pilots conduct *reading doings* and thereby apply the manual as a *constitutive means* to calculate the appropriate landing speed. By then it becomes a thinking instrument; it is a prescription of a mandatory sequence of doings to be conducted by the two pilots. Likewise, some of the electronic instruments in the cockpit display the actual conditions and, from time to time, the pilots read this information; it is a *reading doing* of the representation depicted on the instruments. These *reading doings* might have a constitutive effect, but not necessarily. It depends on the actual situation.

Taking an in-depth look at the manual for landing the commercial airliner, this manual is created by highly skilled engineers. They have made a series of calculations and analyses dealing with this specific type/version of an airliner. Their convergent interpretations of the relation between landing weight and appropriate speed are written in the landing manual (*writing doings*). Likewise, other manuals available in the cockpit act as a prescription of how to handle all feasible scenarios, for instance if the plane is lacking fuel or the engines suddenly stop functioning. The engineers have written down procedures for how to handle various critical and *indeterminate situations*. It is an imaginary interpretation of a potential *indeterminate situation* in the sociotechnical cockpit. This "crisis manual" is a prescription for the pilots of how to transform the *indeterminate situation* into a *determinate situation*, but it is not the same as actual doings. Instead, the doings are determined by the interpretations of the *constitutive means* within the particular sociotechnical cockpit.

To summarise, the understanding of a PD activity draws on a textual metaphor. The textual metaphor refers to *reading doings* of the *constitutive means* (interpretation) and *writing doings* adding text into the *constitutive means* (development). The latter is the result of arriving at a convergent interpretation of the *indeterminate situation* as well as the transformation of the *indeterminate situation* into a *determinate situation*.

However, the PD of a new WTC is a gradually progressing process that starts with an idea and moves on to the creation of sketches, drawings, mock-up to pilot production, etc. The next section focuses on increasing hardness during this progressing PD process. It discusses how hardness influences the constitutive effect of artefacts as well as *effort* to change an artefact.

## 7.4. The progressing PD causes increasing hardness of the artefacts

All other aspects being equal, hardness of the technical specifications (artefacts) increases as one gradually moves along the path to completion of the WTC being created. This changeable nature of the artefact has been a focal point for a number of researchers.

Law (1989:111) describes it as a process of stabilisation in which closure is achieved when debates and controversies concerning the artefact are completed. Bijker (1993:121) defines the process of stabilisation in relation to the interpretation of an artefact, by which closure is linked to a convergent interpretation; increasing stabilisation causes a decreasing interpretative flexibility. These two similar concepts draw on the viewpoint that stabilisation is achieved (closure) when/if the interpretations of the artefact become homogeneous. Thus, stabilisation, and thereby increasing hardness of the artefacts, is an ongoing process.

Henderson (1998:145) addresses the consequences of an increasing hardness of the artefacts. She emphasises that the progress of the PD causes an increasing complexity of the final drawing as *"information is accumulated in a continual progression back and forth from paper to machine to paper…"*. Referring to Henderson (1991:459), sketches being used in the beginning of the PD process are *"the most important carriers of visual knowledge…"*. At the end of the PD process, final drawings are considered the *"official carriers of information…"* (ibid. p.462). The latter is the result of a gradual refinement of sketches, causing a continuous addition of codes, indexes and symbols. Henderson (1991:462) denotes this "multifunctioning" and it implies that the final drawing encompasses many details and interfaces among components as well as organisational functions. Drawing on Henderson (1991 and 1998), flexible sketches and inflexible final drawings are two extremes on a continuum addressing hardness.

Other researchers have formulated various concepts, such as a *ductile* tool for actors (Koch, 2000:119) or a malleable technology (Orlikowski, 2000:409), to describe the extreme composition of a technology corresponding to Henderson's flexible sketches indicating a low degree of completion. The opposite extreme, identical to Henderson's less malleable machine, arises from a high degree of completion and it is described as hardness is the result of closure (Misa, 1992:134) or it is considered to be *obdurate* (Akrich, 1992:207).

In sum, the two terms being applied in this research to illustrate the two extremes on the continuum are *ductility* and *obduracy*.

Henderson (1991 and 1998) sheds light on the advantages of applying *ductile* artefacts. The final drawings are often misinterpreted as too much complexity is written into these *obdurate* artefacts. However, how does this increasing hardness influence the constitutive effect?

### 7.4.1. An unsettled relationship between hardness and constitutive effect

Drawing attention to Hutchins' (1995) sociotechnical cockpit, the landing manual is the outcome of a deliberate process in which specialist engineers have written text into the manual. Hardness of this artefact is high; the manual is *obdurate* and, according to the above argumentation, the constitutive effect is low.

However, for the pilots, the constitutive effect of the manual is high as it enables them to conclusively determine the landing speed. Oppositely, if randomly taking one of the passengers from the commercial airliner, this person will most likely not be able to conduct a *reading doing* and thereby determine an appropriate landing speed. If the passenger in question is a pilot trained in another type of airliner, he/she might be able to calculate the landing speed.

The above is in keeping with pragmatism, as heterogeneity is regarded as a central concept in the pragmatic learning understanding. Hence, *obduracy* does not automatically cause homogeneous interpretations and thus a less valuable role as an artefact. Instead, the above demonstrates an unsettled relationship between *obduracy* and the constitutive effect.

In the same vein, Carlile's (2002) analysis of PD in a cross-functional setting illustrates that the constitutive effect of a drawing does not necessarily facilitate a convergent interpretation. In the beginning, the *constitutive means* (the drawing), which the engineers apply to enable a convergent interpretation, is *too ductile* to aid the *reading doings* of the *indeterminate situation*. Following an update of the drawing in question, and thereby a decrease in the *ductility*, the constitutive effect increases, resulting in the attainment of a *determinate situation* (Carlile, 2002:450).

### 7.4.2. Effort to change an obdurate artefact

Bijker (1992:76) emphasises that the PD process is reversible. Nevertheless, *obduracy* might imply that it becomes rather difficult to change an artefact. First, the *reading doings* of the artefact might be complicated due to a high level of complexity as indicated by Henderson (1991). Second, the *writing doings* of new text into the artefact necessitates a certain level of convergent interpretations among engineers belonging to different *STP*s. In this regard, Orlikowski (1992:421) emphasises that an increasing *"temporal and spatial distance…"* between the creation of the artefact and implementation of the change (Orlikowski terms it application) complicates the process.

Drawing on the work of Bijker and Orlikowski, Koch (2001:67) emphasises that the *obduracy* of an artefact should not be overestimated; yet, he specifies that changing an *obdurate* artefact is a strenuous struggle – *"The position adopted here leads to an understanding of flexibility and hardness as a complicated pattern of elements of negotiability, resources and distance."* (Koch, 2001:77). Thus, an *obdurate* artefact can be changed, but it requires a strong *effort* to conduct the doings.

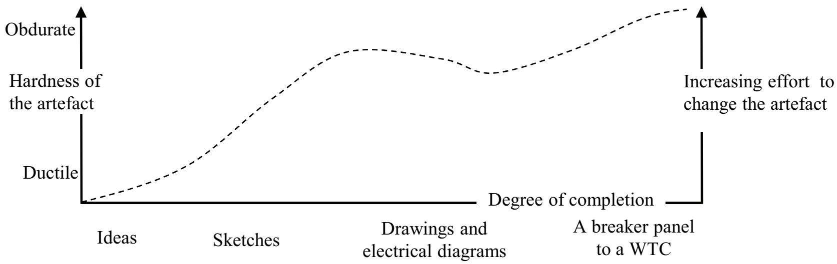


Figure 7.3. The ductile and obdurate artefacts.

In sum, as depicted in figure 7.3, the two terms *ductility* and *obduracy* are applied to illustrate different degrees of hardness of the artefacts; the left vertical axis on the figure is a continuum of hardness. *Ductility* indicates a low degree of completion, as for instance a sketch, while *obduracy* is the other extreme designating a high degree of completion – e.g. a fully developed WTC breaker panel; the increasing degree of completion is evident from the horizontal axis. The right vertical axis addresses the *effort* required to change an artefact. Thus, an *obdurate* artefact, as for instance a fully developed WTC breaker panel, can be changed if the customer requires it. However, the engineers have to make an *effort*; it is time-consuming and resource demanding. Please note that the dotted line in the above figure is just an example and not an accurate rendering of the truth.

When using the term a "*too ductile*" or "*too obdurate*" artefact to describe the nature of a *constitutive means*, I refer to a particular PD activity within an *STP*. In this situation, the *constitutive means* constrains a transformation of an *indeterminate situation* into a *determinate situation*.

While the above has mainly addressed different natures of the artefacts, the next section addresses the *constitutive means* within the *STP*.

## 7.5. The constitutive means within sociotechnical practice

Artefacts as for instance sketches and drawings are *constitutive means* within the *STP*. The individuals apply these artefacts as *constitutive means* to enable PD (Henderson, 1991). Henderson (1991:468) considers artefacts to have a crucial role to play in the social organisation among the engineers conducting PD in teams. The *STP* is influenced by the applied artefact(s) and vice versa. This reciprocity among engineers, artefacts and *STP* is elaborated by Henderson (1998). [2]

Drawing on Hutchins' (1995) analysis of the sociotechnical cockpit, the manual for landing the commercial airliner is a *constitutive means* for the two pilots to organise a "landing *STP*" in order to determine the descent and landing. This *STP* consists of the two pilots, the manual, a calculator, a pencil, a pad, some instruments in the cockpit, Air Traffic Control, other incoming commercial airliners, etc.

With reference to the pragmatic learning understanding, a *process of inquiry* addressing PD causes the doings to enter into a "*means-consequence relation*". The **consequence** is the outcome of the *process of inquiry*. The (*constitutive*) ***means*** being applied to enable a gradual approach towards the consequence are the two operational dimensions of the *process of inquiry*. The first operational dimension encompasses observations of social and material *constitutive means* within the *STP*, while the ideational dimension draws on *habitual/reflective experience* to create working hypotheses for achieving the consequence.

Thus, three inseparable categories of *constitutive means* appear within an *STP*; social means, material means and artefacts. The *reading doings* of an artefact within an *STP* are an interactive process. It involves social interaction among the engineers as well as different materials, for instance a laptop, Computer Aided Design (CAD) system, TV screen and an intranet connection to display the electrical diagram (the artefact). However, neither Henderson (1991 and 1998) nor Hutchins (1995) explicitly defines the boundaries of the *STP*.

[2] Henderson (1998:169) demonstrates how a managerial decision to follow Total Quality Control combined with the application of a predefined computer graphics system causes a rigid and hierarchical working practice . She compares this working practice with a flexible and interactive working practice. The analysis highlights the need to have a flexible working practice as well as flexible artefacts. Another finding suggests that the application of a computer to depict the artefacts is less important than the aforementioned flexibility.

With reference to pragmatism (Dewey, 1938), the boundaries of the *STP* are determined by the constitutive effect of a particular *constitutive means*. If a *constitutive means* does not have any constitutive effect on the individual's thinking-in-doing within a particular *STP*, the *constitutive means* is beyond the boundaries of the *STP*.

In this regard, the space-distance challenge discussed in section 6.6 illustrates the possibility to cross boundaries between *STP*s. Dewey (1925:213) proposes to apply "recorded speech" to influence individuals who are beyond the boundaries of the *STP*. That is, the application of diverse *constitutive means*, for instance mobile phones, e-mail, etc., makes it possible to penetrate the boundaries of the *STP*. For instance, if an engineer working at a Danish location makes use of a Japanese supplier's homepage, the *constitutive means* accessible at the homepage will be within the *STP*. Hence, this *penetrating doing* accomplished by the engineer expands the *STP*.

To summarise, PD is the creation of a new WTC. A PD activity is the ongoing *reading* and *writing doings* that make it possible to grasp that the individual and the *STP* are evolving in a reciprocal interaction. When conducting a PD activity, the *reading* and *writing doings* are facilitated by reciprocal interchanges between the *constitutive means* within the *STP* and the engineers' *habitual/reflective experience*.

The *reading* and *writing doings* of/into the *constitutive means* are crucial for conducting a PD activity. While a sketch is a *ductile constitutive means*, the final WTC is an *obdurate constitutive means*: this changing hardness influences the *reading* and *writing doings*.

The remaining part of this chapter addresses the creation of the analytical framework for the study of learning within *STPs*.

## 7.6. The analytical framework and guidelines

Viewing the PD of a WTC as ongoing *reading* and *writing doings* calls for a division of the PD activity. Goffman's frame analysis (1974) makes it possible to perceive a PD activity as a *strip of doings*. The focal point for the analysis is the single doing. It paves the way for appreciating the reciprocity between the engineers and the *STP*.

Goffman's theoretical position in relation to the frame analysis is three-part.[3] He positions himself within the symbolic interactionism derived from American pragmatism – George Herbert Mead and Blumer. Some similarities to the theoretical position discussed in chapter 6 and the first part of chapter 7 are apparent. For instance, the creation of meaning is conditional on the specific event in a situational setting. Furthermore, different *constitutive means* are applied to guide doings.

Referring to Goffman (1974:8), when confronted with an *indeterminate situation*, the individual attempts to understand *"What is it that's going on here?"*. Facing an event, the

[3] The three sources of inspiration are: William James, who was a pragmatist (for a brief description of William James, please see chapter 6.1), Alfred Schutz, who drew upon the work of William James, and Gregory Bateson.

individual makes use of its frame to enable the creation of meaning; this is termed the primary frame. Goffman divides this frame into two inseparable parts; a natural and a social frame.

The natural frame makes it possible to identify naturally occurring events as for instance "it is raining" or "sunrise and sunset". From start to finish, these events take place unaffected by human actions and are thus unguided by the individuals; one might say that it is a kind of natural determinism.

The social frame constitutes the individual's interpretation of daily events. Goffman (1974) describes this social frame as the means to guide doings. For instance, the weatherman applies his/her social frame to guide his/her interpretations of various signals and information to create the weather forecast. These doings are not just events but human agency. Referring to Goffman (1974:22), the social frame:

> *"incorporate the will, aim, and controlling effort of an intelligence, a live agency,…".*

### 7.6.1. Rules and structures

According to Goffman (1981), the social frame consists of rules used to determine the situation. In this regard, Goffman (1981:63) emphasises that the individual's social frame has:

> *"its own logic, its own set of motives, its own meanings, and its own activities,…".*

The individual's doings are apparent in the above quotation and in the previous quotation (*"a live agency"*). However, agency does not indicate a "free will to act" and, according to Goffman, it is in this light that the term "rules and structures" has to be understood. I.e., the individual navigates through rules/structures in the attempt to live in a society, for instance when playing chess, when buying shares at the stock market, etc. Goffman (1974:22) describes this as the available "standard doings" and "standard reasons" for conducting these doings.

### 7.6.2. Guidelines for the analytical framework

Pentland (1992) makes us of Goffman's concept of moves in his analysis of two different hotline support centres. He makes a point of stressing that Goffman's contributions, although widely applied within discourse analysis, should not be restricted to this field of application. In this connection, Pentland (1992:530) accentuates the fact that Goffman's analytical approach includes non-linguistic features of the interaction as well and, as it will appear in section 7.8 dealing with "the three doings", this viewpoint is rather apparent in Goffman's 1974 contribution.

Pentland's (1992) application is very interesting and, honestly, his work is the source of inspiration for bringing Goffman's frame analysis (1974) to the forefront. The objective of Pentland's research is to "transcend the ghost and the machine" by articulating a pragmatic theory of organisational knowledge. He draws upon Dewey's pragmatic understanding to define knowledge as being situational and temporal; action and knowledge are regarded to be crucial for transforming the *indeterminate situation* into a *determinate situation*. Thus, pragmatism bridges the ghost (a cognitive learning understanding) and the machine (a structural approach to learning).

Pentland's analytical approach entails addressing structural features of the situation; more specifically how physical, ritual and competence structures enable or constrain two different "moves" within the hotline centre. Accordingly, if applying the contribution from Pentland and Goffman as well, two subject matters spring to mind.

### 7.6.3. Considerations regarding identifications of guidelines

First, smouldering beneath the surface of Pentland's (1992) explanation of the structural dimension is some doubt as to the interpretation of the term structure. Pentland (1992:531) considers Goffman's approach to the structural dimension to be *"opaque and confusing"*. However, in his description of the physical and ritual structures, Pentland employs the concept of affordance,[4] an ecological approach to visual perception emphasising an inseparable relation between the perceiving subject and the object; the concept addresses "what a perceivable object makes possible". Thus, this visual perception of structures is, in Penland's analysis, the enabling and/or constraining means for "moving" the problematic situation to be unproblematic.

As it appears elsewhere, the theoretical stance taken in this thesis is to consider the *constitutive means* as situational within an *STP* and crucial in transforming the *indeterminate situation* into a *determinate situation*. Accordingly, section 7.7 illuminates and clarifies the approach being applied in relation to the analytical framework by linking doings and the *constitutive means*. This addresses the uppermost (light grey) part of figure 7.4.

Second, Pentland's (1992) analysis deals with repetitive tasks triggered by an incoming call from a customer. Beyond doubt, the problems are not identical, but the support specialist is sitting in the same office and the problems being handled may be categorised within the same umbrella, namely that of providing customers with support. If the technical supporter is not able to do this, the call becomes a "get help" move or "give away" move. In other words, an *indeterminate situation* arises if the supporter is not able to identify a suitable solution. And the transformation from this *indeterminate situation* into a *determinate situation* is handled by getting help or moving the task.

The PD doings being analysed in this thesis diverge from those mentioned above and have a space and a time dimension as well. A problematic task is not just handed over to another engineer, but calls for continuous interaction among engineers and employment of diverse *constitutive means*. Hence, it is necessary to identify an approach for analysing this myriad of

[4] Gibson (1979) is credited for coining this theoretical concept. Referring to Gibson (1979:141), the interpretation of an object is a process of perceiving a value-rich ecological object that offers what it does because it is what it is. Gibson defines "what it is" in terms of the ecological physics of the object instead of its physical physics; thereby the object possesses meaning and value. In other words, *"the information to specify the utilities of the environment* (object, author) *is accompanied by information to specify the observer himself, his body, legs, hands, and mouth"…. "to perceive the world is to coperceive oneself."* (Gibson, 1979:141). In other words, the perception of an artefact is not value-free as it is marked by an inseparable interplay between 1) an unconscious perception arising from endogenous stimuli and 2) exogenous stimuli arising from the perception of the ecological artefact.

doings. This will be elaborated on in section 7.8 (the three doings), which addresses the middle part of figure 7.4.

Given that the hotline tasks are of a somewhat repetitive nature, Pentland (1992) points out that the individual makes use of "unwritten rules" to guide the moving act. Again, the PD doings are not repetitive and the engineers make use of diverse *constitutive means* as well as <u>*habitual/reflective experience*</u> to transform the indeterminacy into determinacy. Hence, section 7.9 will shed light on the transformation process, thus addressing the light and dark grey area between the <u>*indeterminate situation*</u> and <u>*determinate situation*</u> in figure 7.4.

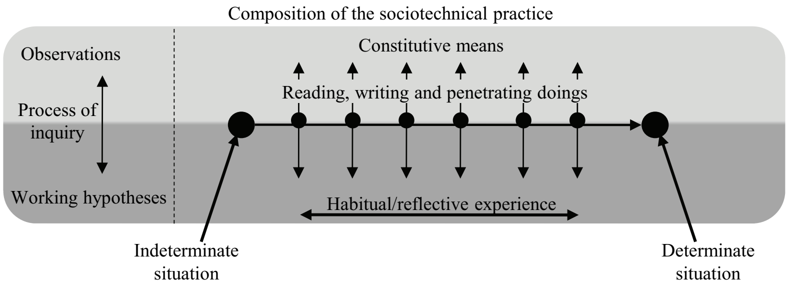


Figure 7.4. The analytical framework.

The leftmost part of the analytical framework depicted in figure 7.4 illustrates the <u>*process of inquiry*</u>. It starts with an observation of the *constitutive means* within the *STP*, whereupon a working hypothesis originating from <u>*habitual/reflective experience*</u> is created. The <u>*indeterminate situation*</u> triggers the <u>*process of inquiry*</u>. The <u>*process of inquiry*</u> draws on reciprocal interchanges between the *constitutive means* and <u>*habitual/reflective experience*</u> proceeding until the <u>*determinate situation*</u> is achieved.

The small black dots between the <u>*indeterminate situation*</u> and <u>*determinate situation*</u> illustrate doings. The categorisation of these doings draws on section 7.3 explaining a PD activity to be *reading* and *writing doings*. A third category of doings is the *penetrating doings* that indicate that the engineers retrieve information from another *STP* remote in time and/or space. The doings are a *strip of doings* that might transform the <u>*indeterminate situation*</u> into a <u>*determinate situation*</u>.

The *strip of doings* is influenced by the composition of the *STP* and, simultaneously, it influences the composition of the *STP*. The two-way arrows attached to the black dots indicate that each of the doings draws on reciprocal interchanges between the *constitutive means* and the <u>*habitual/reflective experience*</u>.

The analytical framework focuses on the composition of the *STP* and the *strip of doings* transforming the <u>*indeterminate situation*</u> into a <u>*determinate situation*</u>. By doing so, the analytical framework makes it possible to identify and analyse the characteristics enabling or constraining the learning process when engineers conduct a PD activity. The analytical framework is the focal point for the explanations in the next three sections.

## 7.7. Doings and the constitutive means

The PD of a WTC is not a single PD activity (doings), which can be located to one particular *STP*. The PD follows a *trajectory* charted by all PD activities (doings) conducted so far; the actual *trajectory* of these doings can only be identified retrospectively. Furthermore, it is a web of doings having a space and a time dimension as well. Therefore, the web of doings has to be divided into manageable units.

For Pentland (1992), the *indeterminate situation* begins with an incoming call to the hotline centre. Either the receiver of this call handles the problem or performs a "get help" or "give away" move. The closing of the call illustrates the ending of the situation; that is, a *determinate situation*. If the hotline service centre is able to manage the call successfully, it indicates performance and thereby organisational learning. As Pentland (1992:530) points out *"Moves[5] transform situations into new situations, and in doing so, moves express practical knowledge."*.

Referring to Pentland (1992), performance is an indicator for learning. He defines performance as corresponding to the resolution of the customer's problem. However, performance addresses an immaterial outcome, a service to a customer. With that, the following calls are not restricted to this particular immaterial outcome; a circumstance that contrasts with the doings surrounding the PD of a WTC. For Pentland, there is no *trajectory* to be followed in this regard.

Owing to the fact that the analytical approach in this thesis differs from Pentland's (1992) analytical settings, Goffman's frame analysis (1974) is brought to the fore.

Goffman applies the term "doing" rather than "move" in his 1974 contribution, for which reason the term doing[6] will be used from now on when referring to Pentland's (1992) move.
The doing is initiated when an individual is confronted with an *indeterminate situation* and tries to make sense of "what is going on here" (Goffman, 1974:8). This indeterminacy incorporates the natural as well as the social world. In addition, Goffman (1974:24) emphasises that the doings might result in a manipulation of the natural and/or social world. Besides:

> *"intelligent agents have the capacity to gear into the ongoing natural world and exploit its determinacy, providing only that natural design is respected. Moreover, it is felt that, with the possible exception of pure fantasy or thought, whatever an agent seeks to do will be continuously conditioned by natural constraints, and that effective doing will require the exploitation, not the neglect, of this condition."* (Goffman, 1974:23).

### 7.7.1. The process of inquiry as a strip of doings

The above understanding of doings as being initiated by indeterminacy and concluded by a manipulation of the natural/social world is in line with Dewey's (1938:108) *process of inquiry*. A *process of inquiry* addressing PD transforms an *indeterminate situation* into a

[5] Pentland does not strictly follow Goffman's definition of moves. They are tailored to the specific analysis.
[6] In addition, the term doing is rather often applied within the pragmatic learning understanding.

*determinate situation* triggering new experience; i.e., learning (Dewey, 1933:233). And as Dewey (1938:121) points out, the transformation is an existential modification of the constituents of the indeterminacy; that is, the social and material *constitutive means* as well. However, seen from an analytical point of view, there is a slight difference between Goffman's (1974) concept of doing and Dewey's *process of inquiry*.

Goffman's (1974) considers the *strip*[7] *of doings* to consist of a number of sequential doings that transform the *indeterminate situation* into a *determinate situation.* Each single doing is thereafter treated as a topic to be subjected to an analysis (ibid. p.564), making it possible to observe a concrete occurrence in relation to the empirical observations. Dewey's (1938) *process of inquiry* is a five-phased process. Apparently, it might be problematic to analyse and interpret the phases between starting and ending the *process of inquiry*. In other words, if employing the *process of inquiry* as the transformation method, the analysis might prove too generic and coarse for studying each single doing. By drawing on Goffman's *strip of doings*, it will be possible to open up the *process of inquiry* and thereby identify a number of doings carried out during the transformation of the *indeterminate situation* into a *determinate situation*.

### 7.7.2. Starting doing

The *starting doing* is initiated when an engineer is confronted with an *indeterminate situation* or a task to be handled. A proper *anchoring* of this *indeterminate situation* within a particular composition of the *STP* makes it possible to carry on the *starting doing* and thereby conduct a *strip of doings*. The *strip of doings* transforms the constituents within the *STP* to make up a new *determinate situation*, which triggers learning.[8] A *successful strip of doings* results in a modification of the constituents of the *STP*, causing new experience. If the transformation process becomes blocked before achieving a *determinate situation*, the *strip of doings* will not result in new experience (learning) or, for that matter, in the creation of an artefact.

### 7.7.3. Anchoring indeterminacy and sustainable determinacy

With reference to the pragmatic learning, an *indeterminate situation* occurs due to a disturbance in the *habitual experience*. To transcend this precognitive phase and thereby activate the *reflective experience*, the *indeterminate situation* has to be real and empirically *anchored* (Dewey, 1938:112). To ensure that the *starting doing* develops into and thereby results in the performance of a *strip of doings*, a proper *anchoring* of the *indeterminate situation* within the *STP* must occur.

The outcome of a *successful strip of doings* (*process of inquiry*) is a *determinate situation* in which the constituents of the *STP* are changed. Nevertheless, the outcome is not conclusive,

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[7] *"A strip is not meant to reflect a natural division made by the subjects of inquiry or an analytical division made by students who inquire; it will be used only to refer to any raw batch of occurrences (of whatever status in reality) that one wants to draw attention to as a starting point for analysis."* (Goffman, 1974:10).

[8] As propounded by Dewey (1933:233), every time an indeterminate situation is going to be handled, the doings enter into the means-consequence relation. By avoiding blocking the process of inquiry, the situation becomes determinate and new experience is the outcome. Hence, in addition to a manipulation of the constituents, the result will be new experience within the sociotechnical practice.

rather it is a warranted assertion that remains open to further inquiries (Dewey, 1938:42). Therefore, the handling of an <u>*indeterminate situation*</u> does not guarantee a high level of *sustainable determinacy*. As the research is a longitudinal study, it is possible to observe whether or not a specific subject matter has been an issue previously. It paves the way for an analysis of the sustainability of the achieved determinacy. Hence, *sustainable determinacy* means that the achieved <u>*determinate situation*</u> does not reappear as an <u>*indeterminate situation*</u> later on in the PD process.

So far, I have deliberately refrained from discussing Pentlands three structures by applying the term "constituents". The next subsection addresses this subject matter.

### 7.7.4. Understanding of constitutive means

For Pentland (1992), the structure does not exist prior to a situation; instead, it comes into being in relation to an individual's interpretation of an <u>*indeterminate situation*</u>. The physical structures consist of various communication media facilitating the interaction. The ritual structures deal with social interaction, while the third structural element is the competence structure. To explain the latter, Pentland employs Hutchins' (1995) analysis of the "sociotechnical cockpit", while he draws on the aforementioned concept of affordance (Gibson, 1979) to explain the other two – the physical and the ritual – structural elements.

This viewpoint draws on interpretivism, indicating that the affordance of an object is perceived as an inseparable relationship between the individual and the object. That is, when Pentland explicates the physical structure, the various communication media, he accents what kind of action the phone, for instance, makes possible for the individual. Anyhow, Pentland's approach addresses micro-sociological means (structures), which seems to be in accordance with the *constitutive means* identified in section 7.5.

Summing up, the *constitutive means* being applied in the analytical framework are categorised into three inseparable categories; these are artefacts and social and material means. A *starting doing* is initiated when or if one or more of the *constitutive means* within the *STP* have to be modified/created, corresponding to the <u>*indeterminate situation*</u> in figure 7.5. A proper *anchoring* of the <u>*indeterminate situation*</u> enables to carry on the *starting doing* and thereby conduct a *strip of doings*. A *successful strip of doings*, illustrated in the left part of figure 7.5, results in a modification/creation of the *constitutive means*; that is, learning and PD. However, as depicted in the right part of figure 7.5, if the *strip of doing is blocked*, the doings will fail to result in any detectable modification/creation of the *constitutive means*; i.e. neither learning nor PD occurs.

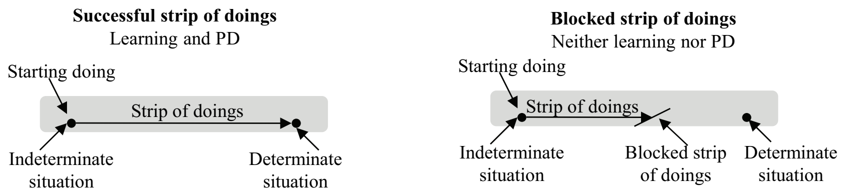


Figure 7.5. Successful versus blocked strip of doings.

The next section addresses three kinds of doings to transform the <u>*indeterminate situation*</u> into a <u>*determinate situation.*</u>

## 7.8. The three doings

Goffman (1969:11-28) describes five different basic doings[9] for interaction; these doings address interaction in games. Despite the fact that his definition of the doings is rather vague, the doings are considered as sequences in the interaction. Referring to Goffman (1974), the individuals make use of their primary frame to conduct doings. The primary frame is not purely cognitive perceptions of the natural and social world; it includes the organisations of doings in practice as well.

> *"these frameworks (frames, author) are not merely a matter of mind but correspond in some sense to the way in which an aspect of the activity itself is organized – especially activity directly involving social agents. Organizational premises are involved, and these are something cognition somehow arrives at, not something cognition creates or generates."* (Goffman, 1974:247).

The doings to be applied in the analytical framework therefore have to be unearthed within the *STP*. This approach is in line with the work of Das (2003:419) who identifies three different doings in his effort to analyse a technical support centre; the three doings are "locate, adapt and generate". Das perceives the working practice as problem-solving activities. Drawing on this understanding, the three doings are identified. Thereby, the nature of the problem is the determinant for categorising the doings. Pentland (1992:535) identifies the "get help and give away doings" by categorising the doings performed by the hotline supporter when solving problems. Instead of using the nature of the problem, Pentland addresses the unwritten rules within the hotline centre to identify the two doings.

As mentioned previously, the hotline service solely deals with immaterial outcomes. These doings shed light on services – to listen, to ask questions, to understand problems and propose solutions. It might include writing or rewriting new standards for hotline support, writing invoices to the customers, etc., but the outcome does not result in an artefact; an artificial or a physical WTC.

### 7.8.1. Reading, writing and penetrating doings

As described in section 7.3, a PD activity is held to be a series of *reading* and *writing doings* within an *STP*. Accordingly, the *strip of doings* consists of *reading doings* of the *constitutive means*. If these *reading doings* enable a convergent interpretation, a *writing doing* is

[9] Goffman terms these as moves in his 1969 contribution. Goffman (1969:11-28) defines the five basic moves of social interaction as: The *unwitting move* indicates an unintentional act. For instance, during a bargaining between a supplier and a customer, the former accidentally reveals the actual production cost of the product to be sold. The *naive move* is an unwitting move judged by the other actors. For instance, the customer considers the supplier's disclosure of the production cost as a naive move. The *covering move* will improve the actor's position if it is accepted by the other actor – it is later on termed the control move. The *uncovering move* is a countermove made by the other actor to the previously made covering move. The fifth move is the *counter-uncovering move*.

conducted. This *writing doing* takes place in one or more of the *constitutive means*. Hence, it triggers a modification of the constituent(s) of the particular composition of the *STP*. Figure 7.6 illustrates this.

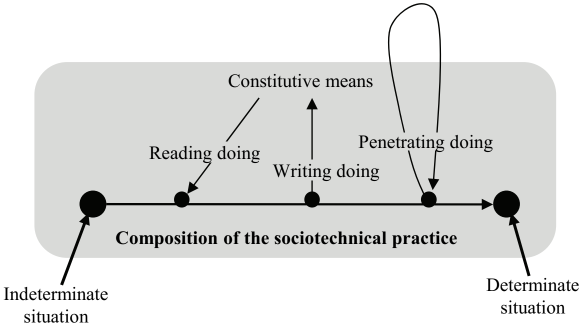


Figure 7.6. The three doings.

As mentioned in section 7.7, the PD of a WTC is made up of a web of doings; i.e., PD is characterised by having a time as well as a space dimension. Despite the engineers' endeavours to predict the information necessary to achieve a convergent interpretation, it is sometime necessary to retrieve information from past activities or from another *STP*. This doing is termed a *penetrating doing*, which appears from figure 7.6 above. It illustrates that the engineers penetrate the boundary of the *STP* by for instance applying the internet to retrieve information from a supplier's homepage.

The next section sheds light on how to grasp the transformation of the *indeterminate situation* into a *determinate situation*.

## 7.9. Transforming the indeterminate situation into a determinate situation

Referring to section 7.6, Goffman (1974) divides the primary frame into a natural and a social frame. The natural frame[10] encompasses the unguided doings, while the social frame encompasses the guided doings. As the quotation below indicates, in its transformation of the *indeterminate situation* into *a determinate situation*, the individual is guided by the social as well as the natural frame.

[10]Goffman (1974) does not seem to be straightforward in his explanation of the natural frame. On the one hand, the individual does not have a special status in relation to the natural frame as all individuals are subject to the same deterministic will-less frame (ibid. p.18), a kind of natural determinism (ibid. p.22). On the other hand, intelligent or guided doings (both terms are used by Goffman) require entrance into the natural world (ibid. p.23). An even more radical position surfaces later on as a guided doing is perceived as being able to manipulate the natural world. *"there are guide doings such as fixing a sink or clearing a sidewalk in which sustained, conscious effort is given to manipulating the physical world, the doing itself taking on the identity of an "instrumental procedure," a task, a "purely utilitarian" activity – a doing the purpose of which cannot be easily separated from the physical means employed to accomplish it."* (Goffman, 1974:24).

*"In the everyday business of living, the individual routinely treats others from within both social and natural perspectives and does so, moreover, with a close, effortless interweaving of the two types of frameworks. Thus, traditionally, medical practitioners have felt they obtain two kinds of information from a patient, signs and symptoms, the first involving objective biological indicators, the second subjective reports."* (Goffman, 1974:188).

### 7.9.1. Unwritten rules as means to ensure the transformation process

Pentland's (1992) analysis of the hotline supporters' considerations when handling an incoming call addresses three different events. If the supporter is not capable of handling the call himself, he is compelled to conduct one of two doings. The means to guide this decision are described as "unwritten rules" in the hotline centre *"If you can't respond to the call yourself, either get help or give the call to someone who can."* (Pentland, 1992:535).

Pentland's (1992) explanations of the unwritten rules as the means to guide the doings bear some resemblance to the *habitual experience* explained in sections 6.5 and 6.6. As pointed out by Dewey (1938:21), the individual has a tendency to construct its own habitual way of conducting inference. If the indeterminacy is rooted to "the great flywheel of society",[11] it might be appropriate to draw on *habitual experience* (Pentland's unwritten rules). However, if the root-cause of the indeterminacy is not well-known, this might prove problematic; according to Dewey (1938), it is essential to create a disturbance in the habitual way of making inference in order to activate *reflective experience* and thereby improve the understanding of the root-cause.

### 7.9.2. Reciprocity between constitutive means and habitual/reflective experience

With reference to pragmatic learning, *habitual/reflective experience* and the *constitutive means* are embedded within the *STP*. This reciprocity is illustrated in figure 7.4 by the two-way arrows. For instance, drawing on an example occurring during a meeting addressing the PD of the WTC to Oldtimer, the responsible engineer applies his laptop to depict an electrical diagram on the TV screen in the meeting room. All participants within the *STP* take a good look at the wiring appearing from the depicted electrical diagram. The *reading doings* of the *constitutive means* cause disturbance within the *habitual experience* and thereby enable one of the engineers to apply his *reflective experience* to propose an idea (a working hypothesis) for handling the *indeterminate situation*.

This short example illustrates that the individuals use diverse *constitutive means;* the social interaction in the meeting room, the laptop, the TV screen and the electrical diagrams. These *constitutive means* within the *STP* can be compared with Dewey's (1938:32) *"extra-organic energy"*, while the engineers' mental processes drawing on *habitual/reflective experience* are the *"intra-organic energy"*.

Accordingly, the transformation of the *indeterminate situation* into a *determinate situation* is facilitated by reciprocal interchanges between the *constitutive means* and the *habitual/reflective experience*; in Dewey's (1938) terminology, this reciprocity constitutes the

[11] A term I have borrowed from Miettinen (2000:68).

energy enabling the transformation process. This understanding is applied in the analytical framework.

Referring to Dewey (1938:19), to avoid ending the transformation process without having achieved a *determinate situation*, the challenge is to guide the *process of inquiry*.[12] When an engineer is confronted with an *indeterminate situation* to be handled, the doings enter into the *means-consequence relation*. To handle the gradual advance towards the consequence (e.g. creating an electrical diagram), the engineer makes use of diverse *constitutive means* accessible within the *STP* to guide the doings. That is, a *strip of doings* is guided by the reciprocal interchanges between observations of the *constitutive means* and the individual's mental processes[13] drawing on *habitual/reflective experience*. Both have to be guided in order to achieve the *determinate situation*.

Naturally, it is not possible to look inside the mind of the engineer and thus observe directly the mental processes. This might complicate the analytical approach. To handle this challenge, I draw on Dewey's (1938:109-118) criteria for ensuring a continuation of the reciprocity between the two operational dimensions – observations and ideational solutions.[14] As soon as one of these becomes non-operational, the transformation process is cut short; i.e., the *strip of doings is blocked*. Thus, the mental processes are operational as long as the ideational solution fulfils two criteria. First, the working hypothesis has to be targeted at a suitable solution to the *indeterminate situation*. Second, the ideational solution has to prompt and outline the need for further observations of the *constitutive means*.[15]

## 7.10. Summary and what now

The main purpose of the chapter was to create an analytical framework for the study of a PD activity within a working practice, making it possible to analyse learning. Another purpose was to present an understanding of how a PD activity unfolds within a working practice.

Drawing on the discussions of pragmatism in chapter 6, Pentland (1992) and Goffman's (1974) frame analysis, an analytical framework is created. As the basis for this creation, the applied understanding of PD has been presented, the details of which are summarised below.

**PD understanding**: PD is the creation of a new WTC. The working practice unfolds when engineers conduct a PD activity in a contextual setting in which the social and the technical elements fuse into a sociotechnical composition, for instance in a meeting room or in the production area. An STP is neither purely social nor purely technical; it is a sociotechnical composition.

The pivot of the research is the single PD activity. A PD activity unfolding within an STP is understood as ongoing reading and writing doings. Having the ongoing reading and writing

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[12] For an elaboration, I kindly refer to section 6.7.1, the means-consequence relation.
[13] Please notice that I use the term mental processes instead of cognitive processes in order to emphasise the inseparable interplay between the three biological faculties – doing, thinking and emotion.
[14] For an elaboration, please see sections 6.7.4.1- 6.7.4.5.
[15] According to pragmatism, a working hypothesis can only be tested and verified in the empirical settings.

doings as the focal point makes it possible to appreciate that the individual and the STP are evolving in a reciprocal interaction.

The constitutive means are the starting point and, at the same time, the ending point for the reading and writing doings. While a sketch is a ductile constitutive means, the final WTC is an obdurate constitutive means: this changing hardness influences the reading and writing doings.

The reading and writing doings are facilitated by reciprocal interchanges between the constitutive means and the engineers' habitual/reflective experience. This reciprocity makes it possible to transform an indeterminate situation into a determinate situation; in other words, to conduct the PD activity.

**The analytical framework**: The focal point for the analytical framework depicted in figure 7.7 is the single PD activity. A PD activity is considered as a strip of doings; be it reading doings of constitutive means, writing doings in one or more of the constitutive means or penetrating doings making it possible to retrieve information, for instance from a supplier's homepage.

The reciprocal interchanges, illustrated by the two-way arrows, between the constitutive means and the habitual/reflective experience facilitate the strip of doings. By addressing how the strip of doings unfolds when transforming an indeterminate situation into a determinate situation, it becomes possible to grasp the reciprocity between the constitutive means and the habitual/reflective experience.

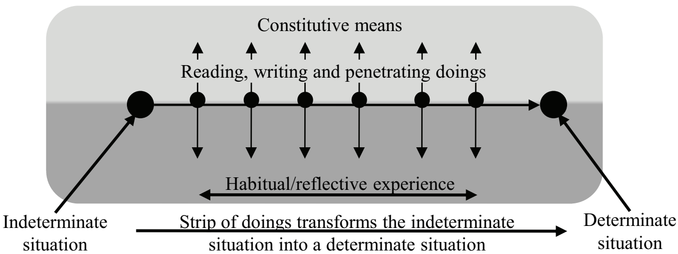


Figure 7.7. The analytical framework for analysing a PD activity as a strip of doings.

As it appears from the lowermost part of figure 7.7, a strip of doings transforms the constituents within the STP to make up a new determinate situation. A successful strip of doings results in a modification of the constituents of the STP, thus generating new experience; in other words learning. If the transformation process becomes blocked before a determinate situation has been achieved, the strip of doings will not result in new experience; i.e., no learning will take place. The analytical framework paves the way for identifying and analysing the characteristics enabling or constraining the learning process when engineers conduct a PD activity.

| Applied terms | Brief explanation of terms being applied throughout the analyses | Refer to |
|---|---|---|
| Sociotechnical practice | An STP is a working practice in which the social and the technical fuse into a sociotechnical composition. A working practice is the inseparable interaction between the individuals and the environment unfolding when conducting a PD activity. | 7.5 |
| Constitutive means | A constitutive means is an object that influences the transformation of the indeterminate situation into a determinate situation. | 7.5<br>7.7 |
| Ductility | Ductility indicates a low degree of completion of an artefact, e.g. a sketch. | 7.4 |
| Obduracy | Obduracy indicates a high degree of completion of an artefact, e.g. a fully developed WTC breaker panel. | 7.4 |
| Effort to change an artefact | Effort to change an artefact emphasises that the PD activity is time-consuming and resource demanding. | 7.4 |
| Anchoring indeterminacy | Anchoring is defined by how well the indeterminate situation is understood by the engineer(s). | 7.7 |
| Sustainable determinacy | Sustainable determinacy is achieved if the particular determinate situation does not reappear as an indeterminate situation later on. | 7.7 |
| | Terms in relation to the analytical framework | |
| Reading doing | A reading doing is an interpretation of the constitutive means, e.g., reading a drawing (a doing is defined in table 6.1). | 7.3, 7.8 |
| Writing doing | A writing doing is a creation or modification of one or more constitutive means, e.g. creation of a sketch, drawing or a breaker panel. | 7.3<br>7.8 |
| Penetrating doing | A penetrating doing retrieves information decoupled in a time and/or space dimension, e.g. retrieval of information from a supplier's homepage. | 7.5<br>7.8 |
| Starting doing | A starting doing initiates the transformation of the indeterminate situation. | 7.7 |
| Strip of doings | A strip of doings is a series of doings that transforms the indeterminate situation into a determinate situation. | 7.7, 7.8 |
| Successful strip of doings | A successful strip of doings results in new experience and the creation/modification of constitutive means. | 7.7 |
| Blocked strip of doings | A strip of doings where the transformation from the indeterminate situation into a determinate situation becomes blocked; i.e., no learning and no creation/modification of constitutive means occur. | 7.7<br>7.9 |

Table 7.1. Overview of applied terms examined in chapter 7.

### 7.10.1. What now – the empirical work

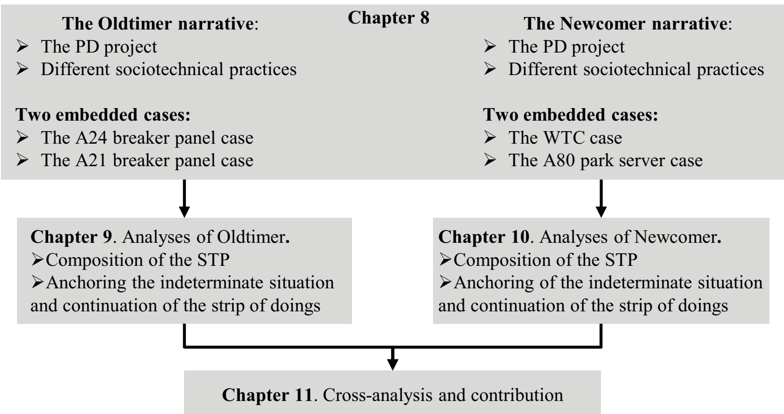


Figure 7.8. The narratives and the analyses.

The framework depicted in figure 7.7 above is the analytical "instrument" applied to carry out the analyses. Before conducting these analyses, the Oldtimer and Newcomer PD projects will be presented. As it appears from figure 7.8, chapter 8 describes two narratives and four embedded cases. Subsequently, chapter 9 and chapter 10 analyse the Oldtimer and Newcomer cases, respectively. Finally, chapter 11 continues the analyses by drawing on both PD projects to present the contribution of the research.

# Chapter 8. The two narratives and four embedded cases

The chapter presents an Oldtimer and a Newcomer narrative. Furthermore, each of the two narratives consists of two embedded longitudinal cases. The Oldtimer narrative sheds light on the Product Development (PD) of a Wind Turbine Control (WTC) to a 3.0 MW gearless wind turbine. The Newcomer narrative addresses the PD of a WTC to a 2.0 MW wind turbine.

The objective of chapter 8 is to form the basis for the analyses in the following two chapters; Oldtimer in chapter 9 and Newcomer in chapter 10. Additionally, the intention is to pave the way for various interpretations of the two narratives and the four embedded longitudinal cases.

The structure of chapter 8 follows the division of the two narratives. First, the Oldtimer PD project is presented. The narrative addresses the tasks to be handled by the employees as well as the various PD working practices for conducting these PD activities; from now on, the term SocioTechnical Practice (STP) is applied to illustrate this PD working practice.[1] The presentation of the narrative is thematic, as the intention is to shed light on the composition of the various STPs. Following this, the two embedded cases are described. Unlike the narrative, the presentation of each of the two cases follows a chronological timeline, making it possible to identify the unique trajectory of each of the two cases. By doing so, the composition of the various STPs as well as the trajectories of the two selected cases becomes perceptible, which makes it possible to analyse the learning process. The second part of chapter 8 presents the Newcomer PD project. The overall structure is identical with the presentation of Oldtimer.

## 8.1. Oldtimer narrative

kk-electronic a/s (kk) has developed and produced WTCs for Oldtimer for nearly three decades. The project manager (Andy) in charge of the WTC intraorganisationally in Oldtimer is a former kk employee. He was employed at kk as development engineer for nearly 20 years before embarking on his present employment at Oldtimer in 2006.

### 8.1.1 Deliveries to Oldtimer – the task to be handled

Figure 8.1 illustrates the extent of the PD project and the timing of all breaker panels as well. Each of the grey bars illustrates a breaker panel, including the starting and ending of the doings.

A breaker panel is not just different mechanical components. It also contains high and low voltage electrical components/devices. Because all these components are built into the breaker panel, a great many mechanical and electrical interfaces have to be taken into consideration when designing and producing a breaker panel.

The breaker panels denoted "A" followed by a number are big in size and consist of a great many components. Another group denoted "MO", having a six-digit number, consists of smaller breaker panels; "small boxes" as the kk jargon has it. Compared with the "A" breaker panels, the small boxes are much simpler and consist accordingly only of a limited number of components. The cable tray development consists of four bottom plates and, roughly

[1] This terminology will be used unless one of the informants applies another term.

speaking, they are comparable to the small boxes with regard to size and number of components. The last one depicted is the PMSG test breaker panel. The physical dimensions of this breaker panel are considerable.

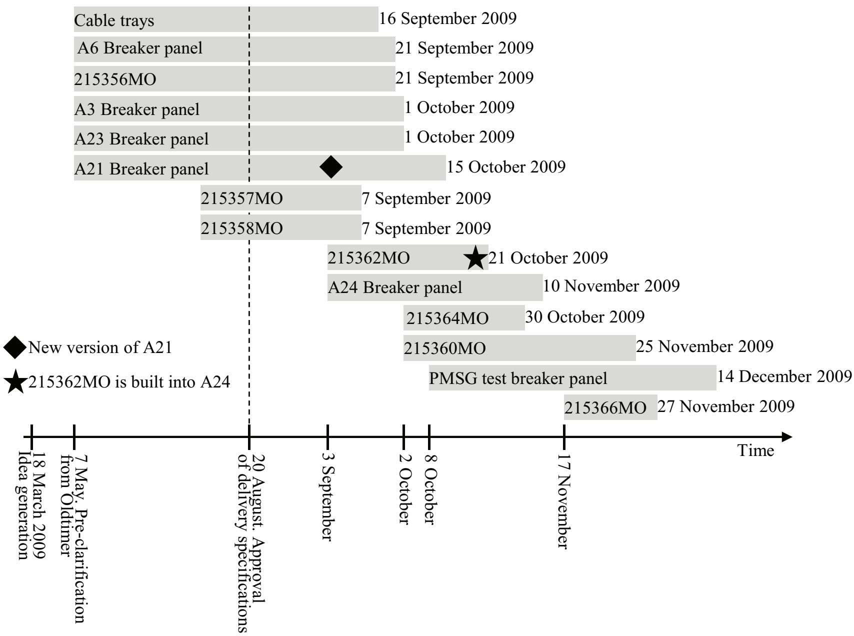


Figure 8.1. Overview of the extent, timing and trajectory of the 3.0 MW project.

<u>8.1.1.1. Complexity of the task to be handled</u>

The A6 breaker panel is the smallest of the "A" breaker panels. Furthermore, it is used across the three different WTCs being produced; that is, the 2.3, 3.0 and 3.6 MW WTCs. Hence, it is a well-known product. Likewise, the A21 is a well-known breaker panel, as it is applied in the 2.3 MW. The A21 breaker panel consists of many components, for which reason it is considered a very complex product. The other breaker panels as well as small boxes are more or less unknown products, but:

> *"a great many of the components and technical solutions are applied in the other two wind turbines* (2.3 and 3.6 MW, author).*"*...*"Actually, they* (Oldtimer, author) *want us to reuse as many as possible of the components and solutions applied in the other wind turbines."* (Technical project manager, 16 November 2009).

Oldtimer develops all Software (SW); consequently, the deliveries from kk solely consist of Hardware (HW) solutions. In this regard, an I/O overview[2] is a crucial document. Oldtimer defines the I/O interfaces, for which reason kk has to develop all HW in accordance with

[2] I/O is an abbreviation for Input and Output and it describes the interfaces between the HW and SW.

these guidelines. Because the I/O is a crucial document, it receives much attention during the PD project and is quite often a point of debate at the interorganisational meetings. For instance, at the meeting held 21 August 2009, the technical project manager (Jack) connects his laptop to the TV screen in the meeting room and displays the I/O overview of the A6 breaker panel, thus prompting the following doings:[3]

| |
|---|
| Interorganisational meeting, 21 August 2009<br>Jack➔ *I think there is a mistake with this I/O profile, something is wrong.*<br>Andy➔ *I do not think so, because it is a copy and paste from the 2.3 MW, and this is identical with this one. If there is a mistake, then it is probably in the HW.*<br>Jack➔ *No, I do not think it is in the HW because this interface…* (Jack now uses the PCschematic – a CAD-system – to explain his concern regarding the I/O. He uses the mouse to point out the different wiring depicted at the TV screen).<br>Andy➔ (goes to the TV screen and takes a close look) *yes, I can follow you* (then he goes back to the meeting table, starts up his laptop and finds the I/O profile)➔ *I do not know what the problem is.*<br>(Jack and Andy now engages in a very technical dialogue and after a while, Andy takes his mobile phone and calls Oldtimer's project manager on the 2.3 MW wind turbine and Andy says in the phone)➔ *When I copy/paste the 2.3 MW version 15, I noticed that two cards have been shifted around, but why are there so many discrepancies in this I/O-profile?*<br>Andy➔ *I suggest to stop it now and then we can take up the discussion later on when we know more.* |

As it appears, the doings do not result in determinacy, for which reason this issue is discussed again at a later interorganisational meeting.

8.1.1.2. Starting and ending – timing of tasks to be handled

Figure 8.1 illustrates the process from idea generation to pilot production, thus covering the period extending from the idea generation meeting held 18 March 2009 to the erection of the wind turbine in Drantum on 2 December 2009. The left side of a grey bar indicates the starting time of a specific breaker panel, while the right side indicates the time of handing over the breaker panel to Oldtimer.

At starting time, the scope of the PD consists of four "A" breaker panels, four cable trays and one small box. As it appears from figure 8.1, a number of breaker panels and small boxes are introduced later on. Accordingly, the PD project consists of six big breaker panels, six small boxes and four cable trays.[4] Regarding the 215362MO, 21 October 2009, it is decided to integrate this small box into the A24 breaker panel; the A24 is one of the cases in this chapter. The A21 is the other breaker panel illustrated in a case. A new version of the A21 is scheduled for 3 September 2009.

The PD is initiated in the early spring of 2009. Referring to a revised project plan,[5] the delivery specifications should have been approved by Oldtimer before the summer vacation. However, the approval is postponed to 20 August 2009 and, according to the Minutes of Meeting (MoM) of 13 august 2009, this causes changes in the planned delivery timeframe.

The creation of the breaker panels is not an isolated event.

[3] Text placed within brackets describes my observation(s) during the dialogue. A ➔ followed by italic text indicates that a person is saying something.
[4] From now on, the term breaker panel includes "A" breaker panels, the small boxes, the cable tray and the PMSG test breaker panel.
[5] The first plan indicates an approval of delivery specification to be 22 May, ePM to be the 1 July and hand over of the breaker panels to be 28 August 2009. (kk project manager, cross-functional meeting, 20 August 2009).

*"The creation of a wind turbine necessitates very close interaction with my colleagues. Some of them are working on the alternator, some on the converter and so on. I am responsible for all the electrical parts; kk-WTC connects it all."* (Oldtimer project manager, 26 November 2009).

The progress of the PD activities taking place intraorganisationally in Oldtimer is the centre of rotation for the creation as well as ongoing revision of the project plan. The project plan is regularly adjusted to ensure that it is in line with the actual circumstances. These timing challenges are handled by kk's project manager in charge (Mick).

8.1.1.3. Three-part outcome of the task being handled

Referring to figure 8.2, the outcome of the PD activities is three-parted.

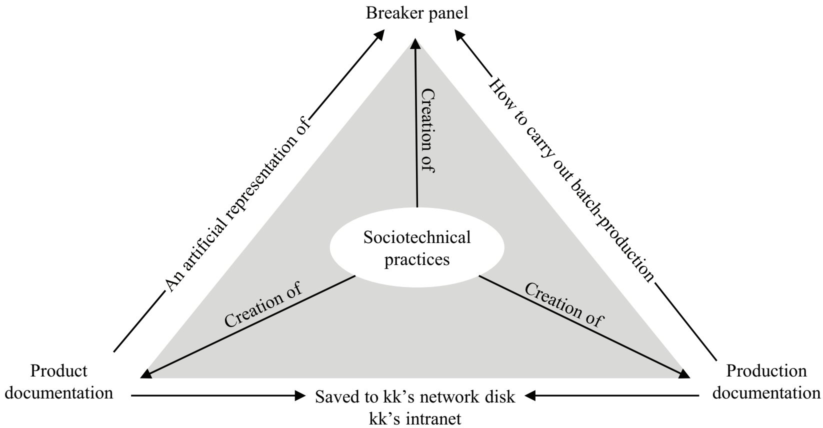


Figure 8.2. The three-parted outcome of the PD activities.

As depicted at the top of the triangle, the physical breaker panel is one of the outcomes. A second outcome illustrated at the leftmost part of the figure is all product documentation, for instance drawings, electrical diagrams and various specifications. This part of the documentation is handed over to Oldtimer and, finally yet importantly, it is archived into the kk intranet. The third outcome, appearing from the right side of the figure, is all production documentation. Among other things, it consists of a Bill Of Material (BOM), working instructions, checklists, etc. This kind of documentation is not handed over to Oldtimer; instead, it is handed over to the Polish batch production facility and saved on kk's intranet.

The product and production documentation being filed in kk's intranet, illustrated at the lowermost part of figure 8.2, acts as a kind of virtual stock[6] of technical solutions. If possible, the engineers make use of these artefacts to create a breaker panel. The next subsection contains a brief introduction to this working principle. The other two sides of the triangle illustrate the purpose of the documentation. The product documentation is artificial representations of a physical breaker panel. This documentation is, among other thing, used

[6] I kindly refer to the pilot case for an elaboration of the virtual stock principle. Briefly, the term virtual stock is used to explain the reuse of a previously used technical solution.

when repairing and maintaining the wind turbine. Besides, it is crucial documentation when erecting the wind turbine on site. The third side of the triangle is an elaborated explanation illustrating how to carry out the batch production in the Polish production facilities.

kk's quality manual prescribes a verification of the coherence between the breaker panel and the two different kinds of documentation. The coherence between the breaker panel and the product documentation is handled as a First Article Inspection (FAI); a cross-functional FAI is conducted followed by an interorganisational FAI. An ePM (electronic production documentation) verification safeguards the coherence between the breaker panel and the production documentation.

<u>8.1.1.4. Handling the task is an iterative PD process</u>

The creation of a breaker panel is an iterative process. As far as possible, the technical project manager retrieves suitable product documentation from kk's intranet; the virtual stock. Drawing on this, he makes calculations and sketches directly on these documents/ specifications; i.e., the rewritten specifications become the point of departure for the engineer(s).

> *"I receive the information directly from Jack. He takes a similar breaker panel and makes a number of changes directly on this documentation. The technical solutions to be removed are marked with a red pencil, and the technical solutions to be added are marked with a green pencil. It is very simple, but very efficient."* (Electrical engineer 1, 2 December 2009).

Instead of finishing all product/production documentation before starting up the pilot production, only the bare minimum of documentation is drawn up.

> *"A 3D drawing provides a good means for communicating, but the 3D draughtsman is not familiar with the exact placement of components and wiring inside the breaker panel. There are a great many issues to take into consideration…"* (Prototype worker 1, 19 November 2009).

The electrical engineer(s) only finish the electrical diagrams and an outline of all components to be built into the breaker panel. In close cooperation with the mechanical engineer(s), a sketch is created. It roughly illustrates the placement of all the components and the wiring.

> *"When I developed the A23, I made the electrical diagrams and, in cooperation with the draughtsman, I created a sketch indicating the rough placement of all components. I handed over this sketch and the electrical diagrams to the PTM,[7] after which he produced the prototype"…"That is, drawings are made after the pilot production."* (Electrical engineer 2, 23 November 2009).

### 8.1.2 Oldtimer – different STPs

As it appears from figure 8.3, the PD activities are conducted within different STPs.

[7] PTM is an abbreviation for Prototype Worker.

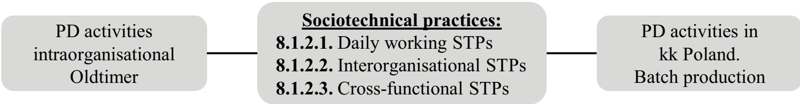


Figure 8.3. Different sociotechnical practices - Oldtimer.

The rectangle to the left illustrates intraorganisational PD activities being conducted in Oldtimer. The PD of a wind turbine is complex. It consists of many components, which dictates comprehensive coordination.

> *"Basically, the function of the WTC is to support all the mechanical parts"…"So I have to find out what kind of mechanical and electrical devises are going to be built into this 3.0 MW wind turbine and then I have to make up my mind about how to control it. It necessitates dialogue with all the persons responsible for the various devices."* (Oldtimer project manager, 26 November 2009).

The rectangle to the right in figure 8.3 addresses the STPs in which the batch production of the breaker panels is carried out. The interaction with kk-Poland is elaborated in section 8.1.2.3.

The rectangle in the middle illustrates various STPs in which the PD activities have to take place. In the following, the daily working STPs, interorganisational STPs and cross-functional STPs will be described. The structure of the presentation appears from figure 8.3.

8.1.2.1. Daily working STPs

Compared with other PD projects conducted, this project has been managed differently.

> *"This 3.0 MW PD project has been handled differently by kk, as there has been a clear division between Mick and Jack, and I have really profited by this division. Mick has cleared a lot of obstacles, making it possible for Jack to become absorbed in complex issues, and I have really drawn on Jack's technical expertise in this regard."* (Oldtimer project manager, 26 November 2009).

This division is reflected in the daily working activities. Hence, all technical clarifications take the form of interplay between the technical project manager and the responsible engineers. The technical project manager acts as a technical linchpin in this regard, translating Oldtimer's requirements/wishes to the engineers.

During the first period of the project, the PD project group is physically divided; some are sitting at ground level, while others are sitting at the first floor. Just after the summer vacation, it is suggested to consolidate the PD project group in one open-plan office. Hence, during the rest of the development period, the employees are sitting next to each other in the same open-plan office. In this office, two desks are made available for the prototype workers; from time to time, they make use of this option. Consequently, the majority of the technical clarifications are now handled when performing the day-to-day working activities.[8]

[8] Previously, a great deal of the clarifications was handled at the cross-functional meetings.

> *"The physical relocation has been very beneficial. If Oldtimer wants a change, Jack tells it immediately. Often we hear the conversation with Andy, or Jack explains the changes just after he has finished the conversation. The technical meetings are not that important anymore"…"as specifications are now just handled over the desk."* (Electrical engineer 2, 23 November 2009).

kk's project manager (Mick) is responsible for all PD with Oldtimer; i.e. the 2.3, 3.0 and 3.6 MW. He ensures coordination among the three different WTCs, entailing that he always knows what is going on within each of the three projects.

Before addressing the interorganisational STPs, it has to be emphasised that a great deal of the communication between Oldtimer and kk is handled by either phone or e-mail.[9]

8.1.2.2. Interorganisational meeting as forming STPs

Two different types of meetings are conducted. One focuses on clarifications, while the other addresses the verification of the breaker panels, including product documentation. Apart from the divergent purposes of the two interorganisational meetings, they also point to some differences influencing the composition of the STP.

First, the interorganisational clarification meetings are repetitive. In the first half of the project period, the meetings are conducted fortnightly; after the summer vacation, however, the meetings take place on a weekly basis. Several issues are dealt with during a meeting and fairly often, it is not possible to achieve clarification within a single meeting. Hence, indeterminacy might be a recurring theme in a number of meetings before determinacy is achieved. The contrary is in evidence with respect to the interorganisational FAI meeting, as this is a single PD task.

Second, the interorganisational FAI meeting is conducted solely in the production where Oldtimer's project manager examines the breaker panel. The opposite is perceptible with respect to the interorganisational clarification meetings as this STP is often three-parted.[10] Normally, the interorganisational clarifications start in the meeting room with logistic as well as commercial clarifications, after which the technical aspects become the focal point. When finishing these clarifications, all participants leave the meeting room and go out into the production area. In the production, the different breaker panels are subjected to a thorough examination.[11] Hence, the setting of the STP changes radically during a single meeting.

A common characteristic of the two interorganisational meetings is the temporary participation of other attendees. While the three project managers are regular participants in both kinds of meetings, various employees participate depending upon the technical issue.

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[9] *"I think more than 400 e-mails have been sent so far. Not later that one hour after Jack has received an e-mail from Andy, he responds."* (kk project manager, 20 August 2009).

[10] This three-parted structure becomes perceptible after the interorganisational meeting on 13 August 2009. Due to the progress of the pilot production, it is decided to move part of the upcoming meetings to the production area.

[11] *"In an ideal world, we only need electrical diagrams and 3D drawings to develop a breaker panel, but this is not possible in the real world"…"Obviously, the electrical diagrams have to be created, but when looking at the physical breaker panel in the production, we are able to see many aspects that are not apparent on a 3D drawing."* (Technical project manager, 16 November 2009).

8.1.2.3. Cross-functional meeting as forming STPs

Different kinds of cross-functional meetings take place. The first one is the project meeting, during which kk's project manager provides information about the progress of the project dealing with logistics/commercial issues. Afterwards, the technical project manager goes through the technical aspects of the project.

The second group of meetings has much in common with the interorganisational clarification meetings; the meetings are repetitive, conducted regularly and MoM is written after each meeting. However, the above-mentioned relocation of the project group results in an increase in physical proximity among the involved employees. Hence, the need for technical clarification during these meetings is reduced, as the majority of issues are handled within the daily working STPs as illustrated in section 8.1.2.1. Due to this, the meetings are not conducted regularly after each of the interorganisational meetings as was the standard procedure before the relocation.

Two cross-functional meetings, internal FAI and ePM verification, address the verification of the three-parted outcome depicted in figure 8.2. The former is a preparatory meeting to the interorganisational FAI and has much in common with this activity. Contrary to the interorganisational FAI, all participants are kk-employed and besides, a checklist is strictly followed to ensure a thorough verification. This checklist consists of 19 different areas of inspection and addresses three focal points: the physical breaker panel, the product documentation and coherence between the physical breaker panel and the product documentation. According to the quality manual, a standard procedure has to be followed. Thus, kk's project manager reads aloud from the checklist, after which one of the other participants controls the breaker panel and/or the relevant documentation. If a discrepancy is detected, it is recorded in the MoM and in notebooks. The latter verification addresses the production documentation. In contrast to the FAI meetings, these activities take place in a meeting room; hence, the physical breaker panel is not a part of the verification. As is the case with the internal FAI verification, a checklist is strictly followed. The checklist is available online and it consists of 12 focus areas. A laptop is applied to retrieve the necessary documentation from kk's intranet, and the checklist and the production documentation in question are depicted on the TV screen. If a discrepancy is detected, it is noted down on the online checklist.

As regards the PD of the WTC to Oldtimer, the cross-functional collaboration between kk-Ikast and kk-Poland is minimal. At the time of project launch, a video conference with the Polish subsidiary was held. Furthermore, a number of selected MoMs are sent to Poland. I.e., the communication is mainly one-way. Consequently, the WTC, including all production documentation, are created by employees working within the pilot production STP.

> *"When we construct a breaker panel, we really do our best to achieve an optimal production afterwards"…"but because most of the prototype workers have never visited Poland, we do not have any experience regarding their production machinery."* (Prototype worker 1, 19 November 2009).

Summing up, the narrative describes the deliveries to Oldtimer and illustrates the various STPs in which the PD activities are performed; the daily working STPs, the interorganisational STPs and the cross-functional STPs. The next section links the narrative to the two embedded cases.

## 8.2. The two embedded cases

The description of the different STPs in section 8.1 makes it possible to identify and analyse the characteristics enabling or constraining the learning process. However, in order to be able to analyse learning, it is crucial to understand how the PD unfolds in a time perspective; i.e., the trajectory of a breaker panel case. Focusing on the trajectory paves the way for analysing the process characteristics in relation to the life story of the PD of a breaker panel.

The two embedded cases in the next two sections dealing with the A24 and the A21 breaker panels will be used to describe the unique trajectory of each of the two cases. One could get the impression that the PD process is sequential and straightforward. However, as it will appear from each of the two cases, some changes in the PD process emerge. The description of the two cases is chronological and not thematic, thus differing from the structure applied in section 8.1.

## 8.3. The A24 breaker panel case

The timeframe depicted in figure 8.1 shows a fairly late start-up of the A24. Oldtimer's project manager introduces the task to kk at an interorganisational meeting 3 September 2009. The information handed over to kk emphasises that the delivery date is 6 October 2009 and that the necessary product specifications will be handed over not later than 10 September 2009. Based on this information, kk's project manager is requested to draw up a project plan; the short period available to accomplish the necessary activities results in a rush-order.

When **10 September dawned**, the specifications had not yet been developed. However, as usual, an interorganisational meeting is conducted that Thursday and just after the logistic clarification, the technical project manager asks about the specifications of the A24.

> <u>Interorganisational meeting, 10 September 2009</u>
> Jack➔ *the only issue I have is the new maximum circuit breaker.*
> Andy➔ *we are to deliver the circuit breaker, or are we? As I remember, we did it last time. There are many interfaces to other components in the wind turbine that we struggle with at the time being…*
> (This dialogue stops, but another one starts up immediately).
> Jack➔ *why apply a PLC? It has to pass through all the software code each time…*
> Andy➔ *it is because we apply these diodes, but...er...we have to find out what we want.*
> Jack➔ *with this CPU, it will simply pass through all the software and cycle round…*

The task turns out to comprise two breaker panels instead of one: An A24 and a smaller box, which is termed 215362MO just after the meeting. As stated above, there are many interfaces to take into consideration, which complicates the process.

**The following Thursday, 17 September**, the technical clarification is on the agenda. Andy reaches across twelve drawings showing dimensions of, for instance, the huge copper bars to be mounted; however, Oldtimer has yet to determine all material types. Although the specifications are not finally determined, a 3D drawing is available.

Andy connects to the Oldtimer network,[12] retrieves a 3D drawing and presents it on the laptop screen. He displays the A24 breaker panel from various angles; it is revolved and cover plates are dismantled. Simultaneously, he expounds verbally and he "creates" a drawing in the air by using his hand. Following Andy's explanation, Jack's body language clearly indicates a reflection going on and after a few minutes of silence, the following takes place:

Interorganisational meeting, 17 September 2009
Jack➔ *oh…what about the cabling in and out of the breaker panel?*
Andy➔ *the cables among A3 and A24 and 215362MO, yes how to connect them? Can we take these four cables here* (points with his finger at the laptop screen).
Jack➔ *yes, we can…no, it is not a good idea because the A3 is finished. Can we connect 215362MO to these two connections?* (Points with his finger at the laptop screen).
Andy➔ (after a close look at the laptop screen). *No, it is of no good as one of them is an earth cable.* (This dialogue stops, but another one starts up immediately).
Andy➔ *I can see you have three amperes here.* (Takes a close look at an electrical diagram just in front of him and then his eyes move to the laptop). *You have three amperes here and…*
Jack➔ *yes, it is correct.*
Andy➔ *we have as much as 9 amperes to use, why not increase it to 4.5 amperes?*
Jack➔ *yes, let's do it.*

The above produces two outcomes. First, regarding the cabling and electrical interfaces, it is highlighted as a problem and written down in the MoM and notebooks; thus, the present version of the WTC is not modified. The second issue results in the drawing up of a sketch.

At **the meeting held 24 September,** Andy indicates a major revision of the A24 when saying *"what topics do you want to discuss before I drop the bomb?"* Jack continues as if he has not heard this comment and asks for further documentation, resulting in the following comments from Andy *"okay, I think I have to drop the bomb now; the breaker panel will be completely redesigned"*. Still, Jack persists in continuing the technical dialogue in order to clarify the length of a crucial cable clam as this component has a rather long delivery time. Following the clarification of the dimensions, Jack asks *"what is changed in the setup, is it a minor change?"* Andy replies:

> *"no, we have decided to change it all, but unfortunately, I only have the external measurements at present"…"We have just realised it."* (Oldtimer project manager, 24 September 2009).

Andy really tries to explain the changes by using verbal as well as body language; his hands make sketches in the air, but after a while, he goes to the blackboard and constructs a comprehensive sketch. The sketch does not result in any technical clarification.

According to the original plan, the A24 has to be delivered on 6 October 2009, for which reason the technical project manager has ordered all long-delivery materials. Hence, it is necessary to revoke the order for these materials and cease the cross-functional work in this regard.

[12] All meetings take place at kk.

**Four days before the planned delivery date**, **that is, 2 October 2009**, an ordinary interorganisational meeting is held. Due to the radical changes of the design, no specifications are available yet. Instead, Oldtimer's project manager goes to the blackboard and makes a highly informative sketch of the A24. Simultaneously, he explains the technical ideas in this regard. The sketch facilitates a technical dialogue, but it is not possible to reach clarification.

The design activities are in progress intraorganisationally in Oldtimer and Andy is actively involved in the creation of a 3D drawing; a rather complicated task due to the odd shape of this breaker panel.

Just before **the interorganisational meeting 8 October 2009,** this 3D drawing is sent to the technical project manager who barely has had a chance to open the file. However, the 3D drawing is the focal point of the technical clarification during the meeting; Jack zooms in or out and the virtual maximum circuit breaker revolves, making it possible to see the A24 from various angles. When explaining an issue, Jack normally uses the mouse cursor to emphasise his point of view. Likewise, in connection with a discussion dealing with cabling,[13] Andy goes to the TV screen, points with his finger and explains his ideas in this regard. The issues being discussed proceed in this way.

At the end of the meeting, two issues are emphasised. First, Oldtimer has not yet finished the design, for which reason small alterations might occur. Second, as some of the components have four weeks of delivery time, the sourcing of the material is the number one bottleneck. Mick writes down all decisions in the MoM, and Andy and Jack do the same in their notebooks.

So far, the maximum circuit breaker functions have been divided into two breaker panels, the A24 and the 215362MO, respectively, but at **the interorganisational meeting 21 October 2009,** it is decided to build the latter into the A24. This prompts some modifications of the specifications; all of these are written down in the MoM. Moreover, the delivery date is postponed to 6 November 2009; however, to comply with this delivery date, Oldtimer has to deliver a crucial component not later than 30 October 2009.

At the next **interorganisational meeting taking place 29 October 2009,** only logistic issues are discussed. Especially two components are in focus; a heating element and the aforementioned crucial component that Oldtimer has to deliver not later than 30 October.

The A24 breaker panel is ready for **FAI verification 5 November 2009**. Just arrived at the breaker panel, Oldtimer's project manager takes a close look at the bottom plate and says while pointing with his finger:

> *"this hole turns upside down, it is not what I want"..."I would like you to change it, how long time does it take to rework it?"* (Oldtimer project manager, 5 November 2009).

[13] This is not the same cabling issue as discussed at the interorganisational meeting 17 September 2009. The discussion taking place in this meeting deals with the cabling from the generator to the maximum circuit breaker.

As the necessary components have to be sourced from kk's Polish facilities, the modifications will take some days to carry out. Because the nacelle has to be finished within a three-week time frame, the delivery of the A24 is becoming extremely critical. Consequently, Andy decides to implement this modification at a later time.

Later on, Andy sits down on a chair and takes a close look inside the breaker panel. After a while, he gets up and takes a long look at a specific group of components:

> <u>Interorganisational FAI meeting, 5 November 2009</u>
> Andy➔ *I really do not know what our engineers were thinking when designing these copper bars…*
> Jack➔ y*es, you are right, something is wrong. Can we straighten them by mounting a washer there?* (Jack points with his finger).
> Andy➔ *yes, and I would like to strap the isolators to the copper bars…*
> (Soon after, Jack finds a cover and shows Andy that it cannot be mounted).
> Andy➔ *what! It looks strange; I wonder what the problem is*?
> Jack➔ *if we take a new plate of isolator and relocate these three varistors…then I think it…*
> Andy➔ *yes, it would be possible, but I also think we should replace these three long supporting bolts with traditional bolts, that would help very much.*

In addition to the above issues, Jack and the responsible prototype worker have noted down a number of inappropriate designs dealing with the assembly of the breaker panel. These issues are discussed. Hence, the FAI entails that the A24 is to be reworked before it can be delivered, resulting in the delivery date being postponed to 9 November 2009.

The prototype worker conducting the rework assesses the modifications to be rather complex, as it is necessary to disassemble a great part of the A24.

> *"I have to call Andy Monday morning* (9 November 2009, author) *to inform him that we will not be able to deliver the breaker panel before 10 November."…"He has also decided to replace some bolts in a transformer as they have to be stainless."* (Prototype worker 1, 19 November 2009).

Although the breaker panel is delivered 10 November, the A24 becomes a subject matter at the **interorganisational meeting 17 November 2009** as Oldtimer wants to change the aforementioned electrical interface between the A3 and A24 breaker panels.[14]

Additionally, as kk is responsible for product and production documentation, all drawings from Oldtimer are handed over to the technical project manager. A draughtsman from kk is supposed to construct the documentation, but the odd shape of the breaker panel seems to complicate the process. Despite the fact that the specifications are written down, everyone agrees to a meeting between the kk draughtsman and the designer from Oldtimer.

In continuation of a telephone conversion at the ordinary **interorganisational meeting 2 December 2009**, the project manager from Oldtimer takes his notebook and makes a sketch depicting the cabling between the generator and the maximum circuit breaker. The sketch clearly illustrates that the cabling is inappropriate. He explains his ideas for improving it.

[14] This subject was an issue at the interorganisational meeting held 17 September 2009, but at that time, it was decided to postpone the modification to the next version of the WTC.

*"The maximum circuit breaker, can we mount it inside the generator? Some* (other employees at Oldtimer, author) *want to mount the maximum circuit breaker where the A4 was installed"…"but it is too far away from the generator."* (Oldtimer project manager, 2 December 2009).

The dialogue is a "feel-one's-way" process as a great many issues have to be taken into consideration. However, one conclusion is written down in the MoM.

*"For certain, the A24 will be changed: consequently, kk has to cease the handing over of drawings and specifications."* (Interorganisational meeting MoM, 2 December 2009).

The specific A24 described in the above is in complete operation. Hence, the changes discussed will not have any influence on this A24. Instead, the modification will probably be implemented in the next version of the A24.

The next section sheds light on another trajectory taken by the A21 breaker panel. In contrast to the A24, the A21 is a known breaker panel.

## 8.4. The A21 breaker panel case

The A21 has been applied in the 2.3 MW WTC since the late summer of 2008. As this version of the A21 has been produced in the Polish batch production facilities for some time, all product and production documentation is available. Actually, the A21 technological platform is even older, as it can be traced back to a merger between the A1 and A2; these two breaker panels are still applied in the 3.6 MW wind turbine.

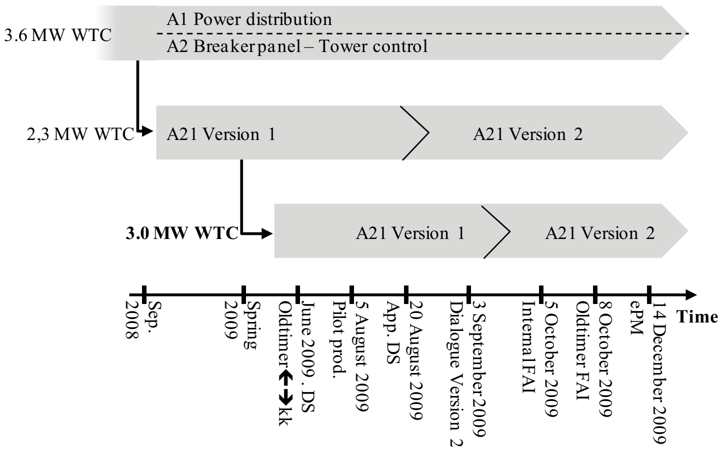


Figure 8.4. Timeframe for the A21, including the relations among the three WTCs.

The above relations between the three different WTCs are depicted in figure 8.4. The 2.3 MW A21 version 1 uses as its point of departure the A1/A2 technological platform from the 3.6 MW. Initially, the intention was to reuse this 2.3 MW A21 version 1 in the 3.0 MW WTC, but as it appears from figure 8.4, the 2.3 MW A21 is updated to a version 2 in the middle of 2009. Consequently, this update affects the 3.0 MW WTC after Oldtimer has approved the delivery specification. This update is the focal point of the A21 case.

Until the **interorganisational meeting to be conducted 3 September**, the A21 does not receive much attention and it seems to be on track. The introduction of the potential changes is put forward by Mick when passing by the almost finished A21 in the production area 3 September. Both Oldtimer's 3.0 MW project manager and the technical project manager are quite interested in being informed about the changes, but Mick is not able to explain these offhand. When returning to the meeting room, Mick takes a look in his notes from a meeting with the 2.3 MW project manager and explains all changes. However, it does not result in any technical dialogue and nothing is written down in the MoM or notebooks.

The **following day, a cross-functional meeting** is conducted. Just before the meeting starts, the technical project manager asks the responsible A21 engineer[15] (James) to elaborate on the changes to be made to the 2.3 MW A21. A technical dialogue is initiated in this regard, but nothing is concluded.

During the **interorganisational meeting 10 September,** the A21 is hardly noticed when passed by in the production area.

Likewise, at the next **ordinary interorganisational meeting taking place 17 September 2009,** the A21 is not an issue, but a comment concerning the delivery date is written down in the MoM.

However, during the **interorganisational meeting one week later, 24 September**, kk's project manager starts as usual with the logistic clarifications, resulting in the following dialogue:

> <u>Interorganisational meeting, 24 September 2009</u>
> Mick➔ *Tony* (Oldtimer's project manager on the 2.3 MW) *keeps introducing changes to the A21. How do you want us to handle it – what about the delivery time?*
> Andy➔ *I know that a number of internal meetings have taken place as there are a number of disadvantages with the current A21…But of course, we have to draw a line in the sand at some point.*
> Mick➔ *Yes, but how to handle it?*
> Andy calls a colleague at Oldtimer and says in the phone➔ *Tony is continuously introducing changes* (to the 2.3 MW, author)*. How should we handle these?...Beyond doubt, we benefit by having the majority of the changes implemented…How long can we postpone the delivery of the A21?*
> Following this conversion, Andy➔ *The converter is delivered 12 October and other components are delivered 5 October. Hence, we have to hold on to 12 October as the delivery date.*

At the next **interorganisational meeting 2 October**, the A21 is discussed twice, namely in terms of updates of the product documentation and changes to be implemented.

First, as the specifications of the A21 have been established for quite a long time, the changes of the physical breaker panel dictate an update of the documentation. The update of the documentation does not seem to be straightforward and Oldtimer's project manager has to examine which version of the I/O he has previously sent to kk.

[15] This engineer, James, is responsible for all versions of the A21, be it the 2.3 MW or the 3.0 MW.

The second topic being discussed focuses on the opportunity to implement additional changes as the delivery of the converter is postponed three or four days.[16] After a while, Andy and Jack agree upon involving the 2.3 MW project manager from Oldtimer and the responsible A21 engineer in this clarification; Andy meets with the 2.3 MW project manager, while Jack discusses the issue with James. In closing, Mick writes down in the MoM.

> *"The last changes proposed by Tony dealing with the I/O have to be implemented in the 3.0 MW A21. An exhaustive outline of all changes has to be submitted to Andy. Jack and Andy will afterwards discuss these issues on Monday 5 October and hence clarify which changes to implement and which to postpone to the next project."* (Interorganisational meeting MoM, 2 October 2009).

The **cross-functional FAI takes place 5 October**. From this internal verification meeting, three discrepancies emerge.

First, the technical project manager has brought along two folders; one containing electrical diagrams and one containing all delivery specifications. He takes one of the electrical diagrams from the folder and goes to the physical breaker panel where he takes a close look at the electrical diagram and the physical breaker panel in turns. By reading the diagram and comparing it with the physical breaker panel, he identifies a discrepancy dealing with an agreed-upon update that has not been implemented.

The second situation takes a similar course; that is, it is identified by comparing the product documentation with the physical breaker panel. The discrepancy is a wrong connection[17] of wires to a component and referring to James, *"it is only a minor discrepancy"*; a statement which prototype worker 1 disagrees with.

The third discrepancy is between the delivery specifications and the physical breaker panel. According to the delivery specifications, an option dealing with an acoustic alarm should be available, but James is unable to locate this feature in the physical breaker panel. James and prototype worker 1 search different documentation, mainly at the intranet. At a time, they use two different laptops to search in BOM, working instructions etc., but they are unable to retrieve the necessary information.

The **interorganisational FAI is conducted 8 October**.[18] At the beginning of the verification, a supposed change becomes an issue, resulting in the following exchange:

| |
|---|
| Interorganisational FAI, 8 October 2009<br>Andy➔ *as I remember, we had a dialogue concerning the fact that this should be changed* (points with his finger at an electric circuit and afterwards he takes a close look in his notebook).<br>Jack➔ *yes, I see, it is not particularly appropriate* (while sitting on his knees right in front of the A21).<br>Mick➔ *we have an A2 breaker panel over here. The other day, I conducted an FAI with David,*[19] *why not take a look at this breaker panel* (now all participants move across the production towards the A2). |

[16] According to the plan, the converter should be delivered 12 October, but Andy announces that the delivery is postponed to the end of week 42; that is, 15 October or 16 October.

[17] The component is an UPS. UPS is an abbreviation for Uninterruptible Power Supply; a kind of battery backup.

[18] As mentioned elsewhere, the changes also take place on the 2.3 MW project. Today, the responsible A21 engineer is requested to take part in some of the rework on the 2.3 MW. Consequently, James does not participate in the meeting.

[19] David is Oldtimer's project manager on the 3.6 MW.

Andy/Jack➔ *this breaker panel has the same problem.*
Andy➔ *I have to talk with David, as the 3.6 MW might have the same problem.*
Mick calls James and afterwards Mick says➔ *James is aware of this change…*
Jack➔ *yes, but it is not evident from the drawings and the specifications of the A21.*
Mick➔ *James told me that it has been implemented on some of the A21s, but not yet on this one*.

Another discrepancy between the physical breaker panel and product documentation turns up soon after.

Due to resource considerations, it is agreed to postpone the verification of all production documentation until 14 December although the A21 is delivered in accordance with the plan.

In the meanwhile, various changes still turn up; for instance, the need for modifying the emergency stop in order to be able to assemble/erect the wind turbine, cooling of the converter in the A21 and finally, during the construction of the wind turbine in Drantum, it was necessary to modify a flange and some of the wiring inside the A21. Regarding the latter, Oldtimer's project manager has received an e-mail problematising the validity of the product documentation. In an attempt to understand what is going on, the technical project manager proposes to compare the documentation employed by Oldtimer to assembly/erect the wind turbine in Drantum with the product documentation used to create the A21 at kk. This dialogue takes place at the **interorganisational meeting 10 December**.

Addressing the **ePM verification 14 December**, the many changes being implemented after finishing the production of the A21 become a challenging subject matter. For instance, the verification of the working instructions gives rise to doubts regarding the validity of this documentation. A dialogue is initiated, resulting in the conclusion that all working instructions are "copy and paste" from the 2.3 MW; consequently, kk's project manager blocks the process as it is necessary to conduct a new ePM verification later on. During the meeting, other discrepancies turn up; the majority of these are due to copy and paste[20] from earlier documentation.

The PD project group regards the creation of the A21 to be a process marked by a steady stream of changes.

> *"There have been many changes to the A21"…"Often a change is introduced and then we modify it. Shortly after, they want to have it built back again."* (Electrical engineer 1, 2 December 2009).

kk's project manager interprets the development as a continuous process with no deadline, a viewpoint to which the technical project manager subscribes. He emphasises that it has been a challenge to keep track of all the changes from the 2.3 MW project and to ensure the alignment between the physical breaker panel and the product and production documentation.

[20] For instance, when discussing item seven on the "checklist" (an instruction to the blue collar workers after assembling the breaker panel), Mick asks why to clean the bottom plate before putting it into the packaging, because there is no bottom plate in this A21. After a while and some discussion back and forth, the logistics engineer says *"oh, I think it is from the old A1 because we had a removable bottom plate, which we put into the packaging; consequently, I think it is a copy and paste from the A1 breaker panel"*.

This concludes the presentation of the Oldtimer PD project. Hence, the rest of the chapter addresses the PD project being conducted with Newcomer. The structure of this presentation has much in common with the above. It starts with a presentation of the deliveries to Newcomer, which is followed by a presentation of the various STPs. Finally, two embedded cases are presented.

## 8.5. Newcomer narrative

Newcomer is a Strategic Business Unit (SBU) within a huge concern based in the Far East. However, Newcomer only has a limited level of experience in relation to wind turbines.[21] The company has developed and produced two different wind turbines, which regrettably have failed to perform successfully.

> *"Actually, for that reason Newcomer has contracted with Alpha as they are specialists in mechanical design. Alpha is located in X city* (in Germany, author). *In addition, Newcomer has contracted with an English company, Bravo, and they are specialists within the dimensioning of gearboxes."* (Salesman, 4 December 2009).

The mechanical stability is a focal point for Newcomer. Therefore, two consulting organisations, Alpha and Bravo, are actively involved in the design of the new wind turbine. Referring to SW engineer 1, the way in which a WTC regulates the other components/systems will result in vibrations in nearly all components in the wind turbine. In order to minimise these vibrations, Newcomer makes use of kk's experience[22] within the development of WTCs.

Given that the above-mentioned three crucial suppliers to Newcomer's new 2.0 MW wind turbine are located in the northern part of Europe, Newcomer has decided to locate the development team abroad in X city next to Alpha.

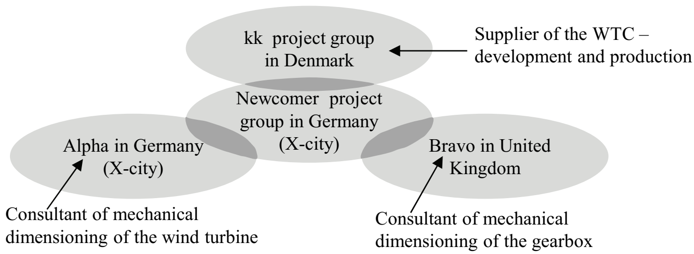


Figure 8.5. Different tasks to be handled by the three suppliers.

Figure 8.5 illustrates different roles of the three suppliers. As Alpha and Bravo act as consulting organisations, they do not supply physical products; instead, their value-creation

[21] Newcomer's technological development concerning wind turbines can be traced back to 1997. At that time, the focus was on the component level; that is, gearboxes and generators. In 2002, Newcomer develops its first wind turbine with an output of 750 KW. In 2007, Newcomer launches a 2.0 MW wind turbine. (Vice president sales, cross-functional meeting, 31 August 2009).

[22] *"Depending on how we pitch the blades in the wind, you will get different vibrations at the components."* (SW engineer 1, 4 December 2009).

for Newcomer is to provide advice and information. This collaboration is rather close and it facilitates Newcomer's engineers to gain new experience in this regard. In contrast, kk supplies physical breaker panels; an operational cost-effective and reliable WTC. These rather different roles give rise to conflicting perceptions of the task to be handled by kk.

### 8.5.1. Deliveries to Newcomer – the task to be handled

Referring to figure 8.6, the text in the grey bars states the name of the breaker panel in question as well as the product platform applied to create the breaker panel. For instance, the A10 – Charlie 5.0 MW indicates that the breaker panel draws on solutions developed and used in a WTC for another wind turbine manufacturer, in this case, Charlie.[23]

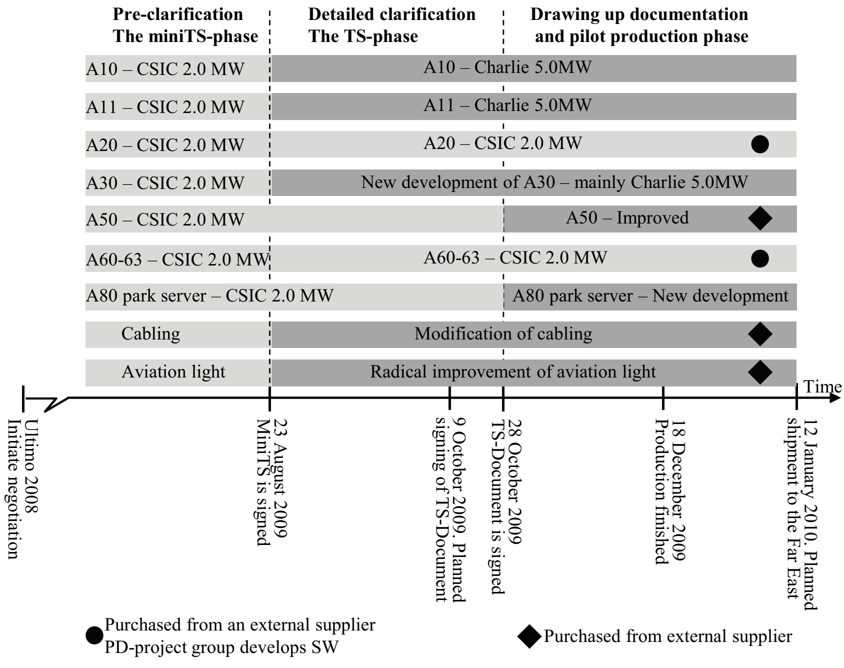


Figure 8.6. Overview of the extent, timing and trajectory of the 2.0 MW project.

<u>8.5.1.1. Starting and ending – timing of the task to be handled</u>

Figure 8.6 illustrates the timelines of the phases. The three phases listed are the pre-clarification, the detailed clarification and the pilot production activities. The former PD activities are written down in the miniTS, the second in the Technical Specification document (TS-document) while the latter includes the creation of a great deal of documentation necessary for carrying out the physical production.

[23] Charlie is another newcomer within the wind turbine industry.

As depicted in the figure, the pre-clarification phase is protracted; it starts at the end of 2008 and the miniTS is signed 23 August 2009. According to the agreement, the detailed clarification has to be signed on 9 October 2009, but due to various circumstances, the signing is postponed to 28 October 2009. Despite this delay, the development of the necessary documentation for carrying out the pilot production and the accomplishment of the pilot production comply with the original project plan. The start and finish time for all breaker panels coincide. The PD activities addressing the detailed specifications await the approval of the miniTS. Likewise, the pilot production awaits the approval of the TS-document. Finally, all breaker panels are embarked on simultaneously and therefore delivered to Newcomer as one delivery.

8.5.1.2. Complexity of the task to be handled

The task to be handled consists of more than specifying the breaker panel depicted in figure 8.6. First, the engineers focus great attention on the interfaces within and among all breaker panels; that is, the Input/Output (I/O) challenges. To be able to specify these I/Os, the engineers have to achieve a detailed understanding of the technical solutions; be it from own PD activities or from external suppliers. Especially the A20 (the converter) and the four breaker panels A60-A63 (the pitch system) are crucial in this regard. However, SW engineer 1 emphasises that the converter as well as the pitch system is based on previous solutions, making the clarification of the I/Os relatively easy. Second, the PD project group is responsible for the development of all SW to the WTC, including the purchased breaker panels. Given that the PD task includes HW and SW development, the task is comprehensive. But on the other hand, the HW/SW engineers consider it to be an advantage as they are in charge of specifying the HW and SW.

8.5.1.3. Changing the task to be handled

The light grey boxes in figure 8.6 illustrate the PD activities to be conducted in accordance with the miniTS, while the dark grey boxes indicate the applied product platform. According to the miniTS, the task is to produce a WTC similar to that of the China Shipbuilding Industry Cooperation (CSIC) (a 2.0 MW WTC). However, just after signing the miniTS, it is decided to change the A10, A11 and A30. The product platform being used as the underlying basis for the PD activities is not a CSIC 2.0 MW. Instead, the technical specifications draw on a 5.0 MW WTC developed for Charlie. Especially the latter breaker panel is subject to comprehensive changes.

Regarding the A80 park server, the specifications are not changed during the TS phase. Instead, the chosen product platform becomes the subject of an intense discussion just after signing the TS-document on 28 October 2009; i.e., the A80 is not based on a CSIC platform.

8.5.1.4. Present level of experience to handle the task

As the New Business Department (NBD) area of business is rather new, kk has so far developed and produced a number of WTCs to two different customers, which can be categorised as newcomers. The project manager in charge of the Newcomer PD project was/is also responsible for one of these, namely the Charlie 5.0 MW project. The other newcomer project is the CSIC 2.0 MW;[24] this, however, was managed by another kk project manager.

Some of the engineers have been involved in both of these PD projects. In this regard, the general view is to consider the CSIC WTC as a simple technical solution,[25] while the WTC designed for Charlie ranks alongside the WTC delivered to Oldtimer.

### 8.5.2. Newcomer – different STPs

The PD activities in relation to the miniTS, the TS-document and the pilot production take place within different STPs. These STPs are depicted in the middle of figure 8.7; the daily working, interorganisational and cross-functional STPs will be described in the below.

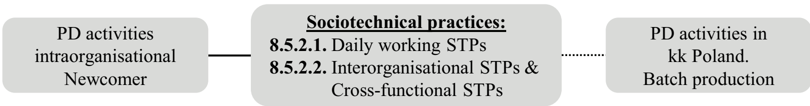


Figure 8.7. Different sociotechnical practices - Newcomer.

The rectangle to the left illustrates some of the PD activities taking place intraorganisationally in Newcomer that might influence the STPs during the creation of the WTC. As mentioned elsewhere, Newcomer's engineers are sitting next to Alpha. Referring to one of the kk engineers, the two organisations interact intensively. In addition, seeing that the gearbox often proves to be problematic, another consulting company visits Newcomer in X city from time to time.

> *"They* (Newcomer, author) *had a completely different perception of what they had procured"... "They had expected a relationship in which we would act as a full-line supplier and that we would offer the same level of support as Alpha and Bravo do."* (Technical salesman, 7 December 2009).

The progress of the PD activities is a focal point in Newcomer. Marked by the less successful PD projects of its past, the 750 KW and 2.0 MW wind turbines, Newcomer is determined that this PD project be successful. Newcomer's top management has outlined some guidelines to be followed by the involved project managers.[26] It might be the reason why Newcomer's project manager and his engineers have a basic need for understanding all technical aspects in detail.

> *"Me and my engineers really need to gain insight into the functionalities. How does kk identify a solution and how do they ensure that it is the best solution?"..."I am an engineer and I have a basic need to gain insight into how it works."* (Newcomer project manager, 7 October 2009).

[24] The CSIC solution is developed for the Chinese market. The production takes place in a joint venture in China.
[25] Beyond doubt, kk has not compromised the reliability of this WTC.
[26] Newcomer's project manager is referring to this internal pressure on 25 September and on 7 October 2009 as well.

The rectangle to the right illustrates the Polish batch production. It appears from figure 8.7 (symbolised by the dotted line between the STPs and kk-Poland) that the batch production in Poland is not involved in the PD activities.[27]

8.5.2.1. Daily working STPs

kk has just finished an extension of the administration. At the first floor of this extension, an open-plan office has been allocated to the PD project. kk's project manager and the "active"[28] kk engineers are sitting next to each other in this office termed "the war room" by kk's project manager. The war room is established a while before signing the miniTS.

The majority of all technical clarifications are accomplished within the walls of the war room. Normally, the technical dialogues take place while the engineers are sitting at their desk. Various topics are discussed across the desk, e.g. the coordination between HW and SW.

> *"It is crucial to coordinate the I/Os as we* (HW and SW engineers, author) *are very dependent on each other. If the HW is far ahead of the SW development, it rather often gets problematic to coordinate crosswise."* (SW engineer 1, 4 December 2009).

The computers are used intensively to retrieve different information from the internet or from kk's intranet. This information is used both to carry out a specific PD activity and to facilitate dialogues across the desk. When facilitating clarification, telephone conversions often take place or one of the engineers reads aloud from an e-mail or from a standard concerning wind turbine development, etc. Additionally, the blackboard is normally filled with sketches, calculations, etc. During a working day, a number of kk employees come by. Some employees, normally at management level, ask for an update with regard to the progress of the project, while others participate actively in the PD. Clearly, many PD activities take place in the room.

Referring to electrical engineer 1, this Newcomer PD project is completed twice as fast as the Oldtimer project despite the fact that both projects employ the same working methods.[29] He points out that one of the reasons why the Newcomer project is successful is because the engineers have been sitting next to each other since the very beginning of the project.

The A80 park server is not handled by the kk engineers sitting next to each other; actually, the A80 HW/SW engineers do not belong to the PD project group. Consequently, the detailed clarification does not take place in the war room. Instead, the responsible HW and SW engineers are sitting in other offices where they are working on other PD activities alongside

[27] *"I have to admit that we leave out of consideration the production facilities in Poland"…"due to time pressure and the fact that we only create the bare minimum of documentation, we have decided not to prioritise this issue."* (kk project manager, 9 December 2009).

[28] The quotation marks symbolise that only engineers who presently are working actively with the Newcomer project are moved to this office. For instance, Bob, electrical engineer 1, was not repositioned from the Oldtimer office area to the Newcomer office until the project required his skill set.

[29] Referring to the interview with Bob of 2 December 2009. Bob is actively involved in the Oldtimer project as well as the Newcomer project.

the A80.[30] For the record, kk's project manager is responsible for all breaker panels to be delivered to Newcomer.

8.5.2.2. Meetings forming interorganisational and cross-functional STPs

The **interorganisational** meetings are conducted in the boardroom. Seeing that the Newcomer engineers are travelling from X city, the meetings normally start in the morning and continue until late in the afternoon. The meetings only take place in a meeting room; consequently, the physical breaker panels are not involved to facilitate clarification. Laptop, blackboard and various artefacts are applied to facilitate the dialogues.

The **cross-functional** technical meetings take place in the war room, while the other meetings are conducted in different meeting rooms. Addressing the cross-functional project meetings, the participants as well as the purpose of these meetings vary. For instance, in the meeting conducted 27 August, the participants from the PD group and the NBD are focusing on achieving a convergent interpretation regarding the content of the miniTS.

One cross-functional Intellectual Property Right (IPR) meeting is held. The participants are from the research department, the NBD and, last but not least, the PD group. The purpose is to increase the awareness of the IPR and thus to avoid a conflict in this regard.

Finally, two cross-functional calculation meetings are arranged. The participants are staff from the NBD, kk's project manager and HW engineer 1. Seeing that the breaker panels being developed and produced deviate from those specified in the miniTS, the expenses have increased. Hence, the purpose of these two meetings is to analyse and thereby explain the causes of the increased cost level to Newcomer.

The next two sections address the two cases. The first focal point is the progress of the miniTS and TS-document, while the second is the A80 case. The presentation of both cases follows a timeline, by which it is possible to identify the trajectory of the PD activities.

## 8.6. The WTC case – the progress of the miniTS and TS-document

The WTC case is divided into two subsections. The first one describes the creation of the miniTS. The second section sheds light on the creation of the TS-document.

### 8.6.1. A retrospective description[31] of the creation of the miniTS

The miniTS consists of technical pre-clarification and scope of the PD. Particularly the former calls for a well-developed understanding of the necessary functions[32] to be built into the breaker panels. The salesman for the Asian market carries out the collaboration with Newcomer during the miniTS phase. He is very much aware that it is crucial to achieve an

[30] This aspect is elaborated in the A80 park server case in section 8.7.

[31] The retrospective approach is employed because I did not participate in these interorganisational meetings. Instead, the description is mainly based on interviews. Nevertheless, I was sitting in the NBD office area during the pre-clarification phase and often I had conversions with the involved employees in this regard. I made some notes at that time; however, it is second-hand information.

[32] A function cannot be located to HW or for that matter to SW. Instead, it is the combination of HW and SW that makes it possible to achieve a function.

overview of all the HW and SW to be included in the delivery.[33] In addition, the salesman is in charge of writing the miniTS, including the technical pre-clarification.

As the salesman does not have detailed technical experience regarding WTCs, the engineers draw up a document to guide the pre-clarification. Section 8.6.1.1 focuses on the drawing up of this document. The following section addresses the miniTS phase in which the pre-clarifications are created. The outcome of the miniTS phase is presented in section 8.6.1.3.

8.6.1.1. Inputs to miniTS phase – the drawing up of the document

The guidelines being provided by top management is to "sell" a standard WTC. In other words, it has to be possible to pick the breaker panels from the "virtual stock". According to the engineers, however, a standard WTC does not exist; actually, it does not make sense to sell a standard WTC. Still, in order to prepare the ground for having a standard WTC, HW engineer 2 does his very best when drawing up the documentation to be handed over to the salesman and Newcomer's project manager.

HW engineer 2 takes the TS-document from the CSIC 2.0 MW and makes a shortened version of it. According to the HW engineers,[34] the content of the documentation handed over describes the I/Os and a great part of the HW. But all SW has been deliberately removed from the text. Thus, the documentation handed over is an abridged version of the CSIC 2.0 MW WTC text.

The intention of the documentation handed over is to facilitate a technical dialogue between Newcomer's project manager and the salesman. A part of this documentation is a kind of gross list serving the purpose of assisting the salesman in facilitating dialogues dealing with the pros and cons; but that is not how it is used.[35]

8.6.1.2. The miniTS phase

According to the salesman, there are huge differences between external and internal PD activities. He emphasises the necessity of having different personal experience in order to accomplish external and internal activities, respectively. Regarding the former, it is necessary to be experienced in dealing with when to "give and take" during the miniTS phase; and as the salesman points out, the discussions during the miniTS phase are very sensitive.

According to the salesman, the kk engineers do not have the necessary experience to take the lead in the miniTS phase as they are not accustomed to having contact with the customer.

> *"Being in touch with a customer is very different compared with sitting in front of the computer. Some of the engineers will simply complicate the process and therefore it is much better that they work from home."* (Salesman, 4 December 2009).

The salesman utilises the above-mentioned technical experience in two ways to carry out the technical pre-clarification. First, he makes use of the document developed by HW engineer 2

[33] Referring to the interview with the salesman, 4 December 2009.
[34] Based on the interview with HW engineer 1, 9 December 2009 and HW engineer 2, 14 December 2009.
[35] Mainly based on the interviews with SW engineer 1, 4 December 2009 and HW engineer 2, 14 December 2009.

to facilitate the technical clarification. Second, HW engineer 2 assists the salesman in a part of the technical discussions.

8.6.1.3. The outcome of the miniTS phase

The engineers doubt the validity of the technical pre-clarification appearing from the miniTS.

> *"The miniTS was a copy and paste from the 2.0 MW CSIC and consequently, it has been somewhat lacking in this regard. In the group of which I am a member, we all knew that the customer had other needs, but we were not allowed to rewrite it because it had to be a standard product to be sold to Newcomer. Actually, it was mainly just an I/O list."* (HW engineer 1, 9 December 2009).

Likewise, the technical salesman[36] indicates that there exists a disparate perception of the level of collaboration. While kk interprets the contractual agreement to be an "arm's-length" collaboration, Newcomer's project manager interprets it to be a close collaboration.

Nevertheless, the responsible salesman is aware of the fact that the outcome of the miniTS is only an estimate. Consequently, from the salesman's viewpoint, the miniTS commits neither Newcomer nor kk. Moreover, Newcomer's project manager considers the miniTS to be a non-binding document.[37]

Anyhow, the signing of the miniTS on 23 August 2009 kicks off the TS-document phase, and the above-mentioned two areas of ambiguities dealing with the technical pre-clarification and the level of collaboration become noticeable. The next section addresses this.

**8.6.2. The creation of the TS-document**

The creation of the TS-document follows a time line, for which reason the descriptions of the interorganisational/cross-functional meetings are mixed. In addition, as a great many PD activities take place within the daily working STPs, some of these situations are included in the chronological description.

Three cross-functional and five interorganisational meetings have been selected to describe the creation of the TS-document. The bullet points in the grey rounded rectangles in figure 8.8 describe the main subject matters of each of the meetings in question.[38]

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[36] Based on the interview with the technical salesman, 7 December 2009. Please note that the technical salesman is not the aforementioned responsible salesman.

[37] This stance surfaces in one of the interorganisational meetings during the TS-document phase. Referring to this meeting, if been aware of the importance that kk ascribes to this document, he would never have signed it.

[38] Please note that I did not participate in the interorganisational meetings conducted 2 September and 10 September 2009. The descriptions of these two meetings draw on dialogues (summaries of the meetings) with the technical salesman and the project manager occurring 4 September, 10 September and 25 September while I was working in the war room.

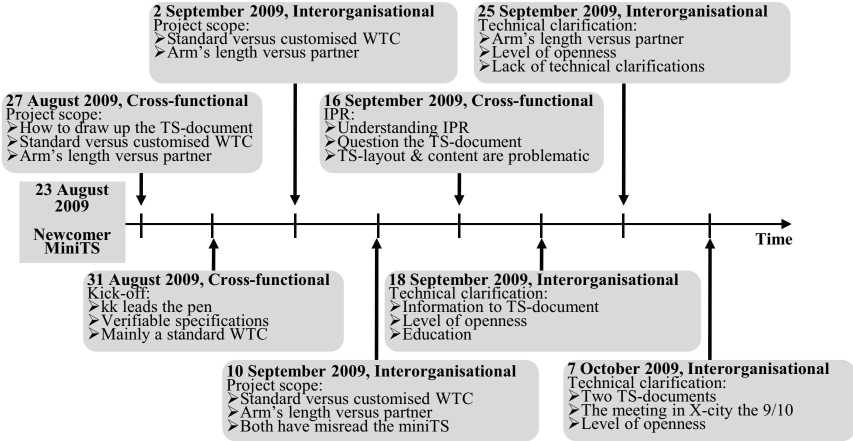


Figure 8.8. The trajectory of the TS-document.

The first meeting is the **cross-functional meeting held 27 August 2009**, in which the technical salesman (Nick) from NBD and four employees from the PD group participate. The intention is to hand over the PD task to the project group.

At present, Nick is employed in NBD, but he has a history within the technical domain. Hence, he has a great deal of technical WTC experience and he is familiar with the technical jargon. For that reason, Nick presents the miniTS which consists of 54 pages. Some of the pages are depicted at the TV screen in the meeting room and he makes use of the blackboard to explain his interpretation of the content.

From an NBD perspective, the WTC being developed and produced is a standard CSIC WTC, whereas the PD group is not satisfied that it will be successful in meeting the needs/wishes of Newcomer. Furthermore, the PD group struggles with how to draw up the TS-document. kk has written a modest number of TS-documents in the past, but according to kk's project manager, this Newcomer project is not comparable with either the CSIC or the Charlie project.

**On 31 August, a kick-off meeting** is held. 24 kk employees participate in this cross-functional meeting. An agenda for the meeting is available and seven topics are addressed; six presentations and one workshop. The presentations are conducted by the CEO for the kk group, the president of kk, the vice president of NBD, the lawyer, kk's project manager and finally, the technical salesman. The six presentations mainly take the form of one-way communication and hence, the discussion is limited. However, many of the participants make notes during the presentations. Naturally, the substance of the six presentations differs. By narrowing down the focus to the guidelines being set out, three themes appear.

First, four of the presenters emphasise that all specifications written down in the TS-document have to be verifiable. The lawyer stresses the importance of writing down all agreements and deviations. In addition, since kk leads the pen when drawing up the TS-document, the lawyer underlines that Newcomer will follow up on this subject matter. The second theme sheds light on the "virtual stock" principle. The CEO says *"we cannot develop from scratch every time"*; the president says *"remember Newcomer has purchased a CSIC WTC with two or three modifications"* and finally, the vice president of NBD emphasises that it is necessary *"to reuse the existing technological platform"*. The third theme deals with the interpretation of the miniTS. The lawyer and the vice president of NBD have participated in the final negotiations and thus have a good understanding of Newcomer's expectations. The vice president says:

> *"it is the first time that we meet such professionalism. They really know what they want. The last part of the negotiation focused solely on technical aspects."* (Vice president, 31 August 2009).

During the **interorganisational meeting held 2 September 2009**, the content of the miniTS becomes the pivotal point. Newcomer's project manager interprets the miniTS to pave the way for a close collaboration and a high level of customisation. Referring to kk's project manager, Newcomer's project manager expects to have the same level of collaboration with kk as he has with Alpha and Bravo. In stark contrast to this viewpoint is kk's interpretation of the miniTS and hence, the meeting is characterised by a great deal of arguing in this regard.

> *"There are different perceptions of what Newcomer has actually purchased. They* (Newcomer, author) *have expected integrated PD equivalent to the collaboration we had with Oldtimer in the past."…"I disagree as we have sold a standard WTC."* (Technical salesman, 4 September 2009).

The dialogues concerning the different perceptions of the miniTS occupy the majority of the interorganisational meeting and the technical clarification is thus minimal.

Obviously, the gap between the different perceptions of the miniTS has to be minimised and a meeting is arranged for that purpose. It takes place in **the war room**[39] **on 7 September 2009.**

| |
|---|
| <u>Meeting in the war room, 7 September 2009</u><br>Rick➔ *they expect us to be experts within electricity, cabling and I/O and that we will help specify the requirements to all other suppliers; a kind of consultancy support.*<br>Nick➔ *Joe* (Newcomer's project manager) *was aware that he was wrong in this regard.*<br>Dean➔ *we have received the questionnaires we sent to Newcomer. Some issues have been clarified, but there are still many doubts and some of them are comprehensive. Compared to the CSIC, we can see some considerable changes* (Dean goes to the blackboard and explains the changes/redesigns).<br>Tom (salesman)➔ *Joe is aware that he has purchased a developed WTC…*<br>Dick➔ *what has been written down in the MoM from the meetings, what have we promised them?*<br>Vice president of the development department➔ *the MoM must not be used to interpret what we have sold. We have to be guided by the content of the miniTS.* |

Three days later, **10 September, an interorganisational meeting** takes place. According to kk's project manager, Newcomer and kk have misunderstood the miniTS. While Joe has considered the miniTS to be non-binding, kk has interpreted it to be too specific.

[39] Please notice that this meeting does not appear from figure 8.8, as it seems to be an informal meeting arranged in the war room where I am sitting. Nevertheless, seven employees participate in this event; two from NBD, four from the PD project group and finally, the vice president of the development department.

The IPR[40] is the theme of discussion in the **cross-functional meeting of 16 September 2009**. The head of research has called this meeting, and he has invited eight participants from different departments. The intention is to discuss how to handle the IPR with respect to the Newcomer project. The reason why it is necessary to take into consideration the IPR is explained by the head of research. This exemplification continues some time until one of the employees from the IPR group asks the head of research:

Cross-functional meeting, 16 September 2009
Employee 1 IPR group➔ *what have we promised Newcomer?*
Head of research➔ *we are responsible for ensuring that all components and solutions that we offer to Newcomer do not conflict with any IPR.*
Rick➔ *what are we going to do? We have to send something to Newcomer later today.*
Head of research➔ *we need to work together in order to handle this.*
Dean➔ *yes, but I do not know all the patents* (body language and voice reveal that Dean is asking for help).
Head of research ➔ (he takes a hardcopy of the TS-document from the table, holds it up and says) *this TS-document is the problem.*

Now the content and the layout of the TS-document become the fulcrum. After one hour during which the discussions have moved back and forth, HW engineer 2 projects the present version of the TS-document on the TV screen in the meeting room. The intention is to scrutinise the present content of the TS-document with a view to potential IPR problems. Nonetheless, the discussion of the content and layout of the TS-document gradually become the focal point again. In sum, no conclusions are drawn as the meeting gradually comes to an end.

Following the signing of the miniTS, a HW and a SW engineer cooperate on formulating some questionnaires and submitting these to Newcomer. The questionnaires request relevant information to be retrieved from Newcomer for the purpose of drawing up the TS-document. In each of the questionnaires, the two engineers have explained the reason why the information has to be retrieved, but they suspect that Newcomer has not understood the questions properly. Referring to HW engineer 2, one reason why they are not able to understand the questions might be due to a lack of knowledge about wind turbines.

Accordingly, the focus of the **interorganisational meeting 18 September 2009** is to retrieve the missing information from Newcomer. Four employees from the PD group and four Newcomer engineers participate in this meeting.

As usual, Dean uses a laptop to depict the TS-document in preparation on the TV screen in the meeting room. The topic to be discussed is highlighted with red letters in this document. For instance, during this meeting, an indeterminacy regarding when to connect/disconnect the wind turbine to/from the grid results in the following:

[40] Intellectual Property Right.

Interorganisational meeting, 18 September 2009
Dean➔ *what is the minimum and maximum generator speed?*
Joe➔ *I don't understand, what do you want to know?*
Dean➔ *number 1 is the minimum generator speed and number 11 is the maximum speed. All the 11 figures are used as input to the SW and hence, it will result in a given reaction. Number 1 will cut off the wind turbine from the grid if the speed is too low and number 11 is used to cut off the wind turbine when the speed is too high. And we really need this information.*
Joe➔ *how do you define the minimum and maximum generator speed, why do you need this…?*
Dean➔ *our SW engineers, they need this information, but I am not able to explain why.*
Rick➔ *I will get Tim* (SW engineer 1).
(After a while, Tim turns up in the meeting room. Dean explains the problems to Tim in Danish).
Joe➔ *why do you need these data? My idea is that kk examines and defines these data* (he points to a graph which he has just drawn on the blackboard in the meeting room).
Tim➔ *I need the data for the SW, but I am not able to explain how to calculate the specific speeds. We need to call Ole* (Ole is SW engineer and converter specialist).
Joe➔ *I want to have specified in the specification that kk decides the minimum and maximum speed.*
Rick➔ *does that mean that you will forward information dealing with the generator to us?*
Joe➔ *oh, you have to define what kind of data you need.*
Dean➔ *you have to define the minimum speed of the generator and the…*
Joe➔ *I cannot understand the problem with the minimum speed. Why don't you use the minimum speed suggested by Alpha to cut off the wind turbine. My point is: why do you need a small band between the minimum speed and cutting off the wind turbine?*
(This dialogue continues until lunchtime and after lunch, Ole turns up).
Ole➔ *it is rather easy to calculate when the speed is within limits; the voltage at the rotor side increases.*
Joe➔ *yes, I see, but we already have the generator at our factory, it has been delivered.*
Ole➔ *yes, I will not change the limits, but I need to understand these in order to make my calculations* (Now an Asian meeting starts and shortly thereafter a Danish one as well).
Joe➔ *how do you make these calculations, I would like to know that.*
Ole➔ *they are not detailed calculations, but I compare the generator that you are using in the wind turbine with the one that I am familiar with.*
Joe➔ *I would like to understand the idea behind how to calculate it…*

The meeting continues in this way until three o'clock in the afternoon without determinacy. In other words, the kk engineers have to make an effort in order to retrieve the missing information. This requires that the explanations be made transparent, but it might be problematic.[41]

Prior to the next **interorganisational meeting scheduled for 25 September 2009**, kk's project manager sends an e-mail to Newcomer's project manager. In this e-mail, Rick presses for the missing information specified in the submitted questionnaires. Among other things, the e-mail says that a consequence of the missing information might be a delay of the project. In addition, a draft version[42] of the TS-document is handed over to Newcomer before the meeting.

The draft version of the TS-document and the e-mail provide a breeding ground for a long-lasting dialogue dealing with the transparency of the technical specifications written in the TS-document; besides, doubts concerning the level of collaboration turns up once more.

[41] *"The biggest challenge for me when explaining the functionalities of our solution is actually to know to which detail I am allowed to explain a specific solution."* (HW engineer 1, 9 December 2009).
[42] Please remember that the two organisations have agreed to let kk lead the pen and hence, the PD project group is responsible for drawing up the TS-document. This work takes place in the war room between meetings.

*"If we continue with this kind of TS-document, I am not able to come up with any suggestions. The present way of working forces me to merely follow your solutions and ideas"…"If you just explain the solutions in the TS-document, I am unable to gain knowledge of the functionalities. And it is crucial for me to understand how we can differentiate our solutions from those of our competitors within the wind turbine industry."* (Newcomer project manager, 25 September 2009).

The reaction from Rick is to emphasise that *"we are a supplier of a WTC, but we are not a supplier of detailed specifications"*. The divergent interpretations of the miniTS become an issue in the dialogue. Consequently, the technical clarification in this interorganisational meeting is very limited. However, at the end of the meeting, the two project managers agree to have Newcomer send the missing information the following Tuesday.

The day for the signing of the TS-document in X city draws near. However, one week before this event, a radical change of the TS-document is announced; that is to say **2 October**. Consequently, the TS-document is divided into two rather distinct documents, a TS-document and a TS-test-document, respectively.[43]

*"We finished the TS-document last Friday* (2 October, author) *in accordance with the agreed timetable, implying that we could send the TS-document to Newcomer"…"But then the head of research came by and he insisted on changing the TS-document. It is extremely annoying that we have to rewrite the TS-document as the contract is planned to be signed on Friday* (9 October, author*) and Joe has invited a great many of Newcomer's employees*[44] *to participate in this event. These dates were fixed a while ago."* (kk project manager, 7 October 2009).

The modifications of the TS-document have much in common with the proposal put forward by the head of research in the cross-functional meeting 16 September 2009 – the aforementioned IPR meeting. Retrospectively, all the interviewed kk employees agree that the modifications have improved the TS-document; however, the process has been frustrating.

The above modification of the TS-document puts pressure on the PD project group. Hence, the engineers have been working around the clock since Monday this week in the endeavour to rewrite the technical specification and thus divide it into two TS-documents. This effort makes it possible to hand over a part of the modified TS-document(s) to Newcomer's project manager prior to the scheduled **interorganisational meeting 7 October**,[45] allowing Newcomer's engineers to be properly prepared.

kk's project manager initiates this meeting by explaining why the technical specifications have been divided into two TS-documents and naturally, Newcomer's project manager has some comments in this regard. However, Joe does not even mention the modification of the TS-document(s). Instead, he focuses solely on the meeting in X City the day after tomorrow. Briefly, Joe wants kk to take part in the presentation of the technical solutions at this meeting.

[43] This is conveyed to Newcomer's project manager the same day in an e-mail in which Rick explains the reason why it is necessary to change the lay-out as well as the content of the TS-document(s).
[44] Joe has invited 17 employees including the vice president to the event taking place at an expensive hotel in X city.
[45] Concurrently with this meeting, a great many PD activities take place in the war room. The kk engineers are still working on the TS-documents; i.e. the specifications are not finished two days before signing the contract.

In particular, he wants the PD group to *"explain why the kk solutions result in a more cost-effective and reliable wind turbine compared with the competitors' solutions."*.

Even though kk made the presentation as requested by Joe, the meeting in X city does not result in a signing of the TS-document. During the meeting, it becomes apparent that Joe is not authorised to sign the contract; instead, it has to be done by a couple of his managers.

The managers do not have a detailed technical understanding and furthermore, they do not have the time to closely read 400 pages of technical description. For that reason, Joe makes a summary of the TS-document. This carries some minor modifications of the TS-document; in general, the requested changes encompass only misspellings, grammar and the layout of text and tables. In addition, Newcomer will only sign the front page of the TS-document.

Accordingly, kk's project manager doubts that Newcomer has read the TS-document closely and calls in question if they have been able to relate to the content of the TS-document.

Despite the above challenges, the WTC to Newcomer is created within the agreed-upon timeframe. The next case addressing the A80 illustrates another situation as the A80 park server is hardly mentioned during the miniTS or TS-document phases.

## 8.7. The A80 park server case[46]

The A80 park server is an application that makes it possible to monitor the wind turbine and ensure data gathering. A park server consists of various HW and a great deal of SW.

As mentioned elsewhere, the HW and SW engineers do not belong to the PD group and they are not sitting in the war room; however, the project manager, Rick, is still responsible for the creation of the A80. In relation to NBD, the park server experience is limited to two newcomers, CSIC and Charlie. The two park servers have much in common.

The case starts with an overview of the necessary information to be collected from Newcomer in order to create a park server. Subsequently, the trajectory of the creation is outlined; first the miniTS phase, next the TS-document phase and finally, the actual making after the signing of the TS-documents.

### 8.7.1. Crucial information to be retrieved from Newcomer

As one of the functions of a park server is to gather data, a database for saving those data is necessary. If using a database, it is mandatory to buy SW licences, e.g. an SQL licence, and the number of SW licences to be purchased depends on the number of clients being connected to the park server. Hence, one factor influencing the price of a park server is the number of wind turbines to be connected to it. Addressing the HW, the majority of the components built into the park server are purchased from external suppliers; these HW components are the main determinant for the price of the A80 park server. The number of components to be purchased depends on how many functions are to be handled by the park server as well as the

[46] The park server is often denoted SCADA; an abbreviation for Supervisory Control And Data Acquisition.

requisite redundancies. In addition to the SW already embedded in various HW components, kk designs its own SW to be downloaded in the park server.

Referring to HW engineer 3, it is crucial to achieve a good understanding of Newcomer's needs, as there is a clear correlation among the four elements depicted in figure 8.9. Consequently, in order to create a park server fulfilling Newcomer's needs/wishes, it is necessary to gather information dealing with the functionality, the number of necessary redundancies and the number of wind turbines being monitored by the park server.

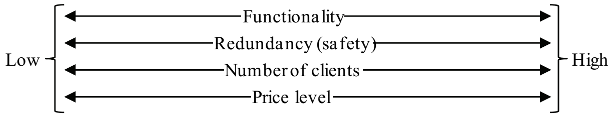


Figure 8.9. Necessary considerations when clarifying the customer's needs.

HW engineer 3 creates A80 park servers to Oldtimer as well. He regards these park servers[47] as being the most outstanding solutions available intraorganisationally in kk. In contrast, he considers the A80 being designed to Newcomer to belong to the other end of the spectrum.

> *"There is nothing in this breaker panel; it is as simple as it can be. It is not a park server as you cannot control a wind turbine park with one server having so little backup security"..."It is just a breaker panel for gathering data."* (HW engineer 3, 8 December 2009).

The next three subsections address the interplay among the employees defining the A80.

### 8.7.2. The miniTS-phase

During the miniTS phase, the A80 park server is handled by the salesman and Newcomer's project manager. In this regard, the salesman considers the technical support for achieving the technical clarification as an area where there is room for improvement.

> *"The park server is created by Leo* (HW engineer 3, author) *and he pieces together the breaker panel, while Frank* (SW engineer 2, author) *makes the SW. In the sales phase, we need input from HW, SW and from the production as well, but they do not talk with each other."* (Salesman, 4 December 2009).

The salesman completes the pre-clarification with Newcomer's project manager and draws up the miniTS dealing with the A80. In accordance with the miniTS, the A80 is a copy and paste from the CSIC 2.0 MW project. HW engineer 3 acknowledges that he was approached about the A80 to Newcomer.

> *"You see, they* (the salesman, author) *contacted me a Friday afternoon about half past one o'clock. They asked whether the park server being used in the China project could be used in the Newcomer project"..."Of course, it will work, or at least the HW will work, but I do not know where the park server is placed or what they want to put into it. But I gave them the price of the park server that we created for the China project."* (HW engineer 3, 8 December 2009).

[47] According to HW engineer 3, 8 December 2009, the park server designed for Oldtimer is much more complex and capable of handling far more functions than the one created for CSIC and Charlie.

kk's project manager considers the interorganisational pre-clarification of the A80 park server to be rather problematic and consequently, he clearly doubts the validity of the information gathered with regard to Newcomer's needs/wishes.

> *"I do not think the customer has spent much time on the park server and honestly, I do not think that we have made enough of an effort to explain to him* (Newcomer's project manager, author) *what he will get. Furthermore, I do not think that we know what is included in a park server and what to offer to our customers. For NBD, a park server is just a thing."* (kk project manager, 9 December 2009).

### 8.7.3. The TS-document phase

Addressing the period in which the TS-document is drawn up, the A80 is mentioned twice;[48] once in a cross-functional meeting and once in the war room. Hence, the A80 is not a subject matter in the interorganisational meetings.

The first time that the A80 is discussed is at the cross-functional meeting on 27 August 2009, the purpose of which is to identify the scope for the PD project. The miniTS is the focal point of the presentation. During a dialogue concerning the interface problematics between HW and SW, Nick emphasises that the PD project group has to remember the SCADA interfaces (the A80). The comment from Nick does not prompt any doings in this regard and hence, the A80 topic fades away.

The second time that the A80 park server becomes a topic is on 8 October 2009. kk's project manager is working at his desk in the war room and, just after lunchtime, the salesman turns up. The following dialogue addresses the TS-document and especially the increased price level. The pivotal point is the deviations between the calculation in the miniTS and the cost level indicated in the TS-document. The A80 park server becomes an issue in this regard. However, the only topic being discussed is the missing SW development costs.

As the A80 park server only receives little attention during the TS-document phase, the technical pre-clarifications retrieved during the miniTS phase are not refined.

### 8.7.4. The creation of the A80 after signing the TS-document

Shortly after receiving the signed TS-document from Newcomer, a cross-functional start-up meeting is arranged. The two responsible engineers participate; HW and SW. Given that all breaker panels are listed on the project plan being depicted at the TV screen in the meeting room, the A80 becomes a subject matter. This dialogue deals with whether or not the SW engineers have the necessary time to make the SW; apparently, it is not a problem for the SW engineers to meet the deadline. However, at the very end of this meeting, the kk project manger indicates with his body language that he wants HW engineer 3 to remain seated and just after the other participants have left the meeting room, the following dialogue takes place:

[48] Please bear in mind that I am only able to comment on what happened when I was physically present; that is to say, in the interorganisational and cross-functional meetings and while sitting in the war room.

| |
|---|
| Cross-functional meeting, 28 October 2009<br>Rick→ *I am not quite happy with the park server situation…*<br>Leo→ *yes, I fully agree that we have a problem with the solution that we have offered to Newcomer.*<br>Rick→ *how is the price calculated? Actually, we have sold it below our cost price. Who has calculated this price?*<br>Leo→ *I have calculated the price, but it draws on information that I received from Tom* (the salesman, author). *He and another guy contacted me to have a price. And we had the CSIC solution and they asked for the price of this solution. But it is just a server and it cannot control a park of wind turbines. This solution is too simple to sell, but we have just carried on with this solution.*<br>Rick→ *yes, and now we stick to a solution for which we are not even able to get the cost price.* |

Since HW engineer 3 considers it to be an inappropriate technical solution, he draws up a proposal for a park server that meets a minimum functionality requirement while being as cheap as possible. Undoubtedly, he considers it to be a challenge as:

> *"I designed a very affordable park server. The cabinet was much cheaper than the one normally being used. But when I was finished, they came by and now they wanted to include new functionalities and obviously, that costs."* (HW engineer 3, 8 December 2009).

It is decided to hold Newcomer indemnified for which reason kk defrays all additional expenses with respect to the A80. In an attempt to find an appropriate approach in this regard, two cross-functional meetings are conducted. The two meetings take place on 30 October and 5 November 2009 and the participants are from the NBD and the PD project groups. Initially, the dialogue focuses on whether or not the SW licenses are included. However, HW engineer 3 has been instructed to reduce the cost price as much as possible. Apparently, it has resulted in a great deal of doubt as to the necessary functionality of a park server. Consequently, the majority of the dialogue concerning the A80 does not revolve around the price issue; rather the functionality of a park server becomes the pivot.

The involved kk employees agree that the PD of the A80 has been miserable. The technical employees describe the problem to consist in a blurred understanding of Newcomer's needs/wishes. The information retrieved by the salesman is inapplicable for designing the A80. NBD acknowledges to have specified a China solution in the miniTS; the functionality of the proposed A80 will therefore be limited. On the other hand, as the pre-clarifications draw on a previous project, NBD expects the technical solution to be acceptable and thus the handed-over price to be believable.

## 8.8. Summary of the two narratives and four embedded cases

The objective of chapter 8 was to form the basis for the analyses in the following two chapters.

Two narratives are presented and in each of these, two longitudinal cases are embedded. Each of the two narratives sheds light on different STPs making it possible to identify and analyse the characteristics enabling or constraining the learning process. Each of the four embedded cases describes how the PD unfolds in a time perspective; i.e., the trajectory of a breaker panel case. It paves the way for analysing the process characteristics in relation to the life story of the PD of a breaker panel. By addressing the various STPs as well as the unique trajectories of the breaker panel cases, it becomes possible to analyse the learning process.

The Oldtimer narrative deals with a PD project characterised by three decades of collaboration. The various STPs are mutable; be it a repositioning of the location from a meeting room/office to the production area as well as the use of a great many electrical diagrams and drawings. The scope of the PD task changes. The two embedded cases are examples in this regard. While the A24 breaker panel case addresses the creation of a new breaker panel, the A21 breaker panel case exemplifies the creation of a new version of a well-known breaker panel. The chronological presentation of the two cases shows that a great many changes take place during the PD. However, the changes are moderate and constitute a continuous adjustment of the trajectory.

The Newcomer narrative deals with a PD project marked by collaboration still in its infancy. The number of breaker panels included in the PD project does not change; however, the kk engineers call in question the technical platform being specified in the miniTS. Hence, the applied technical platform is radically changed, prompting a radical change of the trajectory. The WTC case addresses the consequence of changing the trajectory just after signing the miniTS, while the A80 park server case focuses on a change in the trajectory after signing the TS-document. To demonstrate these changes, the two cases are presented in chronological sequence.

The next two chapters analyse each of the two PD projects; Oldtimer in chapter 9 and Newcomer in chapter 10. The first part of the analyses in both chapters draws on a thematic approach in the attempt to understand the composition of the different STPs. These analyses focus on identifying the constitutive means and the role of these in relation to whether they enable or constrain the transformation of an indeterminate situation into a determinate situation. The second part of the analyses makes use of the chronological presentation of the cases to grasp how the engineers in a time perspective make use of the constitutive means to transform an indeterminate situation into a determinate situation; that is, learning within a PD working practice.

# Chapter 9. Analysis of Oldtimer

This chapter analyses learning when conducting Product Development (PD) of a Wind Turbine Control (WTC) to Oldtimer. The objective of the chapter is to identify and thereby obtain an understanding of which characteristics enable or constrain the learning process when conducting PD of a WTC.

The first part of the analysis is thematic. It focuses on identifying enablers and constraints for learning when conducting a PD activity (PD strip of doings) within an interorganisational, cross-functional or daily working composition of the SocioTechnical Practices (STPs). The second part of the analysis is chronological. It addresses a sequence of events to understand how the engineers are conducting a PD strip of doings within different composition of the STP.

During the analysis of characteristics enabling or constraining the learning process, the subject matters in the rightmost column of figure 9.1 gradually emerge. Thus, to meet the above objective, these subject matters become the means I use to guide my reflective thinking[1] throughout the analysis of enablers and constraints. The uppermost box contains the focal points for the first part of the analysis, while the issues in the lowermost box are used in the second part of the analysis.

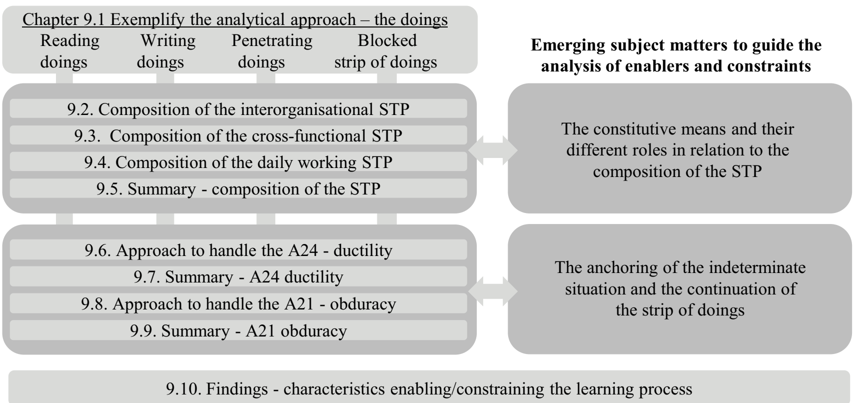


Figure 9.1. The analytical approach and the structure of chapter 9.

Section 9.1 explains the different doings employed to accomplish the analysis, upon which the Oldtimer project is analysed. Sections 9.2-9.5 address the composition of the STP, while sections 9.6-9.9 analyse the approaches being applied to create the A24 and A21 breaker panels. Section 9.10 combines the above analyses and presents the findings.

Throughout the analysis, terms written in *italics* are explained in chapter 7, table 7.1, while underlined terms written in *<u>italics</u>* are explained in chapter 6, table 6.1.

[1] For an elaboration, I kindly refer to section 3.9.

## 9.1. The doings – reading, writing, penetrating and a blocked strip of doings

Jack is the technical project manager of the Oldtimer PD project. He is in charge of the technical clarification taking place internally in the kk project group, for which reason he does extensive preparatory work before each of the interorganisational *STP*s.

Turning to the interorganisational *STP* on 21 August 2009, Jack has connected his laptop to the TV screen in the meeting room before the other participants show up. A Word document containing the pre-clarifications is depicted on the TV screen; the "track changes" feature available in the Microsoft Office Word application has been activated. All indeterminate requirements/specifications are thereby indicated by red lettering. Jack directs the other participants' attention to the indeterminacy depicted on the TV screen. Naturally, they read the text and these *reading doings* guide the *strip of doings*. Often, it is necessary to depict diverse electrical diagrams, drawings or other kinds of information. By doing so, all participants have the opportunity to read and interpret diverse *constitutive means*; this is an example of the first of the three doings – the ***reading doing***.

At the meeting in question, the reciprocal interchanges enable to achieve determinate specifications; a *successful strip of doings*. Consequently, Jack writes it directly into the online document by using the track changes feature in Microsoft Office Word; an example of the second doing – the ***writing doing***.

To carry out a *strip of doings*, it is necessary to have information accessible. Three distinct situations are elaborated: First, the necessary information can be predicted; second, the information accessible within the *STP* is not sufficient, but the employment of IT[2] systems makes it possible to retrieve the missing information; third, a situation similar to the previous one, but this time, it is not possible to retrieve the missing information from external sources.

First, let us start with an example of a situation where the requirement for information is predictable.

> *"The meeting frequency is changed from fortnightly to once a week. Henceforward, Steven will participate in the meetings. Responsible for inviting Steven is Andy."*[3] (Minutes of Meeting (MoM), interorganisational meeting, 13 August 2009).

The reason for Steven[4] to participate in the upcoming meetings is that the cabling between the breaker panels becomes an important issue. Steven has critical <u>experience</u> in this regard.

Second, an <u>indeterminate situation</u> regarding an emergency stop initiates a *starting doing* between Andy and Steven (the two Oldtimer employees) for the purpose of retrieving the missing information. After a while, Andy finds his notebook, turns the pages and starts counting (*reading doing*). In the meanwhile, Steven uses kk's wireless network to connect his laptop to Oldtimer's intranet. By searching in the Oldtimer database, Steven retrieves the specifications of the emergency stop in question. Steven mentions these specifications, which

[2] IT is an abbreviation for Information Technology.
[3] Oldtimer's project manager on the 3.0 MW WTC.
[4] Employed at Oldtimer, Steven is responsible for all external cabling. Steven takes an active share in a number of interorganisational *STP*s until the breaker panel cabling is fixed.

prompts Jack to use his laptop to search for information about the specific emergency stop. By penetrating this specific *STP*, the missing information is made accessible; it is a ***penetrating doing*.**

Third, an example of the opposite situation is perceptible within the same *STP*. A *strip of doings* involving Jack and Andy takes place as they attempt to agree on the pre-clarifications. The electrical diagram depicted on Andy's laptop is the point of reference for the *reading doings*. In addition to the spoken words, Andy and Jack apply body language and make handmade sketches (*writing doings*) as a means to enable a continuation of the *strip of doings*. However, after a while Andy says:

> *"oh, I can see this electrical diagram is not updated, so I have to discuss it with one of my colleagues."* (Interorganisational meeting, 13 August 2009).

The information necessary is not accessible, and at present it is not possible to retrieve the missing information by conducting a *penetrating doing*. The missing information results in the *strip of doings* becoming *blocked*; a ***blocked strip of doings***.

The next three sections analyse the composition of three *STPs*. The analysis centres on identifying the *constitutive means* and their different roles in relation to the composition of the *STP*. First, the interorganisational *STP* is analysed, after which the cross-functional *STP* is examined and finally, the daily working *STP* is the focal point. A summary of the analysis is presented in section 9.5.

## 9.2. Composition of the interorganisational STP

It is possible to identify different composition of the *STP* within each single meeting. The composition of the *STP* to ensure the administrative clarifications between kk and Oldtimer is subject to an analysis in section 9.2.1. In relation to the technical clarification, the physical setting is still the meeting room, yet the *constitutive means* being applied to enable the *strips of doings* are replaced. It results in a different composition of the *STP*, which is analysed in section 9.2.2. The repositioning of the meeting to the production area results in a new composition of the *STP*. The physical setting is changed and another group of *constitutive means* is brought to the fore, which will be the focal point of section 9.2.3. The analysis draws on an interorganisational meeting conducted 2 December 2009. It is a meeting just like any other interorganisational meeting, and it starts in the meeting room; however, today Kevin acts as the technical coordinator as Jack is on vacation.

### 9.2.1. STP addressing administrative clarification in a meeting room

Mick starts the meeting by drawing attention to information[5] missing from Oldtimer:

[5] The administrative procedures at kk as well as Oldtimer necessitate that the above data are accessible before a breaker panel can be delivered; actually, a deviation results in Mick having to *block the strip of doings*.

> *"as we have received the PO number* (Purchase Order, author) *and the Oldtimer part number, the A24 breaker panel will be delivered according to plan. Regarding the 215363MO, we have received the PO number, but so far we have not received the Oldtimer part number; and for the PMSG test breaker panel, we have neither received the PO number nor the Oldtimer part number."* (kk project manager, 2 December 2009).

Mick and Andy conduct *reading doings* of the updated project[6] plan. The project plan is a *constitutive means*, and it has a constitutive effect within this particular *STP*; however, from time to time, Andy reads in his notebook to find information and Mick reads MoMs of previous meetings. These *constitutive means* enable a continuation of the *strip of doings* until determinacy is achieved. The achieved *determinate situation* results in a *writing doing* being carried out in the MoM by Mick,[7] while Andy makes a note in his notebook.

The *constitutive means* are the updated project plan, notebook(s) and MoMs from previous meetings. The *writing doings* conducted in the project plan, MoM and notebook(s) due to the *successful strip of doings* make it possible to *sustain* the achieved determinacy. As the achieved determinacies are written into these *constitutive means*, the role of these is to illustrate the *trajectory* being charted.

### 9.2.2. STP addressing technical clarification in a meeting room

The next phase deals with technical clarifications in the meeting room. Two minor deviations are perceptible; as mentioned earlier, Kevin acts as technical coordinator today and the laptop is not used to display technical issues on the TV screen. Instead, Kevin brings along ten to fifteen electrical diagrams of the PMSG test breaker panel. In a deliberate attempt to make these the focal point for the *reading doings*, Kevin places these *constitutive means* at the meeting table right in front of Andy. Kevin explains how kk has designed the electrical part; he finds one of the diagrams and says to Andy *"here we have 230 voltages, and here we have 24 voltages…"*. Simultaneously, by using a pencil to conduct a *writing doing*, he makes two curly brackets on the electrical diagram in front of Andy. Andy reads this electrical diagram and asks *"where are the interfaces?"*. Kevin finds a new set of electrical diagrams, which are painted over with a yellow marker, and he explains it. The *strip of doings* continues for a while, until Andy, while pointing with his finger at a specific area on the electrical diagram, says *"aha, I can see, it is not in accordance with our wishes…"*. Kevin says *"yes, I see"* and he performs a *writing doing* in his notebook.

The electrical diagrams are the *constitutive means*. These *constitutive means* are the focal point for ongoing *reading* and *writing doings*. The ongoing *reading* and *writing doings* cause disturbance within the *habitual experience* and thereby activate the *reflective experience*. This activation of Andy's *reflective experience* leads to a continuation of the *strip of doings* and thus *writing doings* into the MoM and notebooks. The role of the electrical diagram is to

[6] Today, the plan is not displayed on the TV screen, but Mick has brought along a hardcopy of the plan.
[7] Just after the meeting, Mick updates the project plan, which can be retrieved by all internal project members as the plan is downloaded to kk's intranet.

enable and guide the *strip of doings*, while the MoM and notebooks are applied to *sustain* an achieved determinacy.

### 9.2.3. STP addressing technical clarification in the production area

In the third phase, the meeting is repositioned to the production area to examine the physical PMSG test breaker panel. By doing so, a rather different composition of *STP* is formed. Today, Andy sees the physical breaker panel for the first time.[8] In the production area, Andy walks around the breaker panel, he stops and then dismantles a cover and looks at a component. The physical breaker panel is the *constitutive means* for his *reading doings*. After a while, his *reading doings* shift to another part of the breaker panel; the three huge cobber bars, which go down from the top of the breaker panel to a big component – the maximum circuit breaker.[9] Andy looks carefully at the space between the cobber bars and especially the isolator between these; these *reading doings* initiate the following *strip of doings*.

Andy finds a measuring tape at the workbench and does some measurements, after which he suggest a modification to prototype worker 3. Prototype worker 3 is experienced in assembling breaker panels, for which reason he takes a carpenter's ruler, points at the isolators and says, *"no, it is not possible, but what is your concern?".* Andy draws on his *experience* and says, *"I am afraid of short circuits."*. Different solutions are proposed, but it is not possible to continue the *strip of doings*. Therefore, Andy conducts a *writing doing*. He makes a sketch and suggests a solution, but something apparently conflicts with his *experience* as he says *"maybe there are some guidelines for the necessary space?"*. A *penetrating doing* is accomplished; Andy places his laptop on the workbench and uses kk's wireless network to connect to a technical standard that describes the recommended space between cobber bars. This retrieved *constitutive means* enables a continuation of the *strip of doings*. Andy, Kevin and prototype work 3 make a number of measurements on the breaker panel and, from time to time, they conduct *reading doings* in the standard depicted on the laptop screen. At last:

> *"if we turn the copper bars 90 degrees and fix them to this part of the frame and enlarge the isolators between each of the copper bars, it meets the requirements."* (Oldtimer project manager, 2 December 2009).

When repositioning the *STP* to the production area, the composition of the *STP* changes. First, instead of sitting in a meeting room with a cup of coffee, Andy, Kevin, Mick and prototype worker 3 are standing in a production area. Naturally, the working setting changes as other activities take place next to the PMSG breaker panel. Second, the constitutive effect from the physical breaker panel exceeds the constitutive effect from, for instance, a drawing. Third, the *constitutive means* include various hand tools, the drawing up of sketches, a mobile phone and a laptop used to conduct *reading doings* of external standards. Fourth, the temporary involvement of employees belonging to different functions and the varying physical settings

[8] The PMSG test breaker panel has been an issue in a number of previous meetings, where different kinds of electrical diagrams, sketches and drawings have been used by Andy and Jack for creating the specifications.
[9] This maximum circuit component is not identical to the maximum circuit breaker panel described in one of the two Oldtimer cases, namely the A24 case in section 8.3.

influence the composition of the *STP*. Thus, the composition of the *STP* is mutable, and it requires some *effort* to transform the *indeterminate situation* into a *determinate situation*.

The enabler for the *strip of doings* is the accessibility of diverse and usable *constitutive means*. Unlike the *reading doings* of drawings in a meeting room, the constitutive effect of the physical breaker panel enables to cause disturbance within Andy's *habitual experience*, triggering the *reflective experience*. The role of the *constitutive means* differs. The physical breaker panel and drawings enable and guide the *strip of doings*. The laptop and mobile phone facilitate the *strip of doings*, for instance as tools to assist information retrieval. The MoM and notebooks are applied to *sustain* determinacy, thereby ensuring the *trajectory*.

### 9.2.4. Comparing the STP formed 2 December with "standard STP"

The above analysis addresses the composition of the *STP* being formed 2 December 2009, but the meeting is only one out of 18 interorganisational clarification meetings in which I conduct observations. The 18 meetings are termed "standard *STP*", and by comparing these with the *STP* being formed 2 December, three issues stand out.

First, Kevin replaces Jack. This does not have any consequences in terms of fulfilling the purpose of this specific meeting – the PMSG test breaker panel. Nevertheless, during the technical clarification in the meeting room *STP*, Andy attempts to *anchor* an *indeterminate situation*. It deals with modifications/changes of the A3 and A23 breaker panels, as Oldtimer needs to install a number of frequency converters. A *strip of doings* is initiated, but after a while, Andy *blocks the strip of doings* as he says:

> *"I suggest that we have a meeting on Monday when Jack returns from his vacation."* (Oldtimer project manager, 2 December 2009).

The *experience* critical to continue the *strip of doings* is not accessible within the present *STP*. As pointed out elsewhere, Jack is the technical linchpin and obviously, his *experience* is critical for enabling achievement of a *determinate situation*. Hence, in addition to diverse *constitutive means*, the engineers demonstrate heterogeneity; they have different levels of *habitual/reflective experience* influencing the composition of the *STP*.

Second, only two *penetrating doings* are accomplished at the 2 December meeting. Normally, the laptop is frequently used to connect to different databases[10] and the mobile phones ring several times during a meeting. These two instruments are often used to retrieve missing information beyond the boundaries of the particular *STP*, improving the accessibility of *constitutive means*; consequently, these influence the composition of the *STP*.

Third, in the *STP* being formed on 2 December, the laptop is not used to depict any *constitutive means* on the TV screen. Instead, the participants make use of hardcopies of the project plan, drawings and/or electrical diagrams as *constitutive means* to enable the *strip of doings*. In the "standard *STP*", the engineers depict 2D and/or 3D drawings, electrical diagrams or pre-clarifications on the TV screen; it is an interactive process, in which the engineers apply IT system functions as instruments to enhance and facilitate *reading doings*.

[10] Mainly Oldtimer's intranet, kk's intranet or different suppliers' homepages.

In general, the laptop/TV screen/drawings act as the *constitutive means* for enabling the *strip of doings*.

Referring to the Oldtimer narrative in section 8.1, another kind of interorganisational *STP* is established during the PD project. This interorganisational *STP* focuses on verifying whether or not the physical breaker panel(s) and product documentation are in accordance with Oldtimer's requirements. The next section sheds light on this interorganisational *STP*.

### 9.2.5. Composition of interorganisational STP addressing FAI verification[11]

The production area is the physical setting for the interorganisational *STP*. As James, the responsible A21 engineer, does not participate in this meeting,[12] Jack answers questions concerning technical subject matters. After a while, Andy says:

> *"as I remember, we agreed upon changing this circuit."* (Oldtimer project manager, 8 October 2009).

Andy conducts a *reading doing* in his notebook, while Jack conducts *reading doings* in electrical diagrams and inside the physical A21 breaker panel in an attempt to recall the necessary *experience*. The *reading doings* fail to activate the *reflective experience*, for which reason the *strip of doings* becomes *blocked*. After a while, Mick proposes to take a look inside a semi-similar breaker panel.[13] Thus, the participants move across the production area and conduct *reading doings* on a particular technical solution inside the A2.[14]

The comparison between the electrical diagrams and the two breaker panels – the A21 and A2 – is the *constitutive means* to enable a continuation of the *strip of doings*, and thus a discrepancy emerges. This discrepancy results in Mick performing a *penetrating doing*, as he calls James in order to retrieve the necessary information. It turns out that James is aware of the agreed-upon change, but it has not been implemented yet. Hence, a *writing doing* is conducted in notebooks and the MoM. A similar *indeterminate situation* occurs later on. Again, Mick performs a *penetrating doing* and calls James.

Although the physical breaker panels, drawings and electrical diagrams are usable *constitutive means*, the present *experience* within the *STP* constrains a continuation of the *strip of doings*, by which it becomes *blocked*. Undoubtedly, Andy and Jack have extensive WTC *experience*, but in relation to this specific update of the A21, they lack *experience*. It underlines the fact that the engineers demonstrate heterogeneity. In addition, the *STP* is constantly mutable; repositioning to a "similar breaker panel – the A2", phone calls, *reading doings* on diagrams,

[11] The analysis draws on the A21 case; section 8.4 "interorganisational FAI conducted 8 October".
[12] Referring to section 8.2, the 2.3 MW wind turbine also makes use of the A21 breaker panels. Due to the fact that changes are going to be implemented in the 2.3 MW wind turbine, the responsible 2.3 MW project manager at Oldtimer has asked James to participate in these updates.
[13] Initially, the A21 was divided into two separate breaker panels, an A1 and A2. While the 2.3 MW and 3.0 MW wind turbines make use of the joined version (the A21), the 3.6 MW still uses the A1/A2. I kindly refer to section 8.4 dealing with the A21 case for an elaboration.
[14] The dialogue box in section 8.4 dealing with the A21 elaborates on this dialogue taking place 8 October 2009.

etc. Furthermore, notebooks and MoMs are frequently applied as *constitutive means* to recall experience.

In sum, it is in fact misleading to use the term "standard *STP*" in section 9.2.4 as none of the observed composition of the *STP* is identical. Instead, it is a constantly mutable composition of the interorganisational *STP* that enables a continuation of the *strip of doings*. The next section continues in the same vein; however, the focus changes to the cross-functional *STP*.

## 9.3. Composition of the cross-functional STP

In the beginning of the project, the technical project manager's (Jack) office is located at the first floor, while the other members are located at the ground floor. This occasions a lot of going back and forth between Jack and the PD group. In the midst of the project period, the PD group is relocated, and Jack and the engineers are now sitting next to each other in the same office; a new composition of the daily working *STP* is established. The relocation increases the physical proximity. It reduces the need for clarifications/coordination during the cross-functional meetings, as the majority of the indeterminacies are handled then and there in the office. It causes a change in the composition of the cross-functional clarification *STP*. Thus, the analysis must be alert to the fact that there is different *STP* composition. First, the composition of the pre-relocation *STP* is analysed, followed by an analysis of the composition of the post-relocation *STP*. Finally, two cross-functional meetings addressing the verification will be analysed.

### 9.3.1. Composition of the cross-functional STP before the physical relocation

Prior to the physical relocation, a cross-functional meeting regularly takes place in immediate continuation of an interorganisational meeting.[15] The objective of the cross-functional meeting is to facilitate a convergent interpretation of the *indeterminate situations* to be handled, making it possible to finish the *strips of doings* elsewhere; that is, when the engineers conduct doings within the daily working *STP*.

Drawing attention to an *STP*[16] being formed 26 June 2009, the agenda addresses an update and handover of technical issues discussed at a recently conducted interorganisational meeting. Electrical diagrams are depicted on the TV screen as *constitutive means*. A connection from a specific component to another component is examined by using a great many electrical diagrams to conduct *reading doings*; a Computer Aided Design system called PCschematic[17] facilitates this. Although Jack is the one using the laptop, ongoing *reading* and *writing doings* enable the *strip of doings*; for instance, *"Jack, please find the diagram showing"..."or what happens if we...?"*. In addition to this triadic interplay between TV screen, laptop and PCschematic employed to facilitate a continuation of the *strip of doing*, hardcopies

[15] Jack acts as a kind of technical gatekeeper, and normally, only few of the other engineers participate in the interorganisational meetings with Oldtimer.
[16] Eight kk employees participate.
[17] PCschematic is an interactive programme insofar as if the engineers want to see/understand a specific connection among the many connections displayed, they simply click the mouse button and the system depicts a more detailed electrical diagram.

of diverse specifications are placed on the table. Pencils are used to conduct *writing doings*, as for instance sketches and lines, on these *constitutive means*. It is the ongoing *reading* and *writing doings* on the *constitutive means* that enable the *strip of doings*.

The composition of the cross-functional *STP* is a well-structured composition. The engineers apply diverse and usable *constitutive means*. These means enable a continuation of the *strip of doings* until the engineers reach common ground in relation to the substance of the *indeterminate situation* to be handled. Once common ground is reached, the *strip of doings* is deliberately put on standby and the learning process is thus constrained. As *constitutive means* to *sustain* the convergent interpretation, comments are made in notebooks and in the MoM; last but not least, the *writing doings* on the hardcopies of electrical diagrams and sketches are crucial in this regard.

### 9.3.2. Composition of cross-functional STP after the physical relocation

The composition of the *STP* is subjected to modification due to the relocation. For instance, in the meeting conducted 4 September 2009, Jack gives a summary of the interorganisational meeting conducted the day before. The following round-table discussion deals with administrative issues rather than technical clarifications. No one brings along a laptop or drawings/electrical diagrams; actually, the only *constitutive means* placed on the table are the participants' notebooks and pencils.

The composition of the *STP* has changed; now, the doings within the cross-functional *STP* merely deal with the handing over of information.

### 9.3.3. Composition of cross-functional STP addressing FAI verification[18]

As the verification takes place in the production area, the composition of the *STP* unfolds in the production. A mandatory checklist is strictly followed during the verification. kk's project manger reads aloud each of the issues to be verified, whereupon the alignment between the breaker panel and the documentation is examined. Three *indeterminate situations* are highlighted in the following. First, a *starting doing* is triggered by Mick as he says:

> *"according to the delivery specifications, there is an interface to the A3, A23 and A24 breaker panels; how is this designed?"* (kk project manager, 5 October 2009).

James[19] takes a good look at a particular area inside the breaker panel, but this *reading doing* does not cause disturbance in his *habitual experience*, and he is thus not able to call to mind the particular design.[20] Jack finds a number of electrical diagrams, which he hands over to James. The constitutive effect of these electrical diagrams combined with the physical breaker panel creates a disturbance in the *habitual experience*, making it possible to transform the *indeterminate situation* into a *determinate situation*.

[18] The analysis draws on the A21 case, which is described in section 8.4 "cross-functional FAI 5 October".
[19] James is the responsible A21 engineer. He is highly educated and has many years of experience.
[20] Please be aware of the fact that there are many components and leads in this breaker panel.

Second, prototype worker 1 and James check the numbering of the wiring in the physical breaker panel. This continues until Jack doubts the validity of the electrical diagram used for guiding the *strip of doings*. As the electrical diagram turns out to be an obsolete version, the *strip of doings* has been misguided. Therefore, a valid (usable) electrical diagram is retrieved from kk's intranet by using a laptop;[21] in other words, the *constitutive means* is updated to guide the *strip of doings*.

Third, personal safety is a pivotal subject matter to be verified. Mick reads aloud from the checklist while walking directly to the A21 breaker panel, where he conducts a *reading doing* by taking a close look at a transparent protection plate installed in front of a Printed Circuit Board (PCB). Mick does not say anything, but Jack says:

> *"according to the legislation, the maximum allowable space between the protection plate and the PCB is 12.5 mm. It corresponds roughly to a 12 mm bolt."* (Technical project manager, 5 October 2009).

Jack gets a 12 mm bolt and gives it to Mick, who subsequently checks the space; obviously, the gap is too big. Then Jim says:

> *"yes, I can see it, the gap in this side is too big, maybe some of the support bolts have been replaced without us noticing it."* (Prototype worker 1, 5 October 2009).

The constitutive effect of neither the assembly documentation nor the legislation is able to activate the <u>*reflective experience*</u>, for which reason the mounting of the protection plate draws on <u>*habitual experience*</u>. In addition, why does this <u>*indeterminate situation*</u> emerge? A likely catalyst for the *starting doing* is a previous <u>*indeterminate situation*</u> that is revived when standing in front of the A21 breaker panel. This past event takes place 24 September 2009 when two other cross-functional FAI verifications are conducted. Both breaker panels have a construction similar to that of the A21 in terms of the transparent protection plate in front of the PCB. The first FAI deals with the A3, but the indeterminacy is not detected yet. The next one is the A23. After a while, electrical engineer 3 mounts the transparent protection plate, which prompts a *reading doing*, and Mick asks:

> *"what is the actual purpose of this protection plate? You can easily get a finger behind the plate."* (kk project manager, 24 September 2009).

That is, *reading doings* performed on two *constitutive means*, a checklist and the physical breaker panel, causes disturbance in the <u>*habitual experience*</u>, which revives an <u>*indeterminate situation*</u> originating in a "past *STP*". The *strip of doings* is enabled by diverse *constitutive means*; electrical standards, the physical breaker panel and "a 12 mm bolt". Likewise, the

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[21] Actually, during this meeting, the computer is used several times to conduct *penetrating doings* retrieving information and thus refreshing the <u>*experience*</u>. For instance, according to the pre-clarification, an option has to be available in the breaker panel. James seems to remember the number of the option to be "kk-kit 56". By using the computer, James and Jim search for information on the intranet and find it; Jack, however, says that this option is not required in this breaker panel. Hence, they continue the search for information and at one time they are using two computers, BOM, electrical diagrams and working instructions. When all is said and done, the option should not be available in this breaker panel, resulting in a *writing doing* in the MoM.

other two situations turning up during this FAI also shed light on the importance of a physical breaker panel. In this regard, a comparison of the physical breaker panel with electrical diagrams is the *constitutive means* to activate *reflective experience* enabling a continuation of the *strip of doings* until a *determinate situation* has been achieved. *Writing doings* in the MoM and in notebooks *sustain* the achieved determinacy and these become *constitutive means* to ensure the *trajectory*.

### 9.3.4. Composition of cross-functional STP addressing ePM verification[22]

The verification of the production documentation takes place in a meeting room. The responsible engineer makes extensive use of the laptop to depict the *constitutive means* on the TV screen, for instance 2D/3D drawings, working instructions, Bill of Material (BOM), pictures illustrating the assembly process etc. As all documentation is only accessible online, the laptop is connected to kk's intranet.

In turns, the checklist and the retrieved documentation are depicted on the TV screen. All participants conduct *reading doings* of the depicted *constitutive means*. If a discrepancy is identified, a *writing doing* is conducted directly into the online checklist. The *reading doings* of the working instructions, which act as rules to be followed by the Polish batch production, trigger a *starting doing* as Mick asks:

> *"why cleaning this bottom plate before putting it into the packaging?"* (After a long while, logistic engineer 1 says) *"yes, aha, I think it is a working instruction from the old A1,[23] as it had such a bottom plate."* (ePM meeting, 14 December 2009).

The *reading doings* of the working instructions activate logistic engineer 1's *reflective experience* and thereby a continuation of the *strip of doings*; the achieved *determinate situation* demonstrates that the working instructions are a copy and paste from an old breaker panel. Likewise, a *strip of doings* proves that all pictures in the working instructions are copied and pasted from another breaker panel. Consequently, Mick *blocks the strip of doings* and decides to conduct a new ePM later on.

The composition of the *STP* is characterised by effective utilisation of IT systems to structure the verification as well as to retrieve a great many *constitutive means*. The triadic interplay between laptop, TV screen and kk's intranet facilitates and enhances the constitutive effect of the *constitutive means*. However, as the *constitutive means* are not updated, and thus fail to accurately represent the physical breaker panel, the *reading doings* are misguided. This constrains the *strip of doings*, causing a cul-de-sac with regard to the transformation of the *indeterminate situation*; i.e., *the strip of doings is blocked.*

The next section addresses the composition of the daily working *STP* as it unfolds within the open-plan office as well as in the production.

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[22] The analysis draws on the A21 case described in section 8.4 "ePM verification 14 December".

[23] Please note that the A21 breaker panel is a joining of the A1 and A2 breaker panels.

## 9.4. Composition of the daily working STP

Due to the many electrical and mechanical interfaces in a breaker panel, the electrical diagrams are connected in a web of sorts. This implies that the number of *constitutive means* to conduct a *strip of doings* can be comprehensive. However, it is not crucial for the engineers to understand all aspects and consequences at once due to the physical proximity in the open-plan office after the relocation. All engineers sitting next to Jack have the opportunity to be up to speed with the successive interorganisational *strips of doings*. Actually, when sitting at his desk, Jack often conducts a *penetrating doing* either by phone or by e-mail[24] and thereby gets access to crucial information.

> *"Actually, it is the very first time we are sitting next to each other in the same project group; we have really benefitted from sitting together"..."I do not use the delivery specifications from Oldtimer; it is Jack who handles those. I receive the information directly from Jack. He takes a similar breaker panel and makes a number of changes directly in this documentation. The technical solutions to be removed are marked with a red pencil and the technical solutions to be added are marked with a green pencil. It is very simple, but very efficient."* (Electrical engineer 1, 2 December 2009).

The *constitutive means* applied by the engineers are simple and effective; the *strips of doings* are facilitated by the *writing doings* of Jack, who has made red and green corrections/ comments directly on the electrical diagrams or drawings. These *constitutive means* and the physical proximity in the open-plan office enable reciprocal interchanges drawing on *reflective experience* and thereby *successful strips of doings*. Another interesting sentence in the above quotation underlines the importance of a "similar breaker panel" (the virtual stock principle described in chapter 2). A known product platform accessible from kk's intranet becomes the enabling *constitutive means*, and as such it influences the composition of the *STP*.

### 9.4.1. Composition of the daily working STP within the office/production area

The engineers draw mainly on the electrical diagrams onto which Jack has conducted the *writing doings*. This *constitutive means* makes it possible to design a number of new electrical diagrams. All electrical wiring among the components appears from these new diagrams, but the physical placement of the components is naturally not visualised.

Therefore, the electrical and mechanical engineers (draughtsmen) conduct *writing doings* and make a sketch. The content of this *constitutive means* is an appropriate placement of electrical components inside the particular breaker panel; yet, it is only a proposal. Beyond doubt, all components and electrical wiring among these are fixed. This cannot be changed without having (huge) consequences for the functionalities of the breaker panel. Nevertheless, the exact physical placement of the components as well as the detailed cabling inside the breaker panel draws on a trial and error approach.

[24] *"A large part of the clarification with Oldtimer is handled using e-mail or phone; more than 400 e-mails have been sent so far."* (kk project manager, 20 August 2009). For instance, 4 August 2009, it was necessary to call Andy in order to clarify fourteen issues.

> *"I have made the drawings of the A23. Kevin came with handmade sketches and then we placed the components. When we were finished, Oldtimer changed it all, because they want to use a new outer frame, so we started from the beginning again"…"Anyhow, we hand over the sketches illustrating the placement of the components to Johnny* (prototype worker, author). *Actually, Johnny had already placed many of the components, as he is very experienced in that regard."* (Draughtsman 1, 26 November 2009).

Diverse *constitutive means*, such as electrical diagrams, the physical breaker panel and sketches indicating the rough placement of the components, combined with the engineers/prototype workers' *reflective experience* enable a *successful strip of doings*. The physical replacement is a *writing doing*, as the form of the breaker panel is changed; thereby, it changes the *constitutive means* and, consequently, the composition of the particular *STP*.

Being able to clarify the placement of all components and cabling prior to the pilot production necessitates the accessibility of *constitutive means* about the specific dimensions of all components, heat generation, electromagnetic inference, etc. These *constitutive means* are accessible, but will complicate the *strip of doings*; referring to the conducted interviews, such an approach is overkill and a waste of resources. Instead, the prototype workers are trained as electrical technicians. They have assembled breaker panels for some years and thereby gained *experience* in this regard. Thus, the *constitutive means* – electrical diagrams, the physical breaker panel and sketches indicating the rough placement of the components – activate the prototype workers' *reflective experience*, enabling a *successful strip of doings*.

## 9.5. Summary – composition of the STP

This section summarises the analysis addressing an identification of the *constitutive means* and their different roles in relation to the composition of the *STP*.

Table 9.1 depicts an overview of the analysis. The three columns illustrate the *constitutive means* within the interorganisational, daily working and cross-functional *STP*s.

Enabling a *strip of doings* necessitates the accessibility of diverse and usable *constitutive means*. The enabling *constitutive means* is not just "a sketch" or "a drawing"; rather it is a combination of *constitutive means*. The engineers make use of a laptop, intranet/internet connection and a CAD system to display an electrical diagram/drawing on the TV screen. In other words, the *constitutive means* enabling a *strip of doings* are combined; however, the analysis reveals five groups of *constitutive means* with different roles to play in their guidance of the *strip of doings*.

The five groups of *constitutive means* appear from table 9.1. First, sketches, drawings, electrical diagrams and the physical breaker panel address the technical clarification. The second group is the project plan, which enables the administrative clarification. These two groups of *constitutive means* guide and enable the *strips of doings*. A third group is the instruments/tools applied to facilitate the *strips of doings* by enhancing the constitutive effect of the *constitutive means*; that is, laptop including TV screen, intra/internet, mobile phone and the blackboard. A fourth group consists of notebooks and MoMs from each of the meetings. These are applied to enhance the constitutive effect of previously achieved determinacies if these are blurred; it is a *constitutive means* to bring back past <u>*experience*</u> to the present *STP* composition. That is, the role of notebooks and MoMs is to ensure a *sustainable determinacy*; a written <u>*trajectory*</u>, which highlights the consequences of previous *strips of doings*. Finally, the fifth group is the checklists. By following a checklist, the *reading doings* become regulated.

| | Interorganisational STP | Daily working STP | Cross-functional STP prior relocation |
|---|---|---|---|
| Constitutive means within the sociotechnical practice | Physical breaker panels | Physical breaker panels | Electrical diagrams |
| | Folders containing: | Electrical diagrams | Drawings |
| | -Delivery specifications | Drawings | Sketches |
| | -Technical changes | Sketches | Folders –diverse |
| | -Electrical diagrams | Folders –diverse | Technical changes/request |
| | -Drawings | Product specifications | Blackboard |
| | Sketches | Production specifications | Laptop |
| | Project plan | Approved delivery spec. | kk's intranet |
| | Blackboard | Blackboard | CAD-systems |
| | Laptop incl. TV screen | Laptop | Internet: |
| | Mobile phone | kk's intranet | -Supplier/Standard |
| | kk's intranet incl. CAD- | CAD-systems | Notebooks |
| | system | Phone and e-mail | MoM: Int.org-/cross-fun. |
| | Oldtimer's intranet | Internet: | Checklist to verification |
| | Internet: | -Supplier/Standard | |
| | -Supplier/Standard | Notebooks | |
| | Notebook | MoM: Int.org./cross-fun. | |
| | MoM | | |

➔ Means to guide technical strips of doings

➔ Means to guide administrative strips of doings

➔ Means to facilitate strips of doings

➔ Means to ensure the trajectory

➔ Means to regulate the strips of doings

Table 9.1. The identified constitutive means and the role of these – Oldtimer.

The *STP* is frequently repositioned from a meeting room to the production area or vice versa. This ongoing repositioning of the *STP* as well as the *penetrating doings* (the use of mobile phones and laptops) improves the accessibility of the *constitutive means*. The accessibility of diverse and usable *constitutive means* enables to cause disturbance in the <u>*habitual experience*</u> as well as to activate the <u>*reflective experience*</u>. This entails that the learning process within the interorganisational and daily working *STPs* is seldom *blocked*. As for the cross-functional *STP* prior to the relocation, the learning process is put on standby once common ground regarding the <u>*indeterminate situation*</u> to be handled has been achieved; i.e., the learning process becomes *blocked*.

The composition of the interorganisational, cross-functional and daily working *STP*s is characterised by a mutual understanding between Oldtimer and kk. The generally accepted view among kk employees is that the high level of mutual understanding is the reason why it is possible to develop a WTC based on the specifications received from Oldtimer.[25] The two

[25] For instance, although the approval of the pre-clarifications is postponed for two months, it is possible to proceed with the technical clarifications and, last but not least, to start up the pilot production. E.g. *"I have ordered this flange even though it is not clarified with Andy, but we cannot wait until he returns from vacation."* (Draughtsman 1, 26 June 2009).

organisations have collaborated since the beginning of the wind turbine era nearly three decades ago; thus, it is simply a question of following the *trajectory* established in course of three decades of interaction.

While the above addresses the composition of the *STP*, the analyses in sections 9.6-9.9 emerge gradually to focus on the *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doings*.

## 9.6. Approach to handle the A24 – ductile specifications

The PD of the A24 breaker panel is introduced in an interorganisational meeting **3 September 2009**. Owing to the fact that this breaker panel has a crucial function in the wind turbine and that it is not included in the approved delivery specifications,[26] the PD of this breaker panel is an urgent order. Despite it being an urgent order, no technical *strips of doings* take place within this particular *STP*. However, Oldtimer will hand over the specifications not later than 10 September, which gives kk four weeks to carry out the PD *strips of doings*.[27]

Three interorganisational *STP*s are the focal points in the first part of the analysis, while the second part introduced in section 9.6.4 includes additional seven *STP*s.

### 9.6.1. STP 10 September – Oldtimer's lack of intraorganisational clarification

The delivery date draws near and, contrary to what has been agreed, the specifications are not yet accessible from Oldtimer. Mick and Jack really need these specifications to be able to deliver the breaker panel on 6 October, and Andy does his very best to retrieve these. Several times during the meeting, Andy performs a *penetrating doing* by connecting his laptop to Oldtimer's intranet, but the necessary information is not accessible.

The *indeterminate situation* is apparent for the participants causing disturbance in the *habitual experience*. There is a multitude of spoken words, gesticulations and body language within the *STP*, but the accessible *constitutive means* are too *ductile* to transcend this precognitive phase; that is the *habitual experience*. Hence, the *reflective experience* is not triggered. At present, it is not possible to *anchor* the *indeterminate situation*, by which a continuation of the *strip of doings* is constrained.

### 9.6.2. STP 17 September – increasing degree of completion of technical specifications

A great deal of design work is accomplished and a 3D drawing, twelve 2D drawings and a number of electrical diagrams are accessible *constitutive means* within the *STP* on 17 September; yet, crucial specifications remain undetermined.

The 3D drawing of the A24 is depicted at Andy's laptop. This *constitutive means* is the focal point for the engineers' *reading doings* and as usual, the virtual representation of the A24 is rotated and displayed from different angles. Although the 3D drawing facilitates *reading doings*, it does not result in any *successful strips of doings*. The dialogues among the

[26] The delivery specification was approved in the middle of August 2009, 20 August, to be more precise.
[27] It takes six weeks for a level one product and 17 weeks for a level two product. Please see the pilot case.

engineers are more of an explanatory nature and tend to deal with fundamental ideas of for instance a shield to ensure the cooling of the breaker panel; actually, the dialogues mainly take the form of one-way communication.

Anyhow, the explanations combined with *reading doings* of the 3D drawing cause disturbance within Jack's *habitual experience*, as he after a while says *"oh...what about the cabling…?"*. This prompts a *strip of doings* dealing with cabling among the A24, 215362MO and A3 breaker panels, but it is constrained. Instead, a new *starting doing* emerges, which focuses on the current intensity in a specific circuit.

Drawing attention to the cabling *strip of doings*, the A3 breaker panel and all appertaining documentation have been delivered to Oldtimer at the time. Referring to the MoM from this meeting, the cabling issue is described as a complex and comprehensive task, for which reason it will not be implemented in this version. It indicates that the reason for constraining the *strip of doings* is based on concerns of complexity and reflections related to the necessary *effort* to change the breaker panels. Nevertheless, within the interorganisational *STP* 17 November, it is decided to change this cabling interface between the A3 and A24[28] as previously intended, even though the A24 has been delivered to Oldtimer 10 November.

That is, the reason why it is not possible to enable a continuation of the *strip of doings* 17 September, and thereby achieve *sustainable determinacy*, seems to be due to too *ductile constitutive means*. At present, the *constitutive means* are too *ductile* to activate and guide the *reflective experience*, constraining the *strip of doings*.

Regarding the indeterminacy focusing on the current intensity, the *constitutive means* enabling the *strip of doings* is **one** of twelve electrical diagrams brought along; i.e., the requisite *constitutive means* is accessible. Jointly, Andy and Jack conduct *reading* and *writing doings* in this electrical diagram, by which handmade symbols and sketches are added to this *constitutive means*. This convergent *anchoring* of the *indeterminate situation* enables to transcend the *habitual experience* and thereby to activate the *reflective experience*. Undoubtedly, Andy and Jack are both highly skilled and the majority of laws with respect to ampere, voltages, ohms, etc. are basic knowledge to them. Hence, the approach to enable a continuation of the *strip of doings* is reciprocal interchanges drawing on *reflective experience*.

### 9.6.3. STP 8 October – specifications accessible to enable strips of doings

At present, the planned delivery date has been exceeded by two days[29] due to the fact that the design is more complex than expected. Within the *STP* 8 October, the specifications of the two breaker panels have become more clarified, implying a decrease in the *ductility*; yet minor deviations still occur. One reason why the specifications are not entirely clarified is problems with overcrowding in the nacelle.

Prior to the meeting, Jack receives an updated version of the 3D drawing from Oldtimer and he depicts this *constitutive means* on the TV screen. This *constitutive means* is rotated and

[28] As stated in the Oldtimer narrative and the A24 case, the 215362MO and A24 are united in one breaker panel; a decision explained at the meeting 21 October 2009.
[29] As it appears from the case description, the two breaker panels should have been delivered 6 October 2009.

when discussing certain areas of the A24, the laptop is energetically applied to enhance the constitutive effect of the 3D drawing. Additionally, the *strip of doings* is facilitated by drawing analogies to other breaker panels developed in the past[30]; the virtual stock principle explained in chapter 2.

The decreasing *ductility* of the *constitutive means* being depicted on the TV screen enables a convergent *anchoring* of the <u>*indeterminate situation*</u> and it activates the engineers' <u>*reflective experience*</u>. To ensure a continuation of the *strip of doings*, other *constitutive means* are gradually applied; for instance, the virtual stock and the components retrieved from the supplier's homepages. That is, the approach enabling a *successful strip of doings* draws on the engineers' <u>*reflective experience*</u> and the accessibility of diverse and usable *constitutive means*.

Figure 9.2 summarises the analysis conducted so far. The vertical axis represents the level of *ductility*, while the horizontal axis is a timeline. The grey circles refer to the three analyses addressing *ductility*, and the text to the right of the circles is a short statement from these analyses.

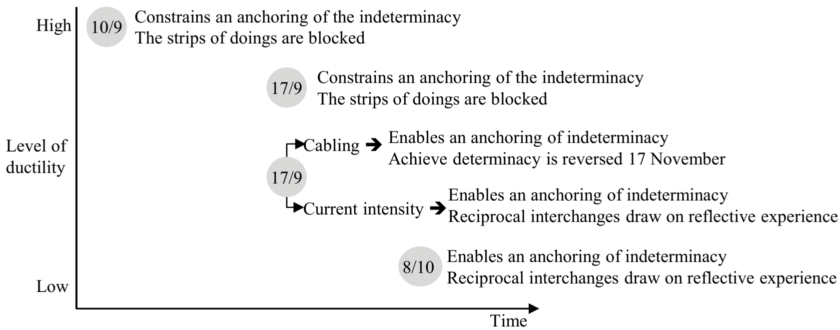


Figure 9.2. Level of ductility in correlation to guide the strips of doings.

As it appears from figure 9.2, the level of *ductility* decreases with time. The high level of *ductility* identified 10 September and in one of the three situations taking place17 September constrains the *strips of doings*, causing these to become *blocked*. The indeterminacy is apparent, but the *constitutive means* are too *ductile* to carry on the *starting doings*; this constrains an *anchoring* of the <u>*indeterminate situation*</u> within the *STP*. Drawing attention to the two other situations 17 September in which it is possible to achieve determinacy, one of these *strips of doings* deals with a limited part of the A24. The decreased *ductility* facilitates a convergent *anchoring* of the <u>*indeterminate situation*</u>. The convergent *anchoring* activates the

[30] For instance, the following *strip of doings* takes place: Andy ➔ *"I have not made up my mind yet about which circuit breaker to use."* (Andy conducts a *reading doing* in his notebook). Jack ➔ *"Should we design it as we did with this breaker panel?"* (Jack explains his ideas). Andy ➔ *"No, I don't think so, but previously we have done it this way and I think it is more appropriate."*. Jack ➔ (Jack conducts a *penetrating doing* and uses his laptop to connect to a supplier's homepage and depict a specific component on the TV screen). Andy ➔ *"yes, that is the one."*.

*reflective experience* and enables a continuation of the *strip of doings* drawing on reciprocal interchanges of *reflective experience*. However, the one addressing cabling has some interfaces with other breaker panels and, as it turns out, the achieved determinacy has a low level of *sustainability*. As illustrated by the analysis of the *STP* 8 October, the approach enabling the *successful strips of doings* draws on reciprocal interchanges of *reflective experience*.

A high level of *ductility* seems to be a necessary method for handling the urgency of the A24 order. The design is not yet finished although the initially planned delivery date has been exceeded by two days; actually, a number of modifications are still introduced. In the next section, the analysis addresses the consequences of these modifications. The analysis draws on seven *STP*s, which are:[31]

- STP 24 September: A new design is introduced due to space problems (crane).
- STP 2 October: Technical clarification in progress.
- STP 21 October: Two breaker panels are united into one breaker panel.
- STP 5 November: The FAI verification causes much rework.
- STP 10 November: Additional rework.
- STP 17 November: Changes to interfaces between A3 and A24.
- STP 2 December: Cancellation of documentation.

### 9.6.4. Consequences of the ongoing changes

The sweeping design changes announced 24 September have a huge effect on all documentation developed so far, as all of it becomes obsolete. Drawing attention to the cross-functional *STP* 5 November, the comprehensive rework does not result in the documentation becoming obsolete; it (just) has to be updated.[32] Actually, simply announcing a change may have consequences for the documentation. For instance, the PD of the first version of the 3.0 MW WTC draws to a close. Thereby, the focus gradually changes to the next version of the WTC. Intraorganisationally in Oldtimer, it is standard procedure to examine the applied technical solutions before starting up the creation of the next version of the WTC. Naturally, the A24 has not evaded critical scrutiny.[33] Thus, Andy prepares the ground for a redesign of the A24 within the interorganisational *STP* 2 December 2009. In continuation hereof, Mick says promptly:

> *"If the maximum circuit breaker panel* (A24, author) *with certainty will be redesigned, it is not expedient to continue the drawing up of documentation, as it will never look like the one we have now, regardless which design is chosen.*" (kk project manager, 2 December 2009).

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[31] A comprehensive description of each of the changes as well as the *STP* is evident from the case description in section 8.3.

[32] Yet, referring to the prototype workers, a simple update of a breaker panel might have a sizeable effect on the documentation. Replacing just one electrical component necessitates an update of electrical diagrams, drawings, the cabling list, working instructions and the BOM.

[33] *"No doubt, the development of the maximum circuit breaker has been really tricky because we had this strange corner into which the breaker panel had to be installed. Normally there are rectangular spaces available for us to mount our breaker panels in."* (Oldtimer project manager, 26 November 2009).

The consequences regarding the documentation are not obvious. Which drawings/electrical diagrams are not usable anymore, what are the side effects of a change or which parts of the electrical diagrams or drawings do not represent the product anymore? The question is how do the changes influence the *constitutive means* with regard to enable a *strip of doings*? This subject matter is addressed in the following.

The period from 3 September to 24 September is characterised by an increasing degree of completion. However, within the interorganisational *STP* 24 September, Andy announces a sweeping change of the design of the A24 due to the crane in the nacelle. A *starting doing* emerges as Jack wants to understand the extent of the change. Andy does his very best to explain this, and he uses verbal language, his fingers make drawings in the air and after a while, he walks to the blackboard where he conducts *writing doings* resulting in a sketch.

> *"Unfortunately, I only have the external measurements of the breaker panel. But I think we will make a hole there* (Andy points with his finger on the sketch, author) *by using an angle grinder; that way we can make room for it. Right now we are discussing the possibilities of having it there* (points with his finger, author)*, but we only have power there* (points with his finger, author)." (Oldtimer project manager, 24 September 2009).

The change of the design has caused a decreasing degree of completion of the A24. Likewise, some of the technical specifications are now rather unclear, which increases the level of *ductility*. Thus, the sketch (*constitutive means*) that Andy draws on the blackboard is too *ductile* to carry on the *starting doings*. The *constitutive means* constrains an *anchoring* of the <u>*indeterminate situations*</u>, entailing that all *strips of doings* become *blocked*. Actually, the "dialogues" consist of Andy handing over as much information as possible by way of one-way communication.

The A24 receives only little attention within the next ordinary interorganisational meeting taking place 2 October, even though the planned delivery date is four days later. However, Andy is actively involved in the PD taking place intraorganisationally in Oldtimer. I.e., he has sufficient information to conduct *writing doings* and he creates a sketch at the blackboard illustrating the change of the design. This *constitutive means* facilitates *reading doings*, but the sketch is still too *ductile* to transcend the <u>*habitual experience*</u>, constraining a convergent *anchoring* of the <u>*indeterminate situation*</u>. It implies that the *strip of doings* becomes *blocked*.

Just before the following interorganisational meeting 8 October, Andy sends an updated 3D drawing of the A24 to Jack, and this 3D drawing is depicted on the TV screen. This interactive visualisation of the *constitutive means* enables a convergent *anchoring* of the <u>*indeterminate situation*</u> and the performance of a number of *successful strips of doings*. I kindly refer to the analysis in section 9.6.3 for an elaboration.

Two weeks later, within the interorganisational *STP* taking place 21 October, Andy announces a new change of the design of the A24. This change deals with the 215362MO as it has to be built into the A24; that is, the two breaker panels are joined. As the placement of the 215362MO has been a subject matter for a while, different alternatives have already been considered. This preliminary work enables a convergent *anchoring* of the <u>*indeterminate situation*</u> and a continuation of the *strip of doings*.

The first mentioned change of design dealing with the crane in the nacelle has a significant consequence for the *constitutive means* guiding the *strips of doings*. The blackboard sketch facilitates *reading doings*, but the technical specifications are now too *ductile*, constraining an *anchoring* of the *indeterminate situation*. Addressing the *STP* one week later, the *strips of doings* are guided by Andy and Jack combining their *experience* regarding the "old version of the A24". However, these *strips of doings* fade away. Thus, the technical specifications are still too *ductile*, constraining the *strips of doings*. One week later, the degree of *ductility* has reached a level enabling a convergent *anchoring* of the *indeterminate situations* as well as a continuation of the *strips of doings*. The second redesign also causes increasing *ductility*, but the joining of the two breaker panels has been a theme for a while. Hence, the increasing *ductility* only has a confined influence on the *constitutive means* to enable the *strips of doings*.

## 9.7. Summary – A24 ductile specifications

The *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doings* became central in the analysis.

Focusing on the introduction of the A24 and the sweeping change in the design announced 24 September, the level of *ductility* is high. The *anchoring* of the *indeterminate situation* as well as the approach to facilitate a continuation of the *strip of doings* is merely to hand over information and draw sketches on the blackboard. The too *ductile constitutive means* constrains the *anchoring* of the *indeterminate situation*. Without a convergent *anchoring* of the *indeterminate situation*, the *strip of doings* becomes *blocked*. It constrains learning.

A decreasing level of *ductility* paves the way for a convergent *anchoring* of the *indeterminate situation*. A convergent *anchoring* enables to transcend the *habitual experience* and thereby to activate the *reflective experience*. This convergent *anchoring* charts the course for the *reflective experience*. The continuation of the *strip of doings* draws on ongoing *reading doings* of the accessible *constitutive means* and the engineers' *reflective experience*. It enables learning.

The degree of completion of the A21 breaker panel is high at the time when the changes were introduced. Moreover, the A21 is a well-known breaker panel, for which reason the technical specifications are *obdurate*. Thus, the analysis of the A21 case in next section addresses *obdurate* specifications to guide and enable the *strips of doings*.

## 9.8. Approach to handle the A21 – obdurate specifications

The intention is to reuse the technical platform of the A21 breaker panel, which is built into the 2.3 MW WTC. As it appears from figure 8.4, this breaker panel has been in production for a while and has much in common with the A1 and A2 breaker panels applied in the 3.6 MW WTC. The A21 has been released for batch production since September 2008, for which reason the technical specifications of this 3.0 MW WTC are easily prepared. Thus, the majority of the technical specifications required to start up the production are accessible in good time; that is, before the summer vacation.

Until 3 September, the A21 is hardly mentioned within the interorganisational *STP*. The *strips of doings* are on track and the creation of the breaker panel is in line with the intention formulated at the very beginning of the project. When passing the A21 in the production area on this date Mick says:

> *"I have just had a meeting with Tony* (Oldtimer's project manager on the 2.3 MW WTC, author)*. He wants to change the A21 being used in the 2.3 MW. In our opinion, these changes ought to be implemented in the 3.0 MW as well."* (kk project manager, 3 September 2009).

This update of the A21 being applied in the 2.3 MW results in the A21 to be built into the 3.0 MW gradually receives more and more attention. Hence, the *strips of doings* accomplished in the 2.3 MW *STP* have a constitutive effect within the 3.0 MW *STP*.

Referring to figure 8.2, the outcome of the PD are three-part; a physical breaker panel and a great deal of product and production documentation as well. It turns out that the changes of the A21 applied in the 2.3 MW are introduced in a steady stream, which gives rise to some *starting doings* addressing this three-part outcome. The A21 breaker panel is subjected to an analysis in the following three sections.

### 9.8.1. STP 24 September and 2 October - creation of the catalogue of updates

Three weeks after announcing the update, the A21 becomes a focal point within the interorganisational *STP* 24 September. Andy, Oldtimer's project manager, wants to implement as many as possible of the proposed updates, but he is neither familiar with the technical substance nor the consequences of the proposed updates to the 2.3 MW A21. Furthermore, as the time for erecting the wind turbine draws near, it is necessary to take this into consideration as well.

> *"Tony continues to introduce new changes to be implemented in the 2.3 MW A21. Seeing that the A21 has to be delivered not later than 12 October, the changes to be implemented must be accomplished within this timeframe. The remaining changes will either be retrofitted or await the next 3.0 MW project."* (MoM, interorganisational meeting, 24 September 2009).

The *reading* and *penetrating doings* being conducted within the above *STP* make it clear that it will take some *effort* to achieve a <u>*determinate situation*</u> in terms of which updates to implement.

One week later within the interorganisational *STP* **2 October** it is therefore decided to create a catalogue of updates.

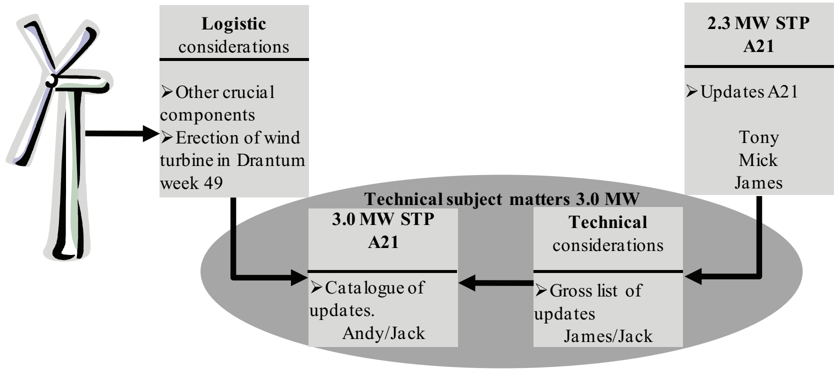


Figure 9.3. Constitutive means to guide the strips of doings.

As depicted in figure 9.3, the *strip of doings* to create the catalogue of updates within the 3.0 MW *STP* is situated in a tension field between logistic considerations and the steady stream of updates taking place within the 2.3 MW *STP*. Although both are beyond the boundaries of the 3.0 MW *STP*, they are crucial *constitutive means* for the *reading doings* and thus for the continuation of the *strip of doings*.

Regarding the **2.3 MW *STP***, the *strip of doings* aiming at identifying all changes to be implemented on the A21 2.3 MW is conducted by kk's project manager, the responsible A21 engineer, James,[34] and Oldtimer's 2.3 MW project manager. Neither Oldtimer's 3.0 MW project manager nor kk's technical project manager, Jack, is involved in this *strip of doings*.

Drawing attention to the **logistic considerations**, the erection of the wind turbine takes place in the beginning of week 49. This date is fixed, for which reason the constitutive effect is high. Thus, the A21 has to be delivered not later than 12 October, leaving two and a half weeks to carry out the rework. However, in the following interorganisational *STP*, Andy announces that the converter will be delayed. This implies that kk has an additional three or four days to implement the updates.

The **technical subject matters in relation to the 3.0 MW** illustrated in the middle/lower part of figure 9.3 address the creation of a gross list of all suitable changes to be implemented on the 3.0 MW and a subsequent creation of a catalogue of updates.

Jack and James handle the **gross list** within the daily working *STP*. James is extremely <u>*experienced*</u> in the 2.3 MW WTC, including all updates to be implemented on the A21, while Jack is the linchpin of all technical subject matters in terms of the 3.0 MW. The two engineers apply an outline of updates to the 2.3 MW A21 as a *constitutive means* to guide their <u>*reflective experience*</u>. All updates, which at present are going to be implemented on the 2.3 MW A21, are subject to a *strip of doings*. By doing so, all suitable updates to be implemented on the 3.0 MW are written down in the **gross list**.

[34] As mentioned in the A21 case, James is responsible for the A21 being applied in the 2.3 MW as well as the one being created to the 3.0 MW. Therefore, he is the linchpin of technical subject matters regarding the A21.

**The catalogue of updates** is created the following Monday by Jack and Andy within the setting of an interorganisational *STP*. Referring to figure 9.3, the **gross list** created by James and Jack and the accessible timeframe in accordance with the **logistic considerations** are the *constitutive means*. These *constitutive means* combined with the Jack's and Andy's *reflective experience* enable the *strip of doings* and thereby the creation of **the catalogue of updates**.

Even though all involved engineers have many years of *experience* in relation to WTCs and despite the fact that the A21 is a well-known breaker panel, the creation of the catalogue of updates is handled as a two-step process. Instead of just asking James to hand over the gross list directly to Andy, or for that matter to Jack, it is necessary to "translate" the technical updates twice.

First, the two kk engineers draw on their individual *experience* to achieve a convergent *anchoring* of the *indeterminate situation*. This convergent *anchoring* of the *indeterminate situation* enables the engineers' *reflective experience* to follow a convergent track, resulting in a *successful strip of doings*; that is, the drawing up of the gross list. Second, this gross list in combination with the time issues is the *constitutive means* enabling the *successful strip of doings* within the interorganisational *STP*.

This two-step *strip of doings* indicates that it requires *effort* to enable a convergent *anchoring* and a continuation of the *strip of doings* when the *reading doings* draw on *obdurate constitutive means*. It is a time-consuming and resource demanding process.

### 9.8.2. STP 10 December - product documentation is the focal point

The steady stream of changes to the A21 has some consequences with respect to ensuring coherence between the product documentation and the physical breaker panel. For instance, Andy has just received an e-mail from the workers on site Drantum, which he reads aloud within the interorganisational *STP* 10 December. The e-mail problematises the usability of the product documentation applied by Oldtimer employees to erect the wind turbine on site Drantum. A *starting doing* emerges, but the *strip of doings* is constrained, for which reason it becomes *blocked*. In this regard, Mick has recently verified similar product documentation in collaboration with Oldtimer's project manager on the 2.3 MW without detecting any deviations. It seems to indicate that the discrepancy occurs on account of different versions of the product documentation. Similar considerations voiced within this particular *STP* call in question the I/O[35]-documentation versions applied. In an attempt to understand the crux of the matter, Jack says:

> *"Andy, I suggest that we examine it from two angles simultaneously. Together with James, I examine the present status of the updates to both the breaker panels and the documentation. Then you can examine which version of the documentation is applied at Oldtimer. As I recall, it is fourteen days ago since I last sent some documentation to you."* (Technical project manager, 10 December 2009).

[35] I/O is an abbreviation for Input and Output. It describes the interfaces between the HW and the SW.

Thus, the examination of the product documentation is divided into two different *strips of doings*. Andy is going to examine which version of the A21 documentation is applied intraorganisationally in Oldtimer, while Jack and James will examine the actual status of the updates intraorganisationally in kk. Later on, these two investigations are compared within an interorganisational *STP*.

Drawing attention to the challenges facing the two kk engineers, the *strip of doings* concerns an examination of the coherence between the physical breaker panel and the product documentation. As it appears from figure 9.4, the examination calls for a comparison between the 2.3 MW version 2 A21 and the 3.0 MW A21; as both breaker panels are subjected to a change of the design, the specifications are not entirely *obdurate*. Although the two versions of the A21 are not 100 percent identical, because of a higher power output in the 3.0 MW, they are both based on the 2.3 MW version 1.

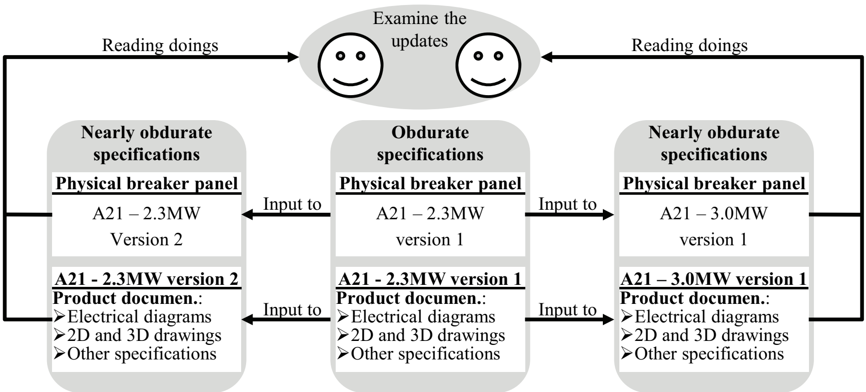


Figure 9.4. Strip of doings to ensure coherence.

As illustrated in figure 9.4, when examining the actual status of the updates/changes, the *strip of doings* is guided by diverse *constitutive means*. The updates of the product documentation and the changes of the physical breaker panels have been done in several operations.[36] Furthermore, as emphasised by several of the engineers and prototype workers, updating the product documentation is very complicated due to the potential side effects.

The many successive updates/changes combined with the potential side effects of these updates/changes obstruct the *anchoring* of the *indeterminate situation*. It is strenuous and time-consuming to cope with this obstacle, for which reason it requires much *effort* to achieve a convergent *anchoring* of the indeterminacy. A convergent *anchoring* of the *indeterminate situation* enables the engineers' *reflective experience* to follow a convergent track and thus the *strip of doings* to continue until *sustainable determinacy* has been achieved.

[36] *"All changes to the A21 were something we just had to adapt to. They were triggered by the 2.3 MW project and it was a steady stream of changes, almost daily. Just a small change, for instance a replacement of a connector, made it necessary to modify drawings and electrical diagrams, so I think it has been really difficult for James to keep the project on track."* (Technical project manager, 16 November 2009).

### 9.8.3. STP 14 December - production documentation is the focal point

The creation of the 3.0 MW production documentation consists in modifying the 2.3 MW production documentation.

> *"Drawing up an ePM* (electronic Production Documentation, author) *based on existing documentation is actually more difficult than starting from scratch because I have to constantly control the side effects. If I replace just one component inside a breaker panel, I have to update the BOM, wiring diagrams and the working instructions. Furthermore, I have to be aware of page numbering and references and it entails much control."* (Prototype worker 2, 23 November 2009).

The verification of the production documentation (ePM verification) within the cross-functional *STP* 14 December exposes some discrepancies. Part of the verified production documentation appears to be copy and paste from the 2.3 MW and from the A1 of the 3.6 MW, for which reason kk's project manager *blocks the strip of doings*; a new ePM meeting is arranged. In this regard, two viewpoints are presented and analysed in the below. The first addresses *reading doings* of the three *constitutive means* illustrated in figure 9.5, while the second focuses on applying a checklist as a *constitutive means* to guide the *strip of doings*.

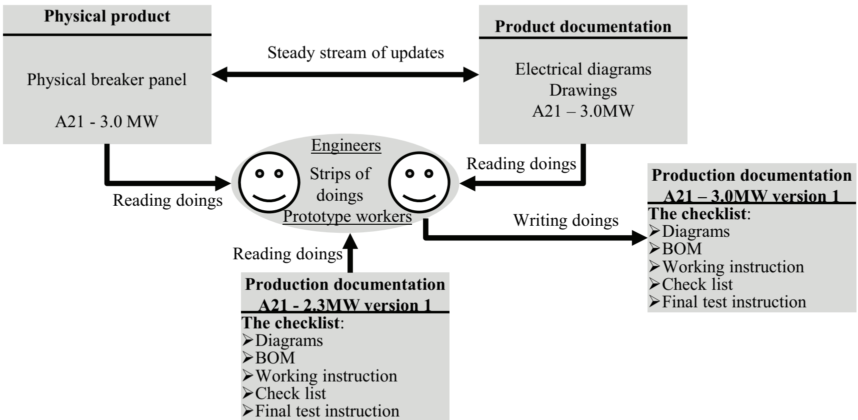


Figure 9.5. Triadic interplay guides the strip of doings when drawing up the ePM.[37]

First, as depicted in figure 9.5, "the physical 3.0 MW A21", "product documentation to the 3.0 MW" and finally, "production documentation from the 2.3 MW A21" make up the *constitutive means* for the *reading doings*. As it appears from the top of the figure, the updates of the physical breaker panel and product documentation are conducted in a steady stream. The *reading doings* draw on these *constitutive means* and the achieved determinacies are written directly into the online version of the production documentation.

[37] I participated in six ePM meetings. The meeting dealing with the A21 is clearly the one showing most *indeterminate situations*. Usually, none or only a few minor discrepancies are detected.

Two groups of kk employees are in charge of drawing up the production documentation. Both groups of employees are familiar with the physical breaker panel and product documentation. Likewise, only approved and valid documentation is retrievable from kk's intranet. The employees' *reading doings* of these well-known and approved *constitutive means* facilitate the *strip of doings*, ultimately resulting in the drawing up of the production documentation. However, as emphasised in the above, a great many of the verified documents appear to be copy and paste[38] from "old documents". I.e., the approach being used to facilitate the *strip of doings* resulting in a *determinate situation* is "copy and paste".

The applied copy and paste approach indicates that the *strip of doings* draws on *habitual experience*. The employees conduct *reading doings* of well-known and approved *constitutive means,* but the *reading doings* of the *obdurate constitutive means* do not cause disturbance in the *habitual experience*, for which reason the *reflective experience* is not activated. The achieved determinacy has a low *sustainability* and learning is constrained.

Second, when drawing up the production documentation, the employees apply a checklist, which consists of 12 focal points. Folders on the intranet reflect these 12 focus areas. Thereby, the creation of the documentation is a systematic process, in which documents are retrieved from the intranet, text pieces are removed/added and the documents are saved once again. Thereby, a checklist establishes a structured approach, which ensures that all *strips of doings* are processed. The checklist safeguards that nothing will be missed; it might give peace of mind to be guided by a checklist.

Drawing attention to the number of "copy/paste discrepancies" detected during the verification of the A21, the safeguarding role of a checklist may give a false sense of security. In this regard, the checklist is the *constitutive means* to retrieve from the intranet suitable production documentation to be modified. However, as the documentation is "copied and pasted" without any modifications, the *reading doings* of the *constitutive means* (the checklist) constrain a proper *anchoring* of the *indeterminate situation.* I.e., it does not create disturbance within the *habitual experience*, resulting in the *reflective experience* not being activated. This suggests a drawback of slavishly following checklists. The safeguarding effect of a checklist may hinder the achievement of *sustainable determinacy* as well as constraining the learning process.

## 9.9. Summary – A21 obdurate specifications

The *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doing*s became central in the analysis.

Figure 9.6 summarises the analysis of the *obdurate* specifications. The vertical axis represents the *efforts* required to enable the *strip of doings*. That is, how time-consuming and resource demanding it has been to enable a convergent *anchoring* and a continuation of the *strip of doings*. The horizontal axis represents the *sustainability* of the achieved determinacy. The

[38] It appears from the A21 case in section 8.4 that a large part of the identified discrepancies is caused by a copy and paste approach.

grey ellipses refer to the analyses in section 9.8 and illustrate the relation between *effort* to enable the *strip of doings* and the level of *sustainability*.

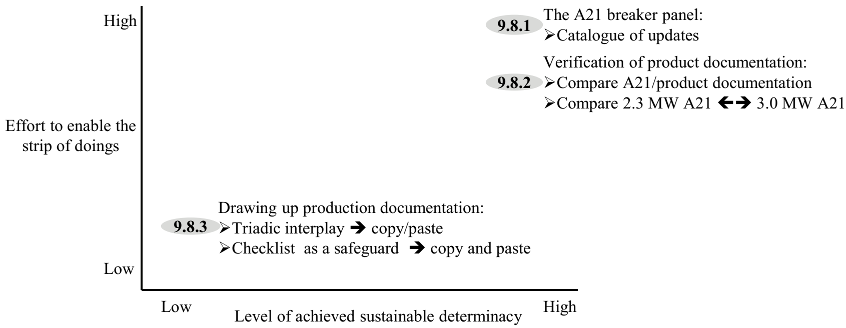


Figure 9.6. Summary of the obdurate specifications – effort and sustainability.

The drawing up of the production documentation is characterised by copy/paste, which, all things being equal, requires less *effort* than rewriting all production documentation. The too *obdurate constitutive means* fail to cause disturbance within the <u>*habitual experience*</u>. I.e., it constrains an *anchoring* of the <u>*indeterminate situation*</u>, implying that the *strip of doings* draws on <u>*habitual experience*</u>. The achieved determinacy has a low level of *sustainability* and no learning occurs.

The verification of the product documentation as well as the creation of the catalogue of updates involves heterogeneous engineers; some are working on the A21 applied in the 2.3 MW, while others are working on the 3.0 MW. Both examples illustrate that a comprehensive *effort* is required to enable a convergent *anchoring* of the indeterminacy and a continuation of the *strip of doings*. The achieved determinacy is *sustainable* and learning occurs.

An *obdurate constitutive means* is complicated due to the many potential side effects of a change to be implemented. It requires much *effort* to cope with this. A convergent *anchoring* of the <u>*indeterminate situation*</u> enables the engineers' <u>*reflective experience*</u> to follow a convergent track. The continuation of the *strip of doings* draws on reciprocal interchanges of <u>*reflective experience*</u>.

## 9.10. Findings – characteristics enabling/constraining the learning process

This section gathers the threads from the above analyses. The intention is to present and explain the findings with regard to the characteristics enabling or constraining the learning process when conducting a PD activity.

The analysis reveals five characteristics of the enablers/constraints. These appear from the left column in table 9.2.

| Enablers/constraints | Explanation |
|---|---|
| Accessibility of constitutive means. | High accessibility of diverse and usable constitutive means enables learning. |
| Ductility/obduracy. | Too ductile or too obdurate constitutive means constrain learning. |
| Heterogeneity of engineers. | Different levels of experience among the engineers enable learning. |
| | Learning is constrained if an engineer with critical experience is not present. |
| Anchoring of the indeterminate situation. | A convergent anchoring of the indeterminate situation enables learning. |
| Continuation of the strip of doings. | Learning is constrained if information is merely handed over. |
| | Learning is constrained if reciprocal interchanges are put on standby. |
| | Learning is enabled if reciprocal interchanges draw on reflective experience. |

Table 9.2. Enablers and constraints for the learning process – Oldtimer.

The first three characteristics in table 9.2 have in common a connection to the composition of the STP. The fourth characteristic relates to the anchoring of the indeterminate situation, while the fifth characteristic is related to a continuation of the strip of doings. As a result, the enablers and constraints for the learning process are categorised into the **composition** of the STP, the **anchoring** of the indeterminate situation and the **continuation** of the strip of doings; these appear from the uppermost row of table 9.3.

As for the cross-functional, interorganisational and daily working STPs, the enablers and constraints influence the learning process differently; this is illustrated in table 9.3. The leftmost column of the table indicates different STPs; each is divided into an enabler and a constraint part.

A **blank cell** in the table indicates that **no learning occurs**; e.g. in the cross-functional STP prior to the relocation, the reciprocal interchanges are put on standby once a convergent anchoring of the indeterminate situation is achieved.

| | Characteristics enabling/constraining the learning process | | |
|---|---|---|---|
| STP | Composition | Anchoring | Continuation |
| **Cross-functional** – prior to relocation **Enabler** | High accessibility of diverse and usable constitutive means. Different levels of experience among the engineers. | Convergent anchoring of the indeterminate situation. | |
| **Constraint** | Too ductile or too obdurate constitutive means. | | Reciprocal interchanges are put on standby. |
| – after relocation **Constraint** | | | Information is merely handed over. |
| **Interorganisational** **Enabler** | High accessibility of diverse and usable constitutive means. Different levels of experience among the engineers. | Convergent anchoring of the indeterminate situation. | Reciprocal interchanges draw on reflective experience. |
| **Constraint** | Too ductile or too obdurate constitutive means. An engineer with critical experience is not present. | | Information is merely handed over. Reciprocal interchanges are put on standby. |
| **Daily working** **Enabler** | High accessibility of diverse and usable constitutive means. Different levels of experience among the engineers. | Convergent anchoring of the indeterminate situation. | Reciprocal interchanges draw on reflective experience. |
| **Constraint** | Too ductile or too obdurate constitutive means. | | |

Table 9.3. Enablers and constraints within different STPs – Oldtimer.

As it appears from table 9.3, learning occurs within the interorganisational and daily working STPs, while the learning process becomes blocked within the cross-functional STP. This is elaborated upon below.

Subsequently, findings addressing the anchoring of the indeterminate situation are presented in sections 9.10.3 and 9.10.4. These findings are not related to table 9.3.

### 9.10.1. Learning process within the cross-functional STP

No learning occurs within the cross-functional STP prior to the relocation.

The accessibility of diverse constitutive means and engineers with different levels of experience enable a convergent anchoring of the indeterminate situation and chart the course for the engineers' reflective experience.

The enabling constitutive means are either the combination of electrical diagrams, laptop, IT systems, TV screen and intranet/internet connection or the ongoing reading and writing doings of red and green corrections/comments made directly on the electrical diagrams or drawings. The engineers apply these kinds of constitutive means to reach common ground with regard to the substance of the indeterminate situation to be handled. As a constitutive means to sustain this convergent anchoring, comments are made in notebooks and in MoMs; last but not least, the writing doings made directly on the hardcopies of electrical diagrams and sketches are crucial in this regard.

Given that the reciprocal interchanges are put on standby, learning is constrained; however, the convergent anchoring paves the way for finishing the strip of doings later on and thereby for creating new experience. In other words, the cross-functional STP is a link between the interorganisational STP and the daily working STP: that is, it is tailored to hand over the indeterminate situations being identified beyond the boundaries of this STP.

After the relocation of the PD project group to an open-plan office, the composition of the cross-functional STP constrains the learning process, as the focus is merely on handing over information.

### 9.10.2. Learning process within the interorganisational and daily working STPs

In general, learning occurs within the interorganisational and daily working STPs.

The composition of the STP is constantly mutable. The ongoing relocations from a meeting room to the production area and vice versa as well as the penetrating doings by the use of mobile phones and laptops improve the accessibility to diverse and usable constitutive means. For instance, in the production area, it is possible for the engineers to see, touch and from time to time replace components in the physical breaker panel. The constitutive effect of a physical breaker panel exceeds the constitutive effect of, for instance, a drawing.

The enabling constitutive means is not just "a sketch" or "an electrical diagram"; rather it is the aforementioned combination of constitutive means and the ongoing reading and writing doings made directly on the electrical diagrams or drawings.

The engineers from Oldtimer and/or kk make an effort to anchor the indeterminate situation. If a convergent anchoring of the indeterminate situation is impossible, the strip of doings is deliberately blocked. In this regard, a too ductile/obdurate constitutive means or the non-attendance of an engineer with critical experience will block the strip of doings.

Achieving a convergent anchoring of the indeterminate situation charts the course for the engineers' reflective experience. The reciprocal interchanges drawing on reflective experience enable to keep on track the engineers' reflections and thereby enable learning as well.

#### 9.10.3. The focal point for learning is the anchoring of the indeterminate situation

A proper anchoring of the indeterminate situation paves the way for a continuation of the strip of doings and thereby learning. Without a proper understanding of the substance of the indeterminate situation to be/being handled, **an engineer's** reflective experience is either not activated or led on a wild goose chase.

To pave the way for **collective learning**, the involved engineers must establish a common ground as for the substance of the indeterminate situation to be/being handled. Without a convergent anchoring of the indeterminate situation, it is not possible to keep on track the engineers' reflective experience, which will block the learning process.

The focal point of the anchoring process is the reciprocity between the accessible constitutive means and the engineers having different levels of experience. The issue is whether the reciprocal interchanges create enough disturbances in the engineers' habitual experience to transcend the precognitive phase and thus activate the engineers' reflective experience. Transcending the precognitive phase paves the way for a continuation of the strip of doings and it charts the course for the reciprocal interchanges to draw on reflective experience; i.e., it enables learning. Remaining in the precognitive phase implies that the engineers are merely handing over information, which constrains learning.

#### 9.10.4. Ductility and obduracy influence the anchoring process

Too ductile or too obdurate constitutive means influence the anchoring of the indeterminate situation as well as the effort necessary to ensure a continuation of the strip of doings.

The A24 case demonstrates that too ductile constitutive means do not cause enough disturbances within the engineers' habitual experience, by which they remain in the precognitive phase. As it is impossible to achieve a convergent anchoring of the indeterminate situation, the learning process becomes blocked.

The A21 case reveals that too obdurate constitutive means are complicated due to a variety of potential side effects of a change being implemented. A too obdurate constitutive means may imply that the engineers are conducting a strip of doings without noticing the indeterminate situation. As the "indeterminate situation remains undetected", the engineers remain in the precognitive phase, implying that no learning occurs. If not making an effort, a too obdurate constitutive means will block the learning process.

### 9.11. Summary of the Oldtimer analysis

The objective of the chapter was to identify and thereby obtain an understanding of which characteristics enable or constrain the learning process when conducting PD of a WTC.

By addressing how a PD activity unfolds within an interorganisational, cross-functional and daily working STP, the analysis reveals five characteristics enabling or constraining the learning process. These are: accessibility of constitutive means, ductility and obduracy, heterogeneity of engineers, anchoring of the indeterminate situation and finally, continuation of the strip of doings.

The five characteristics enabling or constraining the learning process are related to: the composition of the STP, the anchoring of the indeterminate situation and the continuation of the strip of doings. These three categories of enablers and constraints, including the explanation from table 9.2, appear from the analytical framework depicted in figure 9.7.

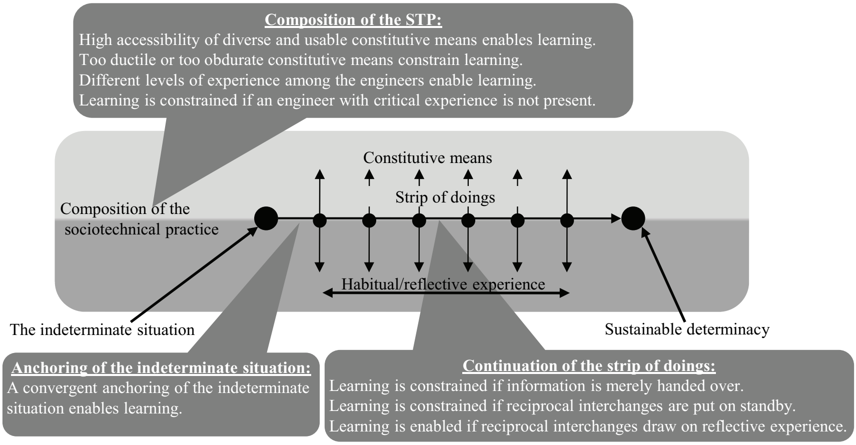


Figure 9.7. Categorisation of enablers and constraints for learning – Oldtimer.

This concludes the analysis of Oldtimer in this chapter. Chapter 10 analyses the Newcomer PD project. Following this analysis, chapter 11 will gather the threads from the analyses of Oldtimer and Newcomer.

# Chapter 10. Analysis of Newcomer

This chapter analyses learning when conducting Product Development (PD) of a Wind Turbine Control (WTC) to Newcomer. The objective of the chapter is to identify and thereby obtain an understanding of the characteristics that enable or constrain the learning process when conducting PD of a WTC.

The drawing up of a **miniTS** and a **TS-document** is central in the analysis of Newcomer. The drawing up of the two documents is a sequential process and simultaneity regarding the degree of completion of the specifications is mandatory. This simultaneity applies to both the miniTS and TS-document, as each of the two documents has to be approved by the management.

The analytical approach is identical with the analysis of Oldtimer in chapter 9. That is, the subject matters in the rightmost column of figure 10.1 become the means to guide my reflective thinking throughout the analysis of enablers and constraints for the learning process. The uppermost box contains the focal points for the thematic analysis addressing the composition of the SocioTechnical Practice (STP). The issues in the lowermost box are used in the chronological analysis; it focuses on a sequence of events in order to understand how the engineers are conducting a PD strip of doings within different composition of the STP.

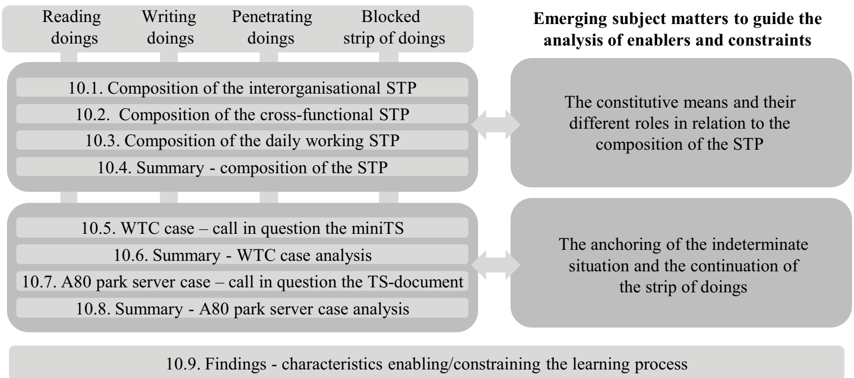


Figure 10.1. The analytical approach and the structure of chapter 10.

Sections 10.1-10.4 analyse the composition of the STP, while sections 10.5-10.8 focus attention on the approaches being applied during the drawing up of the miniTS and the TS-document. Section 10.9 combines the analyses and presents the findings. Just as with the analysis in the previous chapter, terms written in *italics* are explained in chapter 7, table 7.1, while underlined terms written in <u>*italics*</u> are explained in chapter 6, table 6.1.

The analysis below centres on identifying the *constitutive means* and their different roles in relation to the composition of the *STP*.

## 10.1. Composition of the interorganisational STP

The intended role of the miniTS is to be the *constitutive means* to enable the *strips of doings* and, ultimately, to facilitate the preparation of the TS-document; that is, the detailed specifications. The TS-document is an online document; all *reading* and *writing doings* are conducted directly into this document. The TS-document is intended to be the *constitutive means* to enable the *strips of doings* when creating the necessary product/production documentation and to carry out the pilot production.

The interorganisational *STP* only unfolds within a meeting room.[1] The meetings do not follow a specific course, with the exception of the two project managers starting each meeting with agreeing on the agenda.

### 10.1.1. Divergent interpretations of the constitutive means impede the strips of doings

At the interorganisational *STP* 18 September 2009, Dean introduces the first technical issue and displays the TS-document on the TV screen. The "track changes" feature in MS Word is activated and the red text calls attention to an *<u>indeterminate situation</u>* dealing with "LVRT[2] and encoder signal fibre cables".

Automatically, all participants turn their head to this *constitutive means* and conduct *reading doings* of the highlighted text on the TV screen. Dean explains the issue while looking at Joe, Newcomer's project manager. The *reading doings* of the *constitutive means* combined with the explanations enable a continuation of the *strip of doings* and Joe seems to understand the subject matter. Apparently, they achieve a *<u>determinate situation</u>* of this technical issue, and Dean conducts a *writing doing* in the MS Word document – now the text becomes blue. Dean moves along to the next technical issue, which deals with the emergency stop; as before, this *constitutive means* is introduced by depicting it on the TV screen. Dean starts explaining, but Joe soon *blocks the strip of doings*. He wants to know the reason why Dean was asking about the clarification of the converter (the above-mentioned LVRT issue, author). Dean says:

> *"you are not allowed to erect wind turbines using the principles of full loaded generator in the USA before February 2011 due to IPR* (Intellectual Property Rights, author)*. Therefore, you have to be aware of this issue."* (HW engineer 1, 18 September 2009).

The introduction of IPR causes a *strip of doings*, in which kk's project manager explains all measures taken by kk to avoid an IPR conflict.[3] Gradually, a new *starting doing* emerges, which calls into question the scope of delivery in accordance with the miniTS. The miniTS is

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[1] Just after the meeting held 25 September 2009, a guided tour in the production area is arranged for the Asian PD employees. At the time, the assembly of the breaker panels to Newcomer's WTC is not initiated. Thereby, the explanations and presentations are more general and do not include any technical clarification.

[2] Low Voltage Ride Thru is a technology by which all power from the generator is transformed to an exact/stable frequency. In the pilot case, the two available technologies are explained – the double fed induction generator (DFIG) converter technology and the full power (FFIG) converter technology. The DFIG technology converts only a part of the power from the generator; the majority of the effect is transferred directly from the generator to the grid.

[3] Joe agrees with these measures and explains how Newcomer handles this issue.

now the *constitutive means* for the *reading doings*, which paves the way for another *starting doing* addressing who is responsible for defining interfaces, and so it continues for a long time.

The divergent interpretations of the *constitutive means* (the miniTS) result in an inconstant *strip of doings* fluctuating between technical clarifications and identification of the scope of delivery. Actually, this back and forth between the two subject matters continues until the day the TS-document is going to be signed in X city by Newcomer's management.

Apparently, something happens within the *STP* that influences the continuation of the *strip of doings*. Hence, the analysis is divided into two subsections. Section 10.1.2 analyses the contributory causes beyond the physical boundaries of the *STP* that influence the *strip of doings*. The following section continues this analysis and focuses on the composition of the *STP*.

### 10.1.2. Contributory causes influencing the strip of doings

Something occurs in the background of the particular *STP*. Despite occurring beyond the physical boundaries of the interorganisational *STP*, it influences the participants' interpretation of the <u>*indeterminate situation*</u>.

<u>10.1.2.1. Newcomer's cooperation with Alpha and Bravo</u>

The Newcomer project group has recently been posted abroad to X city next to Alpha, a consultancy company. Moreover, Newcomer is working closely together with another consultancy company, Bravo. The core services of these two consulting organisations are to give advice, to explain, to help, to support etc., by which the collaboration is characterised by a high level of openness.

Referring to the interorganisational *STP* 25 September 2009, Joe connects his laptop to the TV screen and depicts some information he has just received from Alpha. He emphasises that he wants to receive similar information from kk. This *starting doing* paves the way for a *strip of doings* between the two project managers, in which the contractual agreement in accordance with the miniTS becomes the *constitutive means*. During this *strip of doings*, Joe raises his hands to his head and says he really needs to understand the technical aspects. kk's project manager has a different understanding of the contractual agreement.

> *"He* (Newcomer's project manager, author) *perceives us as a partner, but we are only a supplier of a WTC. That is what they have paid for. He expects to have the same working relationship with us as he has with Alpha. But Alpha is a consulting organisation and we are not a consultant; we design and produce WTCs to our customers."* (kk project manager, 25 September 2009).

That is, Newcomer's project manager has acquired <u>*experience*</u> from the collaboration with Alpha and Bravo. He expects similar *strips of doings* with kk and thus expects the composition of the *STP* to have a high level of openness. However, due to divergent interpretations of the *constitutive means* (the miniTS), the lack of openness within the interorganisational *STP* is a recurrent subject for *starting doings* throughout the PD project.

10.1.2.2. Managerial guidelines: Newcomer

Previously, Newcomer has developed and produced two different wind turbines without success and evidently, the organisation cannot afford one more unsuccessful wind turbine. For instance, Joe reads aloud from an e-mail. Briefly, the e-mail is from the top management at Newcomer and it instructs all project managers involved in the 2.0 MW wind turbine project to follow some guidelines. The Danish participants' body language and the following discussion among them spotlight some very relevant issues (this dialogue takes place in Danish). Likewise, Joe briefly refers to an internal meeting at Newcomer, at which the top management set up guidelines for the involved project managers.

> *"I have had a meeting at Newcomer and my executives said that the top priority is to develop a cost-efficient and reliable wind turbine. How can I verify this if you do not hand over some detailed documentation? I really need to have access to this kind of specification."* (Newcomer project manager, 25 September 2009).

Joe needs to be convinced that the WTC being created facilitates the erection of a cost-effective and reliable wind turbine. Joe is in charge of the PD project and his basic needs are to know all about the calculations, for which reason he requests more openness. He needs to understand the functionality of the Hardware (HW) and how the Software code (SW) is written/structured; the technical solutions, the formulas and calculations must be transparent.

10.1.2.3. Managerial guidelines: kk

kk's project group also has guidelines to follow. Two of these are elaborated below.

The first issue is actually missing guidelines of how to explain technical solutions. As mentioned elsewhere, Joe pushes hard to make the calculations/solutions more transparent. Undoubtedly, the kk engineers have the *experience* to fulfil this request. However, the kk engineers are not aware of how much information and *experience* they are allowed to make use of when explaining the functionalities/solutions/calculations.

Second, the PD project group is in doubt as to how to draw up the TS-document. Briefly, the doubt relates to the content as well as the layout of the TS-document. Is it "simply a copy and paste" of the CSIC[4] WTC platform or a customised WTC platform to be created. The layout issue addresses the structure of the TS-document.

In the absence of guidelines for explaining solutions/calculations, the kk engineers want to be on the safe side, keeping their cards close to their chest. This results in a low level of openness within the interorganisational *STP*, constraining the *strips of doings*. In addition, the doubts dealing with the technical platform to be created call in question the *trajectory* being charted by all conducted *strips of doings* throughout the miniTS phase. This implies that the role of the miniTS as a *constitutive means* is challenged, often causing the *strips of doings* to run into a blind alley and thereby become *blocked*.

[4] CSIC is an abbreviation for China Shipbuilding Industry Cooperation.

10.1.2.4. Experience gap between Newcomer and kk

As Newcomer has previously developed a 750 KW and a 2.0 MW wind turbine, the organisation has acquired a certain level of *experience* regarding WTCs. The two types of wind turbines, however, do not function properly. kk has nearly three decades of *experience* with WTCs, and the technical platform being created with Oldtimer is regarded as state-of-the-art. In line with this, the kk's project manager considers the "Oldtimer mindset" to be problematic.

> *"Once again, it is this line of thinking which destroys it all. With Oldtimer, our 25 years of experience is embedded within the pre-clarifications, actually it is the sustaining element of it all. Now we have to make these 25 years of experience explicit in the TS-document that is at the core of his demand* (Newcomer's project manager, author). *He wants to know the reason why our 25 years of experience is the best choice for Newcomer."* (Said in Danish by kk project manager, 7 October 2009).

An *experience* gap between kk and Newcomer is apparent. However, the involved employees from both kk and Newcomer have an engineering background as well as practical experience in relation to WTCs.

### 10.1.3. Composition of the STP – experience gap, openness and trajectory

Within the composition of the interorganisational *STP*, the *strips of doings* are often constrained. Some of the reasons for this constraint of the *strips of doings* can be traced back to the issues being discussed in section 10.1.2.

10.1.3.1. Composition of the STP in relation to experience gap

Dean asks about the minimum and maximum speed of the generator; this design question is depicted with red text on the TV screen. The technical considerations are explained, but seeing that none of the Asian engineers understands why the speed of the generator has to be specified, it is not possible to carry on the *starting doing*. Therefore, Dean conducts a *penetrating doing* and calls Tim, SW engineer 1. Even though Tim has critical *experience* in this regard, it is necessary to conduct one more *penetrating doing*, and Dean calls Ole, SW engineer 3; Ole is the converter specialist at kk.

Clearly, the *strip of doings* involving Joe and Tim/Ole is technical. Both the maximum and minimum speeds of the generator are crucial to control a wind turbine, but the minimum speed is more crucial for Joe. The minimum speed of the generator is a RPM[5] measurement criterion used to connect and disconnect the wind turbine to/from the grid. The argumentation advanced by Joe is to follow the guidelines from Alpha[6] regarding the lowest RPM for the generator. As the wind speed determines the RPM of the generator, a low minimum speed of the generator makes it possible to have the wind turbine connected to the grid within a larger wind-span. Tim and Ole fully understand Joe's considerations in this regard, but the wind turbine will not be able to generate electricity to the grid at such a low speed. Therefore, Tim

[5] RPM is an abbreviation of Revolutions Per Minute

[6] The calculation accomplished by Alpha only takes into consideration mechanical calculations regarding strength and vibrations.

and Ole argue for a small band lying between the proposal from Alpha and the one being used to connect/disconnect the wind turbine to/from the grid. However, the kk engineers do not succeed in explaining why it is appropriate to have a higher RPM than that proposed by Alpha.

The kk engineers and the Newcomer engineers have different levels of *experience*; they are heterogeneous. The *experience* received from the consulting company, Alpha, combined with a focus on achieving a high power range[7] guides that part of the *strip of doings* conducted by the Newcomer engineers. The kk engineers have considerable WTC *experience*, but they are in doubt as to how transparent to make their explanations of technical issues. Likewise, due to the low level of openness within the *STP*, no *constitutive mean*s are accessible for Newcomer's engineers. Disturbance within the *habitual experience* is apparent, but the low level of openness makes it impossible to transcend this precognitive phase. The lack of openness constrains the *strip of doings*, by which it runs into a blind alley and becomes *blocked*. Thus, no learning occurs.

10.1.3.2. Composition of the STP in relation to low level of openness

Joe needs to understand the calculations dealing with the above lowest possible RPM to connect/disconnect the wind turbine to/from the grid and the calculations have to be factual.[8] Joe argues for improving the openness in order to be more actively involved in the *strips of doings*.

> *"I need information about how it works if I am to be more active in the development process. I need to receive drawings and electrical diagrams, and the reason why they* (kk engineers, author) *choose the specific solutions. What are their strategies[9] for choosing the solutions? If I do not receive such information, I will just be sitting her, left in the dark"…"I am an engineer and I have a basic need to gain insight into how it works. Otherwise, how should I become convinced? I have pointed out this ever since our first meeting in September."* (Newcomer project manager, 7 October 2009).

Joe considers the lack of openness to be a serious problem and he advances multiple arguments in an endeavour to improve this. In this regard, the miniTS is often the *constitutive means* being applied to initiate a *starting doing*. On the one hand, Joe expects a close collaboration facilitating joint development; that is, a high level of openness. On the other

[7] *"The Asian engineers have been very interested in this cut in speed; that is, when to connect the wind turbine to the grid. A high power range is a good sales argument to be printed in a brochure; hence, they have been really focused on having a low cut in speed. But it is not appropriate to connect to the grid if the wind turbine consumes more power to be operating than it can produce"…"The power factor is the relation between active and reactive power. The reactive power is a kind of blind-effect. Maybe the converter can operate with low RPM, but it is not certain that the owner of the grid allows the wind turbine to be connected to the grid due to a high level of reactive power."* (SW engineer 1, 4 December 2009).

[8] Actually, Ole's "calculations" are a comparison of the generator being applied by Newcomer with one that he is familiar with. Hence, there are no factual calculations, but Ole makes use of his extensive *experience* of converters to propose a lowest possible RPM.

[9] The term strategy is commonly used by the (SW) engineers to describe a technical solution, for instance, *"we have to develop a lubricate strategy and a cool down strategy for the gearbox"*.

hand, Rick considers the interaction to be an "arm's length"[10] collaboration, by which kk delivers a cost-effective and reliable WTC.

The divergent interpretations of the *constitutive means* (the miniTS) cause a great many *strips of doings* to follow divergent tracks. The destination of one (kk) track is to draw up the TS-document, while the end station of the other (Newcomer) track is to improve the openness. Thereby, a *determinate situation* of the agreed openness remains elusive. The composition of the *STP* is characterised by a low level of openness, which is constantly challenged by Newcomer.

10.1.3.3. Composition of the STP in relation to change in the trajectory charted

The creation of the WTC to Newcomer consists of three phases starting with the drawing up of the miniTS, followed by the creation of the TS-document and ending with the drawing up of the necessary documentation and the assembly in the pilot production. These three discrete phases imply that the *strips of doings* are divided into three time dependent phases, in which simultaneity with regard to degree of completion is an essential precondition. Accordingly, the *strips of doings* are divided into three discrete phases.

The *trajectory* being charted by all *strips of doings* throughout the miniTS phase should be the *constitutive means* enabling the *strips of doings* when drawing up the TS-document. Likewise, the *trajectory* being charted throughout the TS-document phase should be the *constitutive means* enabling the *strips of doings* when drawing up the necessary documentation and executing the pilot production.

Drawing attention to the Newcomer narrative in section 8.5, the WTC to be created in accordance with the miniTS draws on a CSIC 2.0 MW platform, yet proves to be mainly created on the basis of the Charlie 5.0 MW platform. As it appears from figure 8.6, the main part of the breaker panels in the Newcomer WTC is replaced in the transition between the miniTS and TS phases. Regarding the A80 park server, the need for replacement emerges after the TS-document has been approved; actually, the A80 remains largely unnoticed in the TS phase. These two transitions result in radical changes of the *trajectories* being charted.

The above problematic transitions entail that the *constitutive means* to enable the *strips of doings* are eroded; i.e., no *constitutive means* are accessible to enable the *strips of doings*. The miniTS does not have a constitutive effect on the TS-document, and the creation of the TS-document only succeeds because the kk engineers take charge and wield the pen. Likewise, the TS-document is not a *constitutive means* to create the A80 park server. Instead, the responsible engineer takes charge.

Hence, a radical change in the *trajectory* causes the *constitutive means* to become unusable to enable the *strips of doings*, and the composition of the *STP* is changed. In addition, notebooks and MoMs become unusable as *constitutive means* to recall past decisions or *experience*.

[10] *"The miniTS was a bible for kk, but for Newcomer, it was just a pure description of what we are able to do; it is just like a data sheet of a car describing what the car can. Clearly, the miniTS was not a binding agreement for him* (Newcomer's project manager, author). *Communication has been extremely insufficient with respect to the scope of delivery."* (HW engineer 1, 9 December 2009).

To summarise, the composition of the interorganisational *STP* is characterised by a low level of openness. A radical change of the *trajectory* implies that no *constitutive means* are accessible to guide the *strips of doings*.

The low level of openness entails that the two groups of engineers carry out divergent *strips of doings*. The low level of openness constrains the ability of the engineers' *reflective experience* to chase a convergent track, for which reason no collective learning occurs.

The next section focuses attention on the cross-functional *STP*.

## 10.2. Composition of the cross-functional STP

While the Newcomer narrative in chapter 8 indicates that Newcomer does not attach much importance to the TS-document, the opposite is the case seen from kk's perspective.

> *"The TS-document is what we have to deliver; neither more nor less. They allow us to lead the pen* (to write the TS-document, author). *We have "sold the TS-document" and they* (Newcomer, author) *will use this TS-document to follow up on our ability to deliver what has been promised in the TS-document. The TS-document is hardcore facts; hence, it must be possible to verify everything"... "It is okay to use the CSIC TS-document as a point of departure, but it must not be a copy and paste; it should be possible to verify it all."* (kk lawyer, 31 August 2009).

Given that it is the first time a miniTS is going to be applied as a *constitutive means* to enable the *strips of doings* when drawing up the TS-document, it is necessary to ensure a cross-functional alignment. Different types of cross-functional meetings are conducted in this regard. Two of these cross-functional *STP*s are analysed. In addition, a cross-functional *STP* dealing with technical clarification after the TS-document has been approved is analysed.

### 10.2.1. Cross-functional alignment – standard versus customised WTC?

Addressing the cross-functional *STP* 27 August 2009, the intention is to hand over the miniTS from New Business Department (NBD) to the PD project group. The kk employees who have signed the contractual agreement (miniTS) have no doubts as to what have been sold to Newcomer.

> *"I have just talked with Brodersen*[11] (lawyer at kk, author*). He told me that the miniTS precisely defines the scope of the project, and he emphasised strongly that the TS-document has to be within the scope of the miniTS."* (kk project manager, 27 August 2009).

Nick,[12] the technical salesman, presents the miniTS. He makes use of the blackboard to accentuate the subject matter of the miniTS and, in addition, the miniTS is depicted on the TV

[11] Assisting the vice president in the contractual negotiations, the lawyer has been actively involved in the dialogue with Newcomer. Referring to the vice president, the focal point of these negotiations has latterly been more technical than commercial.

[12] Nick has grown up within the technical domain. Therefore, he has a detailed understanding of the technical substance of a WTC; in other words, he possesses a high level of technical experience. Besides, he knows how the engineers think and he is familiar with the technical jargon. That is, Nick seems to be archetypical of a bridge builder between the sales department and the technical domain.

screen by applying the laptop. The miniTS is the *constitutive means* and the participants' *reading doings* combined with Nick's explanations are the seed for a *starting doing*. Nick advocates that the technical platform of the WTC to Newcomer has to draw on the CSIC solution in accordance with the miniTS. Conversely, the kk engineers from the project group call in question the content of the miniTS. They consider the CSIC platform to be an unsuitable fundamental basis for creating a WTC to Newcomer. Despite the participants' *reading doings* of the *constitutive means* on the TV screen and energetic application of the blackboard, the *strip of doings* is constrained. I.e., it is not possible to achieve determinacy as to whether it is a standard WTC identical to the one delivered to CSIC or a customised WTC sold to Newcomer.

The explanations from the salesman and the accessible *constitutive means* cause disturbance within the kk engineers' *habitual experience*. It activates the *reflective experience* and consequently, the kk engineers question the *trajectory* being charted by all *strips of doings* conducted throughout the miniTS phase. The fact that the salesman and the kk engineers have different levels of *experience* implies that the *reflective experience* follows divergent tracks, constraining the *strip of doings*. I.e., the composition of this particular cross-functional *STP* is comparable with a blind alley for the *strip of doings* and no learning occurs.

The drawing up of the TS-document is another indeterminacy being addressed in this *STP*, as a common understanding in this regard has not yet been reached. No *constitutive means* are accessible to conduct *reading doings* and consequently, the *strip of doings* encounters a cul-de-sac, just as in the above. A similar *indeterminate situation* emerges within the cross-functional *STP* on 16 September, which is analysed below.

### 10.2.2. Cross-functional alignment – layout and content of the TS-document

The head of research introduces the issue to be handled within this cross-functional *STP* 16 September; it focuses on avoiding any IPR conflicts. As the intention is to scrutinise the technical solutions applied in the Newcomer WTC and thereby identify any kind of conflict with IPR, HW engineer 2 depicts the online version of the TS-document on the TV screen.

Shortly after starting this *strip of doings*, HW engineer 1 asks the head of research to elaborate on the problem. He takes a hardcopy of the TS-document from the table and raises it while saying *"this TS-document is the problem…"*, after which he reads aloud from the TS-document. It results in the *strip of doings* wandering back and forth; gradually, a new *starting doing* emerges as the *indeterminate situation* moves from addressing IPR issues to addressing the layout and content of the TS-document. No *constitutive means* are accessible to enable this *strip of doings*, and the head of research *blocks the strip of doings* by saying:

> *"it is a real learning process for us all, so I think we just have to get started. It takes at least half a year. Some years ago, I tried to implement a similar concept, but all went into a deadlock. We really need to think differently and even though it will take two or three years, we have to think in this way."* (Head of research, 16 September 2009).

The head of research has a clear *end-in-view* of a suitable structure[13] of the TS-document, which is not in accordance with the present layout and content. This *end-in-view* causes disturbance in the engineers' *habitual experience*. Although all engineers from the project group consider the proposal (*end-in-view*) from the head of research to be suitable, it is not possible to really transcend this precognitive phase. This constrained *strip of doings* springs from a low application of usable *constitutive means* to guide and keep on track the heterogeneous engineers' *reflective experience*; i.e., no learning occurs.

The low accessibility of usable *constitutive means* fails to either challenge or achieve a *determinate situation* of the proposal from the head of research. That is, the proposal is neither rejected nor applied to enable a continuation of the *strip of doings*. This makes the engineers' *reflective experience* chase divergent tracks and thereby run into a blind alley. In fact, nothing happens until the day when the TS-document is scheduled to be sent to Newcomer. As it will appear from the analysis of the WTC case in section 10.5, the project group is instructed by the head of research to rewrite the TS-document 2 October. This request has a greater constitutive effect than the *end-in-view* presented within the cross-functional *STP* on 16 September.

The last analysis of the cross-functional *STP* spotlights a composition arising just after the TS-document has been approved by Newcomer.

### 10.2.3. The cross-functional technical clarification

On 28 October 2009, one hour after kk has received the signed contract from Newcomer, a cross-functional meeting takes place. As the contract should have been signed 9 October, the preparation of the necessary documentation and the pilot production have been postponed 19 days; yet, the delivery date is not changed.[14]

kk's project manager applies the laptop/TV screen to depict the project plan. He slavishly follows this *constitutive means* to enable the *strips of doings*, by which it becomes possible to achieve determinacy in terms of the progress of all breaker panels.

> *"I know the contract should have been signed 9 October, but I have had a talk with each of you and you have all indicated that it is possible to deliver according to the original plan."* (kk project manager, 28 October 2009).

A competent homework and the accessible *constitutive means* enable a continuation of the *strips of doings*, leaving the participants with no doubt about the compressed plan. Thus, the well-structured composition of the cross-functional *STP* results in *determinate situations*.

Drawing attention to the interplay between the engineers from the project group and a supply chain engineer, two *starting doings* emerge. The first deals with the allocation of responsibilities between the two functions in the remaining part of the PD project. Even

[13] The head of research considers the TS-document to be too detailed and to describe too much. Therefore, he suggests dividing the specifications into three parts.
[14] The original plan gives 50 working days to create the necessary documentation and accomplish the pilot production. The postponement leaves only 38 working days, reducing the available time by 24%.

though the supply chain engineer argues for achieving a *determinate situation*, the *strip of doings* wanders back and forth, resulting in it gradually fading away. The second *starting doing* sheds light on a lack of coherence between pilot production and the following running production. The supply chain engineer finds it inappropriate to have too many breaker panel versions, as it makes the supply chain complex and thereby too expensive to manage. Conversely, one of the engineers considers this issue unimportant as the pilot production has to be in accordance with the TS-document. Due to divergent interpretations, the *strip of doings* becomes *blocked*, just like in the above example.

The composition of this cross-functional *STP* does not spur *strips of doings* between engineers across functional boundaries. At present, the TS-document is the *constitutive means* and its role is to enable the *strips of doings* throughout the preparation of product/production documentation and the pilot production as well.

As it appears from the analysis dealing with the composition of the interorganisational and cross-functional *STP*s, the *successful strips of doings* are not conducted within the composition of these *STP*s. Instead, the *successful strips of doings* are conducted by the kk engineers when sitting within the daily working *STP*; the aforementioned "war room". The next section addresses this.

## 10.3. Composition of the daily working STP

Within the war room *STP*, the project manager, draughtsmen and all engineers are sitting next to each other; only employees who at present are working actively on the Newcomer project are sitting in this room. The employees sitting within this composition of the *STP* are responsible for drawing up the TS-document as well as the necessary product/production documentation to carry out the pilot production.

The war room is an ordinary open-plan office on the first floor. During a working day, a number of employees stop by. Some just wants to have an update of the progress, while others actively contribute to the progress of the development. In the office space, telephone conversions and reading aloud from e-mails or standards dealing with wind turbine development etc. are often occurrences.

Besides desks and computers, a blackboard is available in the office. The blackboard is always overfilled with handmade sketches of drawings and electrical diagrams. These *constitutive means* at the blackboard often become the pivotal points for ongoing *reading* and *writing doings*. In addition, diverse *constitutive means*, for instance drawings, electrical diagrams, BOM, key components from suppliers, are placed on various desks within the office. Enabling to keep on track the *reflective experience*, these *constitutive means* are used to guide the *strips of doings*. As mentioned elsewhere, the Newcomer WTC draws on reusing previous technical solutions when possible; mainly the Charlie platform. Thus, the "virtual stock" principle illustrated in chapter 2 is crucial in the Newcomer project; solutions, drawings and electrical diagrams from the Charlie platform form the *constitutive means* to enable the *strips of doings*.

One of the electrical engineers is involved in both the Oldtimer and Newcomer project and has thus been sitting in both the Oldtimer daily working *STP* and the Newcomer daily working *STP*. This engineer considers the Newcomer project to be successful.

> *"I think the Newcomer project has progressed twice as fast as the Oldtimer 3.0 MW project. We are using exactly the same working methods, but I think there are three reasons why we have succeeded in doing this. First, we have been sitting together ever since the very beginning of the project. Second, we are responsible for all development in this Newcomer project* (HW and SW, author). *Third, all necessary information/specifications have been accessible from the beginning, and so far they have not been changed."* (Electrical engineer 1, 2 December 2009).

The above indicates a highly adaptable *STP* composition. High accessibility of diverse and usable *constitutive means* combined with proximity among the employees enable a continuation of the *strips of doings*. When an *indeterminate situation* emerges, the necessary information to enable a convergent *anchoring* as well as a continuation of the *strip of doings* is accessible; if not, it is possible to ask the neighbouring engineer. Thus, the composition of the daily working *STP* is adaptable and constantly mutable, enabling reciprocal interchanges drawing on *reflective experience*; this composition of the *STP* enables learning.

## 10.4. Summary – composition of the STP

This section is a summary of the analysis addressing an identification of the *constitutive means* and their different roles in relation to the composition of the *STP*.

Table 10.1 provides an overview of the analysis. The definitions are in keeping with table 9.1, which presents the Oldtimer *STP*s.

The accessibility of *constitutive means* to enable the *strips of doings* within the interorganisational *STP* is low. From the outset, the intention is to apply the miniTS, but the miniTS is rejected by the kk engineers, for which reason its role as a *constitutive means* is eroded. Hence, it is back to basics, and gradually an online version of the TS-document is brought to the fore as a *constitutive means*; no drawings, electrical diagrams etc. are accessible as *constitutive means* within the interorganisational *STP*. The TS-document, however, only plays a limited role as a *constitutive means* enabling the interorganisational *strips of doings*.

The blackboard is often used by Newcomer's project manager to trigger a *starting doing*. The laptop is applied to depict the online version of the TS-document on the TV screen. It ensures a well-structured handling of all indeterminacies that appear from the TS-document; these *indeterminate situations* have been highlighted by the kk engineers prior to the interorganisational *STP*.

A third group is MoMs and notebooks that make it possible to ensure the *trajectory* of the project. However, very rarely do any of the participants conduct *reading doings* in the MoMs/notebooks to enable the *strips of doings*.

Drawing attention to the daily working *STP*, the analysis demonstrates a high accessibility of diverse and usable *constitutive means*, enabling the *strips of doings* and thereby learning.

The cross-functional column is divided into two areas in table 10.1. The uppermost part illustrates that the TS-document and project plan are *constitutive means* to guide the cross-functional *strips of doings* **after signing** the TS-document. The lowermost part sheds light on the role of the miniTS and TS-document as lodestars for the *strips of doings* in the attempt to ensure a cross-functional alignment. The analysis indicates that both of these cross-functional *STP*s only have a minor influence on the creation of the WTC to Newcomer, and in addition no learning occurs.

| Constitutive means within the Sociotechnical practice | Interorganisational STP | Daily working STP | Cross-functional STP **Clarification** | Cross-functional STP **Alignment** |
|---|---|---|---|---|
| ➔ Means to guide technical strips of doings | miniTS<br>On-line TS-document | miniTS<br>TS-document<br>Electrical diagrams<br>3D drawings<br>Sketches<br>Folders –diverse<br>Product spec.<br>Production spec. | TS-document | MiniTS<br>TS-document |
| ➔ Means to guide administrative strips of doings | | | Project plan | |
| ➔ Means to facilitate strips of doings | Blackboard<br>Laptop ➔ TV-screen<br>kk's intranet | Blackboard<br>Laptop<br>kk's intranet<br>CAD-systems<br>Phone and e-mail<br>Internet:<br>-Suppliers<br>-Standard | Laptop ➔ TV-screen | Laptop ➔ TV-screen<br>kk-intranet<br>Blackboard |
| ➔ Means to ensure the trajectory | Notebooks<br>MoM: | Notebooks<br>MoM: | Notebooks | Notebooks |

Table 10.1. The identified constitutive means and the role of these – Newcomer.

The low level of openness within the interorganisational *STP* constrains the learning process. Newcomer's project manager really needs to understand the technical solutions. Constantly, he attempts to *anchor* an <u>*indeterminate situation*</u> in this regard. This lack of openness is often the focal point when the *strips of doings* become *blocked.*

The radical change in the <u>*trajectory*</u> influences the composition of the *STP*, as the accessible *constitutive means* become unusable. As Newcomer's project manager was actively involved in the drawing up of the miniTS, he often refers to the content of this document. This causes a great many *strips of doings* to follow divergent tracks, by which these run into a blind alley and become *blocked*. It constrains the learning process.

The engineers from kk as well as from Newcomer have different levels of <u>*experience*</u>; they are heterogeneous. The analysis indicates that the *strips of doings* do not draw on a convergent interpretation of the indeterminate situation being handled, but merely on one-sided interpretations. Thus, the low level of openness within the composition of the interorganisational *STP* constrains the ability of the engineers' <u>*reflective experience*</u> to follow a convergent track, for which reason no collective learning occurs.

While the above addresses the composition of the *STP*, the analyses in sections 10.5-10.8 emerge gradually to focus on the *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doings*. These analyses are preceded by a short introduction.

As depicted in figure 10.2, the interorganisational clarification with Newcomer is divided into two separate phases. The miniTS and TS-document have to pass through a "gate"; each of the two documents has to be signed by the management. This transition causes the kk engineers to question the *trajectory* being charted by all *strips of doings* conducted so far.

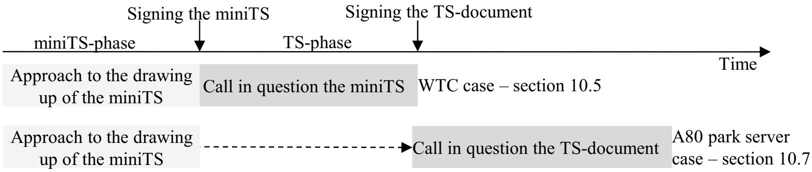


Figure 10.2. The structure of the analysis of the WTC case and A80 park server case.

The WTC case is analysed in section 10.5. The first part addresses the drawing up of the miniTS, while the second part focuses on how to handle a situation in which the miniTS is called in question. Section 10.7 addresses the A80 park server case to conduct a similar analysis. The dotted line from the miniTS phase to the "call in question the TS-document" signifies that the A80 escapes attention during the TS phase; the radical changes occur after the TS-document has been signed.

## 10.5. The WTC case – call in question the miniTS

The object of the miniTS phase[15] is to achieve an understanding of Newcomer's requirements and wishes regarding the WTC.

> *"The miniTS is an instrument we make use of to determine the need of the customer. It includes HW and SW deliveries, and based on this information, we make a budget price."* (Salesman, 4 December 2009).

The salesman handles all interorganisational *strips of doings* in collaboration with the aforementioned project manager from Newcomer, while the kk engineers handle all internal *strips of doings*. To facilitate the interorganisational technical pre-clarifications, the kk engineers hand over information to the salesman, who then conducts the *strips of doings* with Newcomer' project manager. In this regard, three subject matters spring to mind. First, what is the current level of *experience* to create the miniTS? Second, what kind of information do the kk engineers hand over to the salesman? Third, how is this information created?

[15] Please note that I did not participate in these pre-clarification meetings. The data foundation for making the analysis consists of interviews, comments/dialogues in subsequent interorganisational/cross-functional/daily working *STP*s and observations within the open-plan office during the miniTS phase.

### 10.5.1. The experience to draw up the miniTS

A limited number of miniTSes have been drawn up and sent to potential customers. Two of these have resulted in PD projects; the CSIC 2.0 MW and the Charlie 5.0 MW. According to the kk employees, the CSIC and Charlie PD projects differ substantially from each other. While the WTC created to Charlie is regarded as state-of-the-art, the CSIC WTC is as simple as possible. In addition, Charlie's project manager is a former Oldtimer employee with a great deal of <u>*experience*</u> with wind turbines. As illustrated in the below quotation, the <u>*experience*</u> in drawing up the miniTS is minimal.

> *"It is actually the first time we draw up a miniTS and make use of this document to create the TS-document. Of course, we have sent out a number of miniTSes to other customers, but Newcomer is the first customer where the collected information is used."* (HW engineer 2, 14 December 2009).

By habit, the kk employees are accustomed to be searching and asking for information, but in relation to the interorganisational *strips of doings* with Newcomer, the salesman has to give away information to demonstrate the capabilities of kk and thereby prove that the company is a trustworthy WTC supplier. The salesman is not a technical specialist. Therefore it is crucial to hand over usable *constitutive means* to him; *constitutive means* that can cause disturbance within the <u>*habitual experience*</u> and thereby enable the acquisition of new <u>*experience*</u>. The next section addresses this.

### 10.5.2. The information being used to draw up the miniTS

The salesman is in charge of drawing up the miniTS, and the kk engineers facilitate these *strips of doings* as they hand over technical information to the salesman and to Newcomer. A part of this material is a gross list of sorts.

> *"The material is a tool to be used by our salesman, but actually many issues that our customer does not need have been included in this material. We did that in order to facilitate a dialogue between the customer and the salesman, enabling them to sit next to each other and decide what the customer actually needs and then add or delete it in the document. But that is not how it was used."* (SW engineer 1, 4 December 2009).

The *constitutive means* handed over to guide and thereby enable the interorganisational *strips of doings* is an extract from the CSIC 2.0 MW WTC. The shortened document does not draw on a previous miniTS, but a previous TS-document.[16]

> *"We told Newcomer that we have a standard 2.0 MW WTC; actually, a standard WTC does not exist, but we have been preparing the ground for having a standard WTC. Therefore, I took a TS-document from the CSIC 2.0 MW and shortened it; that is, breaker panels used at present, for instance the A10 and A11, form the basis of drawing up the document. This document says something about I/O and about HW, but we have really focused on keeping SW descriptions out of the material."* (HW engineer 2, 14 December 2009).

[16] The TS-document is not a functional description of the WTC, but a detailed explanation of all specifications within all breaker panels.

Thus, the *constitutive means* to guide the *strips of doings* is mainly an I/O overview, from which all SW descriptions have been deliberately removed. Accordingly, it is not a functional description[17] of a WTC as expected by the salesman; instead, it deals with product specifications of the breaker panels. Apparently, the *reading doings* of this *constitutive means* within the interorganisational *STP* cause disturbance in the *habitual experience* and thereby an *anchoring* of the *indeterminate situation*. However, the *reading doings* of this unusable *constitutive means*, which is assumed to be a functional description of a WTC, but actually is a product description of breaker panels, will constrain to keep on track the *reflective experience*. The next analysis addresses this unusable *constitutive means*.

### 10.5.3. An inappropriate end-in-view takes charge and is not called in question

At the time when the kk engineers start drawing up the *constitutive means* to enable the interorganisational *strips of doings* in relation to the miniTS, the kk engineers' *end-in-view* of a usable technical documentation takes charge. Neither prior to nor during the drawing up of the miniTS does anybody call this *end-in-view* in question.

The salesman questions the kk engineers' *experience*[18] in collaborating with a new customer, for which reason the salesman is in charge of all interorganisational *strips of doings*. Thus, although HW engineer 2 from time to time joins the interorganisational *STP*, his *end-in-view* of an appropriate approach to retrieve the usable information from Newcomer is not challenged. The reciprocal interchanges do not result in a proper *anchoring* of the *indeterminate situation*, causing the *strip of doings* to draw on *habitual experience*.[19] This constrains learning.

By shifting focus from interorganisational to cross-functional issues, it becomes obvious that the *experience* necessary to accomplish a miniTS phase is still in its infancy. The kk employees are not experienced in dealing with how to retrieve usable information, as it is the first miniTS being drawn up in this way. Instead, the kk engineers are very aware of the fact that business is generated by selling breaker panels. In line with this, the deliveries to Oldtimer, which makes up the majority of the business, consist solely of the HW part of the breaker panels as Oldtimer creates all SW by itself. Thus, due to the lack of *experience* in retrieving information from a new customer, this business understanding becomes the *end-in-view*. This *end-in-view* guides the *strip of doings* when drawing up the unusable *constitutive means* handed over to the salesman. According to HW engineer 2, nobody challenges this *end-in-view* when he, in cooperation with SW engineer 1, created this *constitutive means*. I.e. it is not possible to ensure a proper *anchoring* of the *indeterminate situation*, by which the *reflective experience* is not activated.

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[17] According to HW engineer 1, behind each I/O, a great deal of SW as well as HW facilitates the functionality.

[18] *"R&D is not accustomed to having customer contact. They are accustomed to be sitting with their headphones in front of their computers and carry out very complex calculations and development. There is a Chinese wall between the external and internal activities."* (Salesman, 4 December 2009).

[19] *"we all knew that the customer had other needs, but we were not allowed to rewrite it, because the product to be sold to Newcomer had to be a standard product."* (HW engineer 1, 9 December 2009).

The majority of the achieved determinacies prior to as well as during the miniTS phase draw on <u>*habitual experience*</u>. This constrains the learning process. However, the salesman and Newcomer's project manager complete the drawing up of the miniTS, as:

> *"I have told them several times that we will explain it in detail after the contract has been signed. Honestly, I have a feeling that Newcomer has accepted our argumentation saying that the miniTS is drawn up by sales with the support of the other departments."* (Salesman, 4 December 2009).

The content of the miniTS fails to have any constitutive effect when drawing up the TS-document. The next section addresses this.

### 10.5.4. The engineers' end-in-view challenges the content of the miniTS

After signing the miniTS, NBD hands over this *constitutive means* to the PD project group. The content of the miniTS addresses a standard CSIC WTC; a technical platform that the kk engineers consider to be unsuitable. According to the kk engineers, "NBD has just sold a CSIC WTC". They are quite certain that the miniTS does not reflect Newcomer's requirements/wishes. In general, the miniTS is perceived as a document that does not describe any functionality. Instead:

> *"it is just a document describing the breaker panels to be included in the delivery; all of these are well-known. The majority of its content deals with I/O and only little HW, while nearly all SW has been omitted."* (HW engineer 2, 14 December 2009).

Referring to the cross-functional *STP* 27 August addressing the handover of the miniTS from NBD to the PD project group, the *strip of doings is blocked*. The *reading doings* of the miniTS cause divergent interpretations to arise. In general, employees from NBD emphasise that *"the miniTS precisely defines the scope of the project…"*, while the kk engineers have a different take on the document *"are we allowed to utilise our 25 years of experience to create a WTC to Newcomer?"*.

As it is not possible to establish a common ground regarding the substance of the <u>*indeterminate situation*</u> being handled, the *anchoring* of the <u>*indeterminate situation*</u> diverges. This divergent *anchoring* implies that the engineers' <u>*reflective experience*</u> follows divergent tracks, by which the *strip of doings* becomes *blocked*. The divergent *anchoring* of the <u>*indeterminate situation*</u> constrains the learning process.

The kk engineers consider the miniTS to be unfit for enabling the *strips of doings* to be conducted in connection with the drawing up of the TS-document. The kk engineers are convinced that Newcomer's project manager has not achieved an appropriate level of <u>*experience*</u> as regards WTCs. They are rather sure that he does not understand the technical subject matters of the *writing doings* conducted during the miniTS phase. By doing so, the kk engineers call in question the <u>*trajectory*</u> charted by all *strips of doings* when drawing up the miniTS.

The kk engineers have a high theoretical education as well as extensive practical <u>*experience*</u> in dealing with the development of WTCs. Besides, some of the kk engineers have participated in the Charlie 5.0 MW PD project, which they regard as a usable WTC platform; it constitutes their *end-in-view* of a usable WTC to be created to Newcomer. Referring to figure 8.6 illustrating the planned and actual delivery to Newcomer,[20] the Charlie 5.0 MW platform is brought to the forefront at the expense of the CSIC platform. Thus, as it appears in the next section, this *end-in-view* activates the *reflective experience,* by which the miniTS is replaced as an enabler for the *strips of doings* when drawing up the TS-document.

### 10.5.5. The engineers' end-in-view takes charge

The procedure for drawing up the TS-document instructs the kk engineers to send out a number of questionnaires to Newcomer; these questionnaires are handed over to Newcomer after signing the miniTS.

> *"We noticed that Newcomer did not understand the questions we sent to them. They could not understand why we need this information, even though we had explained it in the questionnaires. I do not know why they could not understand it. It might be due to a lack of in-depth knowledge of wind turbines – as we possess. You see, at present, they only have limited experience with wind turbines. So, they could probably not understand why it was important to hand over this information in order for the wind turbine to have a 20-year life span instead of 10."* (HW engineer 2, 14 December 2009).

Some of the questions are answered directly by Newcomer, while others are clarified elsewhere. In this regard, the *strips of doings* can be divided into three groups. First, having the necessary *experience* to enable the *strips of doings* makes it possible for Newcomer to submit the answers by the use of electronic media. Second, Newcomer lacks the necessary *experience*, but face-to-face dialogues within an interorganisational *STP* enable to achieve determinacy. Third, the low level of openness within the composition of the interorganisational *STP* constrains a continuation of the *strips of doings*, by which these become *blocked* before a *determinate situation* has been achieved.

Referring to sections 10.1 and 10.4, the majority of the *strips of doings* within the interorganisational *STP* are unsuccessful as they are *blocked*. Nevertheless, as emphasised in section 10.2.3, all *strips of doings* are handled, resulting in a TS-document being signed by Newcomer's management.[21]

Figure 10.3 illustrates the interplay between the kk engineers' daily working *STP*, Newcomer's daily working *STP* and the interorganisational *STP* in relation to the drawing up of the TS-document.

[20] The A10 and A11 are Charlie breaker panels. The A30 is a new development, but it draws mainly on Charlie solutions. The A20, A50 and A60, A61, A62, A63 are purchased from external suppliers.

[21] As the analysis points out, Newcomer's project manager has not fully understood the TS-document. However, it might be assumed that he has a sufficient understanding and a gut feeling telling him that the technical clarification will result in a cost-effective and reliable WTC; otherwise, Newcomer would not have signed the TS-document.

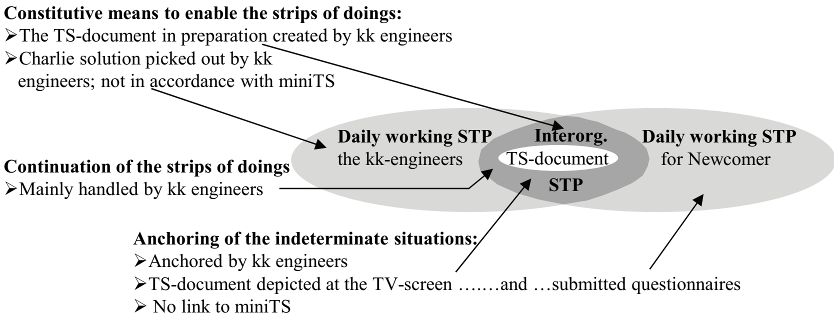


Figure 10.3. The creation of the TS-document.

Addressing the "***constitutive means* to enable the *strips of doings***" depicted in the uppermost part of the figure, the kk engineers take the initiative to "translate" Newcomer's requirements/wishes and thereby carry out the *writing doings* in the TS-document. The TS-document in preparation is the only accessible *constitutive means* to enable the *strips of doings* within the interorganisational *STP*, and this document is drawn up by the kk engineers when sitting within the daily working *STP*.

In this regard, the kk engineers' <u>*end-in-view*</u> of a usable WTC to Newcomer has brought the Charlie WTC to the fore. This WTC platform makes up an essential part of the *constitutive means* applied within the daily working *STP* to enable a continuation of the *strips of doings* and thereby achieve *sustainable determinacies*. Thus, the *constitutive means* to enable the *strips of doings* conducted within the daily working *STP* to draw up the TS-document are deliberately picked out from the "virtual stock" by applying <u>*reflective experience*</u>. These *constitutive means* are not in accordance with the technical content of the miniTS.

Drawing attention to the lowermost part of figure 10.3 dealing with "***anchoring* of the <u>*indeterminate situations*</u>**", the kk engineers submit the above-mentioned questionnaires in an attempt to retrieve the necessary information. If Newcomer fails to provide this information or if further information is needed, the kk engineers highlight the missing information by changing the text into red in the online version of the TS-document; this work is only accomplished within the daily working *STP*. The online version of the TS-document is thereafter depicted on the TV screen within the following interorganisational *STP*.

In other words, the kk engineers deliberately orchestrate an *anchoring* of the <u>*indeterminate situations*</u>. They submit the questionnaires to be completed by Newcomer engineers. Likewise, the MS Word TS-document depicted on the TV screen in the meeting room ensures a well-structured sequence of *anchoring* the <u>*indeterminate situations*</u> to be handled within the interorganisational *STP*.

The next section addresses an analysis of the third focal point depicted in figure 10.3; namely the continuation of the strip of doings.

### 10.5.6. The continuation of the strip of doings

As it appears from figure 10.3, the kk engineers handle the TS phase. For instance, a *strip of doings* within an interorganisational *STP* 18 September addresses the clarification of the lowest possible RPM of the generator if connecting the wind turbine to the grid. SW engineer 3 explains Newcomer's project manager that the lowest RPM setting is not based on transparent calculations; instead, it draws on his *experience* with a similar generator. The *strip of doing* is characterised by Newcomer's project manager doing his best to see through the arguments put forward by SW engineer 3. He demands more openness and transparent calculations or knowing "what is the strategy for this…"; clearly, he is not convinced.

Their *reflective experience* follows divergent tracks, resulting in the *strip of doings* becoming *blocked*. I.e., the *writing doing* in the TS-document does not draw on reciprocal interchanges of information or *reflective experience*. Instead, the *writing doing* is the result of SW engineer 3 merely handing over information. Consequently, no collective learning occurs.

2 October 2009, the kk project group has finished the TS-document according to plan. The intention is to send the TS-document to Newcomer's project manager, which gives him one week to read and comment on the TS-document before signing the contract in X city on 9 October 2009. On the actual day of sending the TS-document to Newcomer, kk's head of research asks kk's project manager to rewrite the TS-document, as he disagrees[22] with the structure of the document. Accordingly, Rick sends an e-mail to Joe, explaining the reasons why it has been necessary to divide the TS-document into two distinct TS-documents with new layout and content.

The kk project group does its very best to rewrite the two TS-documents, and the last two days, the kk engineers have been working around the clock. In so doing, it has been possible to hand over some parts of the TS-documents to Joe before the meeting.

Within the interorganisational *STP* 7 October 2009, the first issue being discussed is the rewriting of the TS-document. kk's project manager is aware that a few *strips of doings* still need to be conducted before the rewriting can be finalised; that is, the technical specifications are not yet finished two days before the signing of the contract. Therefore, the kk engineers attempt to continue the technical clarification, but it is not possible to carry on this *starting doing*. Newcomer's project manager does not even mention the rewriting of the TS-document, as he focuses strictly on the event taking[23] place the day after tomorrow, and shortly after Rick has explained the reasons why it was necessary to change the TS-document, Joe says:

> *"I have some comments in this regard. At the meeting on Friday, there will be some technical discussions, and I ask you to take part in a presentation of the technical solutions. I would like for you to explain why the kk solutions result in a more cost-effective and reliable wind turbine compared with the competitors' solutions"…"Look, I do not need to have all functionalities explained; but for instance, what are your strategies for the pitch, yaw and breaks. And how do you achieve the 95% as you indicate in your marketing material?"* (Newcomer project manager, 7 October 2009).

[22] This issue is analysed in section 10.2.2.
[23] Joe has invited 17 employees, including the vice president, to the event.

Both acknowledge an *indeterminate situation*, but the composition of the *STP* causes a divergent *anchoring* of the *indeterminate situation* to be handled, by which the continuation of the *strip of doings* becomes haphazard and later on *blocked*. As the composition of the *STP* causes the *strip of doings* to run into a blind alley, a *penetrating doing*[24] is conducted.

Following this *penetrating doing*, the two project managers continue the *strip of doings*, and gradually the rewritten TS-document becomes the focal point of the *reading doings*. Dean depicts the TS-document on the TV screen, and the *indeterminate situations* to be clarified are evident from the highlighted text. All participants conduct *reading doings* of this *constitutive means*. When Dean explains the functionality of the emergency stop, Joe says:[25]

> *"yes, this is an example of what I have requested. On Friday, I want you to put forward the same argumentations as you have just done. Please explain that this solution is based on your experience and why it is the best solution for us."* (Newcomer project manager, 7 October 2009).

The online version of the TS-document causes disturbances within the *habitual experience*, triggering the *reflective experience*. Combined with the explanations put forward by Dean, this *constitutive means* enables Joe to advance four issues[26] for the upcoming presentation in X city. Likewise, it enables the kk engineers to conduct a number of *strips of doings* causing *writing doings* into the online version of the TS-document. Thereby, the TS-document is finalised prior to the signing of the contract in X city.

The two groups of engineers carry out divergent *strips of doings*. The highlighted text on the TV screen is the focal point for the *reading doings*, but the depicted TS-document results in a divergent *anchoring* of the *indeterminate situations*. The only accessible *constitutive means* to enable a continuation of the *strips of doings* is the depicted TS-document on the TV screen. This document makes it possible for the kk engineers to conduct *strips of doings* and thereby finish the TS-document. Conversely, "Newcomer's *strips of doings*" address the upcoming presentation in X city. As kk engineers' and Newcomer's *strips of doings* diverge, the *reflective experience* of two groups of engineers follows divergent tracks, which constrain collective learning.

## 10.6. Summary – WTC case analysis

The *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doings* became central in the analysis.

**During the miniTS phase**, the *strips of doings* are guided by an I/O overview (*constitutive means*), from which all functional descriptions have been removed. Apparently, this

[24] The Danish participants leave the meeting room for half an hour in order to search for advice on how to handle the indeterminate situation.
[25] Actually, several similar comments are put forward by Joe when *reading* and interpreting the TS-document. Hence, the *reading doings* of the TS-document enable Joe to illustrate his request.
[26] The four issues are kk's strategies for 1) yawing the wind turbine in complex and mountainous areas, 2) the aforementioned cut-in speed (when to connect/disconnect to the grid), 3) reliability/check points, 4) availability of the wind turbine (higher than XX%). These four issues are written on the blackboard on 7 October 2009.

*constitutive means* enables an *anchoring* of the *indeterminate situations*. However, an unusable *constitutive means*, which is assumed to be a functional description of a WTC, but actually is a product description of breaker panels, impedes keeping on track the *reflective experience*. Thus, within the interorganisational *STP*, the *indeterminate situations* are not properly *anchored*, which constrains transcending the precognitive phase. Accordingly, the *strips of doings* draw on *habitual experience*. As the *reflective experience* is not triggered, no learning occurs; additionally, the miniTS has a low *sustainable determinacy*.

**Addressing the TS-phase**, the kk engineers have a clear *end-in-view* of Newcomer's requirements/wishes, and this *end-in-view* differs from the miniTS. In addition, they have many years of WTC *experience*, which permeates the *strips of doings*, resulting in the TS phase to be handled by the kk engineers.

Within the interorganisational *STP*, the kk engineers deliberately orchestrate an *anchoring* of the *indeterminate situations*, which ensure a continuation of the *strips of doings*. It makes it possible for the kk engineers to draw up a *sustainable* TS-document. However, the *successful strips of doings* are conducted within the daily working *STP*, rather than within the interorganisational *STP*. In relation to the interorganisational *STP*, the *reflective experience* of the two groups of engineers follows divergent tracks, constraining the learning process. The TS-document does not draw on reciprocal interchanges of *reflective experience*. Instead, the *writing doings* are the result of the kk engineers merely handing over information. Hence, no learning occurs within the interorganisational *STP*.

The next section likewise addresses a radical change in the *trajectory*; this change, however, takes place after the TS-document has been signed by Newcomer's management. The analysis draws on the A80 park server case in section 8.7.

## 10.7. The A80 park server case – call in question the TS-document

The two engineers who handle the A80 park server do not sit in the "war room" *STP* next to the kk project manager[27] and the other engineers. Instead, they are sitting in their regular office where they are handling the A80 concurrently with other similar PD tasks.

The A80 is only mentioned twice during the TS phase; none of these two situations deals with technical *strips of doings*. In addition, the TS-document, in which the A80 is included, is drawn up without any involvement from the two responsible engineers.

### 10.7.1. Information required to draw up the miniTS

As the salesman's *experience* regarding the A80 is rather limited, he contacts HW engineer 3, who is responsible for all HW to the A80, in order to acquire information to be used for the miniTS. This *strip of doings* takes place on a "Friday afternoon half past one o'clock" and focus is on whether or not the "China solution" (the CSIC A80) is operable in the Newcomer project.

[27] The project manager and the salesman are the same two kk employees as in the WTC case.

The salesman has a moderate level of _experience_ regarding the CSIC A80 solution. Likewise, as HW engineer 3 is regarded as being "the park server specialist",[28] the salesman ascribes credibility to the answers he receives at the time. However:

> *"the salesman did not tell me how many wind turbines are to be controlled or the number of users of the system or whether or not they want to have online access. Thus, when they contact me this Friday afternoon and ask for the price of the China park server, I just give them this price."* (HW engineer 3, 8 December 2009).

HW engineer 3 considers the accessible information provided by the salesman to be too narrow and unusable for him to be able to put forward well thought-out answers. Referring to figure 8.9, the price level of an A80 park server depends on the needed functionality, the level of necessary redundancies and the number of wind turbines connected to the A80 park server. This kind of information is not accessible this Friday afternoon. Furthermore, HW engineer 3 does not consider himself an A80 park server specialist, because his _experience_ in this regard is limited to HW subject matters.

Nevertheless, the information handed over by HW engineer 3 ensures a continuation of the *strip of doings* resulting in a _determinate situation_. The salesman interprets the achieved determinacy as an approval of using the CSIC technical platform in the Newcomer project.

The information handed over from the salesman constrains an *anchoring* of the _indeterminate situation_. It does not cause the disturbance in the _habitual experience_ necessary for transcending this precognitive phase and thereby for activating the _reflective experience_. The continuation of the *strip of doings* thus draws on _habitual experience_ and the mere handing over of information. It constrains the learning process.

Although the achieved determinacy turns out to have a low level of *sustainability* just after signing the TS-document, the salesman applies the approval of the CSIC technical platform as the *constitutive means* to guide and thereby ensure a continuation of the *strips of doings* when drawing up the miniTS. The next section addresses this.

### 10.7.2. Interorganisational clarification during the miniTS phase

As only HW engineer 3 contributes with input, the salesman does not obtain information dealing with SW issues. That is, the salesman's _experience_ is confined to HW issues of the CSIC platform, for which reason he is not aware of the various functionalities an A80 park server facilitates/has to offer or, for that matter, what kind of information is crucial to retrieve from Newcomer during the miniTS phase. Besides, the kk engineers sitting in the daily working *STP*, who from time to time participate in the interorganisational *STP*, do not concern themselves with the A80; it is not their business. And finally, Newcomer's project manager does not pay much attention to the A80.[29]

[28] Referring to a conversation between HW engineer 3 and kk's project manager just after a cross-functional *STP* on 28 October 2009.
[29] Referring to the kk's project manager, 9 December 2009.

The salesman is alone in deciding which *starting doings* are to be initiated. These *starting doings* originate from his *experience* with the HW components of the CSIC solution. As a result, SW issues and/or functionalities of the A80 neither prompt any *anchoring* of *indeterminate situations* nor any *strips of doings* within the interorganisational *STP*.

As neither Newcomer's project manager nor the sporadically participating kk engineers from the daily working *STP* pay much attention to the A80, the *strips of doings* do not cause the necessary disturbance in the *habitual experience* to transcend this precognitive phase. As the *indeterminate situations* are not *anchored*, the *writing doings* in the miniTS draw on *habitual experience* and the mere handing over of information. Merely handing over information constrains the learning process.

### 10.7.3. Focus on the A80 during the TS phase

The A80 is not the subject of any *strips of doings* throughout the TS phase, be it within interorganisational, cross-functional or daily working *STP*s. That is, the TS phase does not result in any changes or modifications to the pre-clarifications; it is still a CSIC technical platform. At the time when the A80 causes disturbance in the *habitual experience* and thereby activate *reflective experience*, the signed miniTS has been replaced by a signed TS-document. Consequently, the interplay between interorganisational and daily working *STP*s has been completed.

> *"The price of the park server is derived from a previous China project. Following, it appears that we have forgotten something in our calculations; for instance the SW licences. But the real problem lies in the fact that our internal HW and SW engineers will not take responsibility for creating a SCADA* (an abbreviation for park server, author) *similar to the one we sold to the China project. Hence, although we had sold a China solution, they just started designing another park server having another BOM. It results in a great deal of trouble internally as well as externally. It is simply too late to get such information."* (The salesman, 4 December 2009).

The sales price of the A80 does not increase; Newcomer is held indemnified as kk defrays all additional expenses. The following focuses on how the A80 is handled after receipt of the signed TS-document.

### 10.7.4. End-in-view of a usable A80 park server calls in question the TS-document

Drawing attention to the cross-functional *STP* 28 October, the A80 is subject to some *strips of doings*. One addresses the creation of SW, while another *strip of doings* is occurring between kk's project manager and HW engineer 3. Actually, the latter *strip of doings* takes place after the other kk employees have left the meeting room. It addresses the *trajectory* charted by all *strips of doings* throughout the miniTS and TS phases, as it causes disturbance in the *habitual experience*.

HW engineer 3 acknowledges that he has handed over information concerning the CSIC A80 a "Friday afternoon half past one o'clock". Yet, he does not admit to have labelled the CSIC A80 a usable solution for Newcomer. Rather, he considers the specified A80 solution to be:

*"too simple to sell"…"it is not a park server as you cannot control a wind turbine park with one server having so little backup security…"* (HW engineer 3, 28 October and 8 December 2009).

As HW engineer 3 is responsible for all park servers created,[30] he has a great deal of *experience* with the Oldtimer park servers. Beyond doubt, the Oldtimer A80 technical platform appeals to his technical background; he regards the Oldtimer A80 to be the most outstanding technical platform for monitoring and collecting data.[31]

The TS-document is called in question by HW engineer 3's *end-in-view*. This causes a radical change of the *trajectory*, by which the TS-document becomes an unusable *constitutive means* to enable the *strips of doings*.

The next section analyses the approach applied to draw up the product/production documentation and the creation of the A80.

### 10.7.5. Approach to achieve determinacy

HW engineer 3 has never met a representative from Newcomer. As neither the miniTS nor the TS-document is a usable *constitutive means* anymore, HW engineer 3 needs something to guide and enable a continuation of the *strips of doings* in his attempt to create an A80 to Newcomer.

*"Rick* (kk's project manager, author) *only told me that it has to be similar to the one we made for the China project. But I told Rick that it would be stupid, because it is not what they need. Now I have created what I think they need, but I do not know what they need."* (HW engineer 3, 8 December 2009).

This places HW engineer 3 in a tension field. First, the Oldtimer A80 appeals to his technical background; second, he lacks an understanding of Newcomer's actual requirements/wishes; third, he is to comply with guidelines put forward by kk's project manager. The latter indicates that the A80 park server has to be as cheap as possible without compromising reliability and quality. As it appears from the A80 case,[32] this statement made by kk's project manager has a constitutive effect, which makes it possible to achieve a *sustainable determinacy*.

*Reading doings* of the TS-document cause disturbance within the *habitual experience*, which enables a proper *anchoring* of the *indeterminate situation*. It triggers the *reflective experience*,

[30] During the interview on 8 December, HW engineer 3 explains the differences between an Oldtimer and a Newcomer park server. At the end of the interview, HW engineer 3 gives a guided factory tour focusing on an Oldtimer and a Newcomer park server. When standing in front of the Oldtimer park server, he explains all features and securities (redundancies). Later on, the Newcomer park server is in focus and he carries out a similar explanation. Obviously, there are huge differences between these two kinds of technical solutions to monitor and gather data.

[31] This claim is based on HW engineer 3's eagerness, body language and voice when standing in front of the Oldtimer park server.

[32] For instance, *"for the salesman, the matter concerns a park server to Newcomer, but for me, it is about a cheap park server to the Asian market. It must not cost anything. This means that it must not cost more than it costs to produce it. Actually, we have sold it below our cost price. Hence, the challenge for me is to do it as cheap as possible."* (HW engineer 3, 8 December 2009).

by which the *trajectory* charted by all *strips of doings* is called in question. HW engineer 3 has an *end-in-view* of a usable technical platform for an A80 park server. This *end-in-view* combined with the statement "it has to be as cheap as possible without compromising the quality and reliability" guides and enables the continuation of the *strips of doings* during the creation of the product/production documentation and the pilot production.

As the radical change in the *trajectory* takes place after the TS-document has been signed, all *strips of doings* conducted to create the A80 only take place within the daily working *STP*.

## 10.8. Summary – A80 park server case analysis

The *anchoring* of the *indeterminate situation* as well as the continuation of the *strip of doings* became central in the analysis.

During the **miniTS and TS phases**, no *indeterminate situations* are properly *anchored*. This impedes transcending the precognitive phase. In other words, the continuation of the *strips of doings* conducted to create the miniTS and TS-document draws on *habitual experience* and the mere handing over of information. Both documents turn out to have a low *sustainable determinacy*. Merely handing over information constrains the learning process.

An engineer's *end-in-view* calls in question the **signed TS-document**. This paves the way for a proper *anchoring* of an *indeterminate situation*, which causes a radical change of the *trajectory*, by which the TS-document becomes an unusable *constitutive means*. The *end-in-view* of a usable technical platform is combined with a statement from the project manager. This enables the *strips of doings* to continue during the creation of the product/production documentation and the pilot production. As these reciprocal interchanges drawing on *reflective experience* take place within the daily working *STP* after signing the TS-document, there is no interplay between the daily working *STP* and the interorganisational *STP*. Hence, no learning occurs within the interorganisational *STP*.

## 10.9. Findings – characteristics enabling/constraining the learning process

This section gathers the threads from the above analyses. The intention is to present and explain the findings with regard to the characteristics enabling or constraining the learning process when conducting a PD activity. Table 10.2 illustrates the identified characteristics.

| Enablers/constraints | Explanation |
|---|---|
| Accessibility of constitutive means. | High accessibility of diverse and usable constitutive means enables learning. |
| Openness. | A low level of openness constrains learning. |
| Heterogeneity of engineers. | Different levels of experience among the engineers enable learning. |
| Anchoring of the indeterminate situation. | A convergent anchoring of the indeterminate situation enables learning. |
| | A divergent anchoring of the indeterminate situation constrains learning. |
| Continuation of the strip of doings. | Learning is constrained if information is merely handed over. |
| | Learning is constrained if reciprocal interchanges follow divergent tracks. |
| | Learning is enabled if reciprocal interchanges draw on reflective experience. |

Table 10.2. Enablers and constraints for the learning process – Newcomer.

As explained in the previous chapter dealing with the Oldtimer analysis, the enablers and constraints are categorised into the **composition** of the STP, the **anchoring** of the indeterminate situation and the **continuation** of the strip of doings; this categorisation appears from the uppermost row of table 10.3. The leftmost column of the table indicates different STPs; each is divided into an enabler and a constraint part. The learning process within the cross-functional, interorganisational and daily working STP is influenced differently by the enablers and constraints, which appears from table 10.3.

A blank cell in the table indicates that **no learning** takes place within this specific STP; for instance, the non-occurrence of cross-functional learning.

| | Characteristics enabling/constraining the learning process | | |
|---|---|---|---|
| STP | Composition | Anchoring | Continuation |
| **Cross-functional** **Enabler** | Different levels of experience among the engineers. | | |
| **Constraint** | | Divergent anchoring of the indeterminate situation. | Reciprocal interchanges follow divergent tracks. |
| **Interorganisational** **Enabler** | Different levels of experience among the engineers. | | |
| **Constraint** | Low level of openness. | Divergent anchoring of the indeterminate situation. | Information is merely handed over. Reciprocal interchanges follow divergent tracks. |
| **Daily working** **Enabler** | High accessibility of diverse and usable constitutive means. Different levels of experience among the engineers. | Convergent anchoring of the indeterminate situation. | Reciprocal interchanges draw on reflective experience. |

Table 10.3. Enablers and constraints within different STPs – Newcomer.

Referring to table 10.3, the learning process is blocked within the cross-functional as well as the interorganisational STP. Learning takes place within the daily working STP. This is elaborated in the below.

After that, findings regarding the end-in-view are presented in section 10.9.4. These findings are not directly related to table 10.3.

### 10.9.1. Learning process within the cross-functional STP

No learning occurs within the cross-functional STP. The engineers possess different levels of experience, which is regarded as an enabler for learning. However, it is impossible for the engineers to reach a common ground with regards to the real substance of the indeterminate situations to be handled.

The strips of doings result in the engineers transcending the precognitive phase, but the divergent anchoring of the indeterminate situations constrains to keep on track the engineers' reflective experience. The employees each defend their different positions – to the extent that it borders on a war of positions – and the reciprocal interchanges end up following divergent tracks. This implies that the learning process becomes blocked.

### 10.9.2. Learning process within the interorganisational STP

No learning occurs within the interorganisational STP. The engineers are heterogeneous, but a radical change in the trajectory makes the accessible constitutive means within the interorganisational STP become unusable. The unusable constitutive means combined with doubts as to how transparent to make the explanations of technical issues imply a low level of openness within the interorganisational STP. The low level of openness leaves the Newcomer engineers with nothing to guide their reflective experience, making these reflections follow divergent and wavering tracks.

The anchoring of the indeterminate situations diverges, for which reason it is not possible to keep on track the reciprocal interchanges. As a consequence, the learning process becomes blocked, and the strips of doings fail to trigger interorganisational learning. Although the learning process is blocked, the kk engineers wield the pen, making it possible to develop a WTC by handing over information to Newcomer.

### 10.9.3. Learning process within the daily working STP

Learning occurs within this STP. The successful strips of doings are conducted within the daily working STP, which enables learning as well as the creation of the WTC. An end-in-view of a suitable WTC combined with many years of WTC experience paves the way for a high accessibility of constitutive means from the “virtual stock”. The accessibility of diverse and usable constitutive means and the proximity among the heterogeneous engineers within the open-plan office enable a convergent anchoring of the indeterminate situations. This convergent anchoring charts the course for the engineers’ reflective experience, enabling the reciprocal interchanges to draw on reflective experience and thereby learning to occur.

### 10.9.4. The engineers’ end-in-view in relation to the learning process

Table 10.3 does not include constraints for learning within the daily working STP. Likewise, no constraints have been inserted into the **composition** of the cross-functional STP. Nevertheless, the engineers’ end-in-view influences the learning process.

The engineers’ reading doings of the miniTS/TS-document cause disturbance in the habitual experience. This results in a convergent anchoring of the indeterminate situation and allows the engineers to transcend the precognitive phase and thus activate the reflective experience. However, do the engineers make use of the trajectory (the content of the miniTS/TS-document) or the end-in-view of a suitable technical platform to guide their reflections? For more than two weeks, the engineers’ reflections wander aimlessly around and the learning process is constantly blocked.

During this two-week period, the engineers’ end-in-view is confronted by other employees; colleagues as well as managers. Constantly, they have to defend why it is necessary to apply another technical platform than the one specified in the miniTS/TS-document. In addition, it is possible to access usable constitutive means from the “virtual stock” to guide their reflective experience. When all is said and done, the end-in-view results in a radical change of the trajectory, which paves the way for learning within the daily working STP.

Nobody confronts the engineers' end-in-view when creating the documentation (a constitutive means) to assist the salesman during the miniTS phase. The engineers' end-in-view of a "usable constitutive means" guides their experience when creating this constitutive means. As nobody questions this end-view, an indeterminate situation in this regard is not properly anchored. It is thus not possible to transcend the precognitive phase, resulting in the reflective experience not being activated. In the same way, the end-in-view introduced by the head of research during the IPR meeting creates disturbance in the habitual experience. The reciprocal interchanges between the heterogeneous engineers and the accessible constitutive means do not question this end-in-view, which precludes transcending the precognitive phase. In other words, the reflective experience is not activated.

Accordingly, to avoid that an end-in-view blocks the learning process, the end-in-view has to be confronted. Accessibility of usable constitutive means underpins this confrontation that enables to keep on track the reflective experience and thereby learning.

## 10.10. Summary of the Newcomer analysis

The objective of the chapter was to identify and thereby obtain an understanding of the characteristics that enable or constrain the learning process when conducting PD of a WTC.

By focusing on how a PD activity unfolds within different STPs, the analysis of Newcomer has identified five characteristics enabling or constraining the learning process. These are: accessibility of constitutive means, openness, heterogeneity of engineers, anchoring of the indeterminate situation and continuation of the strip of doings.

The five characteristics enabling or constraining the learning process are related to: the composition of the STP, the anchoring of the indeterminate situation and the continuation of the strip of doings. These three categories of enablers and constraints, including the explanation from table 10.2, are evident from the analytical framework depicted in figure 10.4.

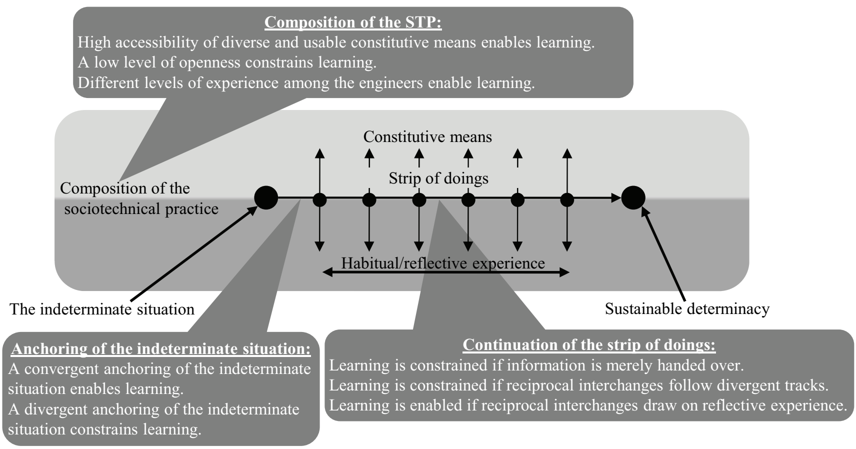


Figure 10.4. Categorisation of enablers and constraints for learning – Newcomer.

The next chapter draws on the analyses of Oldtimer and Newcomer. The link between these two analytical chapters and the cross-analysis in chapter 11 is the categorisation illustrated in figure 10.4; i.e., composition of the STP, anchoring of the indeterminate situation and continuation of the strip of doings.

# Chapter 11. Cross-analysis and contribution

This chapter builds on the analyses of Oldtimer and Newcomer. The purpose is to gather the threads from these two analytical chapters and thereby be able to make visible the implications of the conducted research.

As emphasised in the methodological chapter, the research is empirically driven, for which reason the intention is to learn as much as possible from the analyses of Oldtimer and Newcomer. A comparison, drawing on replication logic (Yin, 2003:47), between the two analyses will reduce the opportunity to learn (Stake, 2000:444). In other words, the two analytical chapters provide a broad base for the cross-analysis in this chapter.

As depicted in figure 11.1, the identified three categories of enablers/constraints are central in the analysis. Four different ways of anchoring the indeterminate situation are explicated. The anchoring of the indeterminate situation takes place within a SocioTechnical Practice (STP), for which reason four different composition of the STP is discussed subsequently. In the same vein, the anchoring of the indeterminate situation charts the course for a continuation of the strip of doings, which paves the way for identifying four different approaches being applied. This results in an anchoring matrix which provides a summary of the four anchoring situations, the composition of the STP and finally, the continuation of the strip of doings.

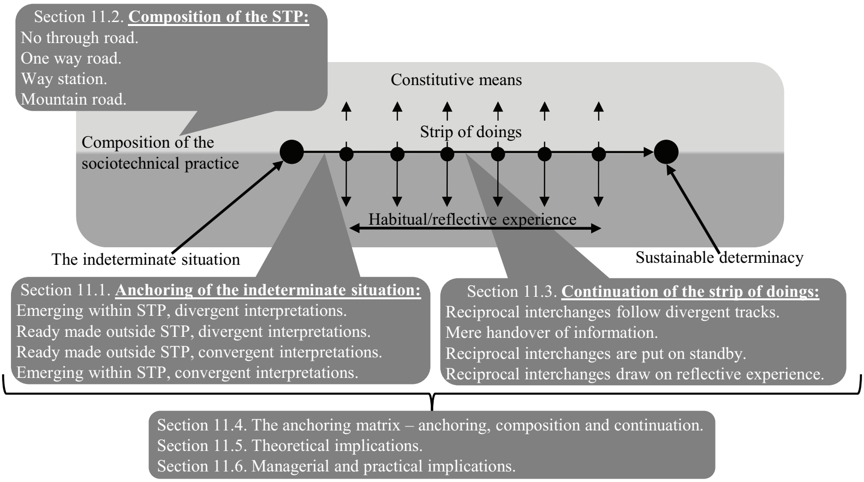


Figure 11.1. The three categories of enablers/constraints and the structure of the chapter.

The chapter starts with an analysis of the anchoring of the indeterminate situation. Four different ways of anchoring the indeterminate situation are identified. Section 11.2 addresses the composition of the STP, which results in the identification of four different STPs illustrated in the upper left part of figure 11.1. In section 11.3, the approach applied by the engineers involved to facilitate a continuation of the strip of doings is analysed. In addition, this section sheds light on the sustainability of the achieved determinacy as well as the nexus between learning and Product Development (PD). Section 11.4 combines the above and summarises the analyses. Finally, the implications from this pragmatic research are presented.

## 11.1. Anchoring of the indeterminate situation

Referring to Dewey (1938:112), *"to set up a problem that does not grow out of an actual situation is to start on a course of dead work,…".* This "dead work" is not intellectual and accordingly, it does not enable learning. Instead, it is a sort of a ready-made problem and thus regarded as an assigned task to be handled.

The indeterminate situation is existential. It cannot be purely endogenous disturbance, as this kind of individual disturbance is considered to be a mental disorder. An indeterminate situation occurs due to a disturbance in the habitual experience. To transcend this precognitive phase, the indeterminate situation has to be real and empirically anchored; in other words, the indeterminate situation has to emerge within an STP.

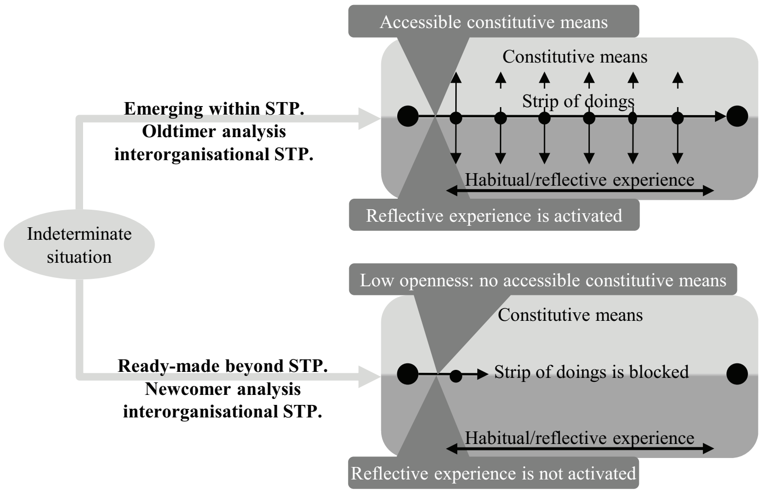


Figure 11.2. Orchestration of the indeterminate situation: ready-made versus emerging.

Figure 11.2 illustrates two different orchestration of the indeterminate situations. The lowermost part of the figure addresses a ready-made indeterminate situation, which is formulated beyond the boundaries of the STP in which it has to be handled. The uppermost part of the figure addresses an indeterminate situation emerging within the STP in which it is to be handled.

Concerning the Newcomer analysis, the majority of the indeterminate situations within the interorganisational STP are ready-made. A ready-made indeterminacy might cause disturbance within the habitual experience, but it is not possible to transcend this precognitive phase due to a low level of openness within the STP. As illustrated in the above figure, the low openness results in a constrained learning process; the engineers' reflections are aimless, for which reason the learning process can be characterised as a fumbling process; i.e., no learning takes place.

The Oldtimer analysis demonstrates that emerging indeterminate situations constitute the main part of the indeterminate situations present within the interorganisational STP. The emerging orchestration of the indeterminate situation makes it possible to apply the constitutive means to transcend the precognitive phase and thereby activate the reflective experience. These reciprocal interchanges between accessible constitutive means and the reflective experience enable a continuation of the learning process; learning occurs.

### 11.1.1. Four different anchoring of the indeterminate situation

With reference to the Oldtimer and Newcomer analyses, the ways of anchoring the indeterminate situations are countless. Yet, focusing on the involved employees' orchestration and interpretation of the indeterminate situation, a pattern emerges.

The light grey ellipse to the left in figure 11.3 illustrates an anchoring of the indeterminate situation. To understand the pattern of anchoring, the first subject matter to be addressed is how the indeterminate situation appears within the STP. Does the indeterminate situation arise from a deliberate orchestration of a ready-made indeterminacy prepared outside the STP in question or does the indeterminate situation emerge within the STP in question? The second issue is to address whether the reciprocal interchanges cause a divergent or convergent interpretation of the indeterminate situation.

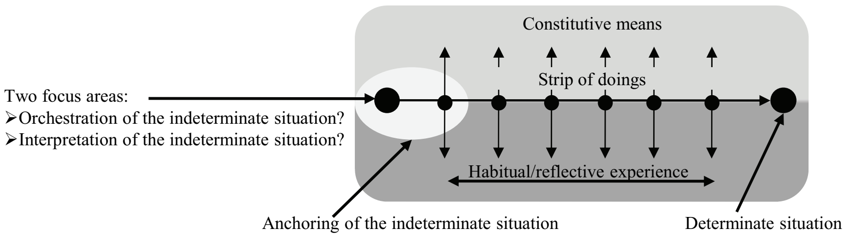


Figure 11.3. Anchoring of the indeterminate situation.

Referring to the Newcomer analysis, the kk engineers submit to Newcomer questionnaires concerning technical issues to be clarified, which Newcomer attempts to answer. In addition, within the interorganisational STP, the only accessible constitutive means is the TS-document in preparation. The kk engineers produce this TS-document when sitting within the daily working STP; i.e., the indeterminate situations to be discussed within the interorganisational STP are ready-made by the kk engineers. The kk engineers make use of the laptop to orchestrate these ready-made indeterminate situations on the TV screen. Thus, the majority of the indeterminate situations within the interorganisational STP are ready-made and deliberately orchestrated by the kk engineers. Nevertheless, as it appears from the Newcomer analysis, this one-sided orchestration of the indeterminate situations results in a sustainable TS-document.

This ready-made orchestration does not automatically prompt a sustainable determinate situation, as the interpretation of the indeterminate situation has a crucial part to play.

As illustrated in the analysis of the A80 case, the interpretation of a suitable park server to Newcomer diverges. This divergent interpretation of the indeterminate situation makes the reciprocal interchanges follow divergent tracks, and it becomes apparent that the achieved determinacy written down in the TS-document has a low level of sustainability.

The Oldtimer cross-functional STP prior to the relocation is likewise characterised by this kind of orchestration. In general, the interpretation of these indeterminate situations converges; actually, the objective of this cross-functional STP is to act as a kind of way station between the interorganisational and daily working STPs.

The other approach is the emerging orchestration.

Referring to the Oldtimer analysis, the technical project manager from kk does his homework prior to the interorganisational STP. He brings along diverse and usable constitutive means to orchestrate the indeterminate situations. Likewise, Oldtimer's project manager orchestrates indeterminate situations. Both engineers make an effort to ensure a proper orchestration of the indeterminate situation. If it is not possible to achieve a convergent interpretation of the indeterminacy, the reciprocal interchanges are deliberately blocked by either Oldtimer or kk.

Although the general approach in the Newcomer interorganisational STP is the ready-made orchestration, the emerging approach is apparent from time to time. For instance, a complete rewriting of the TS-document just before the signing event in X city prompts this kind of orchestration. Whereas kk's project manager attempts to pave the way for a continuation of the technical clarifications, Newcomer's (the project manager) interpretation of the indeterminacy does not address any technical issues; instead, the signing event in X city two days later is the focal point. Both project managers regard the rewritten TS-document as the focal point for the indeterminate situation; however, their interpretations of the indeterminate situation diverge, which causes the reciprocal interchanges to follow divergent tracks.

The above analysis addressing orchestration and interpretation of the indeterminate situation forms the basis for presenting the anchoring matrix depicted in figure 11.4.

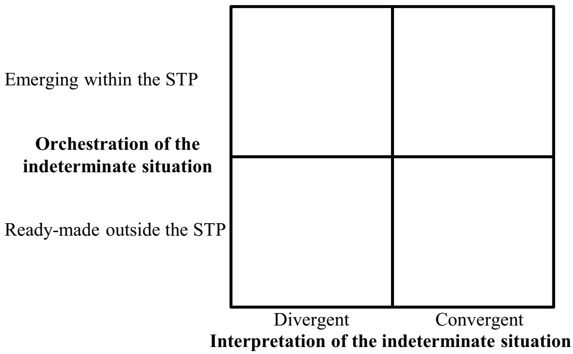


Figure 11.4. The anchoring of the indeterminate situation.

As emphasised elsewhere, the anchoring of the indeterminate situation is influenced by and simultaneously influences the composition of the STP. Likewise, the anchoring charts the course for a continuation of the strip of doings. Accordingly, the analysis of the composition of the STP and the analysis addressing a continuation of the strip of doings are aligned with the different ways of anchoring illustrated in figure 11.4. That is, the next two sections will serve to fill in the above anchoring matrix. A further explanation of the anchoring matrix will be conducted in section 11.4.

## 11.2. Composition of the STP

Dewey (1938:32) interprets each organic function as an interaction of *"intra-organic and extra-organic energies,…"*. The "intra-organic energy" is embedded within the engineers' biological functions such as sensing, thinking and feeling; i.e., the engineers' experience. The "extra-organic energy" is embedded within the accessible constitutive means.

The "sources of energy" are not two separate entities; instead, they are completely embedded within the composition of the STP. The engineers do not conduct a strip of doings **in an STP**; rather they conduct a strip of doings **by actively applying the accessible constitutive means within the STP**. This emphasises the reciprocity between the accessible constitutive means and the heterogeneous engineers who have different levels of experience and commitment.

The next two sections address the constitutive means applied across the two PD projects, after which four different composition of the STP is presented.

### 11.2.1. The constitutive means

The analyses of Oldtimer and Newcomer identify five groups of constitutive means.

Sketches, drawings, electrical diagrams and physical products make up the first group of constitutive means applied by the engineers to achieve technical clarification. This is apparent within the Oldtimer and Newcomer daily working STPs as well as in the interorganisational STP in relation to Oldtimer. The latter STP is often relocated to the production area as reading doings of a physical breaker panel facilitate interpretations not possible from reading sketches or drawings.

A second group of constitutive means, e.g. project plans, addresses coordination of the strips of doings across interorganisational, cross-functional and daily working STPs.

A third group makes it possible to enhance the constitutive effect of the above constitutive means as well as to retrieve crucial information beyond the boundaries of the particular STP. It encompasses laptops, including TV screens, intra/internet and mobile phones; these are applied within the interorganisational STPs, but in different ways across the two PD projects. The Newcomer project employs the laptop to depict the constitutive means on the TV screen, and especially the application of the "track changes" feature in MS Word facilitates a well-structured process. In general, neither laptop nor mobile phone is applied to conduct penetrating doings within the Newcomer interorganisational STP. This is in contrast to the Oldtimer interorganisational STP, as mobile phones and/or laptops are applied several times during a meeting to improve the accessibility to diverse and usable constitutive means.

Addressing the use of laptop and TV screen within the interorganisational STPs, the Oldtimer PD project furthermore employs interactive systems. Often wirings are depicted on the TV screen, and the application of an IT programme makes it possible to follow a particular wiring among a great many electrical diagrams. Hence, in contrast to the Newcomer STP in which the "highlighted red text" ensures an anchoring of the ready-made indeterminate situation(s), the engineers within the Oldtimer STP apply the laptop and TV screen to enhance the emerging indeterminate situation(s) and thereby enable a continuation of the strip of doings.

Notebooks and Minutes of Meetings (MoM) are constitutive means to recall previously achieved determinacies, if these have been fogged by time. This group of constitutive means has a sustainable effect; it is a written trajectory that makes it possible to sustain previous determinacies. The Oldtimer PD project is characterised by an extensive use of notebooks and MoMs to recall experience and decisions. The opposite is observed in the Newcomer interorganisational STP; apparently due to radical changes of the trajectory. For instance, Newcomer's project manager often refers to previous agreements with reference to the MoM, but these reading doings result in divergent interpretations, by which the strips of doings become blocked.

The last group covers various checklists that prescribe the order in which the indeterminacies are to be handled. This ensures a high level of consistency of the activities conducted.

### 11.2.2. The constitutive means in relation to changes in trajectory and hardness

Regarding the Oldtimer analysis, the trajectory is more or less straightforward. The continuous alignment of the trajectory only has a diminutive influence on the constitutive effect of the constitutive means; in other words, the constitutive means are not eroded. The opposite is apparent in the Newcomer analysis. Regarding the trajectory analysed in the WTC case, the content of the miniTS is called in question, by which all constitutive means are undermined; i.e., no constitutive means are accessible. Hence, the technical clarification has to start from scratch again. A similar situation becomes apparent in relation to the A80 analysis; however, it arises after the TS-document has been signed.

As indicated in the above, incremental changes in the trajectory charted do not erode the constitutive means. Nevertheless, the analysis of the two Oldtimer cases demonstrates that it can be problematic to apply too ductile or too obdurate constitutive means, as it influences the anchoring of the indeterminate situation as well as the effort necessary to ensure a continuation of the strip of doings. The A24 analysis demonstrates that too ductile constitutive means constrains a convergent anchoring of the indeterminate situation, while the A21 analysis sheds light on the fact that too obdurate constitutive means tend to cause an accomplishment of a strip of doings without the indeterminate situation being noticed. As the "indeterminate situation remains undetected", it fails to trigger disturbance in the habitual experience and thus fails to initiate reciprocal interchanges drawing on reflective experience.

In relation to the composition of the interorganisational STPs, the reciprocity between the engineers and the constitutive means differs. While the high accessibility of constitutive means has a favourable effect on the reciprocity in relation to Oldtimer, the low level of openness apparent in the Newcomer STP has an unfavourable effect on the reciprocity.

High accessibility of diverse and usable constitutive means enables the engineers' reflective experience to follow a convergent track (or to follow the same road); thus, no obstacles are put in the way of the learning process. In contrast to this, a low level of openness constrains the learning process; a problematic road for learning. Metaphorically, the composition of the STP provides a road for the learning process. This road metaphor allows for the introduction of four different STPs.

### 11.2.3. The composition of the STP is like a no through road

Figure 11.5 illustrates a composition of an STP which constrains learning. The one-way arrows from the "black dots" and the question marks above these symbolise that there is no reciprocity between the constitutive means and the engineers' experience. This kind of STP does not facilitate a convergent interpretation of the indeterminate situation or, for that matter, its participants to challenge the different interpretations of the situation. It causes the reciprocal interchanges to become aimless and, ultimately, to run into a blind alley; the reciprocal interchanges follow a track on a no through road.

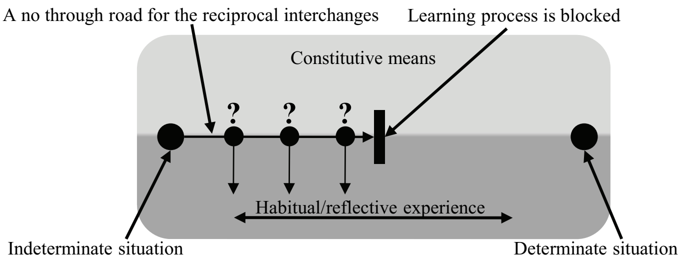


Figure 11.5. A no through road for the reciprocal interchanges.

Addressing the cross-functional STP in the Newcomer analysis, the majority of the learning processes are constrained. In general, the indeterminate situation is emerging. For instance, the head of research has an end-in-view of a suitable structure of the TS-document; an end-in-view which causes disturbance in the habitual experience. Despite the fact that all engineers consider this proposal suitable, the learning process is constrained due to divergent interpretations of the indeterminate situation. The divergent interpretations spring from a low accessibility of usable constitutive means to guide the engineers' reflective experience. Therefore, the proposal is neither rejected nor applied to enable learning. This makes the reciprocal interchanges chase divergent tracks and thereby run into a blind alley. As the engineers' reflective experience are lead on a wild goose chase, the reciprocal interchanges might result in a purported sustainability. By doing so, the indeterminate situation becomes suppressed and after a while, it will/may emerge in a new variant with, at times, more sweeping consequences.

A convergent interpretation of an emerging indeterminate situation is not possible, which leads the reciprocal interchanges into a blind alley; the reciprocal interchanges follow a track on a **no through road**. This kind of STP constrains learning.

### 11.2.4. The composition of the STP is like a one-way road

The composition of the STP depicted in figure 11.6 has a low level of openness, which constrains learning. The one-way arrows from the "black dots" and the question marks above these symbolise that there is no reciprocity between the constitutive means and the engineers' experience.

The figure illustrates a one-way road composition of the STP. This kind of STP does not facilitate a convergent interpretation of a ready-made indeterminate situation. Yet, the Newcomer analysis demonstrates that this composition of the STP makes it possible to achieve a determinate situation and thereby creation of a WTC by merely handing over information.

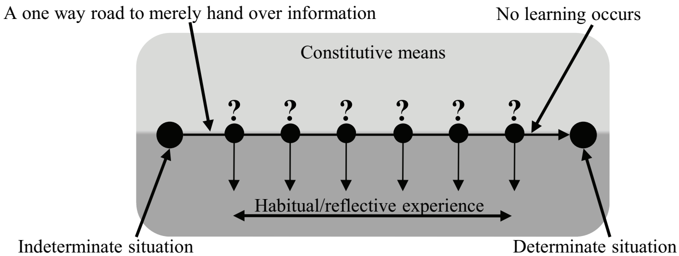


Figure 11.6. A one-way road to merely hand over information.

Drawing attention to the Newcomer analysis, the low openness combined with the radical change in the trajectory entails a low accessibility of usable constitutive means, which constrains learning within the interorganisational STP. Instead, the kk engineers' end-in-view of a proper technical platform takes charge. It facilitates a high level of accessibility to diverse and usable constitutive means from the "virtual stock", which enables learning within the daily working STP. These diverse and usable constitutive means are not accessible within the interorganisational STP. Thus, the reciprocal interchanges enabling the drawing up of the necessary technical specifications to create the WTC are accomplished within the daily working STP; an STP decoupled in a time and space dimension from the interorganisational STP.

The Newcomer interorganisational STP is a one-way composition, deliberately managed by the kk engineers. The accessible constitutive means are restricted to the TS-document in preparation, by which the composition contributes to a sequential and well-structured orchestration of the ready-made indeterminate situations.

A well-structured STP with a composition characterised by a low level of openness occasions a one-way approach. The indeterminate situations are handled by merely handing over information. The lack of openness implies that the learning process is not a collective endeavour. Instead, it is a one-way track to be followed; a **one-way road** for learning.

### 11.2.5. The composition of the STP is like a way station

A way station composition of the STP appears from figure 11.7. The two-way arrows through the "black dots" symbolise reciprocity between the constitutive means and the engineers' experience. However, as the reciprocal interchanges end before a determinate situation has been achieved, learning is constrained.

The composition of the STP is tailored to achieve a convergent interpretation of a ready-made indeterminate situation, after which the reciprocal interchanges are deliberately put on standby. This is illustrated by the small dots in immediate continuation of the horizontal arrow in the below figure. Drawing on the old saying, "well begun is half done", the achieved convergent interpretation renders it possible to continue and complete the learning process later on. Hence, the composition of the STP facilitates an alignment of the reflective experience, keeping the learning process on track. Metaphorically speaking, the learning process is lead to a way station, where it takes a break.

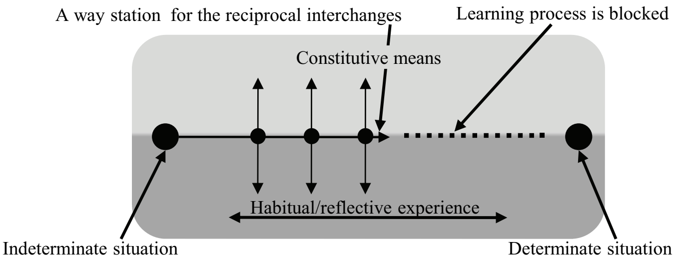


Figure 11.7. A way station for the reciprocal interchanges.

Referring to the Oldtimer analysis, prior to the physical relocation of the PD group to the open-plan office, a cross-functional STP is regularly established in immediate continuation of an interorganisational STP. The intention is to achieve convergent interpretations of the indeterminate situations to be handled in accordance with the interorganisational technical clarification; i.e., the indeterminate situations are ready-made outside the cross-functional STP. After achieving convergent interpretations of these ready-made indeterminate situations, the engineers go their separate ways and finalise the learning processes in, for instance, the daily working STP.

The cross-functional STP is well-structured. High accessibility of constitutive means enables the diversely experienced engineers to achieve a convergent interpretation of the indeterminate situations. As a constitutive means to sustain this convergent interpretation, comments are made in notebooks and in the MoM; last but not least, the writing doings made directly on the hardcopies of electrical diagrams and sketches are crucial in this regard.

The reciprocal interchanges facilitate a convergent interpretation of the ready-made indeterminate situation. The learning process is only half-finished, as the intention is to finish it elsewhere. The composition of the STP is like a **way station**, which is noticeably less resource demanding and time-consuming than the below “mountain road” STP composition.

### 11.2.6. The composition of the STP is like a mountain road

Figure 11.8 illustrates a composition of a constantly adaptable STP that enables learning. The two-way arrows through the “black dots” signify reciprocity between the constitutive means and the engineers’ experience. The curved line in the figure serves to illustrate that the reciprocal interchanges are not effortless, rather they are uphill and downhill; the reciprocal interchanges follow a mountain road track. The reciprocity enables a convergent interpretation of the emerging indeterminate situation and furthermore it enables the learning process.

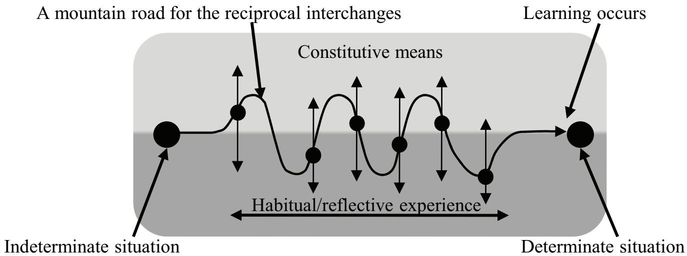


Figure 11.8. A mountain road for the reciprocal interchanges.

The efforts necessary to enable learning vary. They cover both the above-mentioned “half-finished learning process” and the considerable efforts necessary to enable learning if the constitutive means are, for instance, too obdurate. Addressing the former, although the previous section portrays the learning process to have much in common with the saying “well begun is half done”, it is still resource demanding and time-consuming to ensure a continuation of the reciprocal interchanges. For instance, within the daily working STP, the engineers apply diverse constitutive means. Dialogues among engineers, telephone conversions and the improvement of the accessibility of constitutive means by the use of laptops are crucial for ensuring a continuation of the learning process. The STP is occasionally repositioned to the production area. In the production area, the physical breaker panel is compared with drawings and/or electrical diagrams. That is, the reciprocity between diversely experienced engineers and high accessibility of diverse and usable constitutive means enables learning.

This mutable composition of the STP makes it possible to keep on track the reciprocal interchanges and thereby learning. The reciprocal interchanges are by no means effortless as they moves up and downhill in the endeavour to enable learning; metaphorically, the composition of the STP is like a **mountain road** with a rather steep incline and a great number of hairpin bends.

Summing up, four different STP composition has been illustrated; a no through road, a one-way road, a way station and finally a mountain road. Only the mountain road composition enables learning.

As for the composition of the four STPs, the reciprocity between the diversely experienced engineers and the accessibility of constitutive means differs, prompting different approaches to ensure a continuation of the strip of doings. The next section addresses this.

## 11.3. Continuation of the strip of doings

Four different approaches to ensure a continuation of the strip of doings are presented below. Afterwards, the nexus between the applied approach and sustainability of the achieved determinacy becomes the subject matter and finally, the nexus between learning and PD is analysed.

### 11.3.1 Four different approaches in relation to a continuation of the strip of doings

Referring to the discussion of Dewey's process of inquiry (learning process) in section 6.7, reflective experience is an enabler ensuring a continuation of the inquiry until a determinate situation is achieved; i.e., learning occurs. It takes the form of ongoing reciprocal interchanges between the constitutive means and the engineers' reflective experience; accepting a working hypothesis as a solution causes the learning process to be immediately cut short (Dewey, 1938:115). The reflective experience, and thus the learning process, becomes blocked regardless of whether the working hypothesis for achieving the determinate situation is suitable or unsuitable. Hence, to avoid that the reflective experience becomes blocked or follows wrong/divergent tracks, the employees within the composition of the STP have to interpret each constitutive means and be able to manage the process of creating a working hypothesis.

The analyses of Oldtimer and Newcomer reveal various reciprocal interchanges having an influence on the continuation of the strip of doings. Some of the reciprocal interchanges gradually fade away or are deliberately blocked, while others result in a continuation until determinacy is achieved. Regarding the former, the engineers' interpretations of the indeterminate situation to be handled/being handled diverge, by which the reciprocal interchanges follow divergent tracks. In the latter situation, the reciprocal interchanges enable to achieve a convergent interpretation of the indeterminate situation to be handled/being handled. This paves the way for the reciprocal interchanges to draw on reflective experience and to keep on track the reflective experience.

The issue is whether the engineers' interpretations of the constitutive means cause convergent or divergent interpretations. In other words, do the reciprocal interchanges facilitate finding common ground? Another issue is whether the reciprocal interchanges create disturbance in the habitual experience, and especially whether it is possible to transcend this precognitive phase and thereby activate reflective experience. Transcending the precognitive phase enables reciprocal interchanges to draw on reflective experience, while remaining in the precognitive phase implies that the reciprocal interchanges are limited to merely handing over information.

Accordingly, the four approaches to ensure a continuation of the strip of doings are (1) reciprocal interchanges follow divergent tracks, (2) mere handover of information, (3) reciprocal interchanges are put on standby and (4) reciprocal interchanges draw on reflective experience. These four approaches are explicated in table 11.1[1] below. The column in the middle puts forward some examples, while the column to the right sheds light on the underlying reasons.

| Applied approach | Examples from the analyses | Underlying reasons |
|---|---|---|
| Reciprocal interchanges follow divergent tracks. | **Newcomer**: Interorganisational STP dealing with the upcoming meeting in X city and remaining technical clarification. | Not possible to achieve common ground for the indeterminate situation to be handled. |
| | Cross-functional STP addressing the IPR issues – layout/content of TS-document. | No constitutive means accessible to keep on track the reciprocal interchanges; end-in-view of the TS-document is neither accepted nor rejected. |
| Mere handover of information. | **Oldtimer**: Interorganisational STP – A24 analysis, starting up and sweeping re-design. | Too ductile constitutive means. |
| | Daily working STP – A21 analysis, copy/ paste approach. | Too obdurate constitutive means. |
| | Cross-functional STP after relocation. | No accessible constitutive means within the STP. |
| | **Newcomer**: Interorganisational STP – WTC analysis, drawing up the TS-document. | Low openness implies that no constitutive means are accessible within the inter-organisational STP. |
| | Cross-functional STP – WTC and A80 analyses, drawing up the miniTS. | Unusable constitutive means; product specifications and non-functional specifications. |
| Reciprocal interchanges are put on standby. | **Oldtimer**: Cross-functional STP prior to relocation. | High accessibility of constitutive means enables convergent anchoring, yet the reciprocal interchanges are put on standby. |
| Reciprocal interchanges draw on reflective experience. | **Oldtimer**: Interorganisational STP. **Oldtimer** and **Newcomer**: Daily working STP. | Accessibility of diverse and usable constitutive means enables reflective experience to follow convergent tracks. If doubts, the STP is repositioned to the production area. |

Table 11.1. The four approaches to ensure a continuation of the strip of doings.

Addressing the Newcomer analysis, the kk engineers' end-in-view of a proper technical platform improves the accessibility of constitutive means within the daily working STP, signified by the retrieval of drawings, electrical diagrams from the virtual stock. These constitutive means enable *reciprocal interchanges drawing on reflective experience* within the daily working STP.

The majority of the determinacies achieved in relation to the interorganisational STP are ensured due to the kk engineers *merely handing over information* to Newcomer; the

[1] Please note that table 11.1 only includes a few examples from the analyses.

constitutive means applied within the daily working STP do not come into sight within the interorganisational STP.

As no constitutive means are accessible within the interorganisational STP, it is not possible for Newcomer's engineers to transcend the precognitive phase. In line with this, Newcomer's project manager constantly demands an improved openness of the "strategies for…", which draws attention to a third approach explained in the above table 11.1; the *reciprocal interchanges follow divergent tracks*.

In relation to the Oldtimer analysis, the approach to ensure a continuation of the strip of doings within the interorganisational STP is *reciprocal interchanges drawing on reflective experience*. Oldtimer's project manager and kk's technical project manager bring along their experience and diverse and usable constitutive means to the STP. The former project manager draws on experience created on the backdrop of cross-functional strips of doings performed intraorganisationally within Oldtimer, while the latter taps into experience created within the daily working STP within kk.

Due to considerations relating to resources, the Oldtimer cross-functional STP prior to the relocation mainly focuses on establishing a convergent interpretation of the ready-made indeterminacy to be handled, after which the learning processes are finished elsewhere. This addresses *reciprocal interchanges are put on standby*.

As it appears from table 11.1., the *reciprocal interchanges follow divergent tracks* is not identified within the Oldtimer analysis. The three decades of interaction have put the kk engineers in a position to be able to read between lines when conducting reading doings of the technical specifications, making it possible to create a WTC without having precise technical specifications from Oldtimer. Thus, the expected Oldtimer requirements may therefore be regarded as an end-in-view to guide the learning process, should doubts arise. However, the constitutive effect of this end-in-view has its limitations, also apparent in the Oldtimer analysis, for instance when working with too ductile specifications. In the same vein, too ductile as well as too obdurate specifications constrain transcending the precognitive phase and thus activation of the reflective experience. Accordingly, in some of the interorganisational STPs, the interchanges among the participants consist of *mere handover of information*.

The next section addresses the nexus between the above four approaches and the sustainability of the achieved determinacy.

### 11.3.2. Nexus between sustainability and applied approach to achieve determinacy

With reference to pragmatism, the outcome of the learning process prompts a change in the constituents of the STP. However, the outcome of the learning process is not conclusive, but rather a "warranted assertion" that remains open to further inquiries. Thereby, the handling of a specific indeterminate situation by the use of a particular approach is no guarantee for a high level of sustainable determinacy.

Beyond doubt, both PD projects produce operational WTCs with a high level of quality, but when addressing the nexus between sustainable determinacy and the applied approaches demonstrated throughout the analyses of Oldtimer and Newcomer, a variation appears.

As regards the Oldtimer PD project, a high level of sustainability is achieved within the interorganisational STP as well as within the daily working STP. As it appears from table 11.1, the applied approach in these two kinds of STPs is reciprocal interchanges drawing on reflective experience.

Given that the cross-functional STP is considered to be a way station between the interorganisational and daily working STPs, the achieved determinacies within the cross-functional STP only have a confined sustainability. The Oldtimer analysis underpins this claim, which becomes rather apparent after the relocation of the project group to the open-plan office in the middle of the project period. Prior to the relocation, the approach applied is reciprocal interchanges are put on standby, while after the relocation, the approach within the cross-functional STP is to merely hand over information; determinacies with low sustainability are achieved. Likewise, the too ductile as well as too obdurate constitutive means cause a low level of sustainability. The constitutive means are too ductile/obdurate to be able to create disturbance within the habitual experience and thereby transcend the precognitive phase, by which the applied approach is to merely hand over information.

Drawing attention to Newcomer, sustainable determinacy is achieved as a result of reciprocal interchanges drawing on reflective experience within the daily working STP. Subsequently, the kk engineers merely hand over information to Newcomer within the interorganisational STP and wield the pen when drawing up the TS-document. Accordingly, a well-structured interorganisational STP combined with well-prepared engineers makes it possible to achieve a high level of sustainability by merely handing over information.

During the drawing up of the miniTS, the strips of doings within the interorganisational STP draw on unusable constitutive means. As the analysis in sections 10.5 and 10.7 indicates, the constitutive means applied to facilitate the reciprocal interchanges is problematic; it is expected to be a functional description of a WTC, but in fact it is product specifications of breaker panels. This triggers disturbance in the habitual experience, but the unusable constitutive means (the information applied) becomes a roadblock, making it impossible to transcend this precognitive phase, by which the employees' reflections are aimless. The analysis of the two Newcomer cases illustrates that the reciprocal interchanges during the miniTS phase cause the miniTS to have a low sustainability.

Addressing the cross-functional IPR meeting, the reciprocal interchanges follow divergent tracks. It is not possible to achieve a convergent interpretation. In addition to a low sustainability, the indeterminacy is suppressed.

Summing up, reciprocal interchanges drawing on reflective experience make it possible to achieve sustainable determinacies. A high level of sustainability is likewise achievable if the approach draws on merely handing over information, but it necessitates a deliberate orchestration of the ready-made indeterminate situation as well as a well-structured composition of the STP. Putting the reciprocal interchanges on standby does not result in a sustainable determinacy, but it paves the way for achieving it elsewhere. Finally, reciprocal interchanges following divergent tracks do not facilitate a sustainable determinacy. Actually, this approach suppresses the indeterminate situation; often, the indeterminacy resurfaces later on in a new guise with more severe consequences.

As indicated in the above, the anchoring of the indeterminate situation is crucial given that it is possible to achieve a sustainable determinacy without performing a successful learning process; this, however, entails that no learning takes place. The next section addresses this by illustrating the nexus between learning and PD. In addition, table 11.2 presented in the next section summarises the findings as regards sustainability and the nexus between learning and PD.

### 11.3.3. Nexus between learning and PD

Based on the pragmatic learning understanding, the nexus between learning and PD is challenged. It is by no means an attempt to separate the two phenomena, as the stance in this thesis is to regard learning and PD as being contextually embedded within a continuously mutable STP.

Learning and PD do not take place per se, but are potential outcomes of the process of transforming an indeterminate situation into a determinate situation. For instance, it is possible to achieve a sustainable determinacy by merely handing over information within a well-structured composition of an STP, resulting in the creation of a WTC. However, to initiate learning, it is an essential prerequisite to create disturbances within the habitual experience and furthermore to ensure a continuation of the transformation process until a determinate situation is achieved. Addressing Newcomer, disturbances within the habitual experience are apparent within the interorganisational STP, but the lack of openness leaves the engineers from Newcomer powerless to transcend the precognitive phase. Consequently, the learning process is not a collective endeavour; rather, it is a one-way process being handled by the kk engineers.

| Approach to achieve determinacy | Learning | PD |
|---|---|---|
| Reciprocal interchanges follow divergent tracks. | No learning. Either the engineers' reflective experience is not activated or the reflective experience follows divergent tracks. | Low level of sustainability as the divergent interpretations cause the reciprocal interchanges to have no aim. |
| Mere handover of information. | No learning as merely handing over information impedes transcending the precognitive phase. | High level of sustainability if the orchestration of the ready-made indeterminacy is well-structured and the other party accepts this. Otherwise low level of sustainability. |
| Reciprocal interchanges are put on standby. | No learning, but it paves the way for learning. The engineers' reflective experience is guided to follow the same track. | Medium level of sustainability, but paves the way for sustainable determinacy elsewhere. |
| Reciprocal interchanges draw on reflective experience. | Learning occurs. The reciprocal interchanges make it possible to share reflective experience. | High level of sustainable determinacy. |

Table 11.2. The nexus between learning and PD.

The four approaches to ensure a continuation of the strip of doings are depicted in the leftmost column of table 11.2. The middle column addresses a learning perspective on the applied approach, while the rightmost column indicates whether or not the applied approach results in a sustainable PD.

As it appears from table 11.2, the nexus between learning and PD is not clear.

Creating a new WTC in collaboration with a customer on the back of well performed preparatory work conducted within the daily working STP is time-saving and resource-efficient. However, seen from a learning perspective, no reflective experience will be generated within the interorganisational STP; i.e., a sustainable new product/solution is achievable without creating new experience within the interorganisational STP.

A high level of nexus between learning and PD necessitates reciprocal interchanges drawing on reflective experience. Creating a WTC under such circumstances is resource demanding and time-consuming; yet it is instrumental in enabling interorganisational learning.

The purpose of this chapter was to gather the threads from the two previous analytical chapters and thereby be able to make visible the implications of the conducted research. The next section summarises the findings by introducing an anchoring matrix, after which the implications of this pragmatic research are presented.

## 11.4. The anchoring matrix – anchoring, composition and continuation

In the concluding part of section 11.1, a matrix illustrating four different ways to anchor the indeterminate situation is introduced. This anchoring matrix is reproduced in figure 11.9 incorporating the analyses conducted in sections 11.2 and 11.3.

| **Orchestration of indeterminate situation** | | |
|---|---|---|
| Emerging within the STP | **No through road**<br>Reciprocal interchanges follow divergent tracks<br>No-learning<br>Low level of sustainability | **Mountain road**<br>Reciprocal interchanges draw on reflective experience<br>Learning<br>High level of sustainability |
| Ready-made outside the STP | **One-way road**<br>Mere handover of information<br>No-learning<br>Low ←→ high sustainability | **Way station**<br>Reciprocal interchanges are put on standby<br>Pave the way for learning<br>Medium level of sustainability |
| | Divergent | Convergent |
| | **Interpretation of indeterminate situation** | |

Figure 11.9. Anchoring matrix – anchoring, composition and continuation.

The anchoring matrix draws on a distinction between a ready-made indeterminate situation prepared beyond the boundaries of the STP in question and an emerging indeterminate situation within an STP. The vertical dimension illuminates the orchestration of the indeterminacy. A ready-made indeterminacy is a one-sided orchestration, while the other orchestration refers to an emerging indeterminacy within the boundaries of the STP in question. The horizontal dimension distinguishes between whether or not it is possible to achieve a convergent interpretation of the indeterminacy to be handled. Thus, the horizontal dimension addresses divergent and convergent interpretations of the indeterminacy. This facilitates the introduction of four different types of anchoring of the indeterminate situation.

In each of these four categories, the composition of the STP is inserted with bold text in figure 11.9, and as it appears from the anchoring matrix, the road metaphor applied throughout section 11.2 illustrates this composition. The related approach to ensure a continuation of the strip of doings and thereby handle the indeterminate situation is listed immediately below the composition of the STP in question. Finally, the findings related to sustainability and learning are added.

Each of the four different categories in the anchoring matrix is explained in the below.

### 11.4.1. A no through road for the reciprocal interchanges constrains learning

The indeterminate situation emerges within the STP, but the reciprocal interchanges result in divergent interpretations. Seeing that it is impossible to reach common ground with regard to the substance of the indeterminate situation to be handled, the involved engineers emphasise different positions. This borders on a war of positions. Due to a low accessibility of constitutive means, the composition of the STP does not facilitate to handle this.

Even though disturbances within the habitual experience occur, the reciprocal interchanges between the accessible constitutive means and the heterogeneous engineers impede to really transcend the precognitive phase. Consequently, the reciprocal interchanges either follow divergent tracks or are led on a wild goose chase. Regarding the former, the reciprocal interchanges gradually fade away or become deliberately blocked by one of the engineers. The latter leads to suppression of the indeterminate situation; occasionally, the indeterminacy reappears in another variant with even more sweeping consequences.

As the transformation of the indeterminate situation into a determinate situation is not successfully completed, the constituents of the STP are not influenced, by which the sustainability of the "determinacy" is low and no learning occurs.

### 11.4.2. A one-way road to merely hand over information constrains learning

To avoid that this kind of STP results in pure information sharing, it is crucial to ensure an appropriate orchestration of the ready-made indeterminate situation. That is, the sustainability of the achieved determinacy depends on whether or not an engineer or a group of engineers takes charge. If nobody takes the initiative to orchestrate this ready-made indeterminate situation in the proper sense of the word, the doings wander without direction and become aimless.

A well-structured and one-way composition of the STP facilitates achievement of a sustainable determinacy; in this regard, the constitutive means being applied are confined to enhance the indeterminate situation to be handled. This one-way composition of the STP makes it possible to achieve sustainable determinacies with fewer resources, for which reason the approach "mere handover of information" is very efficient for creating a new product.

However, this ready-made problem is "busy work". It does not enable a collective learning process. The reading doings create disturbances in the habitual experience, but the lack of openness within the STP impedes to transcend this precognitive phase and thus to activate the reflective experience; i.e., the engineers' reflective experience is not activated and thereby combined within this composition of the STP.

As the transformation of the indeterminate situation into a determinate situation is not a collective endeavour, no learning takes place within this STP. In order to achieve sustainable determinacy, it is crucial to find acceptance of the asymmetric level of experience as well as the low level of openness.

### 11.4.3. A way station for the reciprocal interchanges constrains learning

The intention of the reciprocal interchanges is to proceed on the indeterminate situation prepared beyond this STP; it is an attempt to make a ready-made indeterminate situation manageable. The composition of the STP is thus tailored to delegate and thereby enable a convergent anchoring of the indeterminacy to be handled as well as to chart a course for the reflective experience. It is a well-structured STP composition. High accessibility of diverse and usable constitutive means combined with different levels of experience among the engineers enables a convergent anchoring of the indeterminate situation. Due to resource considerations, the reciprocal interchanges are put on standby as soon as a convergent anchoring of the ready-made indeterminacy is achieved. The convergent anchoring won combined with the well begun learning process pinpoints the direction for a succeeding learning process.

Given that the transformation of the indeterminate situation into a determinate situation becomes blocked, the constituents of the STP remain unchanged. Besides, no learning takes place within this composition of the STP. However, the half-done learning process prevents the engineers' reflective experience from chasing divergent tracks and/or being led on a wild goose chase. In other words, this composition of the STP paves the way for succeeding sustainable determinacy and learning.

### 11.4.4. A mountain road for the reciprocal interchanges enables learning

The composition of the STP is characterised by high accessibility of diverse and usable constitutive means as well as engineers having different levels of experience. The mobile phone and the laptop improve the accessibility to constitutive means. Likewise, the ongoing repositionings of the STP provide access to diverse and usable constitutive means to activate and guide the engineers' reflective experience. For instance, to strengthen the anchoring of an emerging indeterminate situation and to ensure a continuation of the learning process, the STP is at times relocated from a meeting room to the production area. This makes it possible to apply a physical product rather than an artificial representation to unleash disturbance within the habitual experience and thereby transcend this precognitive phase.

This mutable composition of the STP facilitates the reciprocity between the constitutive means and the engineers' experience. This reciprocity enables a convergent anchoring of the indeterminate situation and a continuation of the transformation process until a determinate situation has been achieved. The reciprocal interchanges drawing on reflective experience are not a linear process; rather they bounce back and forth. Therefore, compared with the three other quadrants, this composition of STP is more resource demanding. However, the achieved determinacies have a high level of sustainability and learning occurs.

Divided into a theoretical and managerial part, the next two sections present the implications of this research.

## 11.5. Theoretical implications

By applying pragmatic learning theory, this research has identified enablers and constraints for learning. Three categories of enablers/constraints emerge. Within the first category, the composition of the STP, the following enablers/constraints appear: The enablers are high accessibility of diverse and usable constitutive means as well as different levels of experience among the engineers. Learning is constrained if an engineer with critical experience is not present, by too ductile or too obdurate constitutive means and by a low level of openness. In general, this is in line with some of the research within the *practising* perspective, for instance Nonaka et al. (2000). These authors point out that the *"Ba* (the contextual setting, author) *should be "energised" to give energy and quality…"* to the learning process. Yet, the findings in this pragmatic research reveal a few differences, mainly due to the fact that the engineers are not passive, rather they exhibit different levels of commitment. This is elaborated in the implication below dealing with the contextual setting as well as in the implication dealing with learning.

In addition to the enablers/constraints within the composition of the STP, this thesis identifies enablers/constraints related to the transformation of the indeterminate situation into a determinate situation; i.e., the learning process. Thus, the other two categories of enablers/constraints are anchoring of the indeterminate situation and continuation of the strip of doings. A convergent anchoring of the indeterminate situation enables learning, while a divergent anchoring of the indeterminate situation constrains learning. Continuation of the strip of doings addresses the following enabler/constraints: The enabler for learning is reciprocal interchanges drawing on reflective experience. The constraints are the mere handover of information, reciprocal interchanges following divergent tracks and reciprocal interchanges put on standby.

The review in chapter 5 categorises the literature into four prevalent perspectives; *rationalising*, *perceiving*, *accessing* and *practising*. Table 11.3 presents an overview of these four theoretical perspectives. The theoretical position applied in this thesis is listed in the lowermost row. The pragmatic point of view originates from a stance saying that the engineers' doings and interpretations are inseparable from a situational STP. First, the engineers are not a homogenous crowd; the engineers do not possess the same level of experience and they demonstrate different levels of commitment when conducting a PD activity (strip of doings). Second, the composition of the STP is constantly mutable. I.e., both the engineers and the STP are regarded as heterogeneous entities, which contrasts with the four other perspectives illustrated in table 11.3.

It seems to be appropriate to divide the theoretical implications into three groups; these appear from table 11.3. The first implication addresses learning, while the second implication deals with the contextual setting in which learning unfold. The third subject matter deals with the nexus between learning and PD.

| Theoretical perspective | Implication: Learning | Implication: Contextual setting | Implication: Nexus between learning and PD |
|---|---|---|---|
| **Rationalising** Analysed in section 5.2 | Learning addresses cognitive processes, mainly individual learning mechanisms. | A relational system consisting of three cognitive processes. | Learning is an instrument to improve the competitive position of the firm by creating new products. |
| **Perceiving** Analysed in section 5.3 | Learning is the merger between a mental model and an artefact. | A sociotechnical system consisting of engineers and artefacts. | Accomplishment of PD fuses a mental model (cognitive structure) and a mechanical representation (product being developed). |
| **Accessing** Analysed in section 5.4 | Accessing a learning community/network causes learning per se. | Structures, procedures and rules in a community – e.g. a network of firms. | PD is considered as a suitable business process for the study of learning; no nexus is identified. |
| **Practising** Analysed in section 5.5 | Learning occurs when conducting PD activities. Being member of the working practice enables learning per se. | A situational and shared contextual setting. It is constantly in motion and it has a time and a space dimension. | Working, learning and PD are inseparable and embedded in a situated practise. Learning is the bridge between working and PD. |
| A pragmatic point of view | Heterogeneity of engineers and accessibility of constitutive means enable a convergent anchoring and reciprocal interchanges drawing on reflective experience. | A continuously mutable STP, which unfolds as a result of the anchoring and handling of an indeterminate situation. | Ambiguous nexus between learning and PD. It is possible to achieve a sustainable product without learning. |

Table 11.3. Overview of theoretical positions.

The contributions from this pragmatic research extend primarily on the practising and to some extent on the perceiving perspectives illustrated in above table. To position the contributions of this research, examples from the practising and perceiving perspectives will be included as references.

**Implication: learning**

Drawing attention to the leftmost column in table 11.3, learning is enabled by the high accessibility of diverse and usable constitutive means and the different levels of experience among the engineers. This reciprocity between the engineers and constitutive means enables a convergent anchoring of the indeterminate situation, triggering reciprocal interchanges drawing on reflective experience; i.e., learning.

Henderson (1991) considers the constitutive means to be a thinking tool for the engineers, a tool that enables communication and interaction among the engineers; the thinking tool is a sketch or a final drawing. This thesis identifies an enabling constitutive means to be a combination of constitutive means. The engineers' reading doings of an electric circuit to guide their reflective experience are an interactive process involving an electrical diagram, laptop, CAD system, TV screen and an intranet/internet connection.

Peltokorpi et al. (2007) describe learning to occur within situational Bas (contextual settings) as an ongoing conversion between socialisation, externalisation, combination and internalisation. The findings in this thesis are in line with this situational understanding of learning; i.e., the practising perspective in table 11.3. However, the findings in this research suggest that learning does not take place per se within the STP; the engineers do not become practitioners per se. First, the reciprocal interchanges drawing on reflective experience are often strenuous, especially when the engineers apply too obdurate constitutive means to guide their reflective experience. Second, the engineers have different levels of experience. This heterogeneity among the engineers is often an enabler for the learning process; however, occasionally it becomes a constraint. Generally, the latter occurs if an engineer with critical experience is not present within the STP. It either proves impossible to achieve a convergent anchoring of the indeterminate situation or to keep the engineers' reflective experience on track and thereby avoid that their reflective experience are led on a wild goose chase.

If transforming the indeterminate situation into a determinate situation, the reciprocal interchanges drawing on reflective experience will result in a collective learning process among the involved engineers. Each of the engineers gains new experience. A viewpoint in line with Brown and Duguid (1991) who consider learning to bestow the engineers with an ability to become a community member. However, this thesis reveals that the engineers have different backgrounds and mental faculties for utilising this new experience, for which reason the reciprocal interchanges drawing on reflective experience will not result in a homogenisation among the involved engineers.

A convergent anchoring of the indeterminate situation is crucial for enabling learning. This viewpoint has some similarities to Beckman and Barry's (2007) four-phased learning and PD model, in which the two first steps focus on understanding the problem to be handled. Yet, the anchoring matrix, figure 11.9, distinguishes between a ready-made and an emerging indeterminate situation, as well as whether the reciprocal interchanges cause divergent or convergent interpretations of the indeterminate situation. In this regard, learning is a potential outcome of the reciprocal interchanges and not something taking place per se.

**Implication: contextual setting**

Referring to the middle column of table 11.3, the composition of the STP is constantly mutable. This mutual composition is the result of an ongoing repositioning of the STP from a meeting room to the production area and vice versa, application of laptop and mobile phone to improve the accessibility to constitutive means and finally, ad hoc involvement of critically experienced engineers.

This ongoing adaptation of the contextual setting is described by Nonaka et al. (2000) to be a shared context in motion, while Miettinen et al. (2008) shed light on the constitutive effect of the trajectory being followed and charted. In general, the focal issue in relation to the practising perspective is to bring the community to the fore at the expense of the individuals; it is a community of practice.

This contrasts with the findings in this study, as the engineers are neither passive individuals nor a homogeneous crowd. Rather the engineers are heterogeneous and they demonstrate different levels of commitment when conducting a PD activity. In other words, the anchoring of the indeterminate situation as well as the continuation of the learning process does not occur automatically, but is facilitated by engineers possessing different levels of experience and commitment.

The reciprocal interchanges to transform the indeterminate situation into a determinate situation influence and will be influenced by the composition of the STP. I.e., the composition of the STP is continuously mutable; it unfolds in line with the anchoring of the indeterminate situation as well as when conducting the reciprocal interchanges in the effort to transform the indeterminacy into determinacy.

Henderson (1991 and 1998) emphasises the advantages of applying sketches as thinking tools for the engineers. The final drawing is often misinterpreted as too much complexity is written into these obdurate artefacts. The finding in this study is in line with Henderson's viewpoint; however, a constitutive means can be too ductile, which constrains the learning process. Besides, the repositioning of the STP to the production area makes it possible for the engineers to see, touch and from time to time replace components in the physical breaker panel. The constitutive effect of a physical breaker panel exceeds the constitutive effect of, for instance, an electrical diagram being studied within a meeting room.

**Implication: nexus between learning and PD**

The rightmost column in table 11.3 addresses the nexus between learning and PD. The applied pragmatic understanding does not separate learning and PD; rather both phenomena are embedded within the STP. This stance is in line with Brown and Duguid (1991), Peltokorpi et al. (2007) and Miettinen et al. (2008). However, the analyses in this thesis indicate that learning and PD do not occur automatically and thereby become a predetermined consequence of the doings. Instead, learning and PD are **potential** outcomes of the reciprocal interchanges; the nexus between learning and PD appears from table 11.2.

This theoretical implication addresses the understanding of PD applied to conduct the analyses, for which reason it does not appear from table 11.3.

By dividing a PD activity into a strip of doings, it becomes possible to consider PD and thereby learning as an unfolding process of reading and writing text. When reading a text, as for instance a scientific article, the readers' understanding of the scientific article are not identical due to different levels of experience as regards the specific subject matter of the article; the aforementioned heterogeneity. Some people will be inspired by the text, while other may consider the scientific work to be difficult to grasp. Correspondingly, when engineers are reading a drawing or an electrical diagram, their background and experience with this specific subject matter trigger different interpretations of the constitutive means.

The above reading doings (of text) are only one side of the coin; more specifically, the consumption side, given that the artefacts are constitutive means being used to conduct doings. Returning to the aforementioned academic work, researchers write text as for example books and scientific articles. Their writing doings in a scientific article constitute the creation of text; it is the other side of the coin, the production side. The production of text is facilitated by reading text; reading other scientific contributions and the accomplishment of various analyses are the building blocks for creating new experience. Hence, writing text originates from the obtained experience. Correspondingly, the engineers' reading doings of constitutive means as well as their reflective experience form the basis of writing doings in drawings, electrical diagrams etc.; that is, the production of new drawings, diagrams and products.

Latour (1992) and Akrich (1992) consider PD as a process of inscription, prescription and description, while Grint and Woolgar (1997) propose to understand technology as text. Neither of the two methods for understanding PD as ongoing reading and writing text takes the reciprocity between the engineers and the constitutive means as its focal point; the two methods have different views on agency. Referring to pragmatism, the engineers have different levels of experience and demonstrate varied levels of commitment when conducting the reading and writing doings.

## 11.6. Managerial and practical implications

The enablers for learning are: high accessibility of diverse and usable constitutive means, different levels of experience among the engineers, convergent anchoring of the indeterminate situation and reciprocal interchanges drawing on reflective experience.

The constraints for learning are: too ductile or too obdurate constitutive means, low level of openness, an engineer with critical experience is not present, divergent anchoring of the indeterminate situation, mere handover of information, reciprocal interchanges put on standby and reciprocal interchanges following divergent tracks.

**Implication: learning**

To enable the development of new experience, i.e. learning within the working practice, the manager should focus attention on the reciprocal interchanges taking place between the engineers and the constitutive means. Accessibility of constitutive means combined with diversely experienced engineers paves the way for the reciprocal interchanges to draw on reflective experience, which enables learning. This implies that the manager should strive to make sure that the constitutive means are accessible as well as ensure participation of engineers possessing the critical experience.

To enable collective learning, the manager must generate attention to the anchoring of the indeterminate situation. It is not enough that one or a group of engineers understands the problem to be handled; it necessitates a convergent anchoring of the indeterminate situation. Without a convergent anchoring of the indeterminate situation, the engineers will not be able to transcend the precognitive phase, implying that the reflective experience is not activated.

To establish this convergent anchoring of the indeterminate situation as well as a continuation of the reciprocal interchanges, the manager should ensure that the constitutive means are usable and accessible to all involved engineers. An unusable constitutive means will either preclude a convergent anchoring of the indeterminate situation or mislead the reciprocal interchanges. Dissimilar accessibility to the constitutive means does not pave the way for achieving a mutual understanding of the problem to be handled; i.e., a convergent anchoring.

Diversity of constitutive means is likewise a crucial focus point for the manager in the effort to facilitate a convergent anchoring and thereby a continuation of the reciprocal interchanges. Diversity is neither the number nor the technicalities of the constitutive means. Instead, an enabling constitutive means is a combination of constitutive means. The reading doings of an electric circuit to guide the engineers' reflective experience will be more effective if these are conducted as an interactive process. An interactive process involves engineers, an electrical diagram, laptop, CAD system, TV screen and an intranet/internet connection. For instance, an engineer depicts electrical diagrams on the TV screen by using a laptop connected to the intranet/internet. A CAD system makes it possible to follow a connection from a specific component to another component by using a great many electrical diagrams. This interactive process enables the reciprocal interchanges to draw on reflective experience. The manager can apply this interactive process to facilitate the learning process.

In line with the above diversity, the manager can make use of the laptop and the mobile phone to improve the accessibility of constitutive means within the STP. Calling a colleague or using the laptop to access usable information from a supplier's homepage paves the way for a continuation of the learning process.

To improve the accessibility of diverse and usable constitutive means, a manager can benefit from repositioning the STP from a meeting room to the production area. This repositioning will make it possible for the engineers to see, touch and to replace components in the physical product. The constitutive effect of a physical product exceeds that of, for instance, an electrical diagram being studied within a meeting room. A combination of electrical diagrams, drawings and the physical product will enable a convergent anchoring of the indeterminate situation and serve to keep on track the engineers' reflective experience.

Ongoing reading and writing doings of/in the constitutive means are an effective working method for the engineers to guide their reflective experience. By adding handmade sketches directly onto drawings/electrical diagrams or by applying a trial and error approach when placing components in the physical product, the engineers are able to keep on track the reciprocal interchanges.

**Implication: too ductile/obdurate constitutive means**

A too ductile constitutive means obstructs a convergent anchoring of the indeterminate situation, by which no learning occurs. This draws attention to when it would be appropriate to involve a customer (or a supplier), for instance, in the interorganisational clarification process. As a too ductile constitutive means constrains the learning process, it is not a matter of involving a customer (or a supplier) as early as possible. Rather, a customer (or a supplier) should be involved in the clarification process when the level of ductility of the constitutive means makes it possible to ensure a convergent anchoring of the indeterminate situation to be handled.

Using a too obdurate constitutive means is complicated due to the many potential side effects when conducting the PD activity. A too obdurate constitutive means complicates the formation of a convergent anchoring of the indeterminate situation to be handled. It requires much effort, which is resource demanding and time-consuming, to cope with this learning process constraint. However, the consequences of not making the necessary effort are technical specifications, drawings, electrical diagrams and physical products of an inappropriate quality.

**Implication: anchoring matrix**

The focal point throughout the thesis has been to understand learning when conducting a PD activity within an STP, for which reason understanding is given priority at the expense of prescribing best-practise tools. Hence, the summary of the findings in the anchoring matrix, figure 11.9, is not a toolbox. Nevertheless, it can be applied as a (constitutive) means to guide practicians' reflective experience (reflections) when accomplishing observations and analyses of their own working practice.

Both PD projects studied manage to produce successful WTCs that are delivered on schedule; the interorganisational learning, however, diverges. Depending on the circumstances, there may be pros and cons with regard to constraining or enabling learning. The four categories in figure 11.9 are central in the explanation below.

If a company wants to protect knowledge embedded in a product/subsystem/component and/or experience dealing with various business processes, it is possible to draw inspiration from the anchoring matrix. For instance, conducting PD without enabling interorganisational learning necessitates a well-structured and deliberate one-way composition of the STP, exemplified by the "one-way road" category in the anchoring matrix.

However, if a company desires to achieve embedded knowledge in a product or in relation to workplace experience, the composition of the interorganisational STP has to address this. The "mountain road" category in the anchoring matrix highlights the necessity of ensuring a convergent anchoring of the indeterminate situation as well as an adaptable composition of the STP. It is crucial to facilitate reciprocal interchanges drawing on a high accessibility of constitutive means and diversely experienced engineers. This reciprocity will enable to keep on track the reflective experience until the indeterminate situation has been handled.

Despite the fact that the "way station" category constrains learning, this composition of the STP is a useful method for coordinating and delegating PD activities. For instance, a meeting with a customer might result in a number of PD activities to be conducted by the PD project group(s). Instead of handling all these PD activities jointly, the focus within the STP should be on achieving a convergent anchoring of the indeterminate situation, after which the reciprocal interchanges are put on standby. Thus, the composition of the STP has to be tailored to delegate and thereby create a convergent anchoring of the indeterminate situation to be handled as well as to chart a course for the reflective experience. The convergent anchoring won combined with the well begun process of reciprocal interchanges will prevent the engineers' reflective experience from following divergent tracks and/or being led on a wild goose chase. I.e., it becomes possible to finish the learning process elsewhere.

The "no through road" composition is problematic, as it can lead to a suppression of the indeterminate situation. Occasionally, the indeterminate situation reappears in another variant with even greater consequences. I.e., this "no through road" composition should be avoided. The "no through road" situation seems to occur when the engineers are not able to reach common ground with regards to the real substance of the indeterminate situation to be handled. Often the involved engineers emphasise different positions, which may border on a war of positions. If this is the case, the manager should strive to facilitate a convergent interpretation of the indeterminate situation to be handled, rather than terminate the reciprocal interchanges. To ensure a continuation of the reciprocal interchanges, usable constitutive means have to be accessible for the engineers to keep on track the reflective experience.

**Implication: implementation of changes**

Referring to the introductory section 1.1, addressing the background of this thesis, companies are continuously reflecting on the competitive situation they are facing. The top management in each of these companies is proactive and struggling to ensure an ongoing adaptation of the business foundation to improve the company's competitive position. A great many managerial initiatives are launched in this connection. Although the top management has pondered for a long while before a change is implemented, the effect within the daily working STP is sometimes not as expected. In these situations, the claim is often that the employees do not take ownership of the changes being implemented. Naturally, the lack of ownership may have different reasons; however, from a learning perspective, the anchoring of the indeterminate situation is a plausible one.

The top management conducts analyses to interpret the substance of the indeterminate situation and this process is often lengthy. In other words, the orchestration of the indeterminacy emerges along the way, and the top management makes an effort to achieve a convergent interpretation of the indeterminate situation. Seen from the employees' perspective, the indeterminate situation as well as the "constitutive means" accessible to handle the indeterminacy is presented in a meeting. It is a ready-made indeterminate situation and often the employees only have a short time to interpret the situation.

Accordingly, focusing on how the orchestration of an indeterminate situation appears to the employees within the STP and whether or not a convergent interpretation is achieved may pave the way for improving the STP, if this is the intent.

Finally, chapters 2, 8, 9, 10 and 11 facilitate managerial insights into various STPs in which employees conduct doings. Insights that may assist practicians in analysing and reflecting on their own STPs throughout a PD project.

# Chapter 12. Conclusion

This chapter concludes on the research dealing with learning within a Product Development (PD) working practice. The research questions presented in the introductory chapter 1 guide the first concluding section. Next, a section addresses the applied research approach, the limitations of the research and the potential for further research.

## 12.1. Concluding the research

The purpose of this research was to develop an understanding of how learning takes place when conducting PD in collaboration with a customer. Specifically, the focus is on identification and examination of the characteristics enabling or constraining the learning process when engineers conduct a PD activity.

The research addresses a PD working practice. The analytical challenge is to discover the PD working practice from the "inside" as it unfolds with all its mess and confusion, rather than to impose an outside perspective on the phenomenon. The applied logic throughout the thesis is abduction.

In line with the abductive research strategy, the research originates from the empirical domain, for which reason the starting point for this PhD journey is a pilot case and preliminary analysis. This preliminary analysis results in a first-hand empirically based understanding of learning. To gain an understanding of the extant research on learning in a PD context, a literature review is conducted.

The literature review is guided by the research question *"which underlying perspectives are prevalent in the literature dealing with learning in a product development context?"*. Four prevailing theoretical perspectives are identified. Two continuums, which have individual/institutional learning mechanisms and engineering/sociotechnical understanding of PD as their extremes, are applied to categorise the theoretical perspectives; these are termed rationalising, practising, accessing and perceiving.

The rationalising category addresses bounded rationality, which focuses on the cognitive limitations on the individual and/or organisational level(s). These theories are decoupled from the context. In contrast, the practising category is highly contextually dependent. Activities, PD, learning and knowledge are thereby embedded in a situated PD working practice; however, these theories perceive the employees or groups of employees to be a homogenous crowd. The accessing view improves our understanding of organisational structures/elements/mechanisms instrumental in gaining access to valuable knowledge. It addresses managerial considerations aiming at accessing and thereby institutionalising knowledge from external sources, by which the employees' doings recede into the background. In contrast, the perceiving view brings the employees to the fore, as the facilitator for doings is the interplay between mental models and artefacts. These contributions help us to understand the role of artefacts in PD.

By comparing the analysis of the four prevailing theoretical perspectives with the preliminary analysis, a gap in the literature appears.

The preliminary analysis reveals a difference between the two selected PD projects. While the Oldtimer PD draws on three decades of collaboration, Newcomer is a new customer. The starting points of the two PD projects differ, which influences the PD working practices. Furthermore, the engineers have different educational backgrounds, practical experience, etc. Thus, both the PD working practices and the engineers demonstrate heterogeneity. The PD working practice is not static; on the contrary, it is mutable. Likewise, the engineers are not a homogenous crowd; instead, they have different levels of experience. Apparently, this kind of heterogeneity has not previously been a subject matter for the study of learning within a PD working practice.

By bringing the pragmatic learning understanding to the fore, it becomes possible to study the above heterogeneity. This learning perspective is valuable for identifying and examining the characteristics enabling or constraining the learning process.

The pragmatic learning literature employs a dynamic understanding of the working practice; the PD working practice is mutable, as it is "in-the-making". In other words, the PD working practice unfolds when the engineers conduct a PD activity.

The pragmatic position implies that an engineer is neither a passive individual purely institutionalised by the PD working practice nor an unrestricted individual free to act at its own will. Thinking and doing is not a step-by-step process; instead it is a thinking-in-doing process. Thinking-in-doing does not take place in an empty "space", but within the PD working practice.

The engineers do not conduct doings in a PD working practice, but "live by means of" the PD working practice. That is, when conducting a PD activity (PD strip of doings), the constitutive means within the PD working practice are inseparable from the experience of each of the involved engineers.

As the pragmatic learning literature does not explicitly address PD working practices, the research draws on the literature review of the practising and perceiving perspectives to identify an understanding of a PD working practice. Thus, the PD working practice is social as well as technical; it is a SocioTechnical Practice (STP).

Learning is defined as the outcome of the transformation of an indeterminate situation into a determinate situation. The indeterminate situation to be handled is existential. It is neither a purely mental disorder, nor purely a disorder in an STP; instead, the indeterminate situation occurs within the constituents of a particular STP. I.e., the disturbances occur in the inseparable relationship between the engineer(s) and the constitutive means within the STP. Restoration of the determinate situation results in learning for the individual. To grasp that the individual and the STP are evolving in reciprocity, the focal point for the research is to address how a PD activity (PD strip of doings) unfolds within an STP.

Drawing on this understanding of learning within an STP, the focal point of the analysis of Oldtimer and Newcomer is to identify and examine *"which characteristics enable or constrain the learning process?"*.

The analysis reveals the following characteristics of the enablers or constraints: accessibility of constitutive means, heterogeneity of engineers, ductility/obduracy, openness, anchoring of the indeterminate situation and continuation of the strip of doings. During the analysis of the enablers and constraints for the learning process, three categories gradually emerge.

As for the **composition of the STP** category, the enablers are: high accessibility of diverse and usable constitutive means, and different levels of experience among the engineers. The constraints are: if an engineer with critical experience is not present, too ductile or too obdurate constitutive means and a low level of openness. Regarding the category **anchoring of the indeterminate situation**, a convergent anchoring of the indeterminate situation enables learning, while a divergent anchoring of the indeterminate situation constrains learning. Addressing the category **continuation of the strip of doings**, reciprocal interchanges drawing on reflective experience enable learning, while the following constrains learning: the mere handover of information, when reciprocal interchanges follow divergent tracks and when reciprocal interchanges are put on standby.

The anchoring of the indeterminate situation is crucial for the learning process. A proper anchoring of the indeterminate situation makes it possible to transcend the precognitive phase and thus activate the reflective experience. It paves the way for a continuation of the strip of doings, enabling learning to occur. To pave the way for collective learning, the involved engineers must establish common ground as for the substance of the indeterminate situation. Without a convergent anchoring of the indeterminate situation, the reciprocal interchanges follow divergent tracks, blocking the learning process.

The reciprocal interchanges between the constitutive means and the engineers are the focal point for the anchoring process. The issue is whether the reciprocal interchanges create enough disturbances in the engineers' habitual experience to transcend this precognitive phase and thereby activate the engineers' reflective experience. Transcending the precognitive phase paves the way for a continuation of the strip of doings and it charts the course for the reciprocal interchanges to draw on reflective experience. It enables learning. Remaining in the precognitive phase implies that the engineers are merely handing over information, which constrains the learning process.

The anchoring of the indeterminate situation becomes central in the answer to *"how does the application of pragmatic learning theory contribute to our understanding of learning within interorganisational product development working practices?"*.

The anchoring of the indeterminate situations within the composition of the interorganisational, cross-functional and daily working STPs varies widely. However, by distinguishing between a ready-made and an emerging indeterminate situation as well as between a convergent and a divergent interpretation of the indeterminate situation to be handled, four different kinds of anchoring appear.

The analysis demonstrates that the anchoring of the indeterminate situation is influenced by and simultaneously influences the composition of the STP. Besides, the anchoring of the indeterminate situation charts the course for a continuation of the strip of doings and thereby the learning process.

Metaphorically, the composition of the STP provides a road for the transformation of the indeterminate situation into a determinate situation; four different roads are identified. In line with this, four different approaches to a continuation of the strip of doings are revealed.

The four different kinds of anchoring the indeterminate situation, the four different composition of the STP, and the four approaches to a continuation of the strip of doings make up the building blocks for the anchoring matrix illustrated in figure 11.9.

Referring to this anchoring matrix, the anchoring of the indeterminate situation to be handled has a crucial influence on the nexus between learning and PD. The PD in collaboration with Oldtimer results in learning within the interorganisational STP and PD of a Wind Turbine Control (WTC). Regarding the PD in collaboration with Newcomer, the creation of the new WTC does not cause learning to occur within the interorganisational STP.

The pragmatic learning understanding makes it possible to reveal that learning and PD are **potential** outcomes of the collaboration. In order words, when conducting PD in collaboration with a customer, learning and PD do not take place automatically. To enable both learning and PD, the challenges are to avoid that the engineers' reflective experience is led on a wild goose chase or a divergent track; this calls for a certain structure and persistence. Therefore, to enable collective learning when developing a new product, a convergent anchoring of the indeterminate situation is required.

Pragmatism paves the way for understanding heterogeneity in terms of the composition of the STP as well as the engineers.

The learning process is influenced by and simultaneously influences the composition of the STP. I.e., the composition of the STP is constantly mutable, as it unfolds concurrently with the engineers transforming the indeterminate situation into a determinate situation, thus acquiring new experience.

Learning does not take place per se within the composition of the STP; the engineers do not become practitioners per se. First, the engineers have to make an effort to transform the indeterminate situation into a determinate situation. The engineers have different levels of experience, and they do not demonstrate the same level of commitment when transforming the indeterminate situation into a determinate situation. Second, a convergent anchoring of the indeterminate situation resulting in the achievement of a determinate situation enables a collective learning process among the involved engineers. Each of the engineers gains new experience. However, the engineers have different backgrounds and mental faculties for making the most of this new experience, for which reason the learning process does not result in a homogenisation among the involved engineers.

The anchoring matrix illustrated in figure 11.9 summarises the findings. In addition, the implications of the research explained in sections 11.5 and 11.6 demonstrate how the application of the pragmatic learning theory contributes to the extant understanding of learning when conducting PD in collaboration with a customer.

## 12.2. The research process, limitations and the "road" for further research

The scope of the research, including the applied methodology, has in course of my five-year PhD journey been subject to modifications. Especially the access to kk-electronic (kk) contributed to shaping the course for the research, as it enabled me to study how the creation of a WTC unfolds over a period of time. Hence, after accessing kk more than two and a half years ago, the scope of the research was tailored to address learning within a PD working practice.

The interplay with kk and the Oldtimer and Newcomer representatives made me "feel at home" after eight years within academia, which may be the reason why I nearly spent all my time at kk in this period. I had permission to freely move around in the open-plan offices as well as in the production areas. Throughout this period, I was not once barred by kk or Oldtimer/Newcomer from participating in meetings, conducting interviews or making small talk. Such privileges meant that I was able to accumulate a large amount of recorded data and impressions of working practices surrounding the creation of a WTC.

The above provides many opportunities. However, this method of working has some drawbacks that should be taken into consideration before choosing it as a methodological approach. The within approach chosen for studying learning within a PD working practice is time-consuming, and, as a researcher, you run the risk of being seized by the mood.

Addressing the time issue, I normally spent a full working day at kk regardless of whether I was participating in meetings, conducting interviews or working on my thesis. Retrospectively, although I attempted to work disciplined on my thesis when sitting at the desk in the open-plan office at kk, the progress of the documenting part of the thesis was too much back and forth during this period; at present, I could really use the time spent then. Thus, looking back on the process from a time perspective, the research should have been more structured and planned. Naturally, the lack of structure is problematic, but on the other hand being an "agile researcher" (Weick, 2002) requires a willingness to drop ideas and working hypotheses despite the great effort invested in constructing these. The following paragraph is an example of this.

As this PhD study is a five-year part-time research, the first three years have been spent fulfilling my part of a contract with my employer (Aarhus University), making it possible to devote the remaining two years to the PhD project. During the first three years, I read literature dealing with learning and/or PD concurrently with adhering to the contractual obligations. Despite the fact that many of my notes and literature overviews dealing with the phenomenon turned out to be inexpedient for studying learning and PD "within the kk empirical domains", these efforts have not been fruitless. Honestly, often I was seized by the mood when observing the dialogues and the high professionalism demonstrated by the involved employees; it made a deep impression on me. In these situations, I benefitted from the theoretical understanding to keep track of the research and thereby avoid losing the research integrity.

The within approach applied to study the phenomenon is an interesting methodological road to follow. It paves the way for gaining a deep insight into various STPs dealing with how engineers apply different constitutive means to guide their doings. The analysis addresses mutable STPs emerging in the production area, in the open-plan office, and in cross-functional and interorganisational working practices. All of these have in common that kk is the focal point; moreover, the interorganisational STPs only include two other companies – Oldtimer and Newcomer. Accordingly, in line with the discussions in the methodological chapter 3, the confined empirical domain calls in question the generalisability of the findings.

First, all PD activities conducted in both PD projects are characterised by a bottom-up approach. This bottom-up approach permeates all doings, for instance the calculations of the rotation speed to connect/disconnect the wind turbine to/from the grid or the exact placement of the components in the physical breaker panels. This feel one's way approach to PD is applied by some companies, while others apply a top-down approach when creating new products.

Some readers of this thesis will probably question the generalisability of the contribution across industrial sectors and thereby regard the findings to be limited to the creation of WTCs. A viewpoint I disagree with, as the findings are independent of whether or not the product specifications/drawings/diagrams/mock-ups/physical products deal with metal, wood, glass, or electrical components. Actually, very few products are constructed exclusively in one industrial sector; instead, a product, as for instance a WTC, a wind turbine, a car, an airplane, a mobile phone, draws on supplies from a great many different industrial sectors.

Accordingly, the applied bottom-up approach to PD, rather than the delimitation of different industrial sectors, forms the basis for indentifying the limitations of the findings. Likewise, the findings are restricted to business-to-business PD.

Second, the analysis indicates that R&D establishes the rules for the cross-functional collaboration; a circumstance influencing the findings. Thus, it seems to be reasonable to consider whether or not this leads to limitations. On the one hand, the majority of the PD-activities take place while the employees are conducting their daily doings in the open-plan offices or in the production areas. The engineers, draughtsmen and prototype workers are working closely together. But on the other hand, as the findings in the analytical chapters indicate, the constitutive effects arising from the sales department, the mainstream production facilities in Poland and/or the purchasing department are limited. Therefore, the findings, and thus the contributions, are in my firm conviction influenced by the lack of constitutive effects from other cross-functional departments. It is not possible for me to estimate how much the lack of cross-functional collaboration influences the generalisability of the contributions, but the readers must take this circumstance into account.

This lack of cross-functional collaboration seems to be a subject matter for further research. Improvement of the cross-functional collaboration is an important point of focus within kk, and a number of managerial initiatives have been launched in this regard. When conducting the pilot case and preliminary analysis, I participated in a number of meetings addressing this subject matter; at that time, I made a deliberate delimitation of this issue.

Therefore, chapters 8, 9 and 10 abundantly illustrate the consequences of the lack of cross-functional collaboration, but the underlying construct of these problems is not examined. For instance, why does a department hand over inappropriate information to another department and why does the receiving department accept this? Likewise, why are proposals for new working procedures not implemented when all involved employees regard these proposals to be an improvement?

The above questions can be summarised by calling in question why an organisation/employee accepts conducting learning processes on a “no through road” as illustrated in figure 11.9.

Continuing in the same vein, does close collaboration with one key customer give rise to a “mindset” among all employees in an organisation? If so, it becomes the way of thinking, and thereby it determines the employees’ doings. This viewpoint was often put forward by the kk employees when I was collecting data for the preliminary analysis, and occasionally when making small talk with the employees afterwards. Beyond doubt, it is a subject receiving extensive attention from the top management, and it is a very interesting subject matter indeed; however, it is deliberately omitted from this thesis. In any case, accepting this viewpoint is to acknowledge that employees are a homogenous crowd and thereby incapable of demonstrating different levels of commitment. In other words, the “mindset claim” has some similarities to the institutional learning world view explained in section 4.2. Accordingly, a road for further research may be to apply a pragmatic learning understanding on the “mindset claim”.

This PhD journey has arrived at its final destination, and it is my hope that it will stimulate reflection and inspire new research challenges.

# Appendix A. Glossary, abbreviations and job-name relations

## Glossary

**Anchoring indeterminacy**: Anchoring is defined by how well the indeterminate situation is understood by the engineer(s).

**Blocked inquiry**: The transformation of the indeterminate situation is terminated without a restoration of determinacy; as the inquiry is blocked, no experience is created.

**Blocked strip of doings:** A strip of doings where the transformation from the indeterminate situation into a determinate situation becomes blocked; i.e., no learning and no creation/-modification of constitutive means occur.

**Constitutive means**: A constitutive means is an object that influences the transformation of the indeterminate situation into a determinate situation.

**Constraint:** A constraint restricts the transformation from the indeterminate situation into a determinate situation; i.e., no learning occurs.

**Determinate situation**: It is the outcome of a process of inquiry. In contrast to the indeterminate situation, the constituents do now *"hang together"* (Dewey, 1938:109). I.e., achieving a determinate situation implies a modification of the existing conditions within the scene of action.

**Doing**: A doing is an act conducted by an individual in the process of transforming an indeterminate situation into a determinate situation.

**Ductility**: Ductility indicates a low degree of completion of an artefact, e.g. a sketch.

**Effort to change an artefact**: Effort to change an artefact emphasises that the PD activity is time-consuming and resource demanding.

**Enabler**: An enabler makes it possible to transform the indeterminate situation into a determinate situation; i.e., learning occurs.

**End-in-view**: The end-in-view is the desired/intended outcome of the process of inquiry. It is a means to guide the individual's reflection in a direction of something needful or desirable.

**Experience**: Experience unfolds in and because of the scene of action; experience is the continual transaction and reciprocal formation of the individual and the scene of action (Elkjær, 2004:423). Experience spans a continuum between habitual experience and reflective experience.

**Habitual experience**: Habitual experience is non-cognitive experience; our habits draw on habitual experience. Habitual experience is the stabilising factor – "the great flywheel of the society".

**Indeterminate situation**: Disturbance in the habitual way of doing things as habits do not work; something disturbs our thinking or feeling, but at the time, we do not know what it is.

**Learning**: Learning is defined by the transformation of an indeterminate situation into a determinate situation. A restoration of determinacy creates new experience.

**Means-consequence relation**: The means-consequence relation is a method for guiding the transformation of the indeterminate situation into a determinate situation; i.e., a method for guiding the process of inquiry.

**Obduracy**: Obduracy indicates a high degree of completion of an artefact, e.g. a fully developed WTC breaker panel.

**Penetrating doing**: A penetrating doing retrieves information decoupled in a time and/or space dimension, e.g. retrieval of information from a supplier's homepage.

**Process of inquiry**: Continuous interchanges between observations of social/material factors and habitual/reflective experience; it is a learning process initiated by an indeterminate situation and ending with restoration – a determinate situation.

**Product development:** Product development is the creation of a new wind turbine control.

**Product development activity**: A product development activity is considered as a strip of doings; be it reading doings of constitutive means, writing doings in one or more of the constitutive means or penetrating doings making it possible to retrieve information, for instance from a supplier's homepage.

**Reading doing**: A reading doing is an interpretation of the constitutive means, e.g., reading a drawing.

**Reflective experience**: Reflective experience is cognitive. Reflective experience makes it possible to reflect on the root causes of an indeterminate situation and thereby transform it into a determinate situation.

**Scene of action**: The scene of action is the contextual setting in which the process of inquiry takes place; e.g., a meeting room where PD engineers are developing a product.

**Sociotechnical practice**: A sociotechnical practice is a working practice in which the social and the technical fuse into a sociotechnical composition. A working practice is the inseparable interaction between the individuals and the environment unfolding when conducting a PD activity.

**Starting doing**: A starting doing initiates the transformation of the indeterminate situation.

**Strip of doings**: A strip of doings is a series of doings that transforms the indeterminate situation into a determinate situation.

**Successful inquiry**: A successful inquiry results in a restoration of the determinacy and creation of new experience; i.e., learning.

**Successful strip of doings**: A successful strip of doings results in new experience and the creation/modification of constitutive means.

**Sustainable determinacy**: Sustainable determinacy is achieved if the particular determinate situation does not reappear as an indeterminate situation later on.

**Trajectory**: A trajectory is the life history of a project (Elkjær, 2004:428); e.g., the life history of the PD of a wind turbine control as *"Each particular activity prepares the way for the activity that follows."* (Dewey, 1938:33).

**Writing doing**: A writing doing is a creation or modification of one or more constitutive means, e.g. creation of a sketch, drawing or a breaker panel.

## Abbreviations

| | |
|---|---|
| ANT: | Actor Network Theory |
| BOM: | Bill of Material |
| CAD: | Computer Aided Design |
| CBS: | Copenhagen Business School |
| CEO | Chief Executive officer |
| COP: | Community Of Practice |
| CPU: | Central Processing Unit |
| CSIC: | China Shipbuilding Industry Corporation |
| DFIG: | Double Fed Induction Generator |
| ePM: | electronic Production Documentation |
| ERP: | Enterprise Resource Planning |
| FAI: | First Article Inspection |
| FFIG: | Full Power Converter Technology |
| HW: | Hardware |
| I/O: | Input/Output (interface between HW and SW) |
| IPR: | Intellectual Property Right |
| IT: | Information Technology |
| JV: | Joint Venture |
| kk: | kk-electronic A/S |
| LVRT: | Low Voltage Ride Thru |
| miniTS: | Document for preliminary Technical Specifications |
| MoM: | Minutes of Meeting |
| NBD: | New Business Department |
| PD: | Product Development |
| PCB: | Printed Circuit Board |
| PLC: | Programmable Logic Controller |
| PO: | Purchase Order |
| PTM: | Prototype Worker |
| R&D: | Research & Development |
| RPM: | Revolutions Per Minute |
| SBU: | Strategic Business Unit |
| SCADA: | Supervisory Control And Data Acquisition (the A80 park server) |
| SCOT: | Social Construction of Technology |

| | |
|---|---|
| STP: | SocioTechnical Practice |
| STS: | Science and Technology Studies |
| SW: | Software |
| TS-document: | Document for detailed Technical Specifications |
| TTM: | Time To Market |
| UPS: | Uninterruptible Power Supply (a kind of battery backup) |
| WTC: | Wind Turbine Control |

## Overview of job-name relations

kk project manager (Oldtimer) ➔ Mick
Technical project manager ➔ Jack
Oldtimer project manager 3.0 MW ➔ Andy
kk project manager (Newcomer) ➔ Rick
Newcomer project manager ➔ Joe
Salesman ➔ Tom
Technical salesman ➔ Nick
Electrical engineer 1 ➔ Bob
Electrical engineer 2 ➔ Kevin
Prototype work 1 ➔ Jim
Prototype worker 4 ➔ Jan
Responsible A21 engineer ➔ James
HW engineer 1 ➔ Dean
HW engineer 2 ➔ Dick
HW engineer 3 ➔ Leo
SW engineer 1 ➔ Tim
SW engineer 2 ➔ Frank
SW engineer 3 ➔ Ole
kk project manager (optimisation projects) ➔ Simon
Oldtimer project manager 2.3 MW ➔ Tony
Oldtimer project manager 3.6 MW ➔ David
Oldtimer engineer ➔ Steven
Electrical engineer 3 ➔ Only job title applied
Draughtsman 1➔ Only job title applied
Prototype work 2 ➔ Only job title applied
Prototype worker 3 ➔ Only job title applied
Logistic engineer ➔ Only job title applied
Employee 1 IPR-group ➔ Only job title applied
Employee 2 IPR-group ➔ Only job title applied
Newcomer engineer 1 ➔ Only job title applied
Newcomer engineer 2 ➔ Only job title applied
Newcomer engineer 3 ➔ Only job title applied

# Appendix B. Interviews and meetings observed

The appendix illustrates an outline of the data collection as regards the preliminary and detailed analyses. Overviews of accomplished interviews as well as meetings observed are presented.

## Overview - unstructured interviews to the preliminary analysis

A gatekeeper helped me identify the informants to be interviewed. The criteria used for selecting the informants imply that different hierarchical levels and all functions influencing PD are represented; these issues appear from the two midmost columns in the table below. Both individual and group interviews were accomplished, which is in evident from the rightmost column. The interviews were not taped; instead, I took notes. Immediately after each interview, a detailed summary was written. Approximated time for each interview was 60 minutes.

| Date | Area of function | Title | Individual or group interview |
|---|---|---|---|
| 9/1 2009 | Marketing | Manager | Individual |
| 26/1 2009 | Quality | Manager | Group |
| 26/1 2009 | Supply chain incl. purchasing | Manager | |
| 26/1 2009 | Supply chain | Engineer | |
| 28/1 2009 | Research & Development | Manager | Individual |
| 30/1 2009 | Project management | Manager | Individual |
| 2/3 2009 | Sales | Salesman | Individual |
| 4/3 2009 | Sales (technical) | Engineer | Individual |
| 5/3 2009 | Sales | Manager | Individual |
| 17/4 2009 | Quality | Engineer | Individual |
| 24/4 2009 | Research & Development | Engineer | Individual |
| 18/5 2009 | Sales | Salesman | Individual |
| 3/6 2009 | Optimisation projects | Manager | Group |
| 3/6 2009 | Optimisation projects | Engineer | |

Table A 1. Overview of unstructured interviews – preliminary analysis.

## Overview - semi-structured interviews to the detailed analyses

The table below describes the conducted 16 semi-structured interviews. The interviews were conducted from 16 November until 14 December 2009. By postponing the interviews to the end of the data collection period, it was possible to take into consideration the in-depth understanding of the two PD projects when constructing the interview guides. Thus, each of the interview guides was tailored to the informant in question, for which reason none of the 16 semi-structured interview guides is identical. All interviews were taped; the taped time appears from the rightmost column. The informants appear from the midmost column.

| Date | Job and name (pseudo-name) | Taped time Hours:minutes |
|---|---|---|
| 16/11 2009 | Technical project manager ➔ Jack | 1:10 |
| 16/11 2009 | kk project manager (Oldtimer) ➔ Mick | 1:25 |
| 19/11 2009 | Prototype work 1 ➔ Jim | 0:54 |
| 19/11 2009 | Electrical engineer 3 ➔ Only job title applied | 0:51 |
| 23/11 2009 | Prototype work 2 ➔ Only job title applied | 0:58 |
| 23/11 2009 | Electrical engineer 2 ➔ Kevin | 0:58 |
| 26/11 2009 | Draughtsman 1➔ Only job title applied | 0:36 |
| 26/11 2009 | Oldtimer project manager 3.0 MW ➔ Andy | 1:19 |
| 2/12 2009 | Electrical engineer 1 ➔ Bob | 0:58 |
| 4/12 2009 | Salesman ➔ Tom | 0:59 |
| 4/12 2009 | SW engineer 1 ➔ Tim | 0:59 |
| 7/12 2009 | Technical salesman ➔ Nick | 0:57 |
| 8/12 2009 | HW engineer 3 ➔ Leo | 0:42 |
| 9/12 2009 | HW engineer 1 ➔ Dean | 1:08 |
| 9/12 2009 | kk project manager (Newcomer) ➔ Rick | 1:15 |
| 14/12 2009 | HW engineer 2 ➔ Dick | 0:53 |

Table A 2. Overview of semi-structured interviews – detailed analyses.

Other than the above semi-structured interviews, five "unplanned" interviews were conducted. In this regard, an "unplanned" interview was accomplished with Newcomer's project manager (Joe) 7 October 2009. The duration for this interview was 45 minutes. As it was an unplanned interview, it was not taped. Instead, notes were written down and later on, a MS-word document was created.

## Overview of meetings in relation to the preliminary analyse

As regards the pilot case and preliminary analysis the meetings observed appear from the table below. The table describes the purpose of the meeting in question, the number of employees participating in the meeting and finally the duration of the meeting.

| Date | Purpose of the meeting | Number of participants | Duration Hours:minutes |
|---|---|---|---|
| 25/2 2009 | Quality issues | 17 | 2:30 |
| 24/4 2009 | Improving cross-functional collaboration | 8 | 3:00 |
| 28/4 2009 | Improving cross-functional collaboration | 2 | 2:00 |
| 6/5 2009 | Improving cross-functional collaboration (Video conference DK/Poland) | 8 | 1:30 |

Table A 3. Overview of meetings observed – preliminary analysis.

## Overview of meetings in relation to the detailed analyses

As for the data-collection to the detailed analyses, 56 interorganisational/cross-functional meetings were observed; the organisational composition as well as the purpose of the meeting appears from the column "Composition of the meeting". The following column describes the number of participants; a "+" indicates a temporary participation of additional employees. The two rightmost columns shed light on the physical location and the duration of the meeting as well; the "P" in bracket 13 August illustrates that only a minor part of this meeting takes place within the production area.

| Date | Composition of the meeting | Number of participants | Location:<br>M: Meeting room<br>P: Production area | Approx. duration<br>Hours:minutes |
|---|---|---|---|---|
| 26/6 2009 | Cross-functional: technical meeting | 8 | M | 0:45 |
| 29/6 2009 | Cross-functional: project meeting | 13 | M | 1:00 |
| 9/7 2009 | Cross-functional: technical meeting | 6 | M | 0:30 |
| 3/8 2009 | Cross-functional: technical meeting | 8 | M | 0:30 |
| 13/8 2009 | Interorganisational: project meeting | 3 | M & (P) | 2:15 |
| 13/8 2009 | Cross-functional: technical meeting | 7 | M | 0:15 |
| 20/8 2009 | Interorganisational: technical issues | 3 | P | 1:00 |
| 20/8 2009 | Cross-functional: project meeting | 17 | M | 1:00 |
| 21/8 2009 | Interorganisational: project meeting | 3 + | M & P | 2:10 |
| 27/8 2009 | Cross-functional: project scope | 5 | M | 1:30 |
| 28/8 2009 | Interorganisational: project meeting | 2 + | M & P | 1:50 |
| 31/8 2009 | Cross-functional: kick-off | 24 | M | 3:00 |
| 3/9 2009 | Interorganisational: project meeting | 4 + | M & P | 2:40 |
| 4/9 2009 | Cross-functional: technical meeting | 8 | M | 0:30 |
| 7/9 2009 | Cross-functional: project meeting | 7 | M | 1:00 |
| 9/9 2009 | Cross-functional: FAI verification | 4 | P | 0:45 |
| 10/9 2009 | Interorganisational: project meeting | 5 + | M & P | 1:40 |
| 10/9 2009 | Interorganisational: FAI verification | 5 + | P | 1:00 |
| 14/9 2009 | Cross-functional: FAI verification | 3 + | P | 1:00 |
| 15/9 2009 | Cross-functional: ePM verification | 5 | M | 1:15 |
| 15/9 2009 | Cross-functional: ePM verification | 4 | M | 1:00 |
| 16/9 2009 | Cross-functional: IPR-meeting | 9 | M | 2:00 |
| 17/9 2009 | Interorganisational: project meeting | 3 + | M | 1:30 |
| 18/9 2009 | Interorganisational: project meeting | 8 + | M | 8:15 |
| 24/9 2009 | Cross-functional: FAI verification | 2 + | P | 0:30 |
| 24/9 2009 | Cross-functional: FAI verification | 3 + | P | 0:45 |
| 24/9 2009 | Interorganisational: project meeting | 3 + | M | 1:55 |
| 25/9 2009 | Interorganisational: project meeting | 9 + | M | 7:00 |
| 28/9 2009 | Interorganisational: FAI verification | 5 + | P | 1:00 |
| 2/10 2009 | Interorganisational: project meeting | 3 + | M | 1:45 |
| 5/10 2009 | Cross-functional: FAI verification | 4 + | P | 1:30 |
| 5/10 2009 | Cross-functional: technical meeting | 8 | M | 0:15 |
| 7/10 2009 | Interorganisational: project meeting | 9 + | M | 8:00 |
| 8/10 2009 | Cross-functional: FAI verification | 5 | P | 1:15 |
| 8/10 2009 | Interorganisational: FAI verification | 4 + | P | 1:30 |

| | | | | |
|---|---|---|---|---|
| 8/10 2009 | Interorganisational: project meeting | 4 + | M & P | 1:00 |
| 21/10 2009 | Cross-functional: technical meeting | 7 | M | 0:30 |
| 28/10 2009 | Cross-functional: technical meeting | 12 | M | 1:30 |
| 29/10 2009 | Cross-functional: FAI verification | 3 | P | 0:30 |
| 29/10 2009 | Interorganisational: project meeting | 3 + | M & P | 1:45 |
| 29/10 2009 | Interorganisational: FAI verification | 4 + | P | 0:30 |
| 30/10 2009 | Cross-functional: calculation/technical | 4 | M | 2:00 |
| 2/11 2009 | Cross-functional: ePM verification | 5 | M | 0:45 |
| 5/11 2009 | Cross-functional: calculation/technical | 4 | M | 2:30 |
| 5/11 2009 | Interorganisational: project meeting | 3 + | M & P | 1:50 |
| 5/11 2009 | Interorganisational: FAI verification | 3 + | P | 0:45 |
| 17/11 2009 | Interorganisational: project meeting | 3 + | M & P | 1:50 |
| 26/11 2009 | Interorganisational: project meeting | 3 + | M | 1:00 |
| 2/12 2009 | Interorganisational: project meeting | 3 + | M & P | 2:00 |
| 7/12 2009 | Interorganisational: technical issues | 3 + | M | 1:00 |
| 8/12 2009 | Cross-functional: FAI verification | 4 + | P | 0:45 |
| 8/12 2009 | Cross-functional: ePM verification | 6 | M | 1:15 |
| 8/12 2009 | Cross-functional: ePM verification | 5 | M | 1:00 |
| 10/12 2009 | Cross-functional: ePM verification | 5 | M | 0:30 |
| 10/12 2009 | Interorganisational: project meeting | 3 + | M & P | 1:40 |
| 14/12 2009 | Cross-functional: ePM verification | 6 | M | 1:15 |

Table A 4. Overview of meetings observed – detailed analyses.

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*Et praksisbasert perspektiv på dynamiske*
*læringsnettverk i toppidretten*
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