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Design for change: *An investigation into the value of manual design practice in organisational learning for highly specialised technology companies.*

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Statement

"This thesis represents partial submission for the degree of Doctor of Philosophy/ Master of Philosophy at the Royal College of Art. I confirm that the work presented here is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Sunday, January, 9, 2022

Petra Müller-Csernetzky

Abstract

Purpose: In organisations, expertise is one of the strongest assets for competitive advantage. It supports individual and organisational learning, the development of sustainable skills and is the capital of the workforce. In particular, tacit knowledge is highly valuable, but hidden in working routines or domain-specific know-how. In many cases this knowledge gets lost when employees leave the organisation or business processes change due to digitisation efforts. The study investigates to what extent the use of visual communication and manual design practice contributes to organisational learning in the context of digital transformation. It also examines ways of dealing with different visualising practices and looks at the complexity of implementing a digital management execution system in a technical environment. It aims to understand the interplay between knowledge worker and design expert, examining the outcome of this co-creational setting. Consequently, the research question is: **How does manual design practice act for facilitation in organisational transformation within digitisation initiatives in highly specialised technology ventures?**

Approach: The use of Action Research enabled me to investigate in a long-term case study at a high-tech company. Research Through Design helped me to develop user manuals for handling a new manufacturing execution system (MES). Within two and half years, three manuals were designed. The manuals are used in the company for training new employees and to enable further installations in other branches. These manuals, the interviews, and recordings of work meetings serve as material for the analysis and to understand the design practice within the transformation initiative.

Results: The study results in an Integrated Framework for Facilitation by Design and contributes to the field of knowledge management in combination with facilitiation through manual design practice. The framework consists of a process to work with individuals and to establish knowledge work. It builds the basis for a system to tackle more complex challenges and to enable full contextual understanding to deal with knowledge and information architectures. The process itself only unfolds its effect in the organisation and in defined spaces for knowledge work. The framework creates principles for an organisational learning culture that will enable the organisation to manage transformation to varying degrees and scales.

Keywords: Tacit and explicit knowledge, facilitation, design agent, transformation, technical and visual communication, co-creation;

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"Between matter and energy there is communication."

[Zwischen Materie und Energie steht die Kommunikation] Anton Stankowski (Stankowski, 1994, p. 36)

List of Abbreviations from Project Context

ALDS – Assembly Line & Lean Design

AVOR – Preparation of Work [Arbeitsvorbereitung]

BOM – Bill Of Material

CF – Abbreviation for the Manufacturing Execution System Brand

EDP – Electronic Data Processing

ENG – Engineer (Industrial Engineer)

ERP – Enterprise Resource Planning

FMBD – Production and Fabrication Operations Portal

IEC – International Electrotechnical Commission

IPQM – Quality Inspection Portal

ITIL – Information Technology Infrastructure Library

MEPT – Equipment and Machine Portal

MES – Manufacturing Execution System

MIS – Management Information Services

PM – Project Manager

PMQM – Product & Process Traceability Portal

PRD – Production Data (Production data that is recorded daily and linked to PROD.)

PRMG – Personal & Responsibility Management

PROD – Production Database (This data cannot be changed afterwards.)

PSWM – Organisational Structure Management

QAS – Production data from the previous day (The QAS database is overwritten daily.)

SAP – System Analysis Program Development [Systemanalyse Programmentwicklung]

SOE – Sequence of Event / SOED – Sequence of Event Design

TRN – Training database (Training database is only updated on request.)

TST – Test database (Test database is only updated and overwritten on request.)

VCPT – Material Portal

VDI – Association of German Engineers [Verein Deutscher Ingenieure]

VFPT – Visual Factory Portal

W/WRK – Worker (Production Employee)

List of Abbreviations from Literature

CB – Corporate Behavior

CC – Corporate Communication

CD – Corporate Design

CI – Corporate Identity and also Corporate Image

DIKW – Data-Information-Knowledge-Wisdom (DIKW-pyramid)

GUI – Graphical User Interface

HCD – Human-Centered Design

HCI – Human-Centered Interface

SECI – Socialization-Externalization-Combination-Internalization

TC/TCOM –Technical Communication

TCBOK – Technical Communication Body of Knowledge

UX – User Experience

Definitions

BA – BA is not an abbreviation. BA means place, or location shared by several people. The concept of BA originally comes from the Japanese philosopher Kitaro Nishida. It has been used by Ikujiro Nonaka to describe places of interaction in organizational learning (Nonaka & Konno, 1998).

DIKW – DIKW is an abbreviation for Data-Information-Knowledge-Wisdom and often defined as DIKW-pyramid or DIKW hierarchy. The model tries to establish possible consecutive relationships between data, information, knowledge and wisdom. It emphasizes the different manifestations of the classes in different disciplines and has been dicussed from numerous scholars (Bratianu, 2015).

SECI – SECI is an abbreviation for Socialization-Externalization-Combination-Internalization and describes the concept of organizational learning in which implicit knowledge turns into explicit knowledge. The process is spiral as well as dynamic and repeats itself. It is therefore often referred to as the SECI-Spiral. SECI has been defined by Ikujiro Nonaka in the context of his research at the Toyota Motor Corporation in the 90s (Nonaka, 1994).

Manual – The term manual is often used for work descriptions and instructions. In technical communication, the instruction manual is common (Wick, 2000). In corporate communications and corporate design, the term brand manual, communications guideline or corporate design guideline is common (Regenthal, 2009). In organisations that define processes or rules of conduct, the term policy is often used. In this research, the term manual is used to describe the developed documents in the project. In the project team and the chapter 6 (Action Research), the term *Manual* is used to refer to the production employees, the term *SOE guideline* is used to refer to the engineers and *System Configuration Manual* is used to refer to project managers or Super Key Users.

LEAN – LEAN is not an abbreviation and stands for “creating value without waste”.

Adobe InDesign – The brand name represents a professional design software to develop layouts for print and online publishing and is part of software bundles marketed by Adobe.

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Working in the project and ultimately using it as a research study allowed me to see my own skills in a new light. I recognised my basic skills as a conveyor for off-process issues but especially in the process as a facilitator and problem solver. This insight should serve as accepted practice for all those who work as designers. During the five years I worked on the study, I discovered different ways of doing research in design. I am convinced that we will grow as a design research community, renew ourselves many times over and that other disciplines will benefit from our body of knowledge.

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1. Introduction

In my professional role as a visual communication designer for many years, I have worked in the field of corporate and marketing communications. In my role as academic lecturer I train design and engineering students in visual design as well as innovation methods. As a specialist in writing and developing content for design guidelines I have led several organizations in their transition to a new identity. I noticed that, through working with the guidelines, issues become visible that can lead to diverse discourses. I would like to find out what role design plays in situations where invisible issues create ill-structured conditions, and whether design can contribute positively in the development of a common understanding therein.

The study explores the role of design in a technology-driven environment and how a design expert can deal with unpredictable challenges as well as knowledge work. It explores how design brings in certain skills to uncover hidden problems and facilitates organizational learning in the context of digitization initiatives. The study investigates solutions for knowledge management by analyzing routines through the iterative development of manuals, and it aims to understand how facilitation and co-creation can be used to break new ground and create value in internal knowledge work of a technology venture.

1.1. Project Brief

To investigate how design can be supportive in the context of knowledge management, I am working with a company that is integrating a new digital environment into existing production processes to become more efficient. It is a manufacturing execution system (MES), which documents and guides all work process in production. The use of the software at the front-end and in the back-end, as well as the implementation of such a project in the organisation, should be documented and made available in manuals.

The design expert's field of activity included (a) understanding the MES software and the various perception levels and user groups, (b) gaining orientation on technical manuals and enabling continuous reflection based on content as well as (c) developing methods to differentiate the various levels of knowledge and (d) distributing manuals at the end of the project to the organisation to be used by production employees, by engineers and by project managers.

1.1.1. Research Project

This thesis is based on the project in industry in which I was involved from November 2017 until July 2020. The project was designed as a large-scale transformation project to digitise paper-based production regulations into a Manufacturing Execution System (MES). Against this background, I was invited to work with the company as a design expert for manual development. The general scope of the new system is to optimise all business processes, from engineering, material flow, and personnel management to manufacturing planning, and visual, paperless manufacturing operations. It was planned that all paper-based processes, as well as all existing databases, will be managed by this new platform application. The investment into this software has large scale implications for all departments and production units, starting from HR, and going on through engineering, controlling and production. The scope for the company was to use the new software to focus on traceability of their production work processes and materials. The production employees must switch from the old paper-based methods to the digital instruction and documentation system when introducing and using the new system. They are guided through the production process only by the digital front-end of the system without further additional material. This project internally took the name *Paperless Lean Project* or just *Paperless Project* and these terms are used in this thesis in this context.

Within the project environment, there are three groups driving the project. It includes various software user roles, the software company and the design expert. The software user roles are divided themselves into three groups: production employees *(workers),* engineers and Key Users *(industrial engineer)*, and the Super Key User *(project manager)*. The *project manager's* task is to set up the back-end structure and organise the overall flow of the application implementation into the organisation. The *industrial engineers* are responsible for setting up the work routines, originally as paper-based production regulations, in the new digital environment. The engineers use templates to visualise the work steps, which are called Sequence of Events, or SOE for short, into the new system. The *workers* use the new system for tracking their production processes along with measuring and documentation tasks. The role of the software company is to programme the system and solve technical issues as well as requirements during implementation. The design expert's assignment is to develop manuals for the three software user roles, who will learn to operate the software and know how to implement the SOE and how to set up a complete system structure (Figure 1).

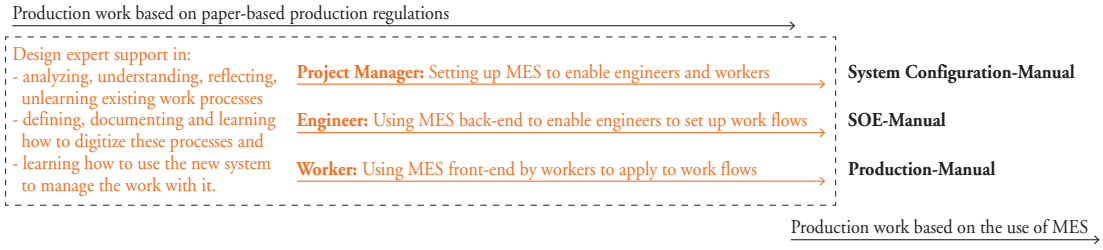


Figure 1: Paperless Lean Project framework (own illustration)

At the very beginning, the assignment focused only on developing the templates to be described in a design manual for the engineers. Its scope was to explain how to set up the work steps in the new digital environment using the templates as well as photography. Soon after the start, it became obvious that the template development is just one part of the implementation and that the manual should become a document guiding on the use of all relevant parts of the new system. The challenge became much more extensive as it then was to develop various manuals, which serve as a reference for the three software user roles, who start using the software from scratch.

1.1.2. The Team and the Challenges in the Project

I worked with employees from the production and planning departments but mainly in a project team on site with two people, the project manager and an engineer. Based on discussions and reflections, I created first manual fragments. They were primarily based on initial findings and experience with the software, but evolved as the project progressed. In the process, they reflected the organisational levels of work and uncovered potential problems in managing work using the new system. I understood that my job was to document organisational knowledge, and that I was actually beginning to visualise their expertise for unlearning old processes and develop new routines and rules.

During the course of the project, I had to look in depth at the employees' work in the production department to understand their capabilities in using the software. The manual fragments were also tested by other employees from other departments and within conversations I was able to understand further aspects of their work. Independent of department and work profile, I was faced with an inability to talk about what they were actually doing. The procedures were so highly routinised that the individuals could not describe them clearly to me. In addition, most of them were not used to describing their work, let alone presenting it. Only by showing them the manual fragments and reflecting together, did mutual understanding become possible.

The following figure (Figure 2) shows how the different team members such as the employees with different work profiles, the external software company and the design expert, work together and what kind of knowledge is available. The three manuals have been aligned to the three internal user roles. There was an exchange between the employees in their three roles, between project manager and software company as well as between the design expert and the employees.

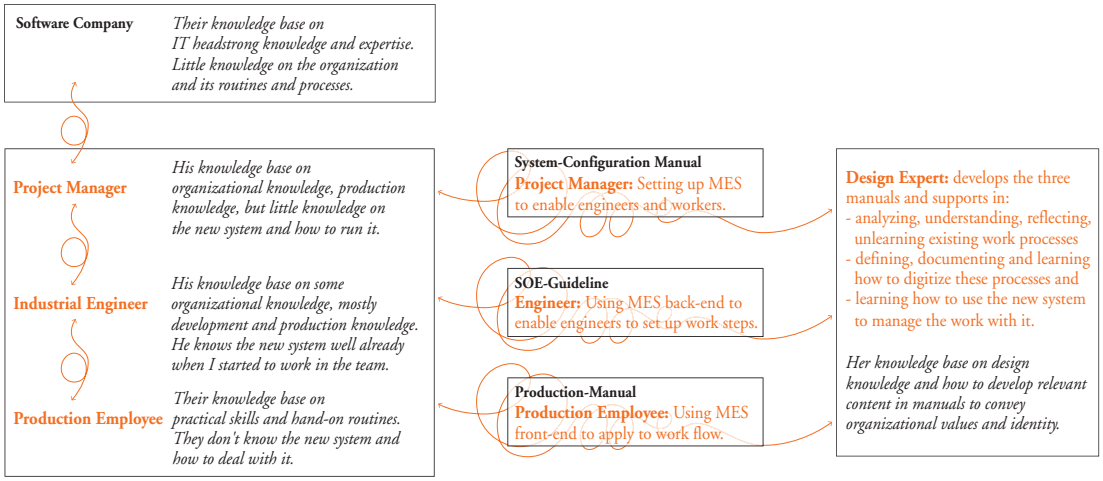


Figure 2: Participants and knowledge base in the Paper-less Lean Project (own illustration)

1.1.3. From Paper to Digital

Before the platform solution was installed, production employees worked with paper-based production instructions and inspection reports. Both working papers were located at the production workstations. The product to be manufactured moved from one workstation to the next, and a run card for the product moved with it to the various workstations had to be checked and secured. By using the new system, these media have been replaced. Due to the real processes taking place and the complexity of the production steps, the previous documents could not be transferred directly and without reflection to the new system. It always required a work step analysis and a test implementation. After testing and after the release of the digitised work steps, the digital process was transferred to the real environment. At the end of the implementation and the transfer, up to 6,000 sub-steps could describe the production of a complex product. It had become apparent that the bottom-up approach was advantageous when creating the production flow of a component and then breaking it down into operations that are assigned to work stations. All operations are located there, and the workers and the work preparation department know exactly what to do. This knowledge was made possible in part by reflecting on the processes in the manual fragments.

1.1.4. Internal Knowledge Management

Without the manuals being developed, the company would have only created MS Word documents internally without outside help. The project manager told me that "these files would simply get lost in our digital clutter and no one would be able to find them again. Also, we would have no evidence of our work and no way to store or communicate our experience and skills" (project manager, 2018). Figure 3 shows two sample pages of the MS Word document pages prior to the project and two sample pages of the new manuals. The prior samples show a typical MS Word structure and the new pages show a reorganisation of all information. The new pages represent the results of process analysis, the partial rebuilding of the same, the incorporated feedback from test persons, new text and image content as well as the observance of basic guidelines of the organisation's corporate design. The manuals, especially the SOE guide, were developed over a period of about 2.5 years in numerous iterations. The challenge lay in the fact that until the launch of the project, there had been a very specific culture of work documentation. This culture was not used to iteratively question the content in other means as the technical means and the product requirements would allow.

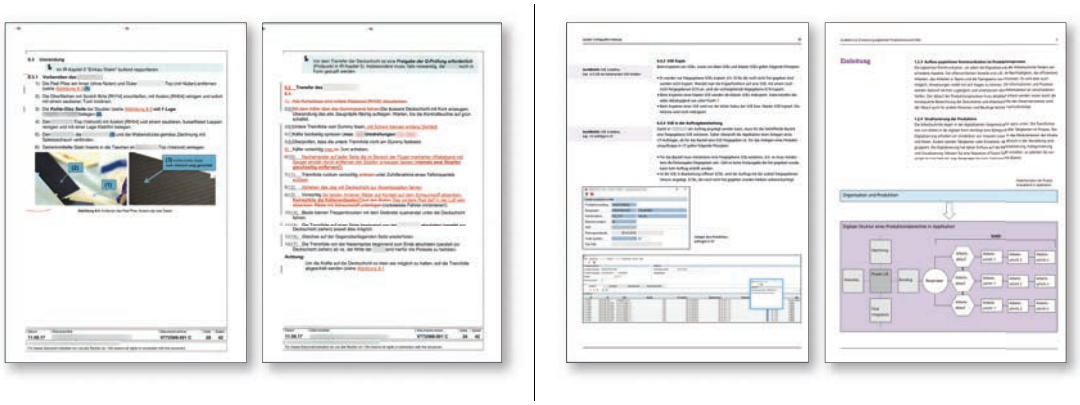


Figure 3: Sample pages of the previous regulations (left) and new manuals (right)

Up to project start, the creation of manuals has tended to be done on its own and only for one user group. There was no reflection with internal stakeholders or users. However, there was the need to develop documents that were comprehensible for different stakeholders, involving a change of perspective. Classical instructions with a linear structure were not useful as they do not reflect the existing complexity of the work organisation. It became clear, that not only click-through processes are documented, but principles and rules, which needed to be understood before starting to use the new software. To develop these different levels, explanations and principles are needed, as well as different types of visualisation to whether or not the they show the concepts correctly.

Internally written documentation had been created using MS Word, but to introduce a more complex structure of layout elements to use a common visual language, MS Word was not considered the appropriate tool for the task. Although all the team members initially requested MS Word files, they were quickly convinced by the layout appearing on the first pages developed using Adobe InDesign would be better. So it was decided that the manuals would be created and developed in Adobe InDesign and used in the departments as PDFs. The Adobe InDesign open files would be converted at the end of the project into a MS Word document so that marginal changes could be resolved internally later.

It was discussed whether the instructions should be offered interactively as an online source or remain in a linear and familiar document format. Various restrictions had to be taken into account, such as the use of the new software via single-screen displays, no open access to the internet via the production terminals as well as the general security rules. For the reasons described above and others, it was decided to use a document as a PDF on a second screen or as a simple printout that the user reads in parallel to working in the software. In the course of time, it also became apparent that a GUI-based comment function would not support the employees learning the software either, as it would imply immense programming efforts.

1.1.5. Project Process

The client's expectations of the design expert were to develop the three manuals. The collaboration spanned approx. 2.5 years and the cost of the support was based on market pricing standards for an industrial service. The long duration can be attributed to the progress of the project as well as the change in the role of the design expert. The company was used to services being standardised, but not practice-oriented. It was greatly appreciated that the design expert worked on site.

Initially, it was thought that it would be sufficient to develop the templates for the software, test it, and document it in a design style guide. However, it turned out that the process of collaboration went much further into the programme functionality and the insights could only be achieved through intensive collaboration. The three manual versions were not defined as such until the project was underway, and the distinction was deemed necessary. The challenge for the design expert changed and technical communication issues had to be addressed. When the design expert took on the task of developing the three user manuals, the role changed and so did the perception of the

design expert. The organisation could have hired a technical writer, but the project manager was not aware enough of this requirement and besides, he saw the diversity of requirements growing. The expectation was based on the professionalism of the support already experienced and the requirement for self-help support. The expectation was related to the development of content for using the software and its organisational embedding. Due to the new areas of work and necessary adjustments, the contract had to be renewed five times at the usual cost. All manuals developed serve as a record of work and include project ownership and a sense of detail.

1.2. Key Concepts from Theory

From the 80s to approx. 2010, design guidelines were documents in which designers explained a corporate design coupled with the communication of corporate values (Olins, 2010). The corporate identity itself was developed over a lengthy process and then not only recorded in these documents, but above all presented in such a way that they were conceived for further user groups inside and outside the company (Regenthal, 2009; Wheeler, 2017). Today, the need for design manuals has changed due to digitisation and the transformation of brand perception by online communication.

In contrast, the development of user manuals for operating machines or steering interfaces of IT systems has been discussed by scholars from technical communication but also from design in respect to information design (Bürdek, 2015). The reflection on information available through user guides or interfaces often links to tacit knowledge leading to engineering or organisational knowledge (Wick, 2000). Technical manuals explaining a machine design and how to handle it, in contrast to corporate design manuals, usually focus on conveying the use of products and machines, the human-machine interface, and its further development through digitisation. The haptic human-machine interface with its levers and sliders has been replaced by the digital interface and dashboards for information on machine status. Today, this does not only apply to the industrial machine per se, but to all processes that are controlled via a digital interface on screens. The human-machine-interface terminology has developed into a concept of human-centred-interaction (HCI) (Johnson, 2014) (Ware, 2020) and is a subject for design activity and research (McDaniel, 2009).

In line with the development of the digital technology, the technical communication community grew in the 90s towards a community of interface and User Experience (UX) specialists. The mindset of technical communication is still technical, also with the current aspirations of UX specialists

committed to human-centred design (Brumberger & Lauer, 2015) which includes usability and perception into concepts. Due to their history, manuals from technical communication show a different visual culture than those which have developed from visual communication. It is therefore not a matter of applying rules with regard to developing and embedding a visual culture, as is the case with corporate design guidelines (Regenthal, 2009).

Practices of knowledge management is discussed in the context of digital information management (Teece, 1981; Tsoukas, 2009), and especially in knowledge intensive businesses such as technology firms and R&D (Björkdahl, 2020). Technical development knowledge becomes available through technical drawings or production regulations, filed and stored on internal networks (Hughes, 2002). To establish a culture of sharing, the use of documented knowledge but also the development of a knowledge base is a challenge, especially in an industrial environment (Nonaka & Teece, 2001), where technical issues drive the mindsets. The SECI-spiral of knowledge dimensions aims to explain how skills and expertise can transform through an active sharing culture (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, et al., 2006). Based on four dimensions in SECI: socialisation, externalisation, combination, and internalisation, knowledge changes from one dimension to the other, and especially tacit knowledge that turns into information becomes available for others.

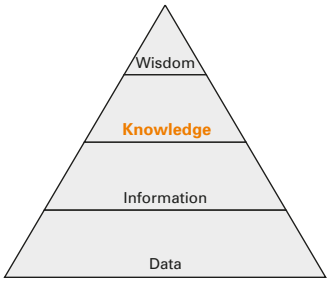


Figure 4: DIKW-pyramid (Rowley, 2007, p. 164)

The mere definition of the term knowledge leads to understanding the differences between information and knowledge (Ackhoff, 1999; Rowley, 2007) in the context of the DIKW-pyramid (Figure 4) and to clarify that information management does not replace knowledge management (Bratianu, 2015). The differentiation between the notion of tacit (Polanyi, 1966) and explicit knowledge (Lam, 2000; Hlatshwayo, 2019) leads to recognise the complexity of actively using our skills, which is a multi-layered combination of situational, abstract, social, and practical knowledge (Holford, 2020) and usually hard to grasp. While the depths of our skills and the combination of

various kinds of knowledge often hinders us to explain what we actually do (Choudrie & Selamat, 2006), methods to ease sharing and turning tacit knowledge into information become useful. Visual techniques and prototyping became popular to tackle individual and organisational knowledge and since Design Thinking first appeared in the 1990s by IDEO and the subsequent dissemination through the d.school (School of Design Thinking) at Stanford by Winograd, Leifer and Kelley (Kelley & Littman, 2006; Brown, 2019) methods and tools of human-centred design have widely developed (Rill, 2016). There is a high degree of transfer and use of visual methods in adjacent and cross-disciplinary areas, especially in business and product innovation (Martin, 2009; Täuscher & Abdelkafi, 2017). Martin's knowledge funnel (Figure 5) is a combination of the Neo-Schumpeterian knowledge funnel and design thinking and shows how the approach makes use of relevant knowledge to iteratively generate a solution coming from a high level of ambiguity.

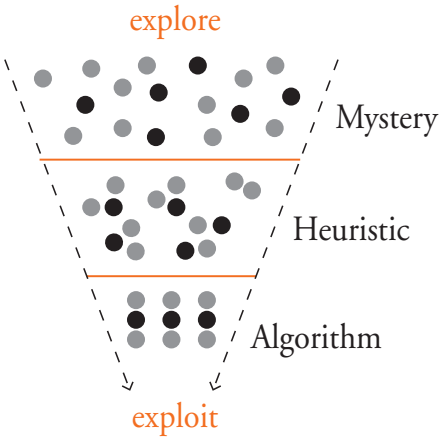


Figure 5: Knowledge Funnel (Martin, 2009, p. 8)

These methods developed from innovation management and storytelling for expressing individual experiences (Perret, et al., 2004; Szkupinski-Quiroga, 2015), life drawing or the use of maps (Varanka & Usery, 2018) have become equally important and are further examples of how visual approaches support the expression of tacit knowledge.

Against the background of the project, the focus lies on knowledge management rather than innovation management, and the moderated use of visual tools is key to understanding the various layers of knowledge. The concept of a boundary object describes an approach in which visual representations can either help the co-ordination or can uncover inconsistencies between parties and their communication (Star & Griesemer, 1989; Carlile, 2002; Star, 2010). A boundary object can be

represented by a note, a document or an object serving to clarify the different perspectives and the commonalities between the borders of the perception of individuals. Visual representations such as illustrations or drawings also serve as boundary objects and provoke a reflection based on the way they present a certain topic (Whyte, et al., 2008; Singh, 2011). Therefore, visual representations also offer the possibility to promote knowledge and cognition, and ease interaction as boundary objects (Ewenstein & Whyte, 2009).

The idea of using design methods and visual representation in knowledge management in the context of a highly technological environment sounds promising, but at the same time very challenging due to a lack of an active visual sharing culture. The role of the design expert will be challenged and constant flexible facilitation (Tann, 2021) through the use of design can support the project's forthcoming. The role exceeds the task of pure content reproduction, as a joint problem solving process (Aarikka-Stenroos & Jaakkola, 2012) will structure the interaction between design expert and team members. As a result of this approach, two outcomes are possible. The first outcome can support the reprocessing of routines and subsequently the definition of them as newly set routines in the MES. The second result could bring about the development and organisation of the information architecture of the manuals, which are to be used later by the employees.

1.3. Scope of the Research

The scope of the thesis is based on the proposition that the extraction and making available of tacit knowledge results from visualisation processes between people. This visualisation is formed via manuals as a boundary object and created co-operatively. The co-creation in the project team is based on joint decisions and reflection, founded on the fact that the design expert is temporarily part of the company's everyday life. The findings from the process are used to support the recognition of manuals for understanding, analysing, reorganising and changing existing routines. In this case, the routines had to become digitised and the manuals served as objects for clarification of the embedded knowledge. After finalising the manuals, they serve as tools for organisational learning. The perspective from design within the technical field supported the manual not to become a pure technical documentation. The project took place at an enterprise with expertise in developing and producing very complex, high-tech engineering solutions. Overall, manuals and visual communication can be positioned as process support in transformation management, even in companies with less complexity in their work processes.

1.3.1. Propositions

(1) My first proposition is that it will be important to establish a process for the interaction and reflection in the team and the design expert as well as amongst the employees. The culture of knowledge sharing should be based on active interaction by visual representations. To support the development of the culture, the design expert must work at the plant together with the employees and actively contribute her skills to the process.

(2) My second proposition is that the design expert supports the organisation and acts by jointly designing highly specific content and developing a system based on contextual understanding. Due to the different areas and levels of work, aspects from technical communication, corporate design, and corporate communication are combined. The visual language and the wording of the documents' content, as well as the information architecture of the manuals, develop in line and iteratively with the transformation of the multi-layered knowledge into information and instructions.

(3) My third proposition is that the development of the information architecture and the understanding of working principles allow the project to become manageable and the outcomes scalable. The developed materials serve as an instructional medium for learning new routines as a basis for renewed institutionalised processes in organisational transformation and learning.

1.3.2. Distinction Towards other Fields

The research does not focus on how the company's manufacturing is organized in detail and how the team members decide. But as a design expert in the context of manual development, I need to understand the context of the project in order to develop the contents of the manual.

I do not investigate the way the interface of the MES software itself is designed, because I do not analyse the usability of the interface, nor whether the software vendor supports the content of the manual or not. These aspects could play a role besides the main focus, but I do not address the relationship between the customer and its software service providers.

Discussing how digitisation affects work today, how it changes existing routines in professional life, and how digital and paperless approaches are implemented in organisations is also not my objective.

1.4. Structure of the Thesis

The thesis is divided into 10 chapters, with this introduction being the first chapter.

1. *Introduction* to the project, its team setting, the approach to the manuals, the intention of the study and the foundations in literature in short.
2. *Literature Review* deals with the existing theoretical basis in the areas of knowledge management, technical and visual communication as well as service and value co-creation. The research gap finalizes the review.
3. *Research Approach* show the approach to the study, exploration of three objectives, the main research objective as well as the research question.
4. *Methodology* describes the foundations in design research, the research strategy, the various methods and how I use them in my approach as well as ethics considerations.
5. *Project Description* expands on the project, its settings and details in the industrial context and how my research fits into the project aim.
6. *Action Research* documents the study and is structured in such a way that the accompaniment of the project in the industry is split into phases. The development of the project enabled me to conduct research in three Action Research Cycles, which also build the subchapters.
7. *Discussion* establishes the findings in respect to the areas of knowledge management and technical and visual communication, as well as services and value co-creation.
8. *Conclusion* reflects on the aims and objectives of the research, concluding on the findings and the contribution to theory as well as practice, closing with the limitations and recommendations for future research.
9. *Bibliography* including a list of citations at the end.
10. *Appendices*

The overview shows the relationships between the chapters and their content, especially those chapters and their sub-chapters which are highlighted by the orange arrows.

1. Introduction
1.1 Project Brief
1.2 Key Concepts from Theory
1.3 Scope of Research
1.4 Structure of the Thesis

2. Literature Review
2.1 Literature Introduction
2.2 Knowledge Management
2.3 Technical & Visual Communication
2.4 Service & Value Co-creation
2.5 Summary and Research gap

6. Action Research
6.1 The Action Research Cycles
6.2 Action Research Cycle 1
6.3 Action Research Cycle 2
6.4 Action Research Cycle 3

7. Discussion
7.1 Summary of Key Findings
7.2 Discussion of Findings and Contribution to Knowledge
7.3 Response tow. Research Question
7.4 Contribution to Knowledge

3. Research Approach
3.1 Research Question
3.1.1 Objective One
3.1.2 Objective Two
3.1.3 Objective Three

8. Conclusion
8.1 Introduction & Background
8.2 Aims and Objectives
8.3 Key Findings
8.4 Contribution to Knowledge and Design Practice
8.5 Future Studies

4. Methodology
4.1 Foundations in Design Research
4.2 Research Strategy
4.3 Research Methods
4.4 Methodological Approach
4.5 Ethics Consideration
4.6 Overview Methodological Approach

9. Bibliography
9.1 List of Citations

5. Project Description
5.1 Introduction to the Company
5.2 The Project at the Company
5.3 The Fit as Research Project
5.4 The Activities in the Project

10. Appendices
10.1 Selected Material Participants
10.2 Material Document Analysis
10.3 Coding by pre-defined Keywords

2. Literature Review

2.1. Literature Introduction

Based on the different challenges there are three main areas in the illustration to be considered as project-related literature forming the base for reflecting the project findings. The foundation of the literature focused on aspects from ***Knowledge Management****, Individual* and *Organisational Knowledge Management* as well as the *Barriers and Impediments*, when knowledge, especially tacit knowledge is in the process of sharing. An adjunct field of literature refers to the ***Technical and Visual Communication*** and its practices in the area of *Corporate Design Manuals.* The third field of literature is approaching ***Facilitation and Co-Creation*** with an examination of *Services in the Industrial Context* followed by *Facilitation as Co-creation for Change* with its *Resources.* The diagram shows the overlap of the fields and how *Manual design*, *Value* and the notion of *Boundary object* shapes through the interplay of the three areas.

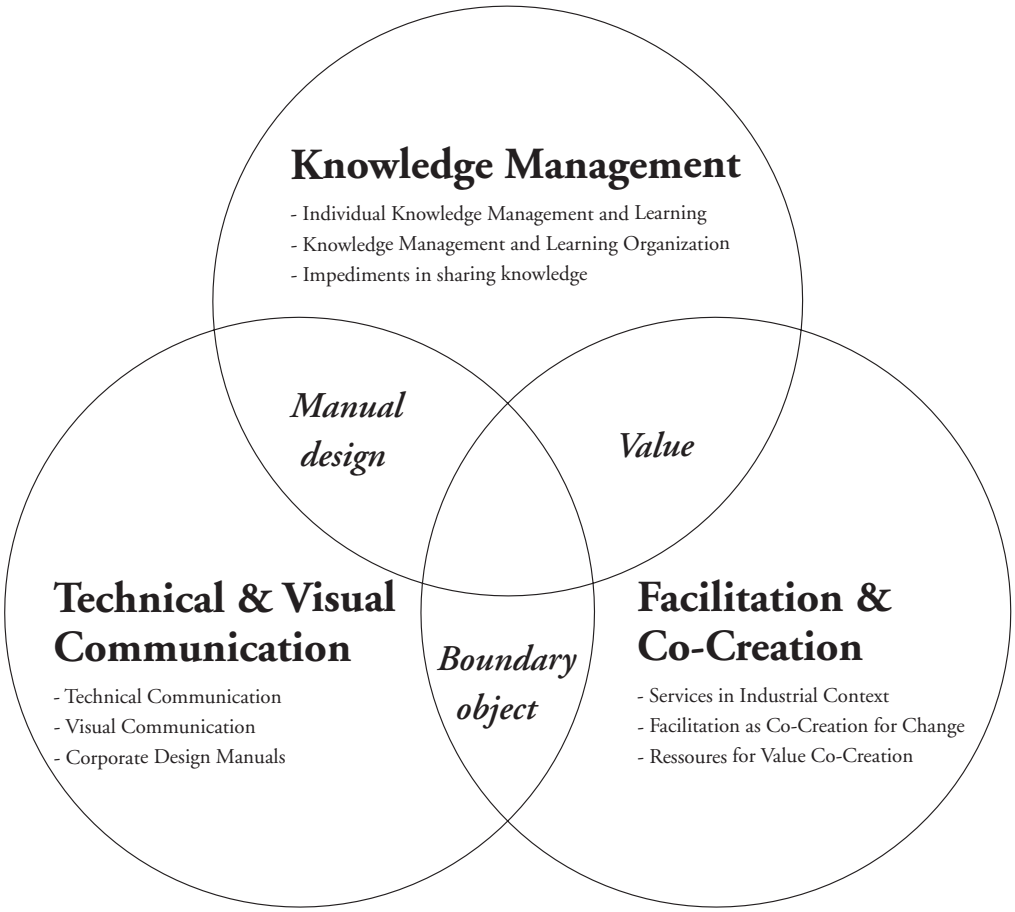


Figure 6: Interplay of Literature

2.1.1. Knowledge Management

The relevant literature for the project study is the investigation of how individuals learn (Kaiser, et al., 2018) and in relation to the organisation, how knowledge acquisition, its interpretation and its transformation (Nonaka & von Krogh, 2009) in industrial knowledge mangagement is situated (Nonaka & Teece, 2001). Another aspect lies on theories about the BA, as a place of transformation (Nonaka & Konno, 1998) and the support of the internalisation of new knowledge (Tsoukas, 2009) into new routines for employees and the embedding of new processes into the organisation.

It appears, that conscious control (Houdé, 2019) breaks down the procedural long-term memory (Carlson, et al., 2009) of the employees and enable reflection via active testing (Revans, 2014). The SECI-spiral as approach to organisational learning (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006) enables the sharing of experience within the organisation. The situational, procedural and strategic knowledge should transform into declarative knowledge and into metacognition (Kaiser, et al., 2018), to understand the levels of complexity and ability of problem handling in a challenging environment (Holford, 2020). The problems of sharing tacit knowledge should be emphasised (Selamat & Choudrie, 2007) and inability in expression or fears about incorrect assessment of one's own knowledge should be resolved (Weightman, 2019).

Subject	Authors	Key Argument	Intent in Study Context
Knowledge Management	(Kaiser, et al., 2018) (Holford, 2020)	Situational, sensorimotor, declarative and procedural or executive knowledge develop through learning and there is meta-cognition.	Unterstanding, how knowledge on the personal level develops.
	(Carlson, et al., 2009) (Houdé, 2019)	There is sensory, short-term and long-term memory with information on a permanent or near-permanent basis. 3-System theory of thinking and reasoning (intuition, logic, executive).	Understanding how long it takes, that memory is developed and to understand the project-loops in the organisation.
	(Lam, 2000), (Bratianu, 2015), (Hlatshwayo, 2019)	The differentiation between collective organisational types of knowledge.	Defining the different kinds of knowledge in the organisation.
	(Nonaka & Takeuchi, 1995), (Nonaka, et al., 2006), (Nonaka & von Krogh, 2009)	The knowledge management circle of organisational knowledge as socialisation–externalisation–combination–internalisation in the SECI-spiral.	Where and how knowledge in organisations can be managed.
	(Nonaka & Konno, 1998) (Buunk, et al., 2019)	The concept of BA as a place in the organisation for knowledge transformation.	What means are neccesary for knowledge transformation.
	(Selamat & Choudrie, 2007), (Tsoukas, 2009), (Weightman, 2019)	The impediments in sharing tacit knowledge can be overcome by meta-abilities.	Abilities to ease the impediments within knowledge sharing
	(Revans, 2014)	Active learning enables better learning and remembrance, especially practical skills.	To test the manuals with the employees using the new system.

Table 1: Key Scholars Knowledge Management

2.1.2. Technical and Visual Communication

The manuals to be developed are based on the specifications of technical user manuals (Wick, 2000) (Brumberger & Lauer, 2015; Reimann, 2016) and therefore focus on technical communication, but will be supplemented by elements of corporate communication (Wheeler, 2017; Eisenberg, et al., 2010) to convey the meaning of the project in an appropriate tone and voice (Regenthal, 2009). The work with manuals is work with visual elements, through which given themes and contents are iteratively mirrored (Barry, 2004) and work (Heimann & Schütz, 2017).

Subject	Authors	Key Argument	Intent in Study Context
Technical & Visual Communication	(Wick, 2000), (Brumberger & Lauer, 2015)	Technical communicators (TC) do knowledge management through their core competencies. TC operates broadly but fokus in content management and writing.	Using the approach of technicial manuals to establish a working base for the manuals to be developed.
	(Regenthal, 2009), (Olins, 2010), (Wheeler, 2017)	Corporate identity arises holistically from the values, the mission, the portfolio and C-Design, C-Behaviour, C-Communication. The identity must be expressed on all tangible levels.	The use of the company's corporate design guidelines enables better acceptance by employees and the corporate head.
	(Eisenberg, et al., 2010)	Organisational corporate communications must strike a balance between creativity and constraints to implement change in the long run.	Understand how job profiles and mind sets can be approached in the manual's communication.
	(Barry, 2004), (Heimann & Schütz, 2017) (Susanka & Kramer, 2021)	Power of visualisation as power of visual language. Design works, when respecting rules of perception and relevant design principles. Graphic Design as core support to convey complex information.	Applying rules to empower the visualisation to become communicative and translative.

Table 2: Key Scholars Techncial and Visual Communication

2.1.3. Facilitation and Co-Creation

All resources (employees, design expert, regulations, new software, database) fundamentally integrate knowledge and skills, are interactional, network related and contextual (Vargo & Lusch, 2014). The team expects the design expert to help under all given conditions (Freytag & Storvang, 2016), to develop and deliver manuals in the role of a facilitator (Tann, 2021). The joint problem-solving (Aarikka-Stenroos & Jaakkola, 2012) of the the manuals' creation defines the value-in-conext. The manuals are part of the practice of all involved employees as boundary objects (Carlile, 2002; Star, 2010) and serve to find tacit knowledge (Ewenstein & Whyte, 2009).

Subject	Authors	Key Argument	Intent in Study Context
Facilitation & Co-Creation	(Vargo & Lusch, 2014)	Service-Dominant logic defines value as determined by the beneficiary, all actors are resource integrators, the client is co-creator and there is a basis of mutual exchange.	These axioms define the actvity of the design expert as part of the complex service network.
	(Freytag & Storvang, 2016), (Tann, 2021)	The facilitator or change agent uses his skills, gets a picture of reality and is courageous. He constantly adapts to different challenges.	The facilitator's attitude is active and must adapt to changing challenges.
	(Aarikka-Stenroos & Jaakkola, 2012)	Through iterative problem solving and co-creative collaboration, value-in-context can emerge.	The manuals can only develop with the help of everyone. The development process is iterative.
	(Carlile, 2002) (Star, 2010) (Ewenstein & Whyte, 2009) (Steen, 2013)	The boundary object is between social worlds where things are poorly structured. The vague identity remains, but becomes specific, can become epistemic and does not move in interdisciplinary groups.	The manuals have the function to create clarity in the corporate environment as a social unit in the project subject and goal.

Table 3: Key Scholars Facilitation and Co-creation

2.2. Knowledge Management

The theories of knowledge management are essential to the investigation because the project is a profound transformation project that reorganises work routines and organisational processes. An understanding of the development of knowledge, its different forms at the individual and organisational level, and the problems of sharing knowledge and experience are essential.

2.2.1. Scope of Application in Knowledge Management

Knowledge and its active effects in the form of institutionalised routines or forms anchored in social role concepts surround us daily. Early scholars realised that we are usually not aware of that what we know, but the codified forms and transparent forces control our actions, our perception and how we perceive and construct reality (Simon, 1955; Polanyi, 1966; Berger & Luckmann, 1966, 2018). In management and organisational theory, the concept of knowledge had been discussed since the 70s and a differentiation between the understanding of knowledge, based on information processing or through learning by practice (Nonaka, et al., 2006) had been established. It was Herbert Simon who considered the ability to solve problems as a central aspect of knowledge-based action and decision-making in the context of the organisation (Simon, 1955; Nonaka, et al., 2006).

A further differentiation between aspects of knowledge such as explicit knowledge, which appears in the form of language and documentation, or tacit knowledge, which appears through skills and experience, appeared in numerous papers during the 90s (Nonaka, 1991; Nonaka & von Krogh, 2009; Nonaka, et al., 2006). Particular attention was paid to the conversion of experiential and tacit knowledge into explicit forms, as from the perspective of the organizations, this is where essential capital and new knowledge creation originates (Nonaka & Takeuchi, 1995; Nonaka & Teece, 2001; Nonaka & von Krogh, 2009; Tsoukas, 2009). It is precisely the so-called expert knowledge that represents a significant part of a company's capital. It serves as core source for new product development and effectuation (Jisr & Maamari, 2017), and hence it is simply important to keep it within the organisation.

Ikujiro Nonaka developed a groundbreaking concept for knowledge transformation that has been used ever since. The so-called SECI-spiral represents the transformation of knowledge from the individual to the group and, at the same time, the transformation of tacit knowledge into explicit knowledge through socialisation, externalisation, combination, and internalisation (Nonaka &

Takeuchi, 1995; Nonaka & Toyama, 2003). It represents a stable structure, but also contains gaps, especially in terms of cultural aspects, since Nonaka is from Japan. The application of his approach has been criticised as it is not readily applicable in the Western way of thinking (Gueldenberg & Helting, 2007; Hong, 2011). Furthermore, little emphasis was placed on examining the dynamics of such a transformation as well as the equal inclusion of explicit knowledge (Yao, et al., 2012). Nonaka additionally developed the idea of *BA* (Nonaka & Konno, 1998) as a concept for place of trustful exchange. It is seen as the place where the transformation takes place and amongst other applicable settings it has beed recognized as place for human interaction, especially in online environments (Sousa, et al., 2013; Dreyer & Wynn, 2016; Buunk, et al., 2019).

However, the source of invisible expert knowledge is seen as individual and, depending on the character of the individual, the ability to share, reflect, or convey expertise depends on various factors (Maier, et al., 2003; Choudrie & Selamat, 2006). In the context of knowledge transformation, and with employees often lacking the skills to explain their expertise in words or visually, the means and locations of knowledge transformation become central. In contemporary business and product development and with the use of various visualisation approaches, such as life drawing or storytelling, the visualisation of tacit knowledge gains importance (Koskinen & Vanharanta, 2002; Buchanan, 2008; Martin, 2009; Knight, et al., 2020).

The relevant area in the literature for the project study is industrial knowledge management (Nonaka & Teece, 2001), namely knowledge acquisition, its interpretation and its transformation (Nonaka & von Krogh, 2009) into a new information system, as well as the support of the internalisation of new knowledge (Tsoukas, 2009) into the routines of the employees and the embedding of new processes into the organisation through manuals. The complexity of the knowledge levels (Olaniran, 2017; Holford, 2020) and the problems of sharing tacit knowledge should be emphasised (Selamat & Choudrie, 2007).

2.2.2. Knowledge Dimensions

Since the 80s we have faced a broad discussion on information and knowledge in front of the paradigm shift from the industrial towards the information- and more recently the knowledge-based society. Scholars refer to knowledge as the result of experience, based on the findings that we receive information by using it in context. The so-called DIKW-pyramid (Data-Information-Knowledge-

Wisdom) (Ackhoff, 1999; Bratianu, 2015) defines information as a unit, which, based on data, is only to be regarded as information if it is placed in a frame that can be used, recognised, decoded and evaluated by humans. In this sense, data alone is worthless, just as worthless as information that is not used. Speaking of knowledge, this can be the result of cognition of being able to experience by means of information in such a way, that this experience results in knowledge and can form a value for man. The DIKW-pyramid sets data to information to knowledge to wisdom in a clear hierarchical order and as results of each other. There is a large discourse on the definitions of data, information and knowledge around information technology and computerisation, which started in the 80s by the contributions of Mike Cooley and information designers such as Saul Wurman and Nathan Shedroff (Wurman, 2001). Against the background of human-machine interfaces, the dissemination of data in human perception called for a redefinition of wording in this context, as data in the shape of *01* simply can not be decoded by humans except as abstract code, as it is representing the *digital*. The realm of information science and knowledge management introduced the difference of data versus information and also knowledge as the result of the dissemination of information in the process of cognition. The development of the model cannot be clearly assigned to only one person. Russell Ackoff, an organisational theorist, set the four elements in an order and a hierarchy, but the discussion on the definition of data, information, knowledge and wisdom has been going on ever since (Ackhoff, 1999). In front of the emergence of the information society, Webster defined five types of information, which determine the information society: technological, economic, occupational, spatial and cultural (Webster, 2006).

In contrast to an information society, Wiig distinguishes in the Wiig Knowledge Management Cycle between building up knowledge, holding, and pooling it, as well as using it as expressed knowledge (Wiig, 1997; Dalkir, 2005). Davenport & Prusak use knowledge as a term with a changing character, since knowledge is a flux of experience, contextual information, expert insights and evaluation (Davenport & Prusak, 1998; Bratianu, 2015). Hence there is also the tacit quality of experience, which colours knowledge as some result of an activity within a transformational process based on long-term, permament activity. The DIKW-pyramid refers to many other approaches scrutinising epistemology and trying to sort out the various types of data, information, knowledge, and also wisdom. From a knowledge management perspective, information is only truly valuable if it is relevant to the user. Dawson emphasizes in this regard that particularly high-value information solves individual or organizational problems, and is the result of customization (Dawson, 2005).

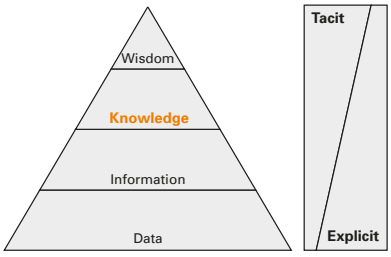


Figure 7: Based on DIKW-pyramid, illustration based on contribution (Ackoff, 1989)

The appearance of information also relies on the physical and communicative aspects. Shannon represents a rather engineering-led perspective towards information and semantics: "These semantic aspects of communication are irrelevant to the engineering problem" (Shannon, 1948, p. 1). A genuine theory of information would be a theory about the content of our messages, not a theory about the form in which this content is embodied (Bratianu, 2015). Shanneon refers to the meaning of data as a technical signal and contrasts his statements with the relevance of meaning, hence the content or the reason for information and communication before it can be used or transformed into knowledge. In addition, Nonaka is talking about knowledge building being a creative, cognitive process, which relates concepts that are far apart in an individual's memory, accessible through metaphors (Nonaka & Takeuchi, 1995). Nonaka claims that especially tacit knowledge can be transformed into explicit knowledge by (1) identifying contradictions using *metaphors* and (2) solving these contradictions via *analogy* (Nonaka & Toyama, 2003). Other scholars claim that learning is not a reproduction of some already known as solid state but rather a dynamic process of building a relationship between the individual and its task as a state of knowing. Hence tacit knowledge as definition bridges back to the statement of Davenport and Prusak (1998), that knowledge is agile and a changing thing.

2.2.3. Personal Knowledge Management

The study of knowledge leads to the concept of learning and cognition. The active use of intelligence in relation to an individual's reality is called cognition. The construction of cognition and the development of mental processes build the base for an analysis of how we learn and how we actively approach new knowledge. Knowledge can be distinguished by the way we achieve understanding through learning, whether it is active or passive, and how we apply already gained knowledge, which is clearly defined by Kaiser such as situational, declarative, procedural and sensorimotor knowledge (Kaiser, 2005). The way we gain knowledge can define the kinds of knowledge. Depending on the

type it can be concepts, theories, models and data, but also recipes and rules. Memories of situations experienced by oneself are concrete and detailed such as sounds, images, and smells as well as emotions, and can also be expressed. Kaiser's four knowledge definitions are:

Situational knowledge refers to situations, which have been encountered in concrete life. They are emotionally loaded and a multitude of very concrete situations we remember. Solving problems on a situational level, we will immediately relate them to another situation we remember. The individual then will do something as a reaction which has already proven itself in similar situations. One usually avoids problems, which have arisen in past and related situations. *In short: Remembering situations, which are similar and choosing the activities that have been proven good.*

Sensorimotor knowledge refers to a set program, which follows procedures running autonomously and without central control. This program can also be called auto-pilot, for example driving a car and not consciously deciding about each single activity as after some time and experience, the gearing process just runs automatically. Other well-managed processes unite with the environment into one system, filters certain measured variables out of perception and combines them with motor reactions. *In short: Using an autonomous set of programs and adaptability to unexpected situations.*

Declarative knowledge consists of rules and definitions that can relate to each other in many ways. One is using a set of procedures and applying a starting point and a target goal. This approach is also called rational planning and is very conscious. The solution found can be determined on the basis of the used and established rules and definitions. Other scholars refer to it as metacognition (Kaiser, et al., 2018). *In short: Using known step-by-step work through refers to the relationship of rules and definitions.*

Procedural or executive knowledge refers to controlling, gearing and planning activities through routines. This kind of knowledge consists of a multitude of if-then rules and routines such as written addition. Problem solving at this level can be imagined as a cyclical process and the first if-situation has to clear and an appropriate rule is selected. The then-part is executed and the situation is changed. Possibly the situation and the cycle start again. Other scholars refer to it as metacognition (Kaiser, et al., 2018). *In short: Problem solving by using if-then rules depend on the awareness of the effect of the rules.*

Additionally Hattie & Yates further set out six "types of knowledge" (Hattie & Yates, 2014, p. 127) representing how knowledge is stored in the mind and differentiate from the rather basic and sensory related recognition of shapes or substances around us up to actual skills enabling task analysis as procedural knowledge. Kaiser et. al. (2018) use the term *metacognition [Metakognition]* for the ability to name one's own knowledge and to differentiate between declarative and executive levels of knowledge. Metacognition is therefore a level of thinking and reflection that includes an active role of the knowledge owner in his own thinking and cognitive process. Every coach and trainer therefore needs metacognition in order to better plan and assess the development of learners (Kaiser, et al., 2018). Declarative knowledge covers the knowledge of people, tasks and strategies and is consciously accessible and can be represented linguistically, graphically or in some other way symbolically. Declarative task knowledge provides information about task types and their respective levels of difficulty. Strategic declarative knowledge refers to the application and performance possibilities of the processes known to the individual.

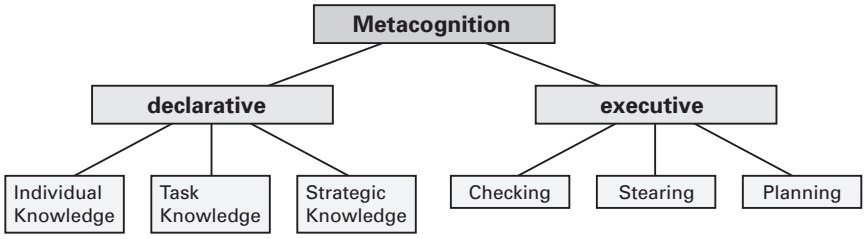


Figure 8: Metacognition, based on Kaiser et al. (2018, p. 6.10.4.14), translated

Declarative knowledge is contrasted with the executive aspect of metacognition such as checking, steering, and planning. Planning involves clarifying and selecting strategies that are appropriate for a situation. Direction and control describes the appropriate use and associated sequence of strategies and the correlation of intended and expected effects. The combination of both aspects as a consciously controlled sequence is possible through the awareness of metacognition. Studies have also proven that checking and steering are the most powerful activities for improving the thinking process and active problem solving (Son & Schwartz, 2002).

On the individual level, tacit knowledge rests silently in individuals. In some cases, knowledge and above all expertise is transferred from experts to newcomers. In-house training and further education is one of the fields that is about learning special skills. These can often be found within a branch of

industry, a craft, or a particularly specialised company, department or even a project, and usually distinguish the result and the quality of the work. To acquire this type of knowledge, we need to understand how we learn and how we build up memory.

Similar to the four Kaiser groups, Piaget defines four stages: the sensorimotor, the pre-operational, the concrete operational, and the formal operational stage for the development of human cognition from the perspective of genetic epistemology (Klann-Delius, 2008). While the first two stages cover the development of elements of language and the use of language, the third is characterised by first usage of logic in reference to real and concrete problems, and the last phase accomplishes the ability of the use of logic in abstract or even hypothetical thinking. In cognitive psychology, the dual-systems theories have so far been valid in the paradigm of thinking and reasoning. In it, system 1 as the fast and intuitive heuristics is contrasted with system 2 as the slow and logical algorithms (as by Piaget and his predecessors). Olivier Houdé extends the theory of cognitive psychology with the 3-system theory over into the exposition of a third control system. System 3 works to inhibit heuristics and activate logic and is seen by Houdé as the switching system of the cognitive part of the brain (frontal cortex). The innovative part of this approach is to create a brain-based synthesis of logical algorithms intuitive heuristics (Houdé, 2019).

It seems a challenge to understand blindly executed routines that have developed as a result of intense and long-term activity. The more practical experience a person achieves, the more implicit, tacit knowledge is built. It becomes more and more difficult to express it verbally compared to explicit knowledge. In implicit knowledge we also often speak of a skill or when one can exercise something *blindly*. Knowing the nuances of proficiency ends in mastery and when a person has developed the *sense* of something. In contrast, scholars conceive *talent* as a characteristic of people such as “Ability, Capacity, Commitment, Experience, Potential or Skills” (Gallardo-Gallardo, et al., 2013, p. 293). Gallardo-Gallardo et al., differentiate between talent as a natural ability or innate gift, talent as mastery based on long-term practice, talent as commitment related to passion, and talent as aptitude for perfect performance based on a specific setting (Tansley, 2011).

From the theories described, it appears that knowledge creation, cognition and learning are closely related to each other. Practical learning, especially when compared to passive learning, is more successful in higher order learning, long-term learning and subsequent work activity (Hunter &

Elliott-Kingston, 2016). Scholars stress that individual embodied knowledge builds up over a long period of time through recurring activity (Johannessen, et al., 2001). It is the paradigm of learning by action, as the complete person, intellect and physique, theory and practice in combination enables long-term learning and knowledge building. A typical example is the learning in vocational education and training, in which trainees learn on the job as well as in school. Action learning is a form of learning in which teaching and coaching aims to involve students in the learning process more directly than in other methods, and is usually used in higher education with adults. The approach was introduced by Reginald Revans and started a change in higher education methods moving from the inactive gathering of information towards a more activating and constructive approach (Revans, 2014). Revans' approach to learning joins the principle of Kolbs' active reflection as a hub in the experiential learning process (Kolb, 1984).

The American educational theorist David A. Kolb claims learning is "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 38). The experiential learning process represents the way we learn, and how we transform our set of skills in a cyclical turn. Learning, from the perspective of psychology, is the tendency to change behaviour as result of experience and reflects on the plasticity of our brain. Memory building is therefore the cognitive process of encoding, storing and retrieving information as an ongoing and active process.

> "Encoding is the active process of putting stimulus information into a form that can be used by our memory system. Storage is the process of maintaining information in the memory. Retrieval includes the active process of locating and using information stored in memory." (Carlson, et al., 2009, p. 216)

From the perspective of psychology, the brain locates the information in storage to actively retrieve it for usage. How fast we can retrieve a certain kind of information depends on the active use of the information. In 1968, Atkinson and Shiffrin found that sensory and short-term memory would mainly retain active traces and that long-term memory retains latent traces (Atkinson & Shiffrin, 1968). According to Carlson et al., sensory, short-term and long-term memory structure the way we receive, store and retain information and build upon each other (Carlson, et al., 2009):

Sensory memory: representations of physical stimuli, such as sounds (echoic memory) or brief visual imagery (iconic memory) also called visible persistence, that has just been perceived.

Short-term memory: immediate memory, that has been received in the short term, which is limited in capacity (72 chunks of information) and duration (less than 20 sec.), also called working memory.

Long-term memory: information is stored on a permanent or near-permanent basis and divides into narrative memory, in which items or situations are linked together through a story, and episodic memory serving as a record for life experience (Nyberg, et al., 1996), also connected with semantic memory, that contains data, facts, and other information such as vocabulary.

Scholars would rather talk about the organisation of long-term memory than use the term *knowledge*. Long-term memory refers to explicit or declarative memory and implicit or nondeclarative memory. Implicit memory is also called procedural memory, as it describes the remembering of how-to skills. The implicit memory appears to us as automatic activities, such as driving a car or using a software function blindly. The explicit or declarative memory consists of storing episodes (sequences of events) and semantic information (facts). The implicit, non-declarative memory stores perceptual (objects, sounds, smells etc.) and procedural information (conditioning and motor skill learning). Retrieving implicit memory in the project context relates to work experience and how-to skills from professionals. This kind of memory is difficult to define, because it is usually not episodic or semantic, but any kind of auto-motor activity is always combined with explicit memory. When we learn to drive a car, we form both kinds of memory. The explicit memory (episodic), which relates to the details of who, where and when we learned it and the implicit memory (procedural), which relates to the skill how-to drive the car.

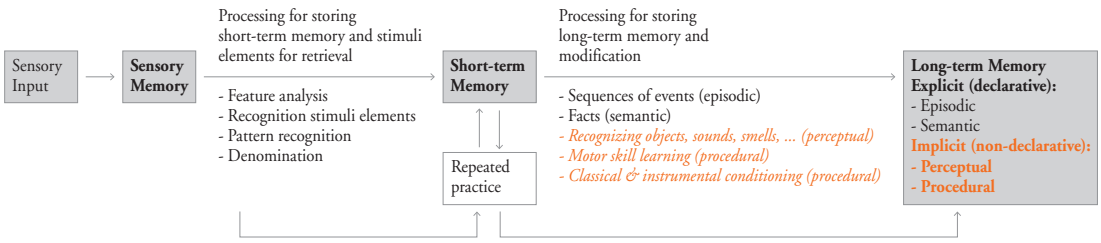


Figure 9: Categories of memory, based on (Carlson, et al., 2009)

The retrieval memory can be supported by stimuli and events. Retrieval cues are contextual variables such as objects or sound. The reconstruction of memory is a creative process and retrieval cues can have a different meaning at the time of memory than at the time of coding and then loose their

effectiveness. So-called schemata provide information about a person, place or a thing by a mental framework or level of knowledge. All types of retrieval activate the long-term memory, the activation of the implicit memory (perceptual and procedural) can be linked to the explicit memory.

In sum, understanding knowledge from a psychological perspective means it depends how memory is used, encoded, and what meaning it has. Remembering and recollecting is the act of retrieving the stored information. The retrieval of implicit memories appears to be automatic. Also some explicit memories appear automatic, when the appropriate stimulus occurs, like whispering your own name to yourself. The way we learn to speak and read is a good example of how our long-term memory develops. The rules of how we relate words to each other are not learned explicitly. Speech understanding also requires the knowledge of the context with its relevant reference. In reading (perceptual and procedural), the meaning of words becomes clear by experience (repeated practice) and when words are retrieved, the meaning immediately occurs. In contrast, suppressing the retrieval of well practiced memories is difficult, as they appear automatically (Carlson, et al., 2009). One can think of the challenge to change a certain motor skill such as changing from gear shift to automatic gear shift. The reading of images, text or numbers also depends on the ability to decode the meaning. The process of cognition and learning goes hand in hand with the process of coding.

Contemporary research adds that our implicit memory is formed by implicit learning. So-called unconscious learning can be observed, for example, in the control of complex systems (Koch, 2017), such as the control of production processes or the organisation of work processes. Here, the procedural elements are hidden in the underlying mechanisms and the solution to a corresponding task is often not clear or unknown. The inability of knowledge holders to explain activities is therefore rooted in this, and solving problems by acquired skills in complex situations could no longer be put into words (Berry & Broadbent, 1984).

The fact that knowledge is based on memory building reveals the challenges in the project, as employees need to learn to see what they know in order to unlearn it and start approaching new routines. The timely aspect is important at the beginning of manual development but also when the production routines are analysed. For example, when production workers go about their work, they unconsciously put routines in place, but also processes where they first have to think about what to do if it can't be done automatically.

The challenge in the project team lies in the procedural knowledge (Kaiser, et al., 2018) and taking on the work analysis, therefore, is to consciously control (Houdé, 2019) and break down the procedural long-term memory (Carlson, et al., 2009) of the production employees but also of the employees who already work automatically with the software and to enable control via active testing (Revans, 2014) by the learning manuals. Analysing and reflecting requires time due to the complexity (Koch, 2017) and patience on the project management. If all participants are aware of the different levels of their work, they will be able to reflect upon it as metacognition (Kaiser, et al., 2018) in addition to execution (Revans, 2014).

2.2.4. Knowledge Management in Organisations

On the organisational level, scholars differentiate between individual and collective knowledge (Lam, 2000; Bratianu, 2015). Powerfully perceived individual knowledge can be verbalised and it is a conscious as well as declarable knowledge in contrast to the embodied knowledge, which is invisible holding internalised skills (Kaiser, et al., 2018; Gourlay, 2002). Collective, explicit knowledge, also called encoded knowledge, exists in companies in the form of regulations or corporate language. It can be represented in organisational structures, in management principles or strategic concepts, often it is documented. Collective, implicit knowledge (Baumard, 1999), also known as embedded knowledge is the unspoken routine, there are non-documented mental models shared by all members of the organisation (Nonaka, 1991, 1994; Lam, 2000; Nonaka, et al., 2006; Nonaka & von Krogh, 2009). Everyday life is structured by these routines and thus valuable knowledge takes root in the company (Hlatshwayo, 2019). Organisations today try to tap this knowledge through digital hubs (Maravilhas & Martins, 2019) and channel it to secure it for themselves, but with varying degrees of success (Sousa, et al., 2013). In social media channels tacit knowledge can be made accessible through the way it is shared (Panahi, et al., 2016), but companies do not share their detailed know-how through these channels, especially not highly specialised technology businesses.

Ontological dimension			
Epistemological dimension		**individual**	**collective**
	explicit	Embrained knowledge *Conscious, expressed skills and competencies*	Encoded knowledge *Rules, procedures, regulations, crystallised knowledge*
	tacit	Embodied knowledge *Internalised knowledge, auto-motor skills*	Embedded knowledge *Routines, culture, mental models of procedures*

Table 4: Based on Cognitive Level: Knowledge Types (Lam, 2000, p. 491 ff), italic text added as explanation

The SECI-spiral of knowledge dimensions, introduced by Ikujiro Nonaka in 1995, explains how tacit knowledge can turn into explicit knowledge and how the knowledge creations develops dynamically inside organisations (Figure 10). Nonaka defines four knowledge dimensions: **s**ocialisation, **e**xternalisation, **c**ombination, and **i**nternalisation forming the acronym *SECI* (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006). Subsequently, the model of knowledge creation consists of three elements: the transformation of tacit knowledge into explicit knowledge through knowledge acquisition via the SECI-spiral, the BA, as a common context or place for knowledge creation, and the resources and intermediaries of the knowledge (Nonaka & Konno, 1998; Nonaka, et al., 2000).

SECI–Fist dimensions: Tacit to Tacit (**socialisation**): The focus is on interaction as a social act. It is a silent, non-verbal transfer of knowledge. This can take place through direct contact with others or through experience with others, e.g., in a brainstorming session. As a rule, this knowledge, since it has no form, is acquired through experience and co-working. A good example of the socialisation of knowledge is the traditional way of teaching a handicraft.

SECI–Second dimension: Tacit to Explicit (**externalisation**): If you share implicit knowledge within a new product development and make it available to the team, it becomes externalised and loses its invisible character. Any kind of visual method can support the transformation into the explicit state where it is "crystallised to explicit concepts" (Nonaka & Takeuchi, 1995, p. 85), shared with others, and forms anew.

SECI–Third dimension: Explicit to Explicit (**combination**): The conscious combination and organisation of already declared knowledge promotes the acquisition of knowledge by accumulation of knowledge, data networks, etc. Prototypes can help to implement new knowledge. This usually happens within social groups or organisations.

SECI–Fourth dimension: Explicit to Tacit (**internalisation**): The inversion from an recognised combined knowledge back to tacit knowledge is also seen as an ability to reflect on interrelationships. The recognition of patterns is often the result of reflection, and then forms a value for an organisation or the individual. Nonaka places the four fields in a dynamic process of the "Spiral of Organizational Knowledge Formation" (Nonaka, 1994, p. 20) symbolising the interrelated and constructive formation of knowledge in organisations.

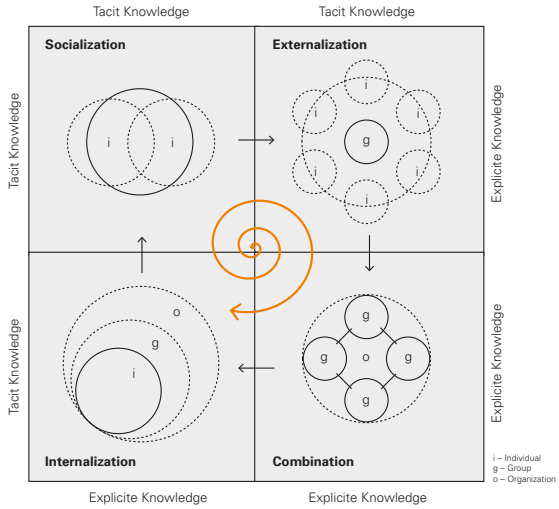


Figure 10: SECI-spiral (Nonaka & Takeuchi, 1995)

The SECI approach looks closely at the change of knowledge moving from one dimension to another; there is always a conversion from one state to the other. To convert from tacit into tacit, tacit into explicit, explicit into explicit, and explicit into tacit one needs to handle information in a tangible way in order to convert it (Figure 10). Nonaka emphasizes metaphor and sharing as a method to convert the status of information to another level. "As a method of perception, metaphor depends on imagination and intuitive learning through symbols, rather than on the analysis or synthesis of common attributes shared by associated things." (Nonaka, 1994, p. 21)

Besides the resources and intermediaries of knowledge, Nonaka also places emphasis on the issues of power relation, and introduces the concept of *BA* managing the "knowledge creation" (Nonaka & Konno, 1998, p. 40). The BA-concept refers to four spaces (=BA) within the SECI knowledge spiral where knowledge transformation is harnessed to create a competitive advantage (Nomura, 2002). Nonaka understands space as a mental space for sharing experiences, a virtual space for digital exchange, and/or physical space such as offices or production spaces. He emphasises the difference between the activity itself and the creation of knowledge through the interaction in the shared *BA*. In relation to the four dimensions of the spiral this means (Nonaka & Konno, 1998):

Sozialisation – Originating BA: *The place where individuals exchange feelings, experiences or emotions.*

Externalisation – Interacting BA: *Through dialogue, mental models and abilities transform to concepts.*

Combination – Cyber BA: *The mental models are reflected and adapted in a* virtual *space.*

Internalisation – Exercising BA: *The place where new knowledge transforms back to individuals.*

Industrial knowledge management and organisational learning is widely seen as the basis for developing competitive advantage and dynamic organisational learning (Bratianu, 2015). Nonaka's approach has found great appreciation in the field of organisational management and his model represents a stable structure, but also contains gaps, especially in terms of cultural aspects, since Nonaka is from Japan. The application of his approach has been criticised as it is not easily applicable in the Western way of thinking (Gueldenberg & Helting, 2007; Hong, 2011). Also, little emphasis was placed on examining the dynamics of such a transformation and the equal inclusion of explicit knowledge (Yao, et al., 2012). The practical gaps in the application of the model in everyday life are discussed, but are also put in a new light by the emerging efforts to digitize work processes.

Due to the digitisation efforts in industry, scholars are engaged in fundamental discussions about the differentiation between information and knowledge management (Webster, 2006; Clarke, 2010; Bratianu, 2015; Hlatshwayo, 2019). Through the realisation that information, in the form of digital documents and their collection on central drives, neither represents nor enables knowledge development or learning (Sousa, et al., 2013; Newell, 2015); the use of new systems requires new skills, and this is where the overlap of the various activities and knowledge levels becomes complex (Alavi & Leidner, 2001). Due to digitisation and with the internet as an information resource, the differences between information and knowledge management stay blurry. To adequately promote the advancement of knowledge development in the organisation and in individual learning (Payne & Fryer, 2020), know-how and practical intelligence become more important than ever for companies.

With regard to the practical processes and interfaces within product development, different types of knowledge were discussed by Wong and Radcliffe against the background of project-related work in smaller companies (Wong & Radcliffe, 2000). They searched for tactics for knowledge retention of mental processes and used, among others, Venselaar's categories of knowledge (Venselaar, et al., 1980) for classification. In discussing the results, they assumed the understanding of explicit knowledge to work with unknowns and to manage knowledge retention through minimisation, sharing, and automation (Table 5). Sanchez & Mahoney focus on how product components are coupled, creating a desired flexibility by standardising the coupling itself (Sanchez & Mahoney, 1996). They argue that elasticity in product development, particularly through modular product systems and associated product design, helps to make information and knowledge management easier and more flexible through the interfaces that are created (Sanchez & Mahoney, 1996).

KN-Type	Domain-specific basic knowledge	Domain-specific design-knowledge	General process knowledge
Declarative knowledge	Knowledge of facts and formulas	Knowledge of design and methods	Knowledge of methods to optimise the process
Procedural knowledge	How to use these facts and formulas	How to use these design facts and methods	How to use general optimisation methods
Situational knowledge	When and where to use this basic knowledge	When and where to use this design knowledge	When and where to use this process knowledge
Strategic knowledge	Knowledge of algorithms and heuristics of relevant domains	Knowledge of heuristics in solving design problems	Knowledge of algorithms and heuristics in problem soliving

Table 5: Categorisation of knowledge by (Venselaar, et al., 1980) applied in (Wong & Radcliffe, 2000, p. 499)

This early approach of integrating the operational aspects and practical experience into the early development phase, supports the further development of knowledge and a more knowledge-based production model (Johannessen, et al., 2001; Spronken-Smith, et al., 2015). The focus on organisational learning and the existence of a learning loop between continuous improvement and production was perceived as a key moment in innovation management. Design Thinking as an approach to innovation initiatives (Kelley & Littman, 2006) by its practical iterative as well as human-centred focus (Uebernickel, et al., 2015) especially revolutionised numerous areas in industry and still fosters innovation (Uebernickel & Brenner, 2016; Elsbach & Stigliani, 2018). Making use of visual prototyping in makerspaces and *Fablabs* also shows that direct testing supports faster cognition and fosters solutions (Maravilhas & Martins, 2019).

The digital factory model takes this knowledge-based approach further and includes the production system during the product development process in order to be able to identify potential for improvement by simulating the production process. Here, it is clear that an immense body of knowledge is already being incorporated into the digital environment, but the researchers also emphasised that there is a lack of exchange among the process actors (Marwa, et al., 2017). In addition, recent research shows that companies face numerous challenges in digitising their operations and they usually do not achieve more growth but increased efficiency. This is attributed to the identification of valuable skills and data created by digital technologies being translated into practical insights into the business (Björkdahl, 2020). In contrast, Holford examines the issues of AI development in highly technical and other professional domains supressing mètis as a unique way for human beings to solve complex issues in dynamic and unexpected emergencies.

This specific set of knowledge is found in professionals such as pilots or engineers, who apply situational spontaneous and informed problem solving. Intentional ambiguity as a reaction to emergencies or unexpected crisis uses “obscure knowledge” (Holford, 2020, p. 260) to solve challenges appearing in a situation, which do not indicate direct patterns of action. These situtations, as Holford defines, are taking place in moments of transformation where no measurements or digital intelligent interactions introducing artificial intelligence (AI) would help. This specific knowledge is involved in the ambiguous elements of the situation and envolves the internalisation of formalised abstract (technical processes) and situational (collective experience) knowledge, social practice in communication and repetitive individual practice of technical knowledge (Holford, 2020).

In sum up, the SECI-spiral as an approach to organisational learning (Nonaka & Takeuchi, 1995) (Nonaka, et al., 2006) enables the sharing of experience within the organisation of the project dealing with declarative, situational, procedural and strategic knowledge (Wong & Radcliffe, 2000). The study examines how employees share their experiential knowledge to support the transformation of work processes into the digital environment for process support and organisational development (Marwa, et al., 2017).

In the project are two levels that are addressed in the literature: the sharing of the workers’ tacit knowledge, but also the understanding of the partly automatic operation of the new digital environment by the Key User. The knowledge available in the company is particularly embedded in the work processes, it is transferred to the digital environment and secured (Marwa, et al., 2017).

Documenting the software operation forms the basis for the development of a new knowledge base in the use of the digital environment from the perspective of production, development and project management (Björkdahl, 2020). The situational, procedural and strategic knowledge should transform into declarative knowledge and into metacognition, in order to be able to work with it considering the multiple levels in the given technically specialised industrial environment (Olaniran, 2017; Holford, 2020).

2.2.5. Impediments in Sharing Knowledge

Intention, autonomy and fluctuation are introduced by Nonaka & Takeuchi (Nonaka & Takeuchi, 1995) and others (Nonaka, et al., 2006; Nonaka & von Krogh, 2009) to put emphasis on the knowledge creation process and what kind of involvement is needed, that knowledge subjects can develop. They also underline that the company's knowledge capital can only be developed and secured by the individual and its will to share tacit knowledge to become explicit within the network of the company (Young, 2012). Scholars emphasise the problems of sharing tacit knowledge (Marwa, et al., 2017) and critique Nonaka's methods to point towards the Japanese culture where people develop a lifetime relationship to the company they work in (Gueldenberg & Helting, 2007; Hong, 2011). The bonding between the company and the individual therefore can be much stronger than in environments where people move from one employer to another at shorter intervals, such as in Western organisations. Therefore we face various factors on the individual and on the organisational level, which impede the development of an active and open learning culture.

On the individual level as well as in teams, scholars define impediments of sharing tacit knowledge, such as (1) to express what is obviously self-evident or natural is considered unnatural and not self-evident, (2) the transmission is also made more difficult by linguistic, temporal, topographic and valuing factors as well as (3) a lack of confidence in the environment, fear, confusion and other negative emotions (Harvey & Butcher, 1998; Choudrie & Selamat, 2006). The problems of sharing knowledge, especially in geographically distributed project teams (GDPT), can be found on various levels (Olaniran, 2017). The issues on the personal level among others are demotivation, fear of losing face and credibility if the shared knowledge is not accepted, or the fear of losing the knowledge-based internal competitive advantage through sharing. Problems for the project team level, amongst others, are language problems due to time difference, competition between individuals of the associated organisation ends, or national cultural differences, as well as insufficient informal collaboration or even a lack of process for coordination.

At the organisational level, for example, dominant barriers include a fundamental "lack of mutual trust between units, a lack of shared vision, concerns about the acceptability of shared knowledge, a fundamental lack of support from the business organisation, and a lack of a sense of security issues" (Olaniran, 2017, p. 50). Views of what motivates organisations to collaborate with other organisations focus on calculative and trust-based considerations. When the two aspects are

considered through unique learning-related roles of boundary spanners at the firm and operational levels, both aspects can be reconciled (Janowicz-Panjaitan & Noorderhaven, 2009), but the level of meta-knowledge of managers on their firms' capabilities seems generally still imperfect (Foss & Jensen, 2019) and difficult to approach.

To enrich information systems via a learning-based approach, scholars claim "meta-abilities" (Choudrie & Selamat, 2006, p. 3) such as cognitive skills, self-knowledge, emotional resilience, and personal drive as an option to overcome barriers on the personal level. They define three influencing clusters as crucial to shaping the development of meta-abilities: the understanding of roles in the organisation, internal strengths, formal and informal discussions, and rational discourse (Harvey & Butcher, 1998; Choudrie & Selamat, 2006; Selamat & Choudrie, 2007). These meta-abilities should focus on competencies which are (1) more generic than organisation-specific, (2) not specified or behaviours which need to be measurable and (3) enhancing self-knowledge.

Meta-Abilities	**Description**
Cognitive Skills	Includes the ability to notice and interpret what is happening in interpersonal situations; to entertain multiple perspectives and integrate them; to envision strategic futures; and to sort and analyse data. These skills allow organisational members to "read situations, understand, and resolve problems."
Self-knowledge	Seeing oneself through another's eyes, knowing one's own motivations, and values and distinguishing one's own needs from those of others. These skills allow organisational members to consider a range of options in their own behavior and to make better judgments of what to do. They allow other skills and knowledge to be used more flexibly.
Emotional Resilience	Includes self-control and discipline; the ability to use emotion, the will to cope with pressure and adversity; and balance feelings about oneself. These skills allow organisational members the personal robustness to direct their energies, deal with intense situations and manage challenges healthily.
Personal Drive	This involves self-motivation and determination, a willingness to take responsibility and risks. This helps organisational members to persist, motivate others and meet targets.

Table 6: Meta-abilities, based on (Butcher, et al., 1997) (Choudrie & Selamat, 2006, p. 3)

Easing the development of curiosity, influencing ability, and attitudes toward constant active exchange of tacit knowledge, sharing activities have been triggered in social media initiatives (Panahi, et al., 2016) or by *broker* activities in open innovation projects, who facilitated face-to-face interaction (Terhorst, et al., 2018) also calling project managers to take on this broker-role in such environments. What organisations can still do to empower employees in knowledge sharing was further explored by Weightman (2019). She identifies five areas of how behavioural, procedural, and technological changes can be initiated (Weightman, 2019):

People: support to enable. Connected employees working together, share knowledge by default.

Processes: avoid radical changing processes. Help employees methodically address existing behaviors.

Technology: create a virtual setting. Cross barriers, help the knowledge flow and train them.

Content: find ways to write processes once and use them many times over.

Governance: establish policies and responsibilities.

The challenges of overcoming the barriers in the project on the personal and the organisational level are well represented by the research. There is a high level of interest in supporting the development of meta-abilities (Selamat & Choudrie, 2007) and developing meta-knowledge within the organisation and the organisational units (Young, 2012). Through the guided and learning-based approach, the background issues such as inability in expression or fears about incorrect assessment of one's own knowledge should be resolved (Weightman, 2019).

2.3. Technical and Visual Communication

The manuals to be developed are based on the specifications of technical user manuals and therefore focus on technical communication as a starting point. However, a mere description of the operation of the new system is not sufficient to reflect the various roles and the aspect of transformative quality of the project in the corporate context. Therefore, the influence of corporate communication and the design practice of the design expert as a developer of corporate design programs and its manual practice are also taken into account.

2.3.1. Technical Communication

Technical manuals are used wherever, for example, the operation of a machine or software is explained following a certain content structure. The information is prepared in such a way that it helps the reader to learn an operating concept. Standards are technical documents designed to be used as a rule, definition or instruction using a technical language (Blake & Bly, 1993). Standards are created by bringing together all interested parties such as developers, consumers and regulators of a particular material, product, process or service. Depending on their detailed content and reach, in the technical area, terms such as owner's manual, release note, instruction manual or reference card are used. The terms refer to a technical system especially from the field of human-machine-interaction and software usage. The first technical instructions had been found along the *antikythera mechanism*, an ancient hand-powered Greek analogue computer, which has been dated back to the first century BC (Efstathiou & Efstathiou, 2018). The mechanical-technical guides use a plain language, can become complex due to the related system, are published as printed user guides or in some cases digital support systems, and refer to user-centered design aiming towards efficiency.

Technical communication very much evolved from the necessity, that information became more and more important to be organised and made usable around the 80s alongside the rise of the world wide web. Terms such as, *human-machine-interface*, *interface design*, *information design* and more contemporary *user experience design* derived from the *new digital*. In line with the development of the professions of *interface designer* or *user experience designer*, the job descriptions *content developer* or *technical writer* emerged and today there is the term technical communication, due to the reach also linking to knowledge management as well as education and facilitation as *instructional design* (Coppola, 2011; Watson, et al., 2016). Gerald Alred analysed in an extensive annotated bibliography, all literature, which are essential for the field of technical communication (Alred,

2003). He has analysed approximately 600 titles from 1980 until 2001 and is referencing 115 titles in his final list based on a special coding system. He refers to the literature as of "essential literacy" (Alred, 2003, p. 585) which has influenced the development of the body of knowledge of technical communication including categories from *Landmark Anthologies*, *Philosophy, History and Ethics*, to *Writing and Editing*, *Documentation and Usability*, *Visual and Graphic Design* and *Publication and Information Management*. He refers to Richard Saul Wurman and his reflections on *Information ancienty2* (Wurman, 2001), to Jan White's manual for *Graphic design for the electronic age* (White, 1988) or Donald Norman's *The design of everyday things* (Norman, 2002), as well as the groundbreaking contribution of former VP of Apple Research, Jakob Nielsen's *Designing Web Usability (Nielsen, 2000)*. The selection outlines not only the body of knowledge of technical communication, it also illustrates how the perception of data, information and knowledge evolved up to then (Alred, 2003).

The Technical Communication Body of Knowledge is based on a broad and very interdisciplinary source, including usability, knowledge management, content modeling and user experience (Baehr, 2013). For developing content, Baehr proposes, that the structure and content of a knowledge base should evolve gradually and be put into context with existing practices (Baehr, 2013). The verifiability of the developed taxonomy is another factor that makes the knowledge base relevant for searchers in an online repository. Therefore, the preferences of the users are important and taxonomy in connection with folksonomy support the development of a content strategy sustainbly. The authors approach mirrors the state of the art in how information should be organized within digital information systems and recommends certain strategies and speak of taxonomies, e.g. the value of taxonomy of visuals in science communication (Desnoyers, 2011). In technical communication, the development of taxonomy is one aspects, giving structure to content, complemented by influences from folksonomy, where users feed content and bring a human-centered perspective to this information management approach.

Technical Communication is strongly involved in the development of user manuals for the handling of machinery or utility goods as well as the processing and presentation of digitally managed content, the user interface and UX design. Principles and rules of UX design can be accessed by numerous sources usually designed as guidelines as well, such as the 101 UX Principles, by Will Grant (2018), which likes to enable everyone to become a UX designer, displaying and explaining 101 hands-on

tips and tricks (Grant, 2018). A more critical stance is Johnsons' contribution (2014), pointing out, that it is important to understand the principles behind human-computer interaction (HCI) by setting a focus on a detailed analysis of existing design guidelines from former authors such as Ceriton in 1976, Norman in 1983 or Nielson & Molich in 1990. He compares two lists of best-known user-interface design guidelines from Shneiderman & Plainsant in 2009 and Nielson & Molich recognizing, that there are reasoned overlaps in fundamental aspects for instance "consistency, task flows to yield closure, error prevention, information feedback [or] considering aspects on attention gaps [and] hand-eys coordination" (Johnson, 2014, p. XV). The user interface design guidelines base on interaction science (Ware, 2020) among others also Gestalt theory (Metzger, 2008; Heimann & Schütz, 2017).

Scholars also point out, that by developing user manuals and instructions, the citation and the extraction of knowledge is made possible (Hughes, 2002). But the use of documents and the focus on technology does not touch the depths of the knowledge embedded in organizations, as by promoting individually expressed knowledge to become available to organizational groups. In addition, technical writers develop content which enables reverse engineering processes as well as by developing other artefacts such as templates and information management systems serve for building organizational knowledge (Wick, 2000). Today, Big Data and smart grids (Frith, 2017), as well as artificial intelligence (Graham & Hopkins, 2021), are shaping the work in technical communication. In addition, the classic task of writing user manuals by a technical writer has greatly evolved (Brumberger & Lauer, 2015). Brumberger and Lauer analyzed about 55 job postings that were placed on a technical communication platform. The job titles they used varied from Content Administrator to Documentation Specialist, Social Media Consultant, Technical and Medical Editor, UI Designer, UX Manager, and Web Content Strategist. They grouped the numerous profiles into clusters in terms of competencies and tasks: Content Developer, Proposal Writer, Medical Writer, Social Media Writer and Technical Writer. They examined differences in terms of industry distribution, professional degree level, skills and attributes in demand, software used, and compensation. In the study, it became clear that the career field of technical communication had expanded greatly from an industry perspective, and the breadth of skills also suggests future growth. The evaluation showed that text-based communication in writing and editing is still one of the most important competencies in all five clusters mentioned. Project planning and visual communication in particular have become more important in all five clusters, as has the need for video instruction to

support written content. The will to learn new things and to take an interest in topics outside the profession is also emphasized for the Medical and Technical Writer. The use of supporting software in all clusters at the time of the survey is still MS Office with an average of 45%. The use of Adobe programs such as Photoshop, Illustrator, InDesign or Dreamweaver is only noticeable in Content Developer and Proposal Writer with an average of approx. 12%. All other clusters are inconspicuous in this respect. The use of Content Management Systems and Web Programming dominates the Content Developer cluster with an average of approx. 37%, compared to an average of approx. 15% for the Social Media Writers (Brumberger & Lauer, 2015).

Recent studies also show that working with participatory approaches (Moore & Elliott, 2016) enables visualization of tacit knowledge and design thinking in the field of technical and professional communication broadens the options and applications fostering solutions (Dura, et al., 2019). Despite all these changes, it is clear that technical and professional communication uses words and language as a central tool in its work to give meaning to content and, in context, to guide, motivate and inform the reader (Maylath & Amant, 2019).

In sum, technical communication is the central activity field in which I have to describe the various processes and procedures in the project. The activity concerns the central task field of instructive writing and presentation (Brumberger & Lauer, 2015). Newer presentation methods are not used as the company's security regulations do not allow well-installed video instructions. The writing and structure of the manuals is based on the DIN specifications for quality management and instruction manuals (Reimann, 2016). However, the project manager requested only a rough approximation and wanted to avoid a too tight structure as he saw the focus on the didactic character as well as the quality of the presentation (Hughes, 2002).

2.3.2. Visual Communication

Trained graphic designers or visual communication designers were responsible for the development of brands, corporate images and especially corporate design systems for the professional environment (Olins, 2010; Wheeler, 2017). The skills of the communication designer include the ability to visualize messages and convey meaning through imagination (Heimann & Schütz, 2017). In science communication the declared potential of graphic design is discussed in synergy with rhethoric contributing to knowledge design (Gwilt, et al., 2020; Susanka & Kramer, 2021).

The visual message has a long history, starting with human history, today visual communication is perceived as fundamentally creative process that combines the visual arts and technology to communicate ideas and convey intellectual connections and language visually through text, image and color (Meggs, 2016). Professional fields in visual communication can include font design, illustration, photography, advertising, branding, exhibition design, print media design, electronic and interactice media such as websites, mobile apps and all have been areas of application for the visual and media designer as well as user interface designer (Bergerhausen & Poarangan, 2011).

In the 1990s, people emphasized the distinction between graphic design and visual communication, focusing on whether a graphic designer creates the visualization or whether the designer can control the communication using the visual tools (Aicher, 1994). It was in this debate that the first influences of information design came into play as a control instinct within the sender-receiver model (Eisenberg, et al., 2010). It is the representation of the invisible and "subjects that do not have objects as models that are particularly reliant on visual translation for understanding. This visualization condenses or expands the message" (Stankowski, 1994, p. 36). In particular, abstract concepts of time, order, sensory processes such as reading, movement, invisible matter such as electricity, energy, or cognition are topics for visualization (Barry, 2004).

Through the influence of the then-emerging digital, a community of critics emerged to address the lack of cultural awareness and active engagement with the basic skills of design, as Stankowski described it. Anchoring skills not only in technological application, but referring primarily to reflection on visual outcomes, is the starting point for criticism and that "designers do not read" (Poynor, 2002, p. 125). After all, text is a part of visual communication because it informs about the content while providing an opportunity for critical reflection. However, given the historical development of the use of design and its commercialization in the 1990s, any kind of criticism seemed unfounded (Poynor, 2002). The designer as author approaches a thing from his or her own source as an originator in the form of text or visual design. Michael Rock speaks of two dimensions of authorship, the artist's book and activist design. While the artist book is completely independent of the outside world in terms of content, self-referential, and non-commercial, it tells a story and represents a core concept of graphic authorship. In contrast, activist design relies on the voices of others, and content is determined by input from outside (Rock, 1996).

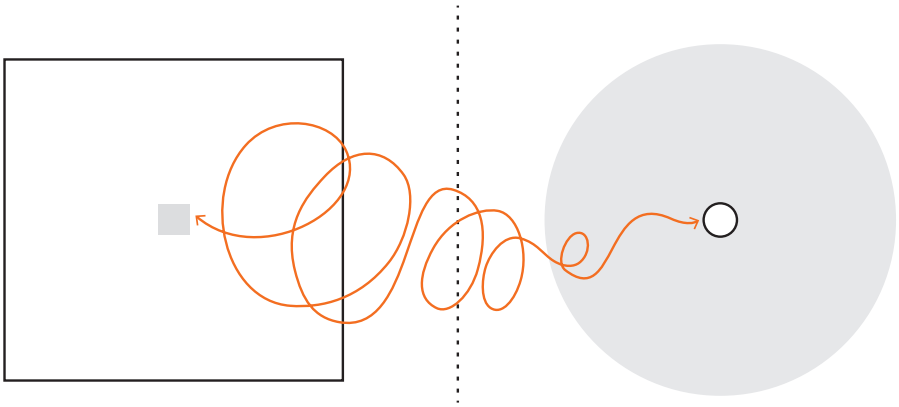


Figure 11: Stankowski, Between materia and energy is communication (Stankowski, 1994, p. 36)

Gestalt constants for visual concepts such as simplicity and yet uniqueness, independence and distinctiveness, concealed yet easy to decode, linking to the familiar, presenting the ordinary in an unusual way, logical and graphic coherence, visual steps in overall and detailed perception, consistent design principles, integration of function and harmony and finally the aesthetic function drive the quality of therein (Stankowski, 1994; Timothy, 2007). Gestalt quality, variables, constants or laws are elementary parts of the body of knowledge in design and are everlastingly valid as they base on psychology and visual perception processes (Heimann & Schütz, 2017). The attitude of Modernism in Visual Communication is a timeless one. As Vignelli stated "It is not a style but a dynamic attitude in continuous flux, with solid foundation based on rational processes" (Müller & Wiedemann, 2015, p. 43).

In my initial role as a design manual writer, as well as my experience in developing and documenting corporate design programs, I work in the tradition of modernity (Müller & Wiedemann, 2015) with the current and appropriate means (Wheeler, 2017). My attitude towards the power of visualization is that of the reading designers (Poynor, 2002) and the activist design concept (Rock, 1996). The work with manuals is a visualisation work, through which given themes and contents is mirrored (Barry, 2004; Heimann & Schütz, 2017). This attitude and skillset accompanies me throughout the entire project.

2.3.3. Corporate Design Manuals

Corporate design manuals are designed for understanding and applying organizational-behavioural and corporate design systems and can be called standards manual, design and brand guideline, design handbook, corporate design guideline, policy or corporate identity guideline. These kind of guidelines give instructions on a business strategy and refer to the field of corporate identity, design and corporate reputation (Roper & Fill, 2012). The first efforts to create a uniform appearance arose during early industrialisation and the demand to appear with a targeted appearance. Peter Behrens dealt with the unification of strategy and presentation in his work for AEG and is known for his structural analyses in architecture and his confrontation with the relationships between the technical and artistic problems of the time (Frank & Lelonek, 2015). Otl Aicher developed corporate design programs and professionalized them with his work for the Munich Olympics in 1972 and the programs for Lufthansa and Erco (Abdullah & Hübner, 2005). Technical communicators also developed knowledge in design guidelines (Bright, 2005) showing the partly soft edge towards the visual communication community. The "design bibles" (Bürdek, 2005, p. 347) of the companies Olivetti and Xerox, united product design with corporate communication (Bürdek, 2015). The awareness of a stringent appearance in the corporate world developed further into the 2000s. Until the effects of digitization corporate design guidelines had been printed with enormous effort. Today, the content of these guidelines is usually published or accessible via online-platforms located on internally managed share points (Schaffrinna, 2021).

The term *corporate design* describes a sub-area of the *corporate identity* and contains the entire, uniform appearance of an organization, hence a corporate design guidline describes the system of the corporate strategy in visual means. The visual concept or a visual design system relates the brand to its applications and the tangibility of a brand becomes real (Olins, 2010). Therefore theses aspects need to be definied first before a visual strategy can be developed and applied. For Regenthal (2009), a holistic corporate identity concept for organizations includes (Regenthal, 2009, p. 30):

> "1. the totality and coordination of all ways of thinking, behaviour, work and communication,
> 2. a homogeneous appearance inside and outside,
> 3. strategic management systems, principles and guidelines,
> 4. strengthening employee identification and motivation,
> 5. actively shaping the organisational culture and working atmosphere,
> 6. an improvement in the quality of work and products,
> 7. to improve customer satisfaction, awareness, profile and images."

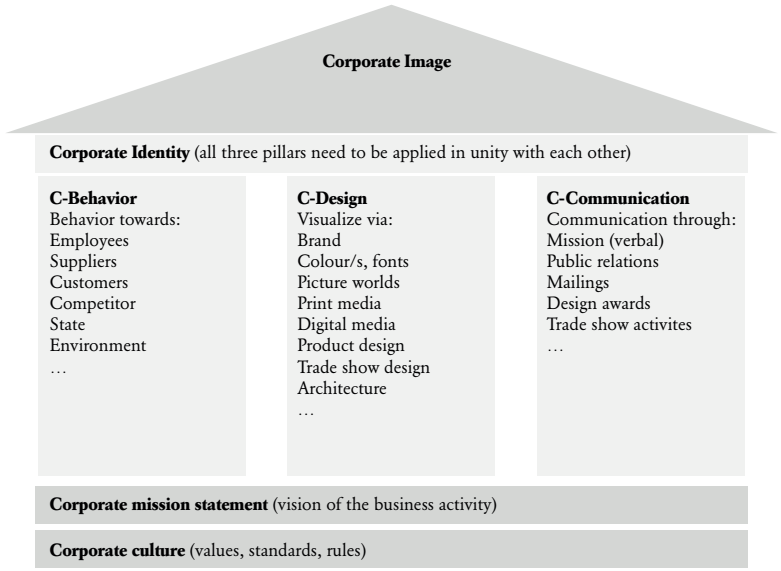


Figure 12: Based on areas of a holistic corporate identity (Regenthal, 2009, p. 31)

Regenthal's identity concept goes beyond a corporate design as it refers to the strategy of a company. Regenthal compreheds the interplay of all *corporate identity* elements in a house-metaphor. The basis of a targeted, professional self-presentation comprises the three areas of *corporate behavior, corporate communication* and *corporate cesign*.

The *corporate behavior* is shaped by the development of the organization and corporate culture. Rules and principles for internal and external cooperation, management style and work processes as well as behaviour are like a codex for the organisation. The strategic concept lays out the core philosophy, principles and mission of the organization.

The *corporate communication* is oriented both internally and externally with the aim of influencing and changing the attitudes of the public and employees towards the organisation/company. The focus here is on image advertising in relation to the organisation with the means of public relations (PR), marketing, employee information and public relations.

The *corporate design* is the defined and formed visual appearance internally and externally by means of the architecture and all forms of presentation (printed matter, exhibitions, trade fairs, product families, etc.). The basis is a design concept. The corporate design elements and measures as a whole convey the impression of a specific style and a uniform appearance.

Design programms base on a defined visual system and rules and how therein elements shall be used are defined in corporate design manuals. This effects the implementation of all activities in media channels, all applications of the brand design, the design of print media, advertising media, packaging, digital and viral media and product design. The aim is to generate one message via all channels. The *corporate image* is the result of the *corporate identity* effects on employees, target groups and the public. Identity has created an external image of the organisation and its control is directed towards the prestige of the organisation, comparability with competitors, imaginability and awareness (Regenthal, 2009).

In identity-oriented communication, the organization is understood as a living being, just like an individual, which also has values, appearance and behavior. Regenthal's model builds on this approach, and the communication theory of identity (Hecht, et al., 2002) uses properties to illustrate that identity is part of communication (Kuiper, 2021). These properties are personal, relational, realized, and communal, whereas, Kiuper adds a physical aspect to these frames of communication. While ambiguity is an important concept in *organisational communication*, in which people can communicate in an unclear way but still achieve their goals, it promotes diversity but preserves privileged positions, statements become deniable and facilitate organizational change (Eisenberg, et al., 2010). From the point of view of the balance between free creativity and constraints, the quality of communication is of central importance. This concept is based on the assumption that the individual is shaped, controlled, ordered, and molded by society, and that communication is a momentary response to balance the tensions between the need to maintain order (constraint) and the need to promote change (creativity). Therefore, to control the effectiveness of guidelines, the content and the requirements for compliance should be kept simultaneously open and closed. Communication should provide the reader with a clear order in practical situations and, on the other hand, allow openness where individual creativity seems appropriate and the different frames and qualities of individual communication become possible.

In summary, corporate design defines a suitable sign system for a company, which can be used to achieve a uniform and positive image of the company in the public (Dietz & Rädeker, 2010). In turn, to build and maintain brand recognition and brand awareness, design manuals are then used to implement the corporate design. They are presented to the company in written form and often offer predefined templates. It summarises all the features of the corporate design and explains the details

on how to use fonts, font sizes, colour palets, tone of voice, slogans, grids and how to set the *look and feel* in layouts (Olins, 2010; Wheeler, 2017). They are also used by media service providers who refer back on the developed corporate design in the following years. This ensures that every channel used can adhere to given rules and that a uniform corporate image is achieved (Birkigt, et al., 2002).

In order to meet the various requirements of the manuals in terms of appearance, but also its attitude to change and communication, the aspects from the corporate design guidelines must be fundamentally taken into account (Dietz & Rädeker, 2010). The visual appearance must therefore be aligned with the existing design guidelines in order to adequately communicate the acceptance of the contents and therefore also of the entire project (Regenthal, 2009). Furthermore, the content that is not related to the use of the system but positions the project, principles and attitudes must be incorporated in a different style (Eisenberg, et al., 2010).

2.4. Services and Value-Co-Creation

Understanding mechanisms in services and value creation in a co-creative setting is crucial for comprehending what is happening in the project. This is in view of the fact that the project plays in front of a contract-based collaboration between a high-tech company and an external design expert. The scope within service literature lies therefore in personal and knowledge-based service against the background of the project partner's experience with consulting firms on the one hand, and the provider performing the technical development of the new system on the other hand.

2.4.1. Services in Industrial Context

Services have a very long history and are usually understood as people-based, accompanied by personal style and expression. The industry in turn, looks at services as a profit-based concept and differentiates between services in which value is created from various forms of exchange based on a *goods-dominant logic* and services in which value develops through co-creational and contextual settings based on a *service-dominant logic* (Vargo & Lusch, 2008; Vargo, et al., 2010). Against the background of digitisation as well as servitisation aspects (Baines & Lightfoot, 2013), technology and human-based services are evolving throughout the value-chain, accompanied by the rising influence of the beneficiary, and become more and more important to industry as the profits are increasingly higher in service business (Barrett, et al., 2015). The two opposite logics are core constructs of the goods- and services-based business and its markets (Lusch & Vargo, 2012) as the creation of value is determined by the surrounding system, its interactional characterisics and its resources in place (Vargo & Lusch, 2008; Vargo, et al., 2010).

Core Constructs	**G-D Logic**	**S-D Logic**
Service	Goods & Services Transaction	Serving & Experiencing Relationship & Collaboration
Value	Value-added Value-in-Exchange Price	Value Co-creation Value-in-Context Value Proposing
System	Supply Chain Asymmetric Information	Value-creation Network Symmetric Information Flows
Interaction	Promotion/Propaganda Maximizing Behavior	Open Source Communication Learning via Exchange
Resources	Operand Resources Resource Acquisition	Operant Resources Resourcing

Table 7: Contrasting G-D Logic and S-D Logic Concepts (Vargo, et al., 2010, p. 144)

The conceptual framework of service-dominant logic is based on ten foundational premises (Vargo & Lusch, 2008), collectively condensed into four axioms (Vargo & Lusch, 2014, p. 240):

> **"FP1/axiom 1**: Service is the fundamental basis of exchange – The application of operant resources (knowledge and skills), 'service,' is the basis for all exchange. Service is exchanged for service.
> **FP6/axiom 2**: The customer is always a cocreator of value – Implies value creation is interactional.
> **FP9/axiom 3**: All economic and social actors are resource integrators – Implies the context of value creation is networks of networks (resource integrators).
> **FP10/axiom 4**: Value is always uniquely and phenomenologicaly determined by the beneficiary – Value is idiosyncratic, experiential, contextual, and meaning-laden".

The framework enables all types of organisations to develop value creation (Greer, et al., 2016) and build up in service economy. Contemporary services are very technology orientened and digitally led, especially within the Information Management field, with approaches such as ITIL (Information Technology Infrastructure Library) also oriented towards knowledge management (Sousa, et al., 2013). The context for services is determined by the way people and technology are integrated (Table 8). The relations of provider, beneficiary, technology, and the number of channels involved relate to specific concerns and methods for developing the service business (Glushko, 2010).

Design Contexts	Concepts and Concerns	Methods
1. Person-to-person	Empowerment, touch points, line of visibility	Ethnography, blueprinting, personas
2. Technology enhanced p2p	Personalization	Customer modelling and segmentation, CRM
3. Self-service	Ergonomics, usability	Iterative prototyping, heuristic evaluation, customer analytics
4. Multi-channel	Complementarity, reciprocity, integration	Process modelling
5. Multiple platforms and devices	Consistency, scaleability	Capability modeling, model-based intefaces, graceful degradation
6. Back stage, computational	Information and process standards, choreography	Use cases, data and document modeling, service oriented architecture, design patterns
7. Location-based and context-aware	Sensor technology	Managing identify and privacy

Table 8: The Seven Design Contexts: Concepts, Concerns and Methods (Glushko, 2010, p. 234)

The role of complexity, of dynamics, of modularity and of the system's integration, of openness as well as the structure of organisations are influencing the progress of service development (Chesbrough & Davies, 2010). Complexity is especially challenging when services are completely intangible and tacit knowledge through codes and roles are dominant, especially on the background

of standardisation or customisation. The dynamics in service are determined by life cycles and whether it is system integration or system sales. In this respect, the modularity leads towards the capability of the supplier's system integration. The role of openness with respect to the system enabling, for example, accessible purchasing, and a required receptiveness to other members of the ecosystem. Finally these roles are reflected in the way an organisation is structured and how it deals with the customer and the back-end of the transactional structure (Chesbrough & Davies, 2010).

The project study takes place in an industrial context using the new software as well as processes and people (employees and design expert) as resources for the transformation. All areas are fundamentally integrating knowledge and skills, are interactional, network related and contextual (Vargo & Lusch, 2014). The person-to-person services as well as the service offered by the software developer, represented in the field of back-stage and computational software achitecture (Glushko, 2010), depend on the dynamics and the modularity of the system integration (Chesbrough & Davies, 2010). The project is affected by the activities in the software programming and its customisation efforts. However, the added value from a manual development perspective lies in co-creation (Vargo & Lusch, 2014) and empowering team members who need to make decisions relating to the software and the manual content.

2.4.2. Facilitation and Co-Creation for Change

As the project study is placed inside a large scale transformation project in the organisation, the success of the project not only depends on the implementation of the software but on the interaction of the involved employees supported by an external facilitator. The dedicated design expert plays the role of an external facilitator to help the team achieve its goals and has the qualities of a change agent, even if not officially designated as such. Change agents have been characterised by Rogers (Rogers, 2003) as introducing a new product or new practices, being an enabler, a networker, understanding structures, and especially taking on different roles on the fly such as supporting by facilitation (Tann, 2021). In addition Gönroos distinguishes: "(1) service as an activity; (2) service as of the customer's activity and value creation; and (3) service as of the activities from the provider (business logic)" (Grönroos, 2008, p. 300). The increasing importance of interaction with the customer, contrasting the service-dominant logic with the customer-oriented logic does not declare service to be a one-way delivery but emphasises the co-creative aspect between organisation and agent (Heinonen, et al., 2010). The perspective of organisations in the context of transformation is characterised by the

numerous problems arising in a transformation process, as well as the often low implementability of the advisory work (Kotter, 2007; Stouten, et al., 2018; Errida & Lotfi, 2021). However, a distinction must be made between measures that change a company from a business management and controlling perspective and those that focus on projects and topics such as innovation or digitization initiatives for long-term transformation. An early approach to advisory practice was given by Turner (1982) introducing eight purposes and hierachised them, with 1-5 being the traditional purposes and 6-8 being additional goals and in many cases a result of the prior (Figure 13). Traditional goals are faster to implement and practice but companies learn and improve slowly (Turner, 1982).

Additional goals	8. Permanently improving organisational effectiveness.
	7. Facilitating client learning – how to resolve similar issues in the future.
	6. Building a consensus and commitment around corrective action.
Traditional purposes	5. Solving a client's problems.
	4. Assisting with implementation of recommended solutions.
	3. Making recommendations based on the diagnosis.
	2. Making a diagnosis, which may necessitate redefinition of the problem.
	1. Providing Information/advice to client, defining the problem

Figure 13: Based on hierarchy of consulting purposes by Turner (1982)

Kotter's 8-step model to transform an organisation thus focuses on a process rather than a short-term event by creating a hands-on approach to avoid typical pitfalls (Kotter, 2007, p. 4):

> "1. Establish a sense of urgency
> 2. Forming a powerful coalition
> 3. Creating a vision
> 4. Communicating the vision
> 5. Empowering others to Act on the vision
> 6. Planning for and creating short-term wins
> 7. Consolidating improvements and producing still more change
> 8. Institutionalising new approaches."

Contemporary measures in the context of organisational transformation are moving away from strongly established management models and use agile methods to bring about change (Calnan & Rozen, 2019). However, the goal is similar: the organisation is learning to help itself based on long-term measures so that the change can become sustainably established in the company. Researchers emphasise the importance of reflection and failure as an opportunity, as behaviour change only occurs when people work on themselves in the long-term, reflect on their own actions, and admit

mistakes (Argyris, 1991; Dawson, 2005). Value-creating approaches, such as agile methods, team building and lean management are increasingly dominating industrial workflows and transformation today (Calnan & Rozen, 2019; Tann, 2021). Knowledge-based collaboration, and the interactive and reflective relationship between client and facilitator enables knowledge communication and discovery (Tann, 2021). The role of the facilitator is strongly characterised by different qualities. On the one hand, the cognitive and knowledge-laden aspect contributes to being able to perceive the dynamic challenges in complex corporate contexts through involvement and competence (Freytag & Storvang, 2016). On the other hand, the facilitator needs good communication skills, empathy and patience to be able to mediate as a boundary-spanner between the worlds or different areas (Guven-Uslu, et al., 2020; Tann, 2021). He needs to be flexible, courageous, strategic, creative to actively contribute his skills, to perceive and implement opportunities and finally he needs to motivate, inspire and optimistically encourage all people involved (Fuda & Badham, 2011; Tann, 2021).

The value of a well-implemented facilitation has two faces – the financial and the social aspect. Business studies analyses value building at its heart, and for customers the pricing models are usually hard to follow. The discours on value and value creation is a myths for outsiders and some models can only be justified by legal and political practices or of governmental services, transportation, energy, health care or education (Spohrer & Maglio, 2010). Positive or negative events, success or failure shape the perception of advisors and their competence in financial appreciation. Spohrer & Maglio introduce the term value in connection with symbol and call "service system entities […] physical symbol systems" (Spohrer & Maglio, 2010, p. 159) but also emphasize on the process of appraisal, as not all services can be measured by price-ratios. The difficulty of measuring elements such as intimacy, trust, openness and presence in relational services and facilitation makes a definition of defined systems difficult, as the value comes from at the moment of performance.

When learning focuses on adapting and the change of human actions, value creation is based on a long-term interplay between the actors involved, specially in knowledge-intensive disputes (Muller & Zenker, 2001; Aarikka-Stenroos & Jaakkola, 2012). In addition, unforeseen dynamics must be dealt with and unpredictability is one of the most challenging factors that people dislike to deal with (Chesbrough & Davies, 2010) especially in front of a large number of actors who can have a decisive influence on the process (Gummesson, et al., 2019). Particularly in collaboration between individuals, the value develops beyond simply producing a service. The process, especially a long-

term collaboration becomes a personal story (Cipolla & Manzini, 2009) and in the context of long-termness and involvement, the expectations of predictability change.

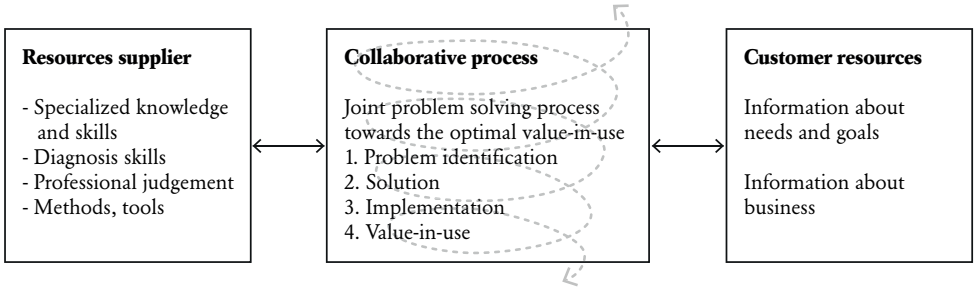


Figure 14: Tentative framework for value co-creation (Aarikka-Stenroos & Jaakkola, 2012, p. 17)

Aarikka-Stenroos & Jaakkola provide a conceptual framework in which intensive facilitation and knowledge-based co-creation enable joint value creation through a dyadic problem-solving process. Central activities such as needs assessment, designing and producing solutions, organising the process and resources, managing conflicts of values, and implementing the solution are the starting point for a repetitive process (Aarikka-Stenroos & Jaakkola, 2012).

The external design expert is confronted with a high level of complexity and tacit knowledge (Gummesson, et al., 2019). The organisation expects the design expert to support the team and to deliver manuals, both outlined as assignments with clear targets (Tann, 2021). The relationship between expert and company is characterised by clear goals and it is clear from the beginning that these goals can only be achieved through co-creative cooperation (Freytag & Storvang, 2016; Guven-Uslu, et al., 2020) and also as a facilitator and a boundary spanner between the team members. The process of joint problem-solving in the long-term collaborative process creates the value-in-context (Aarikka-Stenroos & Jaakkola, 2012), as the manuals creation supports the learning of the new system.

2.4.3. Resources for Value Co-Creation

Due to the co-creative and iterative value creation approach, the methods applied by the design expert must fit in. Design methods have become part of innovation and transformation projects, since the strategic quality of Design Thinking (Kelley & Littman, 2006; Brown, 2019) by its practical and iterative character has leveled the application in the field of innovation management (Knight, et al., 2020) and business transformation (Rill, 2016; Brown, 2019). Through the rise of

the Service Design discipline in the early 2000s and the associated focus on customer experience and human-focused aspects in the context of transformation, it became an ambassador for the *human* perspectives in product and service development. As supporting tools in Service Design, the use of visual mapping such as the customer journey, stakeholder ecosystems, or blueprinting in particular, visualise the various dimensions of complexity and the co-creative dependencies between the various system partners (Stickdorn & Schneider, 2011-2013). In line with the rise of Design Thinking, Service Design Thinking evolved and became relevant for change processes and transformation, as it works on the strategic level connecting the business propositions and not only on how they are delivered, but how the are perceived and emotionally experienced (Polaine, et al., 2013).

The way designers work are in one aspect similar to facilitators, as they co-create value together with the client but communication is made to be understood by design methods and is often non-verbal (Brown, 2019). The illustrative and visual quality of Service Design Thinking tools and the way in which business and process analysis is done, enhances the communication quality and becomes a resource for facilitation. There is an increasing demand for interdisciplinary competences and tools that enable communication and handling of the complexity in professional everyday life. It is reflected in the growing interest in visual tools and in the changing profiles of facilitation professionals (Spohrer & Maglio, 2010; Stickdorn & Schneider, 2011-2013).

The involvement of design in a co-creative interaction, in which designer and client work together, benefits from both activities, inputs, and exchange. Steen builds an argument on Dewey's approach of the "regulated reflected inquiry" (Dewey, 1925, p. 4) by comparing practices, experiences and knowledge of communication, cooperation and change (Steen, 2013). Whereas the acting part within facilitation is the beginning for the reflection process, which is by nature very communicative. It adds to the discourse on the knowledge management literature as practices are the expressive and informative part of knowledge, especially tacit knowledge, and communication begins where people start to exchange information and co-create meaning by socialisation (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006). Design methods support communication and triggers co-creative processes by visualising the invisible through the use of text, drawings, 3-dimensional objects or physical interaction. The imagination is a result of both parties and supports the discourse (Steen, 2013).

The collaborative problem-solving process rely on humans as a resource and on the matter which is used for their communication. Facilitators use a whiteboard, flipcharts or cards for facilitation and these material-based resources become part of the value-in-use. The discovery of design methods and tools in the facilitation of transformation (Rill, 2016; Brown, 2019) such as prototyping, storytelling or life drawing and other visualisation techniques in knowledge management (Wood, et al., 2009; Wang & Jacobson, 2011) relates to the ability of design making invisible things like ideas or processes visible and can, for example, also reflect cultural aspects in a fascinating way. These visible *things* can help to clarify a situation and ease common understanding of a matter, as long as they address the relevant topics which are considered important for the participants to clarify.

Star introduces the scaling and the scope of *boundary objects*, which arise through necessity in the context of the actors (Star, 2010). Scale deals with the boundary object on the organisational level and the *ambiguity* of *things*. Especially the word *finding* of one or less terms can be a long-winded process among experts. The boundary object is a sociological concept placed to describe the different uses of information by diverse groups in an infrastructure. They are plastic, interpreted differently, but contain enough invariable content to maintain a common identity. The term contains the words *border* and *object*. Both need each other, because an object can only become an object if it has a boundary within which its meaning has its own dynamics. Star & Grieshamer are about defining the dynamics of the concept of boundary object in one of their first examinations in 1989. The object is located between social worlds within which there are different perspectives about a *thing*. The boundary object arises in the overlapping area of these perspectives (Star & Griesemer, 1989). This process requires an infrastructure and its characteristics are defined by Star & Ruhleder: "Embeddedness – Transparency – Reach or scope – Learned as part of membership – Links with conventions of practice – Embodiment of standards – Built on an installed base – Becomes visible upon breakdown – Is fixed in modular increments, not all at once or globally" (Star, 2010, p. 611). The concept of a boundary object serves for the course of argument in the project, as especially visual objects such as drawings, notes or the manual fragments, can be used by different employees to clarify their own and the common understanding of the visualised content. In addition to boundary objects as "knowledge boundaries" (Carlile, 2002, p. 442) in product development, they have been analysed to understand the obstacles for finding new knowledge and novel concepts (Carlile, 2002). Designed representations may turn into "epistemic objects" (Ewenstein & Whyte, 2009, p. 7) enabling reflective externalisation of tacit knowledge and can be one approach to the problem

(Ewenstein & Whyte, 2009) and in this way, knowledge can unfold. The communicative character of visual representations, as in Ewenstein & Whyte, establishes epistemic objects as artifacts of knowing (Ewenstein & Whyte, 2009). It is not the design knowledge of the practitioner as described by Nigel Cross (Cross, 2001), which visualises the capabilities of design in an equally tacit way by sketching or experimenting (Mareis, 2012). It is about the ability of design to visualise a thing, which is then perceived in a certain context for clarification. The context consists of different perspectives of the boundaries, and the design becomes an object of consideration and reconciliation.

To support the process of collaborative problem solving and the concept of co-creation, design methods and tools are used by the design expert (Steen, 2013). On the other hand, the development of the manuals is a part of the reflective practice and the manuals become the boundary object (Carlile, 2002; Star, 2010) and serve to find clarity and externalise tacit knowledge (Ewenstein & Whyte, 2009).

2.5. Summary and Research Gap

The literature shows that there are different categories of knowledge (Lam, 2000), information (Johannessen, et al., 2001) and data (Bratianu, 2015). One significant difference is between the knowledge that individuals deal with on a daily basis, such as reading a chapter in a book is looking at explicit knowledge and tacit knowledge such as using a car in an auto-motor behavior (Gourlay, 2002). Many activities happen unreflected (Polanyi, 1966) and are intangible such as knowledge about ourselves, our bodies, our roles, our language, playing an instrument, everything that is done unconsciously as embodied knowledge or even complex multi-layered knowledge which reveals in challenging situations (Holford, 2020). A recent study shows, how the use of social media allows people to access tacit individual knowledge and to make it available to others (Panahi, et al., 2016).

On an organisational level it is challenging to manage tacit knowledge, especially the process-related working knowledge of long-term employees (Baumard, 1999; Gourlay, 2002) or embedded procedures in teams. Organisations carry explicit knowledge in written regulations and at the same time live tacit knowledge as routines in non-verbalised rules (Sousa, et al., 2013). While individual tacit knowledge is associated with the departure of an employee from a company, socially-organised knowledge remains in groups as embedded knowledge (Nonaka & Konno, 1998). In organisational knowledge management, embodied and embedded knowledge can be transferred into the company through socialisation and externalisation for organisational learning (Nonaka & Takeuchi, 1995; Nonaka & Teece, 2001; Nonaka, et al., 2006; Nonaka & von Krogh, 2009).

Against the background that the implicit knowledge of experienced employees is an object of individual memory formation (Carlson, et al., 2009; Houdé, 2019), there are obstacles to the exchange of knowledge in organisational learning for various reasons (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007; Tsoukas, 2009; Weightman, 2019). Attempts to capture it in documents or information management systems present knowledge as one kind of externalised knowledge (Hlatshwayo, 2019). In times of change through digital transformation, the question arises to what extent knowledge can be traced back to the basic elements of work as building activities (Weightman, 2019). The challenge of reorganising work processes and routines is the complex combination of situational, procedural and strategic knowledge of individuals (Holford, 2020) and their strategies to generate solutions (Olaniran, 2017). It is an interplay between the organisational and the individual barriers to achieve clarity in process analysis (Buunk, et al., 2019).

The review also explores different approaches to technical, visual and organisational communication and how they contribute to the project. Technical communication offers a repertoire of theoretical and practical approaches in information management, building structures to describe routines and how to operate within processes (Alred, 2003; Coppola, 2011; Watson, et al., 2016; Maylath & Amant, 2019). By developing taxonomies of information and defining clusters of activites, as well as writing instructions, often, tacit knowledge and habits become apparent (Wick, 2000; Wahl, 2003). Technical communication developed awareness of visual design related to style guides (Bright, 2005), although the main focus remains in organising, defining, creating, and delivering information for the safe, efficient, and effective use of technical systems, software or services, mostly by the written word (Baehr, 2013; Brumberger & Lauer, 2015). In contrast, corporate design guidelines more often are developed from visual designers focusing on brand communication (Olins, 1989, 2010; Regenthal, 2009). One quality of visual communication is to visualise requiring knowledge about the psychology of perception (Metzger, 2008) and how design works (Barry, 2004; Heimann & Schütz, 2017), to present content according to the target groups (Wheeler, 2017). Visual design can even offer a substantial contribution in science communication and deepen understanding of a matter (Gwilt, et al., 2020; Susanka & Kramer, 2021). Organisational communication balances between specification and creativity to promote change (Eisenberg, et al., 2010) and can thus support the project from another perspective.

In innovation management, facilitators use the potential of visualisation and design thinking to help organisations see more clearly where there are possibilities for new pathways (Martin, 2009; Täuscher & Abdelkafi, 2017; Elsbach & Stigliani, 2018; Brown, 2019). Additionally in change management the challenges lie in the settlement of new and lasting routines (Turner, 1982) and to be aware of the pitfalls along the transformation process (Kotter, 2007; Errida & Lotfi, 2021). The concept of co-design (Steen, 2013) and co-creative facilitation enables employees to become part of the solutions (Aarikka-Stenroos & Jaakkola, 2012) whereby agents for transformation deeply foster trust and relationship (Freytag & Storvang, 2016; Tann, 2021). It involves a team's interaction, exchange (Nonaka & Konno, 1998; Nomura, 2002) and representations for collaboration (Whyte, et al., 2008). Since representing different perspectives emerge at the boundaries of the individual perception (Carlile, 2002) (Star, 2010), the boundary objects support the collaborative process and can create "artifacts of knowing" (Ewenstein & Whyte, 2007, p. 81; Ewenstein & Whyte, 2009).

2.5.1. Research Gap

The research gap is found in parts in the areas of Knowledge Management, in the overlapping area of Technical and Visual Communication, and in the area of Facilitation and Co-Creation. In their combination, all areas hold an unequally original possibility of finding new knowledge through utilising the manuals as boundary objects and as resources for value co-creation within the process of manual development against the background of the digitisation initiative and the associated knowledge management within the industrial environment.

Knowledge Management

The knowledge management literature (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006; Nonaka & von Krogh, 2009; Bratianu, 2015) shows a long history of approaches to organisational learning. The concept of metaphor (Nonaka & Teece, 2001) or conversation has been investigated for knowledge sharing and transformation (Tsoukas, 2009). In an organisational context this can be important, especially in the context of introducing an information management system, as the hurdles are usually on the individual level (Weightman, 2019). There is a constant search for optimisation and this with the inclusion of digitisation, however, ambiguous and complex knowledge (mètis) cannot be easily mapped and if AI can take over in simple processes, it cannot do so for mètis (Holford, 2020). It would be interesting to re-examine the concept of the BA, in terms of place (Nonaka & Konno, 1998; Buunk, et al., 2019), in whatever medial form, digital or otherwise, and whether there is room for long-term investigation into levels of knowledge coupled with implementation into everyday industrial work.

Literature uses links to cognitive literature and the methodical approach of meta-concepts is seen more frequently by applying methods from learning psychology (Revans, 2014; Kaiser, et al., 2018) in the context of Knowledge Management (Wang & Jacobson, 2011). Design methods are more often used in strategic management (Knight, et al., 2020) and co-creation in the field of innovation management (Rill, 2016) with relation to knowledge management (Szkupinski-Quiroga, 2015). There is a gap in finding more tools and approaches to understand, analyse and fragmentise complex and multi-level knowledge (Holford, 2020). Especially in front of an organisational transformation it seems important to convey an attitude that can be voiced through a holistic corporate design (Regenthal, 2009) and organisational communication (Eisenberg, et al., 2010) approach.

Technical and Visual Communication

Both fields, technical communication (Wick, 2000; Brumberger & Lauer, 2015) and visual communication (Regenthal, 2009; Roper & Fill, 2012; Wheeler, 2017) claim a deep understanding of how to apply their techniques in industry. Technical communication has developed awareness of visual design related to style guides (Bright, 2005), although the main focus remains in delivering information solutions for the safe and effective use of technical systems, mostly by the written word (Baehr, 2013; Brumberger & Lauer, 2015). Both fields are by their history two self-understood fields of work that show overlaps but do not find each other. It would be an interesting attempt to combine these two approaches, complement the structure of documents used in the context of technology and in the context of brand and corporate communication (Eisenberg, et al., 2010) under certain conditions. Technical manuals are often direct, linear and straightforward. Corporate Design manuals are an extract of organisational visual culture and values. To visualise the externalisation of embodied and embedded knowledge by the means of a manual-creation process is not clearly evident in literature but can contribute to knowledge design (Susanka & Kramer, 2021).

Facilitation by Design Practice

In change management (Tann, 2021) and especially in the area of facilitation, we find numerous design methods today and through the tools that are made available to us via the design thinking wave, this will continue to prove and develop (Elsbach & Stigliani, 2018). When design meets technology, these two mindsets are difficult to unite and especially if one would try to place visual communication in the context of a highly specialized and above all product-oriented (goods-logic) technology company. This might work for a short time, but the daily business pulls the professional back into his habits. But when the designer mentality meets the engineer mentality, this unequal relationship also holds just as many opportunities. Since it is a clearly defined environment but an unclear project, the boundary object offers itself to jointly address the ill-structuredness (Star, 2010) in digitisation projects. The challenge of a co-creative manual development (Aarikka-Stenroos & Jaakkola, 2012) in the context of an Industry 4.0 project (Björkdahl, 2020) within a highly technical company and team partners with highly complex structured knowledge (Holford, 2020), has not yet been investigated in the literature in this combination.

Field	Existing Theory and Findings	Gap
Knowledge Management (and Learning)	The field builds up by a differentiation between ontological and epistemological dimension of knowledge within individual and collective organisational types of knowledge (Lam, 2000). The knowledge management circle illustrates four dimensions of organizational knowledge as socialisation–externalisation–combination–internalisation in the SECI-model (Nonaka & Takeuchi, 1995). Nonaka et al., claim that tacit knowledge can be transformed into explicit knowledge by metaphor and analogy (Nonaka, et al., 2006; Tsoukas, 2009).	Investigation of transformation to find further means than metaphor or analogy.
	The impediments in sharing tacit knowledge can be overcome by meta-abilites (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007; Tsoukas, 2009) and it is important to look at the power relation for managing the process of knowledge creation by using the concept of "BA" (Nonaka & Konno, 1998; Nomura, 2002).	Further means to ease the impediments and power relation issues.
	Within the process of learning, there is a state of *knowing* between individual and task (Reason & Bradbury, 2008) and the distinction between declarative knowledge and practically doing by metacognition (Kaiser, et al., 2018).	Support for *states of knowing* & the creation of meta-cognition.
	Active learning triggers knowledge, skills and attitudes (Revans, 2014). The complexity of mètis (abstract, situational, social practice and repetitive and procedural) knowledge cannot be replaced by AI (Holford, 2020).	Active Testing new sequences and manuals may detect mètis.
Technical & Visual Communi-cation	Citations of knowledge through the development of instruction manuals can transform information to knowledge creation (Hughes, 2002). The reverse engineering approach through *artefacts* enables knowledge management in technical communication (Wick, 2000). Visual corporate and brand communication convince by a holistic appraoch (Regenthal, 2009; Wheeler, 2017). Manuals visualise knowledge in clarified concepts and present it useably for application by other people (Hunter & Elliott-Kingston, 2016). Knowledge design and visual rhetoric in science communication (Susanka & Kramer, 2021).	Instruction manuals miss strategic quality by a holistic approach coming from design as contribution to knowledge design.
	Organisational corporate communication must strike a balance between creativity and constraints in messages of internal communications (Eisenberg, et al., 2010).	Applying this approach to instructions.
Facilitation & Co-creation	The change agent as facilitator offering skills, realises options and support with courage (Tann, 2021). Dynamicaly changing setting calls for different facilitator roles (Freytag & Storvang, 2016)	The design expert is becoming a facilitator.
	The problem-solving framework is a joint value creation through dyadic, iterative actions (Aarikka-Stenroos & Jaakkola, 2012).	Problem-solving by manual development.
	Practices, experiences, communication, cooperation and change result in imagination of the discourse of both parties (Steen, 2013). Invisisble things become visible for perception and support the understanding of a common matter by a boundary object (Star, 2010) and visual objects for knowledge boundaries in product development cross the knowledge-boundaries (Carlile, 2002). Designed representations may turn into epistemic objects enabling reflexive externalisation as artifacts of knowing (Ewenstein & Whyte, 2009).	The practice may uncover new tools for facilitation and manual fragments become a boundary object.

Table 9: Key Literature and Research Gap

3. Research Objectives

In line with my proposition in chapter 1.3.1. (Propositions), the following chapter focuses on the definition of the research objectives in conjunction with the gaps in the literature in chapter 2.5.1 (Research Gap). In order to arrive at new knowledge in the study in a structured way and based on the research question, three objectives and specific sub-questions were developed, which subsequently structure the Action Research in chapter 6. (Action Research).

3.1. Research Question and Objectives

The close connection between design practice and knowledge management, technical and visual communication as well as the focused facilitation of employees, requires a functional and holistic view on the interplay of all participants. The objective of the research thus relates to developing and working with manuals as a visual and tactial medium in an engineering context. It is about the role that the manual author (design expert) can play and to what extent the interaction and the formulation of project related knowledge and principles benefit from design practice. Concluding on these aspects, the following main research question with its sub-questions arises:

Main research question: **How does manual design practice act for facilitation in organisational transformation within digitisation initiatives in highly specialised technology ventures?**

Sub-question 1: **How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?**

Sub-question 2: **What does a design expert need to understand about the working environment in order to systematise and simplify complexity?**

Sub-question 3: **How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?**

3.1.1. First Objective

Scholars have examined how visual communication is used to enable cognition (Susanka & Kramer, 2021) and support reflection (Ewenstein & Whyte, 2009). The concept of metaphor (Nonaka & Teece, 2001) or conversation has been investigated in the literature for knowledge transformation (Tsoukas, 2009) within the SECI-cycle dimensions (Nonaka & Takeuchi, 1995). To overcome the barriers of tacit knowledge sharing (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007), more tools and approaches can be investigated in the context of the project where there is various kinds of tacit knowledge (Baumard, 1999) and obstcles to overcome. While in technical organisations the Visual Lean Approach is successfully accepted in R&D departments, the work with a focus on guided visual reflection could contribute to challenges in front of organisational transformation. It also seems important to convey an attitude that can be voiced through a holistic corporate design (Regenthal, 2009) and an organisational communication (Eisenberg, et al., 2010) approach rather singularly throught technical regulations and information managenent. I believe that design expertise is particularly valuable for the technically minded professionals, as little visual communication can prosper in the technical visualisation culture of the organisation in the project. Moreover, the available technically oriented tools do not support fast and uncomplicated visualisation. The ability of designers to visualise and present topics in a comprehensible way is a central quality that is known and brought into projects as expertise. Based on existing research on visualisation in the corporate context, and as a support to make embedded knowledge visible, I assume that this will also be the subject in the project.

My first objective is to understand how visual communication and design practice support individuals within an organisation to (re-)define their experience and knowledge better, as they might not be able to explain it in words that easy nor are used to visual tools. Furthermore, how creating layout templates and explaining their use and application to non-designers support employees in visualising their work. And, how this reflective practice should adds up in an iterative process for further exploration so that employees should be able to redefine and analyse work procedures to gain the opportunity to express themselves.

This objective relates to sub-question 1: **How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?**

3.1.2. Second Objective

Technical communication (Wick, 2000; Brumberger & Lauer, 2015) and visual communication (Regenthal, 2009; Roper & Fill, 2012; Wheeler, 2017) claim a deep understanding of how to apply their techniques in industry. Technical manuals are often direct, linear and straightforward. Corporate design manuals are an extract of corporate visual culture and values in addition to organisational communication (Eisenberg, et al., 2010). It can be an asset to uncover the complexity of the working structures in the project by combining these two approaches and complement the structure of documents used in the context of technology and in the context of visual and corporate communications. The purpose of the manual is to lead employees towards using the new software environment properly. Being able to iteratively visualise the tacit knowledge of the Key User, the retrieval of embedded procedures, might be detected and a restructuring will become possible. In addition, the conscious use of the manual fragments as a boundary object is interesting in this rather unclear project setting with changing challenges. As the fragements become a plastic tool for the conversation (Carlile, 2002; Star, 2010), this approach could establish a unique system building artefacts of the complex knowledge architecture (Ewenstein & Whyte, 2007).

My second objective is to understand how this reflective practice and iterative process can be used for developing a document structure which reflects the complexity of all related work profiles and roles. Moreover, how working iteratively with manual fragments, developing page types, writing styles and introducing corporate and technical communication access the complexity of the various workflows and roles that they become adaptable. In addition, how the use of the comprehensive manual fragments in combination with the iterative process eases the understanding of the complex knowledge architecture to create a system for further exploration the design expert can rely on.

This objective relates to sub-question 2: **What does a design expert need to understand about the working environment in order to systematise and simplify complexity?**

3.1.3. Third Objective

In change management (Tann, 2021) and especially in the area of facilitation, we find numerous design methods today and through the tools that are made available to us via the design thinking wave, this will continue to prove and develop (Elsbach & Stigliani, 2018). In contrast to cases already studied, the current project differs in that the design practice has changed in the course of time from pure design work towards *facilitation by design*, resulting in managing the perception of information and different kinds of knowledge related to lasting change (Kotter, 2007) towards using a new digital system. The design expert not solely delivers documents but facilitates the *externalisation* (Nonaka & Takeuchi, 1995) and takes a role of an empathetic specialist, using various approaches to iteratively support the four dimension of the SECI-spiral. It would be interesting to examine the concept of the BA, in terms of place (Nonaka & Konno, 1998; Buunk, et al., 2019) and what it takes for a long-term investigation into different levels of knowledge. Especially the combination of a co-creative manual development (Aarikka-Stenroos & Jaakkola, 2012) led by a design expert in the context of an Industry 4-0 project (Björkdahl, 2020) and team partners with highly complex structured knowledge (Holford, 2020) is unique. The project at hand offers the opportunity to understand the role of the design expert as change agent (Tann, 2021) and if the established solutions create a lasting system based on scalable priciples.

My third objective is to explore how this system of interaction between the design expert and the employees establish principles that are hidden in the transformational process. And, how regular on-site team participation, negotiation and co-creative problem solving form a foundation for trust and reliability so that almost unsolvable issues could become detachable. Additionally, how the presence of the design expert and fluent support will enable employees to deep dive into their knowledge structures to integrate new pathways and using the new system becomes manageable.

This objective relates to sub-question 3: **How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?**

4. Methodology

In this chapter, I discuss which methodological approaches to design can be regarded as purposeful when design is used as a practical activity in a business and technical context. Through action research I use design as a channel to enable reflection on tacit knowledge and routines in companies. It shows that the development of user guidelines and manuals can serve as a medium for this. I apply the approach of so-called *Research Through Design* (Frayling, 1993/4) and the company where the long-term study took place serves as a case, also because the research methods such as observation, reflective discussion and interviews represent a second level of the generation of information. Thus, the combination of both approaches is the way for my research to accompany the process of knowledge reflection by means of visualisation in documents and technical writing, and on the other hand to learn about the process itself through the voices of people involved.

I analyse how the different types of knowledge are hidden in working routines and how they make knowledge reflectable through design performance as process-accompanying work and the development of several guidelines. For this purpose, the essential basics of design practice for research are presented through a transformational process and Research Through Design can be seen as an independent method in this course. In combination with *Action Research*, this serves as a starting point for the process-accompanying and iterative approach to use design practice in a project as case related context. Its results serve as material resource for analysis and undertanding the objectives.

4.1. Foundations in Design Research

Bruce Archer was one of the first researchers who dealt with the structure of the design process in 1968. Stephen Boyd David analysed Archers' thesis and earlier work, his educational background and the historical context (Davis & Gristwood, 2016). Boyd Davis found that Archers' intention was to understand design in an incredibly profound manner. His educational background was engineering, and this might explain why his analysis and a hypothesis of the design process is very technical, using numerous diagrams and mathematical formulae, trying to define a general structure for a creative process. Boyd Davis illustrated how this approach changed during the years, as Archer had to change his assumption due to his involvement in practical design projects. Another influence on Archers' thesis came from the effect of rising digitisation. These forces changed his assumptions, and it became visible through his drawings and diagrams, where indirectly he compared the real

process and theory through visualisation. On the one hand, his work is a study of a phenomenal process to derive a theory, on the other hand it is an example of research using design practice combined with development work.

In the 1980s, when Nigel Cross explored the field of design research, he came to the conclusion that *designerly ways of knowing* could be considered a design-specific research method. One of his central claims is that designers "solve problems through synthesis" (Cross, 1982, p. 221) versus scientists through analysis (Cross, 1982). He distinguishes designers' approaches from the other research and working cultures of the natural sciences and humanities. Cross argues that the culture of the sciences is based on observing the natural world through controlled experimentation in order to arrive at *truth* through objectivity and neutrality. In the culture of the humanities, the human experience and analogy is at the centre, in order to arrive at subjective *justice* through interpretation and induction. By contrast, in the design of the already man-made world, *adequacy* is to be achieved through modelling and synthesis for practicability (Cross, 1982).

The approach *Research Through Design* derives from one of the different approaches that deal with understanding and differentiating the design process and design research. One of them divides design research into use-oriented design theory with the focus on active design work and scientifically-oriented design theory with a focus on the development of theory-based ideas about design. Current positions see design alongside a practical skill and product-oriented design in the examination of processes, services and systems. This is linked to efforts to position design as a trans-domain and cross-disciplinary faculty (Buchanan, 2008). Therefore, the role of the designer depends on his focus and here, on the degree of involvement with other disciplines, as Sanders (2006) showed in her *Topography of Design Research*. Furthermore, Chow and Jonas show that the derivation in design by projection produces specific concepts rather than general rules (Chow & Jonas, 2008).

The base of many of these approaches is the division of design research into three categories. Frayling defined three categories (derived from Herbert Read) as a suggestion on what designers do and how knowledge may be produced in "Research in Art and Design" (Frayling, 1993/4, p. 5):
Research into art and design is *covering* studies on existing design and art. It can be an academic examination into design and art history, aesthetic or perceptual aspects or into theoretical perspectives of any other profession, e.g., political, ethical or technical towards design.

Research through art and design is *using* design and art methods to find answers to specific questions, e.g., materials research or development work to use something existing for another reason to discuss a statement or it can be action research whereas the process will lead to contextualization. **Research for art and design** is *producing* art and design in a severe, profound and professional manner. The artifact is the result of the thinking, at the same time, one can read from the object because it is communicating in its way. Frayling also refers here to the *cognitive* and *expressive tradition* in art and that there is much potential for research at all – a very practical one but without an individually loaded discourse.

4.1.1. Theory Construction in Design

Galle proposes the definition of a basic theory in design according to three criteria (Galle, 2011). According to the criterion *public acceptability*, design in general usage should correspond to relevant professional, educational and research organisations. Furthermore, according to *suitable coverage* in the sense of clarifying the scope of design and the *exploratory potential* whereby this should define design in the context of other concepts in order to identify possible avenues of research. Engholm discuss a "scientific and meta-theory-oriented" (Engholm, 2017, p. 2) design theory focusing on research and theory-based ideas to instrumental design theory (Engholm, 2017). Jonas describes that only a trans-domain can rise to the challenge of closing the existing gap between research in science and art (Jonas, 2014). He is looking at the different perspectives of science and design and uses the *Transdisciplinary Studies* introduced by Nicolescu (2010) to bridge the differences. He categorises the Mode-2 Science as problem-focused, context-driven and interdisciplinary in comparison to Mode-1 Science, which is academic, investigator-initiated and disciplinary-based knowledge production (Jonas, 2014). The basis of his argument is to understand Research Through Design through all possible perspectives of design practice, scientific research, and transdisciplinarity. Nicolescu's tirade of system knowledge (Nicolescu, 2010; Jonas, 2014) as analysis and target knowledge as projection leads towards transformation knowledge as synthesis of the research process. It supports Jonas' approach of a trans-domain, which can lead to a new understanding of design research and ends the definition of design as a model for a new type of science (Jonas, 2014).

The Mode-2 approach defines design as the primary attitude for design-specific types of knowledge and "abduction" (Jonas, 2014, p. 50) as creation based on the unknown states as the linchpin in transforming the process into something new. The origin of these processes also lies in dealing with

problem-oriented approaches, which generate new knowledge through the search for solutions, and are to be seen as a basic approach for context-dependent design research. Alain Findeli describes design research as a methodical search for and acquisition of knowledge in relation to design and design activity (Findeli, 2001). Buchanan also discusses four orders of design and explains that the design discipline is at the beginning of knowledge and that design can take place without the development of a physical product. The third and fourth orders of design, as Buchanan describes them, deal with processes that are bound up with problems from environments and systems (Buchanan, 2001). This in turn requires methods linked to transformation knowledge (Nicolescu, 2010; Jonas, 2014), and is based on the ethos of science (Mariş, 2014).

The phenomenon Bruce Archer was working on is that the process of creating something new and finding new knowledge through design cannot be hard coded in formulas. Especially in art and design, we can find a large number of such phenomena. These kinds of phenomena often refer to the tacit quality of art and design as well as our perception of it. Ken Friedman focuses on the challenge of theory construction within design research by a rigorous definition of terminology and meaning of design, research, and theory (Friedman, 2003). Similar to Frayling, he is defining research using given definitions followed by the emphasis of *re* in re-search which underlines the central concept of search by also significantly pointing to the nature of design as a practice, wherein one is practically investigating in a thorough search for a solution. Additionally, Friedman uses research categories from medicine and compares clinical, applied, and basic research approaches as a way to structure design research. Basic research "involves a search for general principles [applied research] adapts the findings of basic research to classes of problems [and clinical research] uses the results of basic research and applied research to specific situations" (Friedman, 2003, p. 510). Friedman also notes that most design practice is limited to clinical research, because, similar to practicing doctors, experienced designers develop a need of clarification of characteristics and kind of problems within their work to find alternatives.

The argument from Morgan and Smircich about the contrariness of science-based methods in qualitative research opens the discourse by a comparison of various typologies of thinking in research. An objectivist would see the world as a concrete structure and studies the nature of the structure through lab experiments and surveys (quantitative methods). The deduction and the interpretation based on the expected results of the investigation creates an objectively formed knowledge by exact and measured terms

and facts. For the subjectivist, the world performs as a projection of human imagination. The subjectivist respects the individual perspectives within exploration (qualitative methods), leading to phenomenological insight. They challenge the idea of comparability and measurability of scientific results, assuming that quantitative and qualitative research methods contrast each other (Morgan & Smircich, 1980).

If one now considers the different perspectives in qualitative research and the different approaches to how design research is presented, a wide range of possibilities emerges. It shows that there does not have to be only one type of approach and analysis and that, depending on the design topic, multiple possible methods of analysis and perspectives are suitable. Nevertheless, when we work with people in design research as participants in the study, social science methods are often used, especially if we want to understand the reflective elements in a study. Davis Murray describes how theories and proposition provoke an audience's interest. The sociology of phenomenology is tackling the different reactions of the audience and how one can define a theory which will trigger interest. One major rule of the phenomenology of the interesting is that "what seems to be X is in reality non-X" and "what is accepted as X is actually non-X" (Murray, 1971, p. 313). He lists twelve characteristics of the phenomenon and renders arguments against counter-argument and provides examples as well as explanatory comments. He distinguishes the Sociology of Knowledge from the Sociology of the Interesting. The former is essentially a study of beliefs and assumptions and the second is a study of the breakdown and building up beliefs, and the transformation of assumptions (Murray, 1971).

If theories are developed, a distinction must be made between the Sociology of the Interesting and the Sociology of Knowledge. The question of knowledge production from the point of view of design universities wants to define a role of being a designer. Contemporary studies, however, tend to be set up for a narrow circle of experts and thus limit the scope of their work. To develop practice-oriented research skills in art and design, research (producing knowledge), teaching (disseminating knowledge) and practice (using knowlede) can no longer exist separately (Jonas, 2014). In contrast, Findeli goes further in developing a design research structure. He argues that the designerly way of thinking extends beyond the framework of a pure design project. With the *Bremen model* (Findeli, 2001), he establishes a basic structure that makes it possible to coordinate a general question with the question in design. Thus, if the working method in design contributes to answering questions in a comprehensible and valid way, this in turn also makes it possible to answer questions from the general world in relation to practicability and empathy.

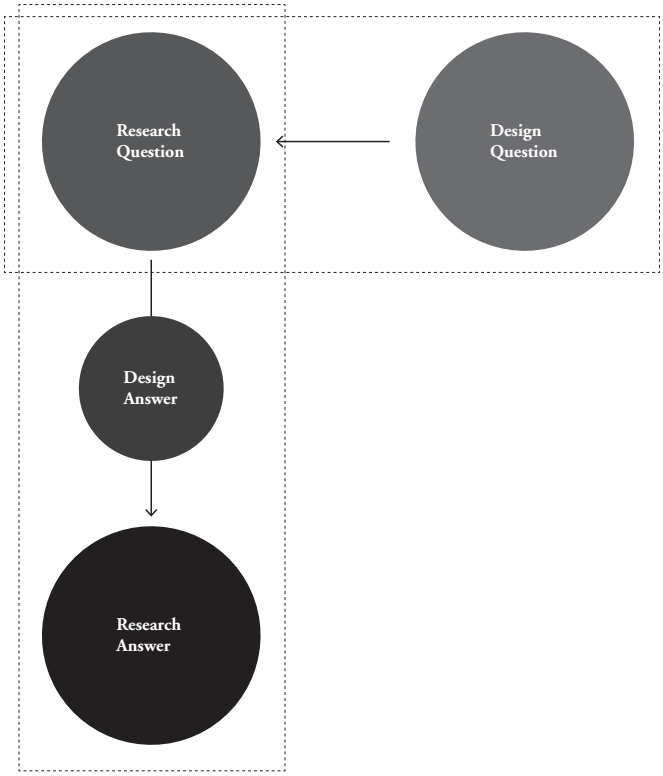


Figure 15: Operational and methodological model of a PhD design research (Findeli, 2012, p. 129)

In design and design research the topic of tacit knowledge has developed into a widely reflected and useful *objective*. Especially when trying to describe practical design skills in general, tacit knowledge seems useful. Mareis emphasises, however, that on closer examination, this knowledge is not only created in a theoretical or practice-oriented design discourse as in the designerly ways of knowing, but also in a social discourse (Mareis, 2012). A reduction of tacit knowledge to a natural and human ability to design would marginalise any historically evolved design practice. Enghölm offers a model representing an inventory of the various disciplinary and scientific contexts that are reflected in the literature on research perspectives of the design discipline (Engholm, 2017). The model concludes on three subject fields of interest in design research comparing Fraylings' categories of design research – such as when design takes place (*research for* and *research through design*), when design is distributed into the markeplace (*research for* and *research into design*) and when design is producing meaning as an object (*research into design*). Engholm divides design and design research into the process of creation, marketing and business positioning, and design as an object in context.

4.2. Research Strategy

This PhD study uses research through design as the project offers me to investigate in my own applied design practice and to observe my work from different perspectives. The use of participatory action research enables me to investigate the project as researcher and structures the investigation by a number of action research cycles. Both approaches help me to find out about how design practice supports the transformation and how the objectives cater to answer of the research question. I use qualitative methods for evaluation, e.g., for statements that result from inteviews and recording. I also focus on indications of recognition, release, and various layers of knowledge from the employees by examining the content of the documents, their structure and their interplay. The action reaseach approach structures my study strategy with the corresponding research questions. The aims, process, and outcome of the project serve as the case (Figure 16). The different categories of outcome support the abductive nature of the research and I use both people's voices and documents as sources.

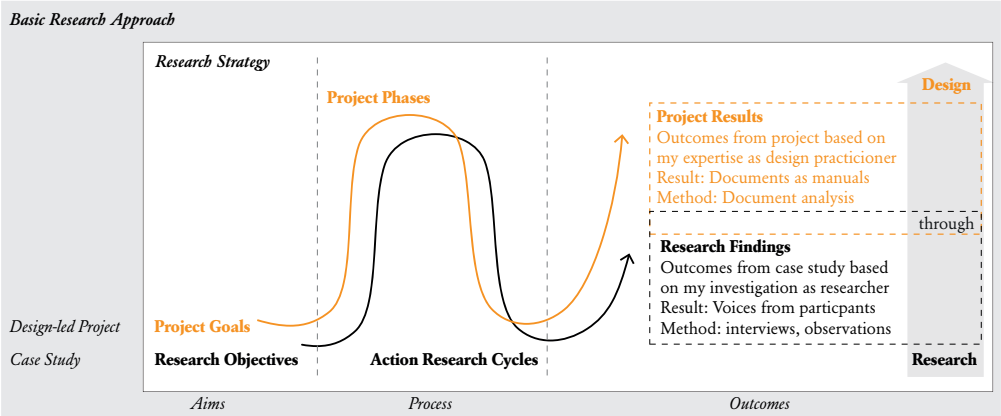


Figure 16: Interplay of research methods and practical approach (own illustration)

Using a case study as a method is particularly suitable for the project, as it offers several advantages for the investigation and its derivation into design practice. The project takes place in reality and I participate in the project at site. It is an unusual project, even atypical because as a design expert I use a design-related document type to meet the challenge of tracing tacit knowledge within the technological surrounding. In addition, propositions about the problems are critically questioned and new insights into the application situation arise, as well as opening up new research possibilities.

Note: Details on the company and the case setting are described in chapter 5 (Project Description).

4.3. Research Methods

Referring to Cross's research framework (1982), the collection of material, its analysis and interpretation is oriented towards the aspect of "practicality [...] and a concern for appropriateness" (Cross, 1982, p. 222). In developing the answer to the research question, I will not follow a deductive conclusion with compelling consequences or an abstracting and inductive statement. Rather, it is an attempt to explain abductively the knowledge that emerges through the research in the given situation in order to formulate appropriate practice that can be useful to design. The way I am collecting insights and outputs is influencing how I interprete and analyse the different outcomes.

4.3.1. Action Research

Based on the nature of the research objectives, Action Research (AR) serves as my approach to iteratively reflect and understand what happens. It allows active collaboration between the researcher and employees of an organisation (Kemmis, et al., 2014). Kurt Lewin's first approach to action research deals with the effects of a transformation, among other things on the basis of repetitive and spiraling activities considering an iterative framework of planning, acting and reflecting (Berg, 2004; Adelman, 1993). The four stages of action research (Kemmis, et al., 2014) are:

Planning Stage: Investigation of the objective, identify the problem, formulate a research question and create a literature review. Followed by the study design, defining the inquiry and material collection methods, organising the ethical requirements and setting up a master plan for the study.

Action Stage: Engagement in multiple cycles of experiments and material collection.

Analysis Stage: Organise the material by using supporting tools and looking for trends. Material needs to be organised, for example, in maps and recordings, before defining the results.

Conclusion Stage: Open a discussion, share results and reflect on practice, leading to new questions.

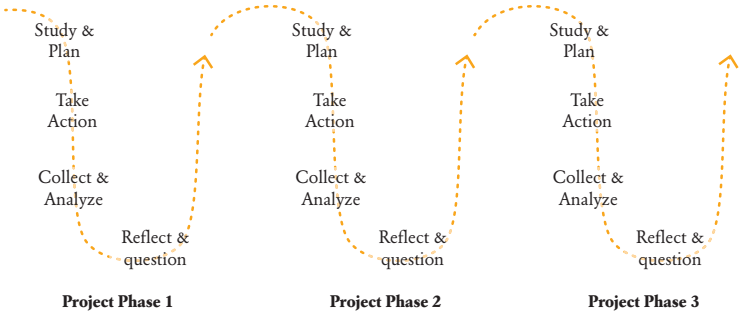


Figure 17: Action research model showing 3 project phases (own illustration)

4.3.1.1. Participatory Action Research

My role in the study is twofold, because I serve as design expert as well as author of the manuals and as researcher at the same time. Since the investigation of reflection and activity takes place in industrial practice, the appropriate kind of Action Research is Participatory Action Research (PAR) as in all phases of the project I play an active role (Burian, et al., 2010). Besides design as supportive element in knowledge externalisation, my roles effect the way I reflect on my own work results and the material collected from the dialogue with the Key Users and the employees. I am able to understand my work as a design practitioner and expert in a project environment beyond the horizon of reflective practice (Riel & Polin, 2004).

The working relationship understands the planning of the research project as the start of the cyclical course of concrete activities, which are jointly observed and evaluated by researcher and participant and finally lead to a follow-up of actions (Kapoor, 2002). Since the different development phases of the software in the company inevitably result in successive delimitable work phases, the work process in the project is thus equally cyclical. On the other hand, this approach is advocated by many, since through its integration and application into everyday life, the method may motivate the transformation of an organisation from the bottom up (Berg, 2004). The integrative nature of action research also supports potential learning on the individual level, as participants take part in defining the objectives for follow up actions. As Action Research enables us to understand insights, PAR in addition "creates conditions for practitioners to participate in and develop the form of action and interaction in which the practice is conducted" (Kemmis, et al., 2014, p. 5). The Participatory Research emerged with the concept of the Action Research participant being critical in his stance towards the research project. As the participants usually show interest in the improvement of some issues, they become critical and selfdirected in their role, still being supervised, but playing a more active and responsive part in the transformation process.

Lewin in 1944-46 once developed a framework primarily for the educational field, to either initiate into immediate problems or research on a reflective progress in solving problems led by individuals working with others in a community of practice, the progressive way formed one characteristic, which suited my research approach. In the 90s Action Research was given a more precise designation towards the role of the participants, and Critical Participant Action Research today has evolved into areas where organisations or groups aim towards learning and improving habits and situations

(Kemmis, et al., 2014). Participatory Action Research and Critical Participant Action Research both involve actively participating in a changed situation, often led by an organisation, which is similar to my case study. PAR also can take place in larger organisations, assisted by researchers or experts, with the aim of improving their strategies, practices and knowledge of the environment in which they work to develop a new course of action. All objectives focus on social action and their change or their transformation for the better by dissolving the barrier between the researcher and the participants.

4.3.2. Analytical Approach and Interpretation

In addition to the four phases of Action Research I am adding the multilevel-interpretation approach by Alvesson and Sköldberg (2018), especially since the material contains meaning in different ways, and I will reflect directly on these areas in multiple stages. The approach aims to structure interpretation and support clarification process in the realm of reflexivity. The level model starts by working with the empirical material, the second level interprets these files and their underlying meanings. The third stage steps ahead with a critical approach to the interpretations, especially to understand roles and their effect on behaviours. Within the last stage, the research's own text elements will be considered as source for interpretation and also to connect to existing theories coming from the related field and its meta theories.

Aspect / Level	**Focus**
Interaction with empirical material	Accounts in interviews, observations of situations and other empirical material
Interpretation	Underlying meaning
Critical interpretation	Ideology, power, social reproduction
Reflection on text production and language use	Own text, claims to authority, selectivity of the voices represented in the text

Table 10: Levels of Interpretation, based on Alvesson and Sköldberg (2018, p. 331)

4.3.2.1. Activity System

Through critical interpretation of the outputs, the distance to my dual role becomes possible and a clearer view of the situation can be developed. As a supportive structure for understanding behavioural aspects, the Activity Theory, first introduced by Lev Vygotsky (Vygotskii, 1978; Hasan & Kazlauskas, 2014) and further elaborated in the collective Activity System by Engeström (Engeström, 1987), makes it possible to examine the activities and practices in a complex project context. The principles of object orientedness, hierarchical structure of human activity, mediation, internalisation and externalisation build the base for development and learning. The use of visual communication or design as mediating artifacts would serve as material for the learner in an anchored instruction, just as a manual or a guideline would do. It is becoming clearer that knowledge mediated by tools and artifacts promotes the inter- and intra-psychological development of the learner as promoted in social constructivism (Vygotskii, 1978).

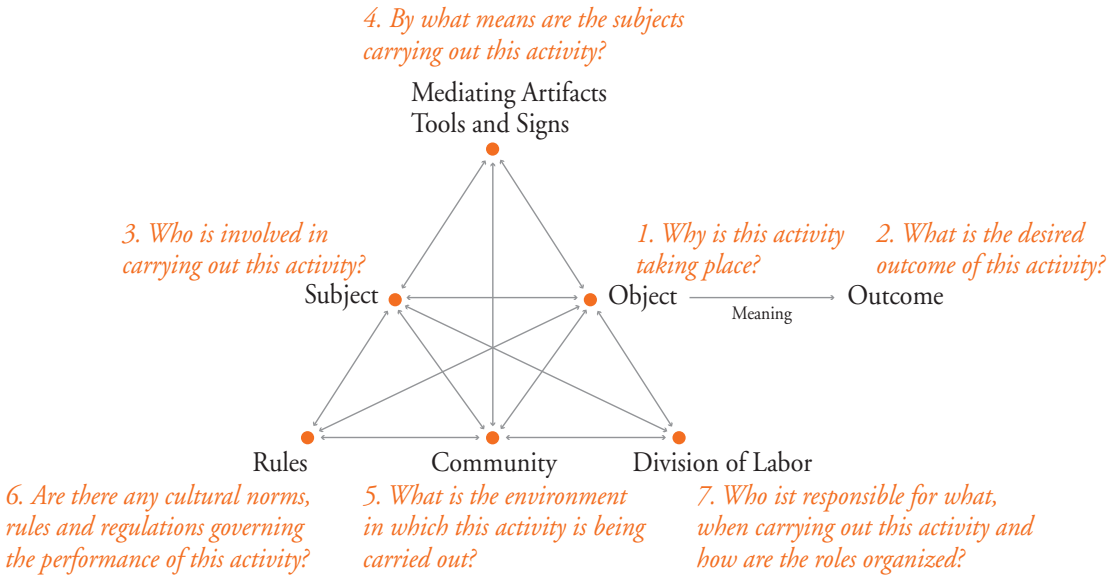


Figure 18: Activity System by Engeström (1987, p. 78)

4.3.2.2. Coding

The pre-defined keycodes for interpretation derive from the various literature areas and are structured hierarchically relative to the analysed material. The goal is to understand the meaning of verbal codes from recordings, interviews and memos as well as visual codes from the manual development in their relation to the transforming context. The codes are then identified by their *category*, *relation*, *origin*, *quality*, or *prevalence* and by their *meaning*. During the coding, further codes appeared and are added to the pre-defined as in-vivo codes in the list indicated.

4.3.2.3. Document Analysis

The quality of the material I have at my disposal is, on the one hand, of an almost quantitative nature as evidence of the work done in the manuals and therefore has a rather static but object like character. The units I work with here are, for example, the number of iterations that were necessary in the development of the manuals. In addition, the content in terms of text types and image types can be measured well, and may provide information about the context of manual use. Due to the diversity of the material at hand, different methods of analysis can be used to study the same process. In order to combine material from interviews and recordings, the document analysis of the manuals complement as physical evidence (Bowen, 2009).

4.4. Methodological Approach

As the project framework within the organisation helps to integrate my work as a researcher, I see not only design practice as a way to answer the question, but also the embedding of design practice applying *transformation(al) knowledge* (Jonas, 2014). The approach forms the practical way in finding answers just in the spirit of Findeli's *Bremen Model* (Findeli, 2001).

The design project work is based on iterative development of user guidelines and manuals using the externalised knowledge of the client. Through my interaction with the client and through the created manuals not only is a final product created, but through the discourse the client is enabled to experience and understand the embedded and embodied knowledge by visual means. My design work in the project and in the corporate context is suitable as a first starting point for a reflection on the design process, taking into account the distinction between practice as a process, the results of practice, and the methods of visual representation of the processes. Over time, it became clear, that precisely this distinction is very important. The outcome of the design process itself, such as how a manual should be designed, did not offer new insights on a scientific level, but the developmental process did support staff by working with the manual iterations in reflecting on their work routines. As a result, design practice served me to understand their processes and to use the results as material to find answers to design challenges. Therefore, I was able to understand how I interrogated the routines and how I use the design process to find the answers at the research questions.

In addition to the structure of Cross's *Three Cultures* in research (Cross, 2001), I would like to point out the particular context in which the project was studied as a research object. The project at the company took a long time, in which I was able to work actively in their organisational culture and an environment characterised by natural sciences. The technological context and the collaborators, who were almost exclusively from engineering and mechanical engineering backgrounds, had little to no access to the way I worked. It was also difficult to understand that I was busy developing the manuals for a long time. Only those who worked directly with me could understand what I did and how I did it. Overall I detected three phases in the project over the time span of approximately three years. Phase 1 was accompanied by many unknowns as the staff and I started the development of the user guidelines, although it turned out later that substantial changes were still necessary in the application. So the first phase mainly involved the development of the visual templates (Visual Lean), which were

not affected by the adjustments, and their explanation to their users as a result. In phase 2 we realised that we had cultivated a way of working together, but the application was changed and updated about halfway through. The guidelines were adapted and in some cases completely redesigned. Phase 3 was given a clear shape by the first two phases, because the way of working together had crystallised and the application now allowed for realistic implementation and documentation.

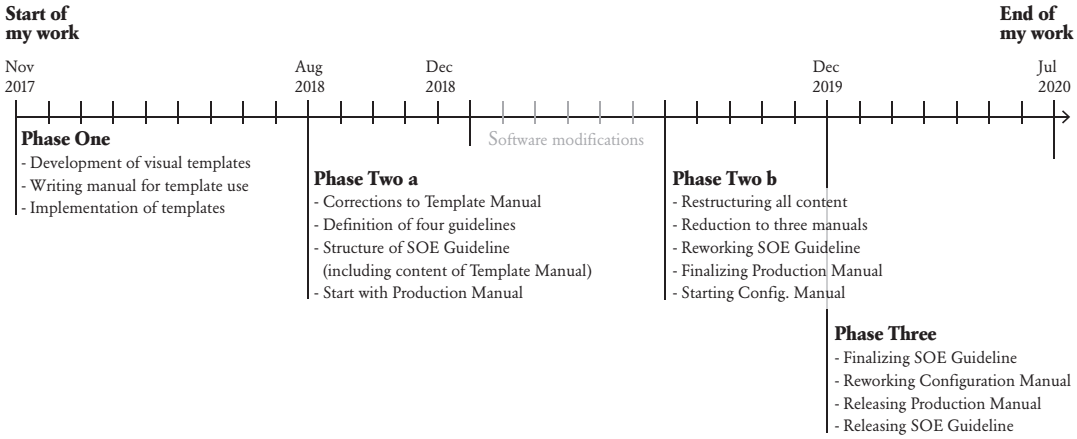


Figure 19: Timeline showing the three phases of the project (own illustration)

These epistemological components are an important element through the recurrent reflection within the *Action Research* approach. Both perspectives, that of the design expert and that of the researcher, are played out in parallel in the *Action Research Cycles*. As I am actively working in the project context as a design expert, I act as a *Reflective Practitioner* (Schön, 1983) and a participant observer (Kemmis, et al., 2014) at the same time applying participatory action research. I am involved in the project myself and personally accompany the research subject on site, so the research does not take place in a laboratory. I work within the framework of the company project, together with the people involved, in their familiar environment. The advantages of being part of the project team show by staying close to the team participants and also recording interviews and in-vivo codes. The *Action Research* as the cyclical planned activity is the same in the *Participant Action Research* and my role as participant does not change the phases of the Action Research in its structure and flow.

The various phases of the project resulted in three research cycles from a research perspective, each with slightly adapted questions. In addition, the long collaboration not only resulted in a deep understanding of the project-related topics, but also of the research-relevant topics and issues. The overlay of the AR cycles with the timeline visualises this alignment.

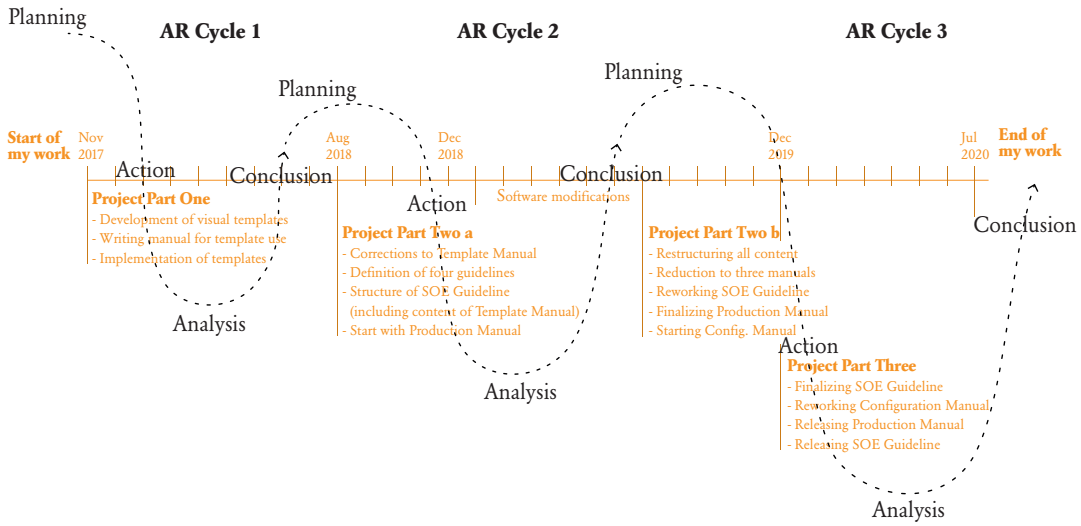


Figure 20: Matching of Action Research Cycles and timeline of project (own illustration)

The research through design helps me to understand the project as the source for my inquiry in applying *Action Research*. AR fits well, as the project itself runs in various phases and the objective also changed along the timeline. The intensity of the understanding of the goal and the importance of the artifacts within the activity cycles increased over time. The questions were answered with new questions and led to further activity cycles. There was also a certain convergence of the tasks in the project and the objectives studied at the research level.

The strict structure of the four phases within the *Action Research Cycles* helped to structure the research and to develop an appropriate perspective. It also supported the iterative development and clarification of the research objective. Depending on the initial situation, the stage-related activities in the three defined phases of the project adapt to each other. In the planning phase, I describe the situation and the people involved. The situation results in a focus starting in the first action cycle describing all people involved in detail. Questions deriving from the *Activity System* are introduced in the second cycle's planning, as they helped to untangle the complexity of the project and to analyse and understand the depths of the knowledge levels and the different roles in the organisation. During the *Action Phase*, the process of the activity is viewed and described from different angles. The actions are reflected on the sub-queries such as *General Setting*, *External Forces* and understanding about what I did: *Comprehension*, *Output*, *Interaction* and the *Consequences*. Scholars classify the *Evidence of Activity* in this phase and start with an analysis. I am moving the evidence into the *Analysis Phase*. Due to the quantity and diversity of the material, the analysis and the interpretation are easier to follow when they are grouped together.

In the analysis, I use Alvesson and Sköldberg's (2018) multi-level interpretation approach, specifically the first three levels: interaction with the empirical material and the material, interpretation, and the critical interpretation. In addition to the text sources I am analysing the visual codes and applying the document analysis. Finally, I the *Conclusion Phase*, I use the results and reflect on the objectives and answer the questions from the *Activity System*. The *Conclusion Phase* leads to further activities and a new approaches for the following cycle. The reflection on the main reaserach question takes place in the discussion.

The in vivo text-based sources from the laddering interviews, memos and observations conducted with several employees of the company emerged mainly during work sessions and represent the different levels of knowledge workers and responsibilities. However, the text-based data come from different intervention methods. The answers within a structured interview already go through a reflection phase with the interviewee, as the person is stimulated by the questions and aware of the situation. The information from the recordings is subject to the rather spontaneous, often unfiltered, impulses of the participants and is often not very well reflected, unless there are discussions within the working session. These discussions were often interesting, but here too, the statements must be viewed in a differentiated way, as the participant was aware of my background in conducting the research and also of the fact that recordings were made during the work session.

To visualise and understand how participants work with their working memory, the coding of the spoken material are defined. The coding procedure base on analysing the live-recordings which are partly transcribed, the interviews and my notes. The codes became a mixture of pre-defined and in-vivo codes. The most often used pre-defined codes were defined by the literature:

Knowledge Management: *knowledge, data, information, individual, socialisation, internalisation, know-how, organisational learning, transfer, reflective, impatience, time, duration, activation, excercising, process, learning, unfamiliarity, knowledge workers, impediments, sharing*

Visual/Technical Communication: *design, Gestalt, technical/visual communication, interdisciplinarity, culture, corporate design, digital, communicative, instructive, codified, authorship, creativity, content, meaning, text, visual, style, balance, solution, documents, manuals, products, process, diagramm*

Facilitation/Co-creation: service*, network, service system, technology, untransferable, intangible, relational, adaptive, communication, knowledge-intensive, stearing, negotiative, collaboration, involvement, facilitation, experience, softskills, moderation, effectiveness, learning, co-creative*

The visual material from the manuals are documentary in the way they are developed. The characteristic elements of the documentary method are based on the separation of generalised and documentary meaning, i.e., it separates concrete actions on the one hand and implicit elements in actions on the other. The method thus tries to connect what is said or done with what is (possibly) meant or expressed. Materials are usually e.g., transcripts of group discussions, supplemented by individual interviews. I see the manuals as a document that has this quality over the whole timespan of the project and they can be used as a good source of evidence. I treat the formal evidence primarily as that which is *visual* and the content-related evidence as that which is *meant*. The development process can be seen, for example, in the amount of manual iterations and the differentiation of knowledge levels can be seen through the use of page types, page structures, text and number of schemas related to the documents' goals. In addition, the embedding of knowledge is visible in the results, through the interconnectedness of the three manuals.

The material coming from three different documents (manuals) developed over the course of approx. three years differ in the content-related statements and the information architecture. Through the development of categories of the different page types, an analysis of content as well as image becomes possible. However, I relate these to existing material and theory from technical and visual communication. This approach to analysis is not reconstructive, as the visual elements are understood as indications of meaning and interpretation within the reflection of, and with, the users. The existing material is coded as *what is visual* and how it produces meaning and relation. The analysis of the visual codes will then be divided into *relative visual codes* by manual. The way in which the visual material was created over the course of the three cycles is documented. Visible structures emerged, such as the development and use of page types or the way elements such as text and images were specifically worked with. I identify certain visual patterns in the pages that lead to page types refering back to a manual type.

Clear differences, which emerged during the course of the work, became apparent in the results and the use of visual elements. The meaning of the codes in context are hierarchised as:

Visual Category for the causal entity; usually the classification of a visual e.g., diagram, text, …

Origin for the used visual material in the category, e.g., schemata, numbers, …

Meaning as category for the effect, e.g., applied process

Relation as category for its embeddedness e.g., events in the application

Value as category for the appearing quantity, e.g., 25% of all visual material

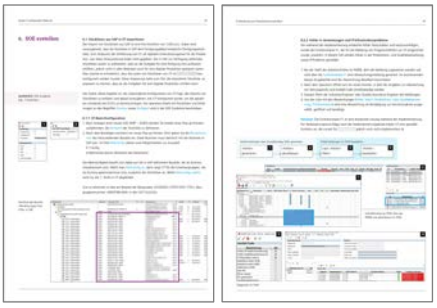
Specific Visual Codes in **System Configuration Manual – Instruction pages**					24%
Vis.Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Value*
text	headlines, copytext, lists, links, captions	naming and describing activity	specific work flow in CF		30-50%
diagrams	abstract schemata	typical process	usage of portals		10%
screenshots	tables, interface, screens, segments	CF / SAP content, functions IP of CF / SAP	interface process at backend		30-50%
photography	-	-	-		-

Table 11: Example for analyzing the different content elements of typical pages

The rather quantitative approach encoded into the value-category supports analysis and evaluation of the developed manual content as a result. I counted the different forms of content, compared their proportional appearance in the manuals as well as their distribution on the page types.

4.5. Ethics Consideration

In this chapter I outline the requirements for conducting the study and the ethical measures which have been taken into account regarding the organisation, its employees and the produced material.

4.5.1. Ethical Principles

4.5.1.1. Alignment with College Ethics

Before starting the study, I completed the *Research Ethics Process*, which is designed for all researchers and research students at the *Royal College of Art*. I have taken and completed the *Online Ethics Training (Epigeum)* and applied for an ethics permit with the *Research Ethics Department*, upon which I was granted permission to continue my studies within this project.

4.5.1.2. Obtaining Informed Consent and Protection of Anonymity and Confidentiality

The study included work with employees (all over 20 years old) who actively take part in the study as they belong to the close or the extended project team. Each person I worked with I informed about my role as a researcher and asked them to sign the *Participant Project Information & Agreement Form* and the head of the organisation signed the *Partner Project Information & Agreement Form.* On the participant form, the organisation added that "the information collected will only be used for the research project" and that "the number of people who have access to the information is limited. […] Images, quotes or other documents that could identify an individual will only be used with their express will or be neutralised." On the partner form, the organisation added that "the company name, participant's names, department's name, software's names will be anonymized" and the same will take effect to specific technical terms. Prior to the publication, the organisation required access to the thesis to provide approval. This approval has been granted by the project manager in July 2021. The relevant signed forms can be submitted on demand, as they are paper-based.

4.5.1.3. Avoiding misleading practices

In addition at the start of the project, the industrial partner required me to accept their specific *Non-disclosure Declarations*. This resulted in the permission to use the new software and to enter their buildings and talk to employees. It did not allow the developed manuals to be shared with others outside the organisation, except selected manual pages, which have gone through the approval process based on the agreement. Both agreements also included the right to withdrawl for all

participants. The interviews, the recording of the conversations and my notes could be viewed by the participants at any time. The interviews with the employees focused on the subject matter of the manuals and their effect as learning material. The interviews and conversation took place in the regular working environment and during working hours. The data in the manuals came from the work-based collaboration in the project. Material that was evaluated in the study was edited based on the agreement, and company name, logo, personal names and technical terms were neutralised.

4.5.2. Research Strategy in Front of Ethics

Originally, I was hired by the organisation only as a design expert, but I was able to convince the project partner of my research interest. The head of the organisation and the project manager were very supportive and we discussed my involvement conducting open research (PAR). But against all reservations and due to the long duration of the project, I was seen mostly as a design expert by the employees and not in my dual role. The project manager himself had a PhD and was able to see the challenges of being influential. The interviews and conversations with him were deliberately conducted at either the project or research level. When asked about my research by other employees, I answered openly and acted transparently. In order to be able to question my own perception once again, I applied the multilevel-interpretation approach by Alvesson & Sköldberg (2018).

4.5.2.1. Sampling Strategy

The research ran as a long-term study and was bound to one organisation only. The long duration enabled me to draw comparisons, especially in terms of document development. In addition, I usually worked with the same people, and statements and insights that were brought to me by the team partners could either be confirmed again by the interviews or were expressed repeatedly by the same person at a distance in time, or against the background of changing manual content.

4.5.2.2. Gatekeeping

The project manager took on the task of organising the schedules and participants for the interviews and doing the paperwork so that the project became my research study. This involved consultation with department heads, their willingness to participate and that of the interviewees. Participation in interviews was rare, as work schedules usually did not allow for many interview slots. However, those I was able to interview gave detailed information voluntarily.

4.6. Overview of Methodological Approach

In each cycle I apply the following structure and logic. Only the objectives change.

AR Phase	Content	Comment
Planning	Sub-headlines - *Context information on project* - *Context information on project participants* - *Definition of situation* - *Extended problem area* - *Research question or its sub-questions* - *Study description* - *Inquiry of material collection* Asking seven questions from *Activity System*: - Why is there this activity? - What is the desired outcome? - Who is involved in the activity? - By what means are the subjects acting? - What is the environment about? - Are cultural norms governing the performance? - Who is responsible for what?	The problem area and the inquiry are defined here. In each cycle the problems change slightly based on the outcome of the prior cycles' results and conclusion. The questions coming from the activity system will only be answered in the second action research cycle!
Action	In the action phase, the process of the activity is viewed and described from different angles. Sub-Headlines: - *General Setting* - *External Forces* - *Comprehension* - *Process Output* - *Interaction* - *Consequences*	Scholars classify the *Evicence of Activity* to be reflected here. I take the evidence and all material types into the analysis phase, as the analysis of visual and in-vivo codes are easier to follow.
Analysis	Sub-Headlines: - *Interaction with the empirical material:* In the first level of interpretation, the in-vivo codes will be used. The material from the manuals are structured according to their content type and examined by the document analysis. - *Interpretation and critical interpretation:* The prior results are interpreted to understand their meaning. - *Evaluation*	In the analysis, I use Alvesson and Sköldberg's multi-level interpretation approach, specifically the first three levels: 1. Interaction with the empirical material and the various material types, 2. interpretation and 3. the critical interpretation.
Conclusion	Each objective will be reflected leading to develop a further proposal for the following action cycle. Sub-Headlines: - *Reflection* - *Further Activities*	Due to the complexity of the material, their diversity and in favour of a better overview, the theory reflection takes place in the chapter 7 (Discussion).

Table 12: Overview of Methods

Note: Based on my methodological approach of Participatory Action Research, I had been part of the team and take the role of a researcher at the same time. The team knows that I am acting in this double role. Therefore, these two aspects might influence the course of the study. The multi-level interpretation approach from Alvesson and Sköldberg (2018) should decrease this influence to an extent, that results from a study in which the design expert does not play a double role becomes equivalent and easier to compare.

5. Project Description

In order to understand how the different kinds of knowledge are initiated and situated in individuals and organisations, I looked for a company in which to place my research project. With my study, I had the opportunity to accompany an organisation that was in the midst of a digital transformation.

5.1. Introduction to the Company

5.1.1. Company Profile

The company develops and markets high-end specifically-engineered technology applications for air and space. The company is a globally operating organisation running 51 sites in 14 countries, the company has a strong international market presence. One division of the company is a global first-tier supplier of aerostructures. The company's services focus on the development, manufacture and final assembly of complete fuselage sections, wing and control components as well as sophisticated assemblies and components. One of the department's strengths is the management of complex supply chain networks. Among other things, it is responsible for the complete global supply chains of fuselage sections for a well known aircraft manufacturer. Another division is the leading supplier of space products in Europe and the States. With 12 production sites in six countries, the division specialises in products for use on board satellites and launchers. Its expertise is divided into the areas of electronics, mechanical and thermal products, and separation systems. Further divisions supply, support, and integrate aerospace systems and components as well as simulation and training facilities worldwide. Its core competencies include repair and maintenance work, upgrades and the development, manufacture, and integration of subsystems and components for aircraft and helicopters.

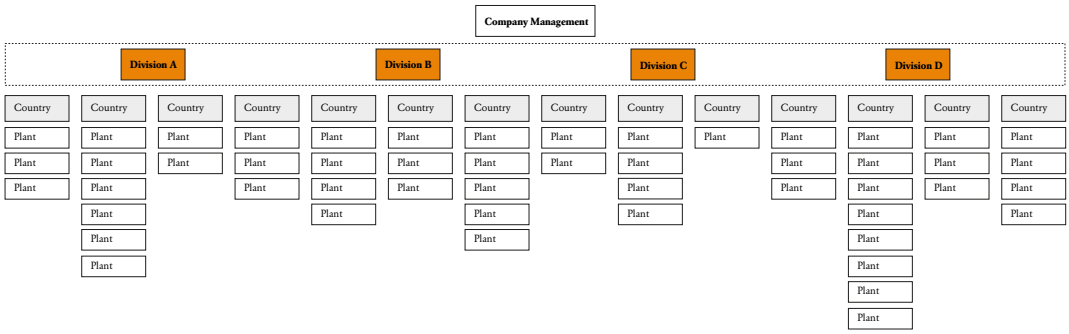


Figure 21: Company network structured by divisions and plants (own illustration)

Based on information from the annual report 2019, the company (before unbundling) had annual Net Sales of CHF 2003 Million and employed 9091 people.

5.1.2. Development and Production Processes

The organisational structure of the company has grown and changed only partially due to years of development. Typically, sales, development and production are located close together. This is due to the structure that has grown with the different kinds of product and the country-based organisation in relation to the type of products. Generally, the various business units and companies in a country or continent are headed by one or more responsible persons. They manage the operational processes in the units, and countries are responsible for their respective business development.

The products and systems are generally configured and developed to customer specifications. There is mainly small series production in the field of aerospace products, in which the development of the product usually takes place before the production. But partially, during production also, if the product is embedded in a complex single but large scale structure, especially within extensive space-related research and development projects.

My research project took place in one of the plants responsible for developing and manufacturing launcher structures. This part of the division is located in one country. The sales processes here are strongly internationally oriented, as are the development and production processes that accompany them. The management of the business unit and the country head office decided to optimise various processes. In the course of these transformation projects, I had to deal with people from central management and with people from development and production at the plant.

5.1.3. Drivers for Change

The fundamental situation is that this particular industry consists only of few suppliers, and pricing is less dynamic. Due to a stable interdependence between the interests of a state on the one hand and a smaller number of companies on the other hand, cost structures could develop which were rarely questioned. The evolved working processes and institutionalised structures of the company, with all its divisions and corporate structures, showed that change and adaptation to more dynamic pricing was a challenge. During the last years, the organisation realised a change in the market sharing because of other suppliers of aerospace technology products offering solutions at a lower price. Due to the new suppliers, the company's accustomed stability was questioned and the financial development forced a rethink. The growing pressure of competition triggered considerations and processes were to be made more rational and transparent.

Due to the decision coming from the division's central management in favour of a fundamental optimisation process, it was decided to transfer the production into a digitally accompanied documentation structure. First experiences with a specially designed software platform were gained by one of the plants (Division C) in the wider company network. The production there is fundamentally linearly structured without any major changes in requirements. The project and the experience with the software in that plant went well, so the decision was made to further use it. Although the software was applied to all organisational levels in that first usage, the Visual Lean approach was not followed there. In the project I focused on (Division D), however, the software was not only to be used for the textual digitisation of work processes, but also to be visually displayed and accompanied. Therefore, a focus on the Visual Lean approach was placed here, also against the background that the project results could be applied later in other production facilities with less qualified production employees (gray and white colored plants).

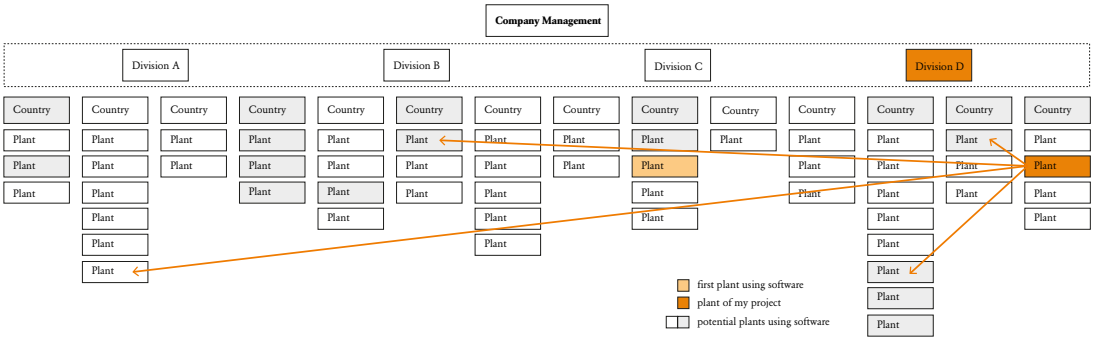


Figure 22: Company network and plant structure (own illustration)

5.1.4. The Digital Transformation Programme

The project took place in one of the division's plants where business is focused on developing and producing spacecraft components. The project titled *Paperless Manufacturing* supported digitisation of production at this specific plant. The creation of paperless production instructions is part of the integration process of *Enterprise Resource Planning* and *Lean Enterprise Innovation* at the division. The so-called *Lean Manufacturing Engineering* and *Visual Manufacturing Operations* follow, among others, the approach of *Paperless Visual Lean* and *Zero Defect & Zero Tolerance Operations*. The aim is to provide digital support for the entire production process with all work areas and steps, thereby making all processes more transparent. The project's internal name was *Paperless Manufacturing*.

To this end, the company has introduced a software as a *Manufacturing Execution System* (MES). Manufacturing Execution Systems are computerised systems used in manufacturing to track and document the flow from raw materials into finished products. The active improvement of business processes depends on qualified IT support, the integration of existing IT systems and the development of specific IT systems to manage operations. The *Association of German Engineers* [Verein Deutscher Ingenieure, VDI] defines MES in its guideline 5600 (Informationstechnik, 2016) as a production management system operating close to the process and as a comprehensive driver for the organisation and execution of the production process with these tasks:
a) organisation and support of all activities in the production process,
b) realisation of the cycle of action for the implementation of the production process and,
c) exchange of information with neighbouring levels such as Enterprise Resource Planning (ERP).

The following operational processes associated with the company's manufacturing activities are to be handled by the software:

- Production Management (resource, specification & execution, data acquisition, tracking)
- Quality Management (specification & execution management, data acquisition)
- Maintenance management (specification & execution management)
- Warehouse and inventory management (resource management).

The choosen MES software manages all work instructions as so-called Sequences of Events (SOE) in production. The implementation of the SOE design includes the management and the preparation of all other related internal IT-systems and their processes as described above. The transfer of the manufacturing process and its work steps into the digital form requires a prior analysis of all processes involved in the manufacture of a component. Digitisation required a rethink from linear reading of the paper-based production guidelines to modularising the activities. In addition, e.g., components that are similar in production are grouped together and this in turn influences the design of the parts lists in the software. These preparational tasks makes the integration of other information related to production as important as the analysis of the process itself.

5.1.5. Technical Environment of the MES Software

The software is offered by a company that has implemented similar solutions for other industrial sectors. As production processes usually varies in the different industries, the software is adapted to each customer. The current development and implementation ran over a number of years and will be adapted if changes are required. The MES is a combination of multiple interacting applications, which are managed at the back-end and accessible via a front-end, the application portal.

The applications are the functional part of the system, which generate data stored in databases. The application package includes different levels of the application system. A basic distinction is made between the application systems and the databases. There are three application systems differing between productive system (PROD), test system (TST) and new system (NEW). Within the productive system, the active production is running at the plant and functions are actively used. The test system is the BETA version of the productive system. Here, functions are tested a second time before they go live into the productive system. The ALPHA version of the test system is represented in the new system. Here functions are tested for the first time. Within the databases there are the firmly linked production database PRD and the selectable databases QAS, TST and TRN.

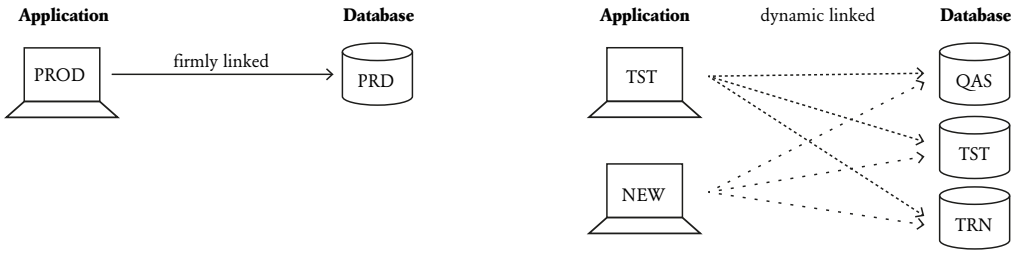


Figure 23: Software architecture and related database (own illustration)

The training database TRN can be used by anyone who is new to working with the application. One can create one's own data sets using the new system and gain an understanding of the functions by following an instruction manual. Before an employees uses the production system actively, they need to understand the use of the application confidently. Since access and use of the applications is only possible via the company's own network and is subject to a multi-stage log-in process, no external teaching material can be easily used parallel to running applications. In addition, the existing teaching material from the software provider is not sufficient to train this customer-specific solution, as this material does not adequately address the real complexity.

5.2. The Design Project at the Company

In order to facilitate the implementation and use of digital production rules in the software by existing and new production staff, the interface of the software should be visually optimised and standardised. The standardisation of the interface was mainly related to the visual representation of the work steps and templates. Specifications for its use were to be developed.

External help was called in and I was commissioned to develop the interface and a related manual based on my expertise as visual designer and manual writer. During the course of the project, the scope of tasks grew and the duration of the cooperation developed. In total it lasted about 3 years and the project was financed with approximately 150.000 CHF. As I was responsible for the execution of the commissioned work as an expert, I also had to give instructions to people who supported me internally such as the interns or the assistants and worked with employees who were using or learning the software within this context.

The overall objectives of the *Paperless Manufacturing* project from the company are the following:

- The replacement of running charts with production instructions, inspection reports, drawings, etc.
- Ensuring that the future working methods will meet audit requirements
- Ensuring the required interface between the SAP and the choosen software systems (data transfer)
- Simplify the work processes involved (less time for reading / understanding the work instructions)
- To standardise the work processes in the best possible way (the know-how experienced employees will be much better integrated into the system)
- The input of proof of work and confirmation to be ensured.

The assignment to support the aims of the overall objectives took place in three stages, although initially it was not expected that the co-operation would develop as it did. The phases were expressed in three orders, each of which was accompanied by an adjustment of the service description. The range of tasks changed from the original scope of developing a visual interface concept and a corresponding manual, to the task of developing and testing software guidelines for various internal user groups. My tasks changed accordingly, and my role evolved from being an expert for visual communication to additionally being an author of technical communication.

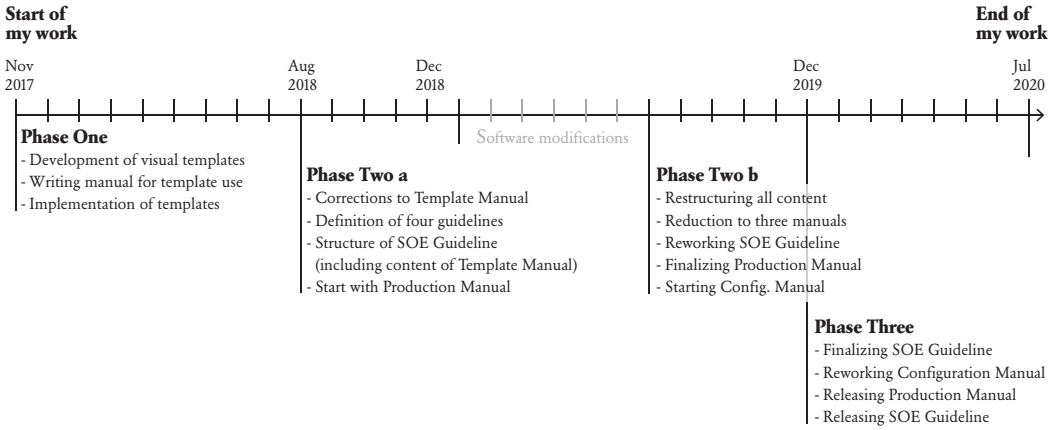


Figure 24: Overview of three phases in my project (own illustration)

Phase One

Aim: In the first sub-project a design guideline for the creation of production instructions was developed so that the visualisations follow a standardised design. At the same time I supported the implementation of the manual.

Scope:

I. Visual categorisation of process sequences (SOE) outlined in a visualisation concept.
II. Creation of templates and a manual for production instructions according to design principles and customer needs, as defined in the specifications, formed in a *Template Manual*.
III. Support in the implementation of the manual in the extension to the areas of production, review and final fine-tuning of the manual by an intern supervised by me.

Timeframe: This first phase started in November 2017 and lasted until August 2018.
Members: Project manager, industrial engineer, production employees, intern, design expert (me).

Relationships: The co-operation was structured by supervising the intern's work on the development of the templates and the parallel development of the corresponding design guideline. The intern was supervised by me and worked together with the production staff. My co-operation as an design expert was structured by interacting with the project manager, the industrial engineer and the production staff. Decisions on content development and visual templates were based on my recommendations.

Phase Two

Aim: In the second phase I was responsible for the corrections and changes to the design guideline, as it could not be completed by the end of the first specified project time. In addition, there was the need for more guidelines describing the use of the software from various perspectives. More detailed guidelines were outlined in a series to support production and quality assurance staff. The design manual that had been started was included in the manual for the Industrial Engineers as Sequence of Event Design, the SOE guideline. In addition, user guides for the production employees and quality management were commissioned. The structure of the manuals was based on the roles in the company. This was to change again in the course of the work, especially with regard to the SOE guideline, which for the time being was only to apply to industrial engineers.

Scope:

I. A manual for production employees as *production manual*
II. A manual for inspection engineers as *inspector's guideline*
III. A manual for quality assurance engineers as *assurance's guideline*
IV. A manual for industrial engineers as *SOE guideline* (including *template manual)*

Timeframe: This second phase started in August 2018 and was planned until the end of 2018. In the end it took until the end of 2019, as the company made major adjustments to the software until mid-2019. A documentation of the use cases until then could therefore not be developed.
Members: Project manager, industrial engineer, production employees, intern, design expert (me).

Relationships: From mid-2019, the collaboration focused primarily on the project manager, another industrial engineer and myself. Based on the experience of the first year, it was possible to build on partial knowledge. However, the intensity of the co-operation increased as final deadlines for the completion of the guidelines were defined internally. From September until the end of 2019, I worked mainly with the project manager on a 1:1 basis in regulated working sessions. In order to execute all necessary changes to the emerging manuals, I had the chance of delegating this work to interns, which enabled me to focus on the core structure and the main content. In addition I had the chance to interview the project manager and various employees on their experience with the manuals.

Phase Three

Aim: In the third phase, the refinement took place and as we had realised in the previous months that the inspector and product assurance perspectives can be covered by the SOE guideline, we included content accordingly. The project manager required a configuration manual, in order to establish a framework for project managers who find themselves establishing similar projects.

Scope:

I. The manual for the production employees as *production manual*
II. *SOE guideline* for all engineers (industrial, inspection and product assurance)
III. *System configuration manual* for project mangers (also for industrial engineers in as PM)

Timeframe: in the time from autumn 2019 to June 2020, we worked intensively on the completion of all three manuals. It became clear that the manuals will be used in the three perspectives listed.
Members: Project manager, assistant, design expert (me).

Relationships: Especially during the intensive phase at the end, the co-operation was structured by mutual reflection, very effective content production and constructive negotiation. The work was very practical and equally distributed on both sides. We knew what had to be done and the roles had become established. Support from the assistant was used in the beginning to maintain correcting the documents. The project manager and myself developed a working routine and were able to detect working patterns and its perception among the employees and the department.

Role	**Project Manager**	**Ind. Engineers and Key User**	**Production Employee**	**Design Expert (Myself)**	**Assistant/ Intern**
Tasks	*Enabling and managing the project, working with industrial engineer, speaking with related departments, IT and the software supplier*	*Using the software, building SOE in the software, developing solutions within the software, building the interface content*	*Using the software in the production, documenting the working process*	*Developing the content of the manuals and visualising processes, developing templates, leading interns, conducting tests*	*Supporting the expert, making changes in the manual documents and testing the templates*
Participation in project	*100%*	*80%*	*40%*	*100%*	*20%*
Frequency of contact with consultant	*Always, when consultant at site*	*often, but on demand*	*partly, on demand*		*partly, on demand*
Effect on material	*interviews, discussions, documents, tests*	*interviews, tests*	*discussions, tests*	*interviews, discussions, documents*	*Documents, templates*

Table 13: Roles involved in the project

5.3. The Fit as Research Project

The project *Paperless Manufacturing* is particularly interesting as a research object, as it deals with internal processes and procedures in the company as well as with practical and manual work in production. I was dealing with people who had difficulty describing what they do. I noticed this especially with the engineers and the workers – one would call this embodied knowledge. After some time I also noticed that the project manager had a certain amount of experience and knowledge about project-related processes – which would identify as embedded knowledge.

The digitisation efforts act as a trigger for a project that was launched primarily to optimise work processes also seem to be an important aspect. It becomes clear that an attempt is being made to take a fresh look at value creation in companies through digitisation. As I am dealing with visualisation in the context of embodied knowledge in individuals and embedded knowledge in companies, this project offers a fitting starting point for the investigation.

The first phase is mainly concerned with how the craftsmanship can be visualised and provides templates and a manual that enable the visual processing in images and text. Anyone who is concerned with presenting the work processes in the software via photography and visualisation will notice that the work processes are, or are becoming, explicit simply by documenting them. In the second and third phase it became clear that the processing of the processes and the presentation in the manuals is a process in itself, which makes the routine and embedded knowledge in the company gradually visible.

The change from the Template Manual as a design guideline, which mainly works with the presentation and documentation of reflected knowledge, is transformed into manuals in the second and third phase. The manuals became a tool for the analysis of work processes. Due to the diversity of the order volume and the resulting phases, I had the chance to regard the project as my research project and to assess the development of the manuals from the perspective as an design expert and a researcher. Not only the understanding of my role as a design expert responsible for design guidelines changed to additionally being an author for technical communication, but also the recognition of the work, as the results were used in the company. The development of the manuals over this long period of about 3 years enabled me not only to have the manuals tested in the company by the relevant people, but also to observe the acceptance of the manuals. It was not a short-term consulting

project, but a project that developed and accompanied the organisation in their own transformation over a long period of time. The employees were able to express themselves openly and honestly about the manuals' usefulness, as a relationship of trust had developed over time. This productive exchange took place between the project manager and myself. The engineers and production staff also developed more openness and interest.

5.4. The Activities in the Project

Initially, I was placed in the company in the role of an expert in designing manuals. The existing technical environment was critical of the design, especially the visual design. The value of the visual design was only partially placed in the context of the project. The value was mainly only related to the development of the templates for visualising working routines in the software. It was classified as interface design and the manual on the same was only considered as a marginal issue. The nature of the collaboration was not clear at the beginning and I first had to establish myself as a practitioner. But most importantly, after the first few months it was recognised that I was able to get into the technical environment and follow the internal processes.

The working environment was extremely technical and the digital working environment on the project was new for everyone involved. Working in the software required numerous internal log-in procedures and the creation of the screens was often difficult. Work on the project was easier at the plant. Access to the software was somewhat easier and questions could be discussed more quickly. In the last phase we worked directly in the manuals and in the software, for reflecting on and co-ordinating the content. Within weekly or biweekly meetings, we reworked the meetings' conclusions and reflected the newly developed content with colleagues by the project manager.

The specifications for the first manual, the *Template Manual*, contained a draft of the templates for the Sequence of Events (SOE), such as instructions for naming the digital structure, functional elements and the visual master templates. The main part deals with explaining the visualisation concept, the definition of a basic layout, instructions for the creation of images and the offer of a symbol library that can be integrated in the software. To prepare the content in such a way that it corresponds to the reading habits and scope of the production employees using the SOE, and the engineers who planned the work in the software, I worked with tests and interviewed various users.

After the first phase, the scope of my work changed and it was decided that various instructions were needed to implement the software in the company. The final guidelines and manuals are specified by the different usage situations and are characterised by the tasks of the different user groups. The content goes beyond the scope of explanations about the use and benefits of the visual elements and moves on to technical communication, which deals with the instructions for using and implementing the software. The findings are documented accordingly in three manuals:

Production Manual: The manual shows the production employee in detail how to use the software during work. Among other things, the activation of production orders or minor rework is described. The manual is made for the production staff. *The content of the instructions reflects the work processes, which have been analysed by the digital instructions developer, i.e., the industrial engineer. Parts of the process demonstrate the arrival of implicit and explicit knowledge.*

SOE Guideline: The guideline provides step-by-step instructions on how to develop, build and release an SOE using the software. It also provides all necessary background information for specific production situations. Among other things, the visualisation of the work steps is described in detail through the creation of test steps. The guideline is used by the Industrial and quality engineer as well as Product Assurance. *The content of the instructions reflects the work processes, which are already regarded by individuals as implicit processes of software use. But they also show how the entire work organisation was defined at the end, after all iterations. Working with this manual shows the unlearning of numerous embedded routines along the manual development process.*

Configuration Manual: This manual describes all the principles, approaches and logic of how the software is configured. The manual therefore contains information that is only useful for a project manager or a Key User in that role. *The content of the instructions reflects the knowledge of how to implement a project of this kind and the embodied knowledge of the project manager becomes visible here, especially through the statements on principles expressed in the digital environment.The project manager deals with various departments and people with different knowledge levels and jobs to be done.*

Especially during phase two and three, I started to understand the different depths of knowledge and became able to work out the principles of the work processes. The project manager and I worked with sticky notes on a wall, on which we repeatedly noted and sorted different work steps. Stepwise

the knowledge was transferred into the documents, whereby I made the first approaches in the description. The project manager read through the documents and commented. During the working meetings we also used a large monitor on which we worked live on the new software and the contents of the manuals in Adobe InDesign. I repeatedly conducted interviews with the industrial engineers, the production staff and the project manager. During the working meetings with the project manager, a recording run in parallel to avoid artificially collecting phrases and to save time.

6. Action Research

The background for this study is a large scale project in which I was an expert for corporate design applications and guideline development. About one year before they hired me in 2017, the company decided to introduce the new MES platform application into the organisation. Its implementation included the modification of the application by the software supplier, with the transformation of all paper-based production specifications to become digital, and in the course of this, the partial reorganisation of work processes. As the work progressed, this aspect turned out to be significantly more important than expected and meant difficult decisions and partial workarounds, since not all of the processes involved could be easily included in the transformation.

The internal project name was *Paperless Manufacturing Operations*, often simply called *Paperless*. My direct project environment focused on three main groups: various software user roles, the software supplier and myself. The users were divided into three groups: production employees (worker), engineers (industrial engineer, product assurance, quality manager), a project manager and one Key User, who is an industrial engineer set up for the project. The project managers' task was to set up the backend structure and organize the overall flow of the application implementation. The engineers were responsible for content development and for setting up the production guidelines as well as the product and quality assurance guidelines in the MES application. The production employees use the software for tracking their production processes. The software supplier is responsible for solving technical issues and implementing requirements. Right from the start I worked with people from all groups.

6.1. The Action Research Cycles

There were three action research (AR) cycles segmenting my research and guiding me to find an answer to my research question. The main focus was to understand the practices, the systems and structures which appeared when working as a design expert with employees who embody special skills and knowledge. It is about finding out how visual communication and design practice can support employees in highly specialized technology ventures in the process of sharing, informing, reflecting and uncovering embedded and embodied knowledge against the background of Industry 4.0 and the digitisation of work and its accompanied processes.

The **AR Cycle 1** focused on finding a process to deal with different visual practices and mind sets. Along the way, the project offered a good basis for investigating how visual design can support the development of a visual system and templates for the MES application's interface in the portal for the production employees. It also looked at how this system is documented and explained to non-designers in a design-led manual as part of a set of guidelines along its implementation to the MES application itself. Through the successful adoption of the *Visualisation Chapter* it became clear that the document structure that had been developed could be used for an expanded range of tasks. It also showed that the nature of the collaboration involved knowledge work even in this initial period. Within this first activity I looked for answers to the question: **How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?**

The **AR cycle 2** dealt with the overarching system and information complexity of the paperless project, and especially with the use of the manuals as a boundary object. The increase in work complexity in the project allowed for a focused search for tacit working knowledge. The scope of work led to opening up the application guidelines and moving away from a manual that only documented templates. At this point, four application manuals were defined for four user groups. This provided the framework for the project as well as the foundation for knowledge management research. During AR2 and intensive work with the documents and the processes, it became clear that some routines (Carlile, 2002) could not be clearly mapped in the software. The internal project team had to decide on far-reaching adjustments to the software. This background led to the question: **What does a design expert need to understand about the working environment in order to systematise and simplify complexity?**

The **AR cycle 3** looked at the way of dealing with professionals and develop principles and scalability. After the adjustment in the software, two guidelines were almost completely revised. The user groups were redefined and three guidelines for different levels of work with and about the application were agreed upon. This last cycle not only answered the questions about the performance of the design in knowledge-driven documentation projects, but also created insight into different levels of competencies depending on the role of the employee. In the end, three guidelines were developed, two of which are actively used in the company. The third guideline provides a good basis for use, but could be further developed if management pursues the project. The work with high profile professionals and the transformation knowledge that was appearing led to the question: **How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?**

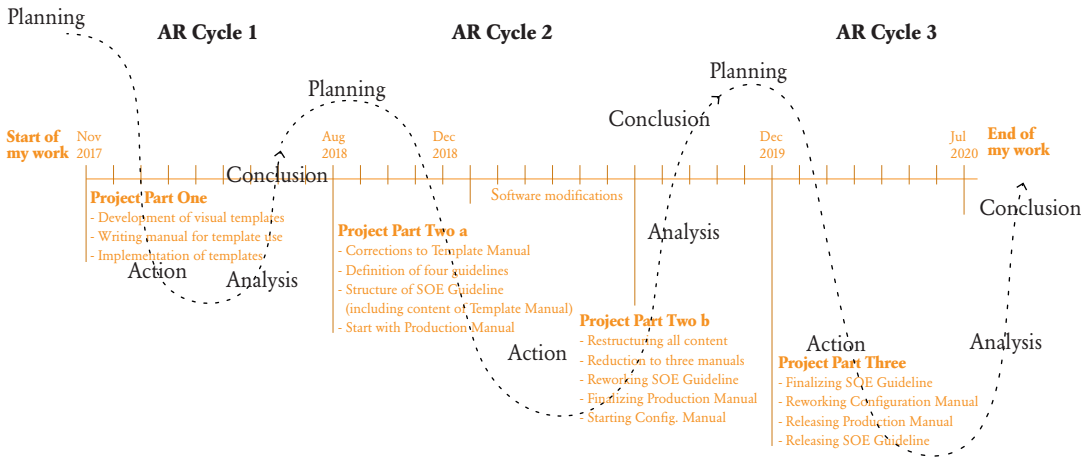


Figure 25: Matching of Action Research Cycles and timeline of project (own illustration)

6.2. Action Research Cycle 1

6.2.1. Planning Phase

I structured my planning by understanding the task, context, the people involved and their roles, plus the problem space, and departing from my research, I described the study and inquiry and defined the timeframe.

Project task: At the beginning, my assignment was to develop a visual system for screen design templates to be implemented in the MES application. The production employees should benefit from the presentation system because the information is always presented in the same way. The engineers who prepare the work steps for the production employees can follow a pattern or system in doing this. The visual system was therefore based on the templates, which were stored in the MES application in the form of PowerPoint. The use of the templates and how to create a visualisation should be explained in a chapter of the SOE guideline. Soon after the first steps, we realized that the screen design is just one little piece of the implementation and that the manual should become a document, guiding all users on how to implement the content for the Visual Lean production setting using the MES software, including all relevant software portals.

Project context information: This part of the project includes support for the creation of paperless production regulations by using visualised work steps within the MES application. The paperless project follows the so called Visual LEAN approach. The aim is to accompany the entire production process digitally in all work areas and steps, thereby making all processes more transparent and manageable. The MES application offers different portals and for the first part of the project, the portal Sequence of Event Design (SOED) is relevant. The visualisation of the work steps, or Sequence of Events (SOE) was created by the engineers. The production employees then use the visualized production regulations displayed on large screens at the workstation on the shop floor. I developed the visual system by means of templates. I described their use and access in a chapter of the SOE guidelines and accompanied the implementation of the templates into the MES application's portal. The software supplier enables the implementation of the templates and in case of modifications the Key User applies changes and manages the back-end.

Project participants and team members: There are three main groups in focus: various software user roles, the software supplier and myself. In this first part of the project, I had mainly worked with production employees (Users), one engineer who had been using the software intensively for one year (Key User), and the project manager (Super Key User). In the following descriptions I am generalising on the roles and their specific characteristics applying the above mentioned titles.

Project Manager:

His task is to organize the back-end structure and organise the overall flow of the application implementation. He is also meeting with board members of the company to report on the project's progress, and meeting with other participants in the overall change project for fine tuning. This role requires knowledge of the company's structure and its people, plus various soft skills in organizing them, as well as understanding the company's product portfolio and its future development. The project manager needs to know the business and how contemporary production functions today, as he maintains active contact with the software development team. Usually these people need to understand the obstacles and pit-falls in projects, especially those with a transformative character.
World perception: management focused; communicates to different levels and adapts quickly;
Average age: 40 to 60 with a good amount of experience in the field and the company itself;
Profession: graduate engineers in the field, often holding a research degree.

General Engineers:

These employees define and develop the operative processes. They are responsible for content development, and for setting up the (digital) production guidelines, as well as the product and quality assurance guidelines. They need to have a good understanding of the local production processes and routines, and the technology of this field. They have used (paper-based) production guidelines before, or know them well, in order to set them up in the digital platform environment. They report to the project manager and can work quite autonomously given the fact that they bring in the knowledge described above. Engineers develop technical requirements and solve complex problems.
World perception: technically driven; tend not to be flexible in their expressive capability;
Average age: 30 to 50 with a good amount of experience in the field and the company itself;
Profession: graduate engineers in the field, some hold a Master of Science degree.

Engineer as Key User:

One of the engineers was involved in the project from the beginning, and had used the software for one year before I was involved. After an initial training period and subsequent intensive use of the software in connection with the cross-platform implementation, he formed the core project team together with the project manager. In the text, he is not referred to as an engineer, but as Key User.
World perception: technically driven; some flexibility in expressing something, own view of affairs;
Average age: approx. 35 to 40;
Profession: graduate engineer in the field and about 10 years of experience in the industry.

Interns:

The company employs young people from the university on a temporary contract. Within this project, they photographed the work steps and help to collect information to be used in the MES application within the SOED. They also supported developing the templates and testing them with the production employees. They usually have good software skills but less detailed know-how on visualisation. They work for approximately 6 months and go back to their studies. Some also write their Bachelor's thesis within this context.
World perception: ususally technically driven; open minded;
Average age: usually between 25 to 30;
Profession: students of Mechanical Engineering or Business Engineering.

Production Employees:

The production employees use the MES application for tracking their production processes in detail. The work sequences existed before the project launch as paper-based production instructions and most workers knew the routines blindly. The sequences covered all levels of knowledge due to the fact that the employees at the shop floor often spend their lifetime working at that company collecting decades of experience. Consequently, there is a level of assets located in their experience such as insights, skills, and know-how.
World perception: practical, hands-on, use basic language and if there is time are open for a chat;
Average age: from approx. 25 to retirement;
Profession: unqualified as well as trained mechanical, electrical and polymer technicians.

Software supplier:

The software team (external) is responsible for developing the application, supporting the implementation of the complete technical back-end structure and managing the app's functionality. They settled the functionality of the portals and all detailed project requirements. They needed to solve upcoming technical issues during the implementation phase and later on. Usually they only reported to the project manager and used him as their voice to solve issues within the firm. Companies with such a profile are experts in their field and have highly-skilled manpower. Often they have collected long-term experience in other large-scale projects and companies in the field.
World perception: technically minded and time-is-money oriented; highly-specialized, less flexible but kind;
Average age: from approx. 30 to retirement;
Profession: graduate engineers in the field, may hold a research degree.

Design Expert (me):

For about 20 years I have worked as a visual designer and offer expertise on manual and guideline development to organisations. Usually these type of tasks take place when organisations aim to be or are in transformation. The expectations of the results coming out of a transformation project are high, and are connected with clear results. Often during the work process, the challenges that such projects bring become clear, as topics become visible that could not be reflected on before. In the case of the paperless project, there was also a clear result to be expected, but the quality of the result depended on the co-creative setting, in which the templates' and guidelines' content developed. To fulfil the job it was important to understand all user roles and their jobs-to-be-done. Needed to talk and work with people from all levels to find solutions.
World perception: technical affinity, value-oriented; specialized in communication, highly flexible;
Average age: 35 to retirement;
Profession: graduate and can hold a Master of Art degree from design and/or management;

Definition of Situation: In visualising the work steps (Sequence of Events) and laying them out in the MES application (Sequence of Event Design Portal), the project participants had to document the practical executed work steps precisely. The work itself had to be photographed, described and incorporated into the MES software as well as aligned to the existing production guidelines. To visualize the events with the MES software, the software suppliers set the visualisation system to a PowerPoint plug-in, assuming that all users (engineers) would be familiar with its functionalities and PowerPoint's own user interface.

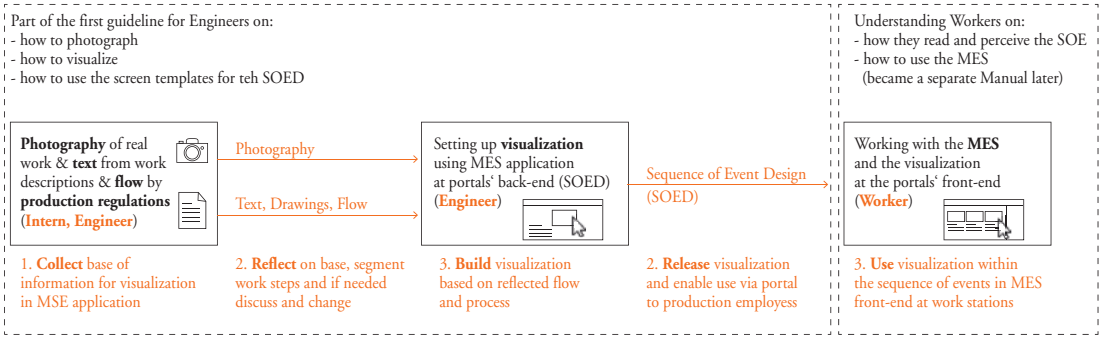


Figure 26: Showing the given task and working context (own illustration)

Problem space: During a closer look at visualising the production regulations, it became clear that the Key User needed support in developing screen templates for visualising the sequence of events. The need to hire an design expert in screen design and manual design arose when he understood that the organisation had neither visualisation skills in-house nor experience in describing a visual system. A professional should be hired to develop the screen designs to follow a system. Therefore, the need for templates was defined within the possibilities of the MES software and their documentation in the roughly designed SOE guideline that had already been started. To understand the requirements for the templates, the Users (production employees) had to be questioned, and protoype designs had to be tested in applied use cases displayed on the screens at the workstations.

Figure 27: Screenshot of first attempt of a visualization in the SOED portal

Figure 28: Screenshot of first attempts to the SOE guideline by the Key User using Power Point

The Key User started to develop some screen designs in a simple visualisation software and in PowerPoint, but soon realized that the output and the outcome was not satisfactory. They attributed this to a lack of expertise in screen design. The screens they created themselves seemed chaotic and overloaded. The production employees who would have to work with the virtual production guidelines need clear visual instructions and orientation in order to be guided through the work process fluently. In addition, the engineers who will feed the application with content need to use well-defined templates, which enable them to follow rules and that are easy to work with. The project manager and the Key User cared about a good solution as well, as it had implications on how the production employees (Users) will receive the detailed instructions on the screens. They also assumed that offering templates will help the engineers without visualisation experience, who implement the sequence of events, to create the visualisation more easily.

As the literature review showed, process documentation of this kind belongs to Technical Communication and indirectly Industral Knowledge Management. Scholars claim that regular use of knowledge and experience strengthens the values of individual employees and the company, especially when it comes to embedded and embodied knowledge. In addition, there are numerous contributions on how visual and interface design support the use of software at the front and back ends. The literature in Technical Communication pointed towards knowledge management connected with interface and user experience design.

Extended problem area: The objectives of the template development were to evaluate the placement of content in a PowerPoint template, to test visualisation methods that guarantee comprehensibility for production, to analyze the perception of information from the user's point of view, taking into account that production instructions are displayed on screens and to expand and complete the SOE guideline in the area of placement rules and visualisation methods. The roughly designed SOE guideline aimed to provide specifications for the placement of the content to the engineers who transfer the various elements of the product instructions into the software, to present the perception of the individual work steps in a clear, distinct, and quickly comprehensible manner, and to make the contents readable internationally, and comprehensible for different levels of education.

Challenges on the macro-level of developing the templates and completing the SOE guideline were:

- the organisation and the project team needed templates, which can be used internationally,
- the templates are used as work process support within production regulations that are heavily loaded with safety, security, quality, and technical requirements and,
- the templates should refer to the existing corporate design system of the organisation, which is a challenge, because the software supplier does not make any adjustments to the interface of the MES application and its visual modules.
- Employees at the organisation and in the paperless team were not used to working with designers, especially not with visual designers.

Challenges on the micro-level of developing the templates and completing the SOE guideline are:

- One core problem within the process of developing a visual system for documenting the sequence of events derived from the fact that the employees sometimes could not easily (or not at all) explain what they actually do. Most routines were executed blindly.
- In addition, they were not used to talking a lot and do not read much. They prefered easy language and straightforward descriptions and guidelines.
- The production employees and the engineer were not used to reflecting on visualised material. They usually felt insecure when asked for an opinion or judgement on something.
- Usually documentation in the organisation were written in MS Word. Handling pictures and various typographic levels were a challenge using this software for writing user manuals.
- The guidelines have to be maintained in-house.

6.2.1.1. Research Sub-question 1

My first objective is to understand how visual communication and design practice support individuals within an organisation to (re-)define their experience and knowledge better, as they might not be able to explain it in words that easy nor are used to visual tools. Furthermore, how creating layout templates and explaining their use and application to non-designers support employees in visualising their work. And, how a reflective practice should add up in an iterative process so that employees should be able to redefine and analyse work procedures by themselves. The first sub-question is: **How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?**

Study design and inquiry: I started my work by supporting the team with my expertise on writing manuals. I worked together with an intern on developing the first attempts at the PowerPoint templates. Conversations with the organisation's corporate communication department and the software supplier started to discuss the possibilities of implementing some visual adjustments at the front end. My plan was to start the structure of the manual using established design standards. I aimed to understand the new software by observing the Key User and the project manager. Material collection took place by actively writing notes during observations and discussions while working and testing out the MES application. I structured the various topics on organisational, conceptual and operative levels and made notes directly in the document. The assistant conducted two surveys on the templates. The first survey focused on reactions to the templates, the second was to find out how the templates are used in the application and whether the work step that had been visualised could be carried out. Finally, the first version of the chapter were created and reflected on with the Key User and the project manager.

Timeframe: Kick-off was in November 2017 and ran until end of June 2018.

6.2.2. Action Phase

I described the action, by outlining my attitude and comprehension towards the project and I differentiated between the description of what happend and the documentation of the evidence and evaluation of the action.

My attitude and comprehension: I planned to use my expertise from writing design guidelines and expected the project to be finished in a couple of months. Working with engineers required a new approach to collecting the relevant information in the form of text and images to develop the templates and their description. In addition, since the technical environment rarely involves visual design, I had to explain some of what I was doing. I also had to make sure that the documentation of the visual system was not in MS Word, but in Adobe InDesign, to give the results a visual solidity.

Description of what happened:

My activity: To develop the visual screen templates, I had to understand the production employees' perspective. Together with an intern, I developed example screen layouts for the production sequences. We had these evaluated by the production staff using a short but structured questionnaire. We verified the results by applying a utility analysis. After the first testing, we choose the best-rated template and compiled a version for a real production process. We tested it again to find out if the work result can be achieved. After evaluation, the screen templates were approved and set to be implemented into the MES application. By testing the example templates and the screens applied to a working process, all insights were consolidated. The final documentation of the visual system and its templates were easy to use at the end. Within approximately 4 months I gained insights into their production culture and into the functional structure of the new MES application, and developed a visual concept for displaying the Sequence Of Events on screens at the shop floor workstations. The familiarisation with the processes and learning the technological aspects on site took a lot of effort.

Process – General Settings: After project kick-off, the team soon realized that I work hands-on and prefer to participate at site. The project manager was used to experts who were not regularly working in the office in the organisation. In the first few weeks it became clear that working on-site could provide good insights and that the project team was comfortable with my presence and this type of collaboration. In addition, there was well functioning access to the MES application within the company's IT system. Setting up users for the application took several days, as the user profiles had

to be set up not only in the application but also in the internal network. Due to the company profile, I had to sign detailed documents about confidentiality obligations. This also had an impact on the possibilities of access to use the internal IT and the software usage rights granted to me. Access from outside was possible but the performance experience was not as good as needed, therefore I prefered to use the system only at site.

After the set-up, I was classified as an External Expert from the internal IT perspective, but had a user profile like an employee. Using the MES application from outside the company premises was difficult and needed further testing. The use of a Macintosh computer did not facilitate this process, therefore, I preferred to work on-site. Getting to know the production environment and its employees was another step that led to understanding the visualisation of the work processes.

Process – External forces: Sometimes there was a change in the software, as of new requirements. It affected the layout of the visual system and the templates, as there were decisions made regarding how to use the templates for implementing the sequence of events. It was decided to apply a PowerPoint plug-in and a reduced number of embedded symbols. Further interface elements were designed and the Software Company was asked to implement them. The project manager and the Key User stated that they “like to make it right” (Chapter 10.1 Selected Material from Participants) and that they trusted my proposed modification to the software interface. Most of the modifications were not accepted by the software company. After, they started to ignore any further requests regarding interface design issues.

Process – Results: I accomplished and delivered a design manual of approx. 20 pages, based on the corporate design guidelines. In addition, I introduced another chapter of approx. 40 pages on photography, for assistants who photograph the work sequences. As photos are needed to visualise the work process and the sequence of events, another colleague developed the content for this part. I fitted it into the then new official guideline structure and language. I was happy to deliver all the new chapters of the SOE guideline, but at the same time I didn't feel satisfied, because most of it seemed too designed to me. As I experienced a deep dive into new terrain and started to understand the depths and reach of the paper-less project, the new chapters seemed somewhat superficial to me. On the other hand, the project manager was positively surprised about the visual quality of the manual and he stated, that “It really looks great. You showed that you can do it. It should be clear for others

too." (Chapter 10.1 Selected Material from Participants). After documenting the templates, the Key User tested the visualisation chapter and laid out several work steps based on the specifications. This worked reasonably well, as questions kept arising while working with the templates and the recordings. The Key User was in frequent contact with me. The description and also the templates were revised again based on his experience and for various technical reasons. The crucial stage was then to test the description of how to use templates to create a Sequence of Events Design with freshmen.

Process – Consequences: The first consequence of the initial results was a decision that a manual should also be created for the production employees. They were to receive support in using the new digital environment. Besides the templates and its documentation in one part of the SOE guideline, a second manual for the production employees was scheduled. This new scope aimed at the production employees' needs to link into the system and use the MES application as a step-by-step walk through. Following this, the company ordered more support work for more manuals and my contract was extended. I needed to develop a structure for understanding the relationship between the digitisation and the software. In addition, I started to research technical communication. At this point of time in of my role as design expert, I became an insider, but did not realize this. The project manager once mentioned at the end of this first part, that "you know much of that what we do, you use the right language." (Chapter 10.1 Selected Material from Participants). I realized that I operate with tacit knowledge such as know-how, process skills and applied intelligence, which is hard to see at the start of a project, when not coming from the same field or having the same experiencial background. From these results and conclusions it became clear that there was more at stake than the development of a visual system with screen templates. Interaction with team members allowed for active reflection and the templates created and the new chapters functioned as boundary objects. This is documented in the chapter 6.3. (Action Research Cycle 2).

Evidence from interaction with manual material, templates and various users:

Evidence is given for two objectives. First, the development of screen layout templates and of a visual concept. Second, the extension of the SOE guideline by a description of how to use the templates and how to visualise a sequence of events in the MES application portal sequence of events design (SOED).

6.2.2.1. Evidence from First Objective

The first task was to develop the visual system and to understand the best way to use pictures and their display mode. For testing, we used example work steps, but not complete sequence of events. Within the second testing, we used a complete sequence of events applied to the preferred layout and display mode with production employees by letting them run through one round. The results should clarify whether the intended work result can be achieved by following the instructions.

Template types in two rounds of testing: The templates offer placement of photography, drawings, text, numbers and arrows to guide the production employee through the event, including the physical movements. In some instances, additional icons were needed to visualise preferred materials or tools. The template should lead the production employee through the sequence of events step-by-step. Three templates using three visualisation methods (a) pictures only, (b) pictures & exploded views, and (c) pictures & CAD views had been developed by an intern. Applying the three variants to three visualisation methods produced nine versions all together. For the first testing we asked the production employees 16 questions. The questions followed, for example, the perception of the sequence shown, the visibility of different work steps, the comprehensibility, or the length of text.

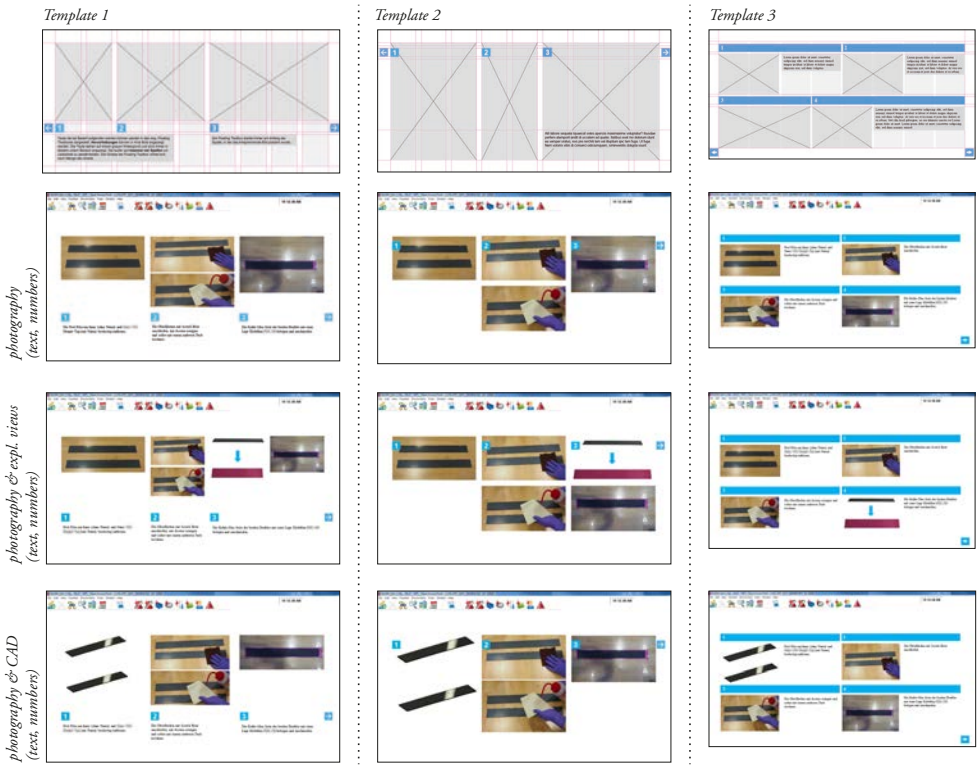


Table 14: Examples of screen templates and layouts tested in first round

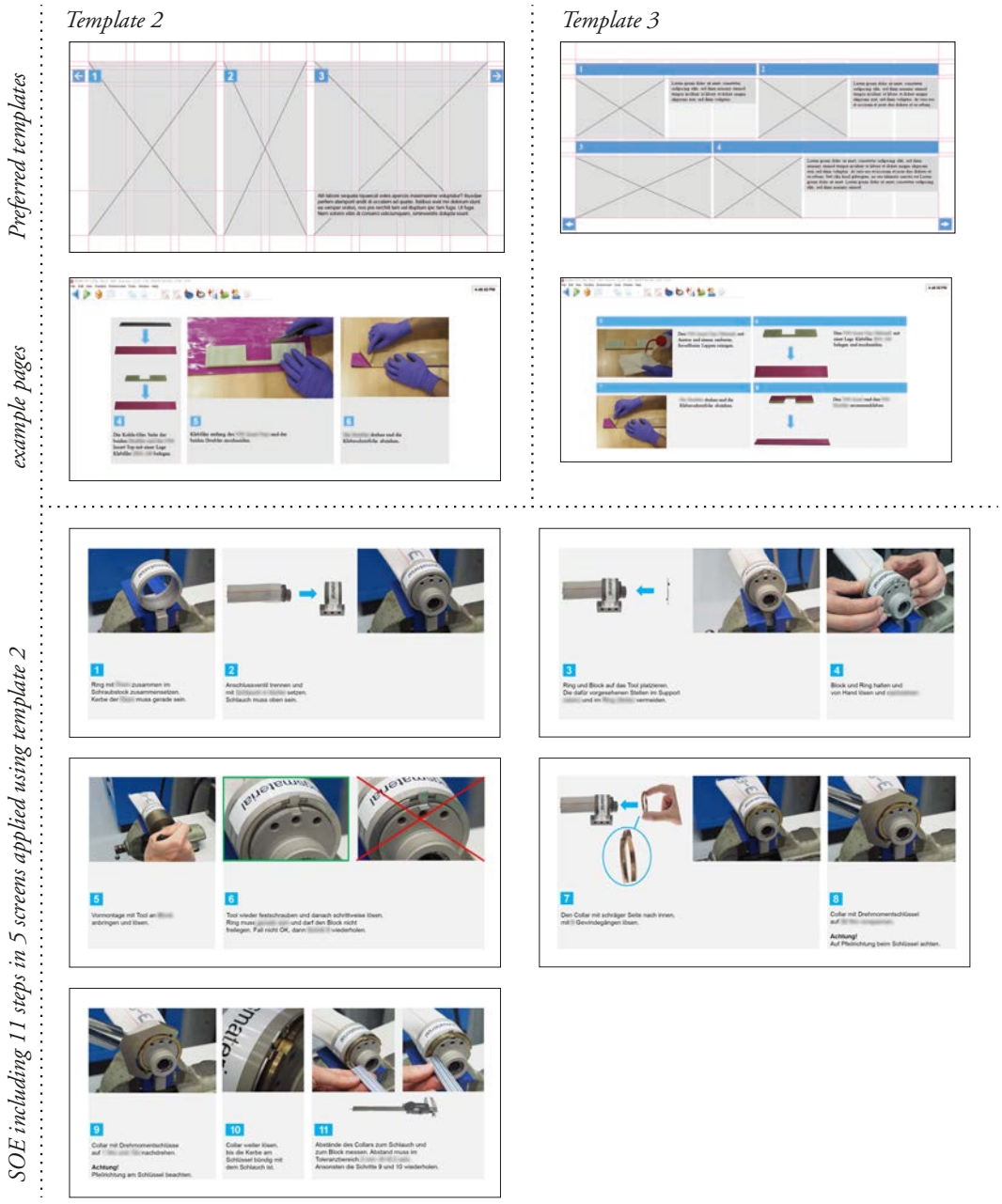


Table 15: Examples of screen templates and one of the two SOE visualizations

6.2.2.2. Evidence from Second Objective

The second objective focused on the iterative development of the SOE guideline. This needed to document and explain the use of the templates, accessing them via the MES application, linking pictures and icons, and how to lay out a sequence of events.

The extension of the SOE guideline for the engineers included the following aspects: First of all, the approach on how to visualise a sequence of events based on the production regulations had to be defined. Second, a basic introduction of how to use pictures, text and further visual elements was needed, as the engineers usually do not have skills in visualisation. And third, the operative aspects of how to photograph and how to use the screen templates for creating the visualisation of the SOE had to be illustrated. And last, how to access the template and its variations, icons and symbols, as well as the pictures taken on the shop floor, and how to feed text into the MES application had to be illustrated by a step-by-step description showing example screens.

The development of the visualisation chapter took many turns. Approximately 15 iterations were neccesary. In 2018 there were about 9 files developed and for each change request it was not set up separate new files. The change requests are mainly rooted in the change of the MES application and during the process the needs and depths of explanations are developed.

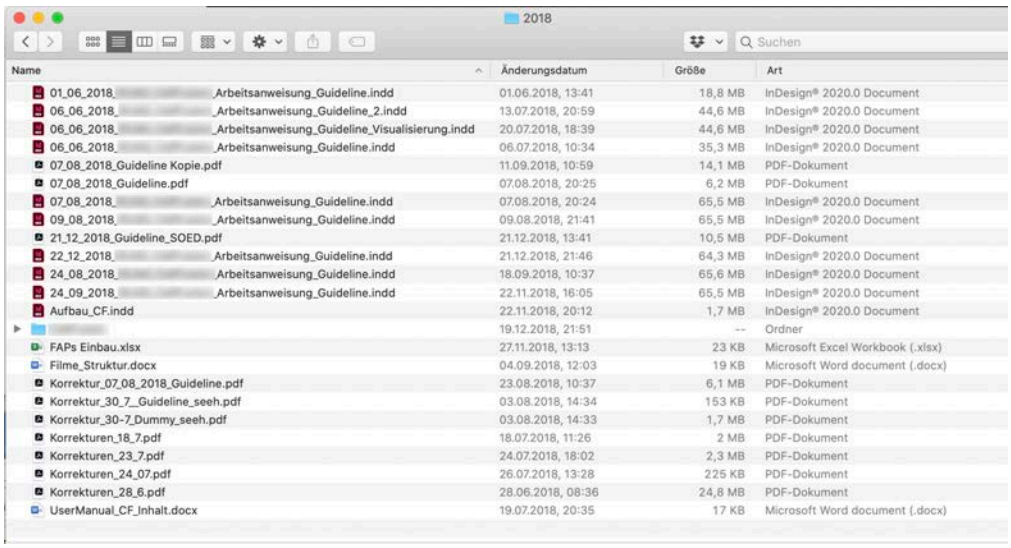


Figure 23: Screenshot of folder content showing file versions in 2018

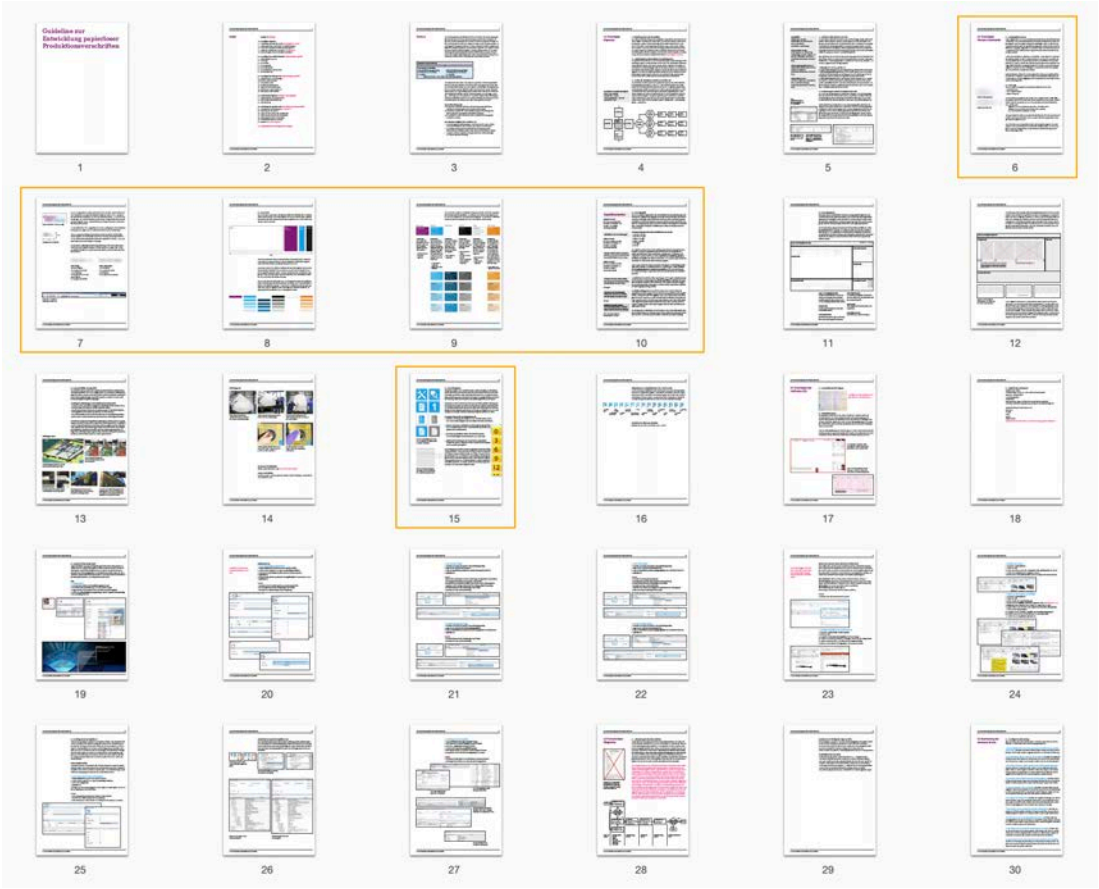


Figure 24: Screenshot of fist file developed in the first weeks

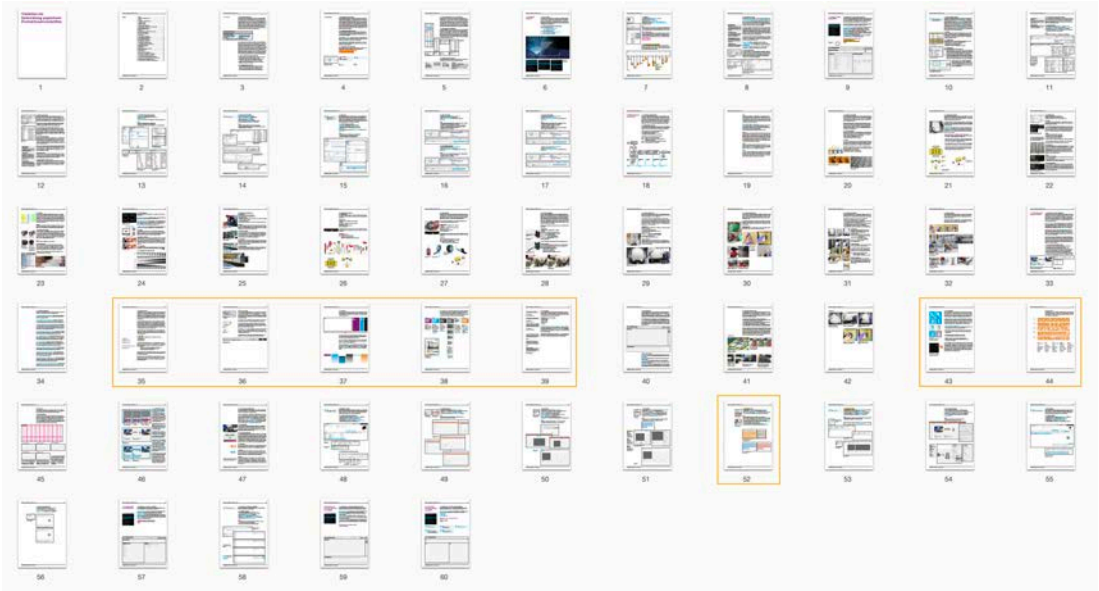


Figure 25: Screenshot of fist file developed in the middle of AR cycle 1

The screenshot shows that all pages developed in the first file had a series of iterations. Initially, the focus was on the development of a visualisation concept, taking into account the existing corporate design and showing several pages of explanations of the same. Later, these efforts became less and less important, as design specifications were not implemented within the MES application. Moreover, it became clear that the explanations of how to create the visualisation were the most important part, especially taking into account that these jobs were to be done by non-designers.

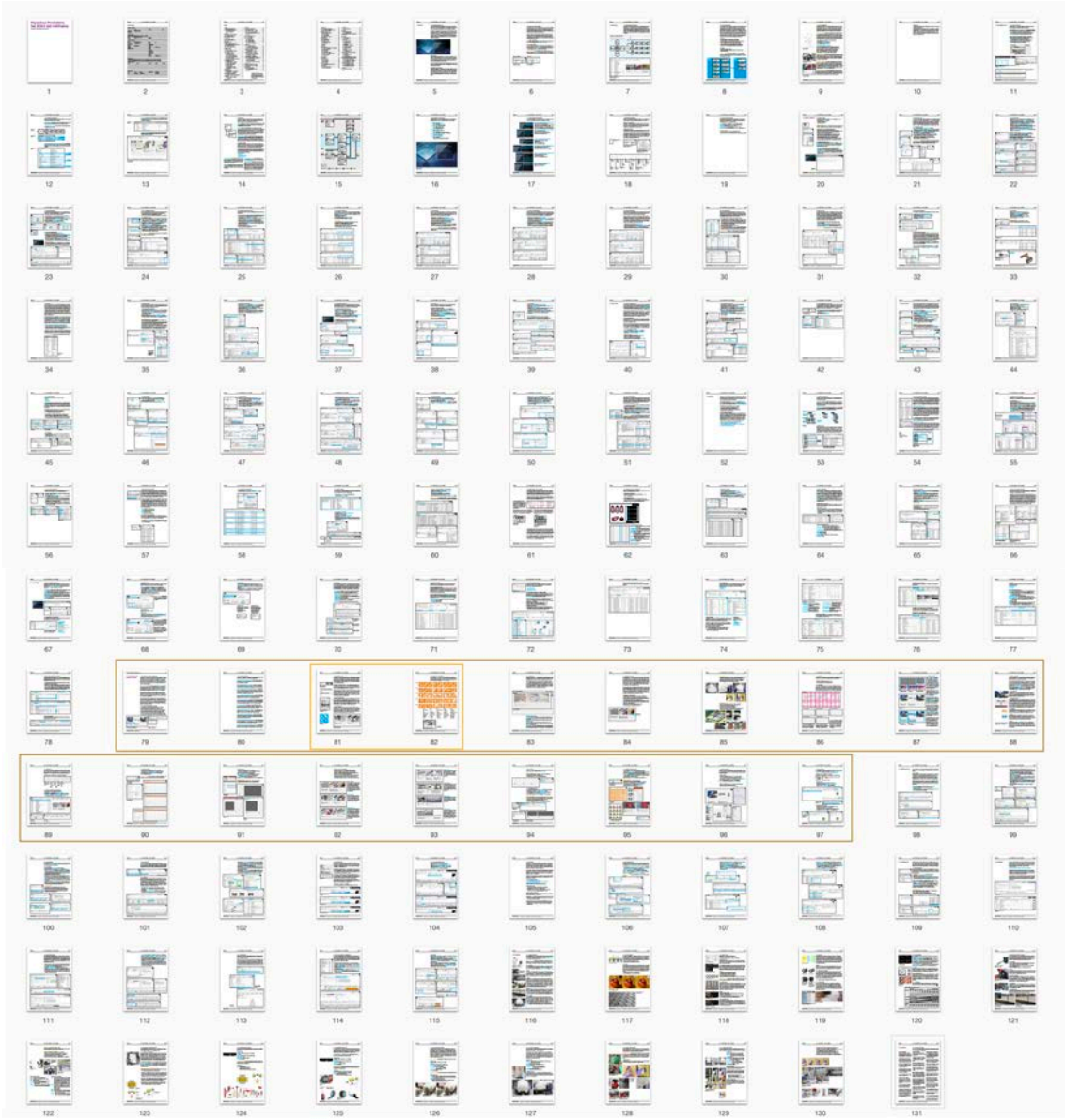


Figure 26: Screenshot of pages from one of the last files SOE guideline

Beginning of project phase one: 6 of 30 pages related to corporate design topics.

Middle of project phase one: 8 of 60 pages related to corporate design topics.

End of project phase one: 2 of 19 pages explaining visualisation related to corporate design topics.

The rest of the document containing 131 pages refers partly to an explanation of the MES. Figure 26 shows that the visualisation chapter (outlined in dark orange) of the document, is a very small portion and that the information about the corporate design has shrunk down to just 2 pages (outlined in bright orange). At this point, the document is mainly characterised by system explanations, the presentation of the basic elements of the SOE, the SOED portal, and instructions for photography.

6.2.3. Analysis Phase

I analysed the material from the empirical material, by using in-vivo coding and the document analysis. The in-vivo codes were tagged by predefined keycodes. The visual material was tagged using page types and document structure. In this first analysis, I identified certain patterns in the pages that lead to page types being specified from them. In the following analysis phases, I always refer back to a specification. In order to be able to follow the flow of the argument, the *interpretation* as well as the *critical interpretation* followed one after the other in each event after the *interaction* of the two material types. At the end of each section, the evaluation took place.

6.2.3.1. Interpretation of In-vivo Codes and Memos

During the first cycle, I noted quotes that refer to the fact that I was present in my role as design expert. I collected the Key User's reflections upon this comprehension of the new MES application and how he was using it. Especially when he started to talk about the usage, he mentioned how he learned by rebuilding processes in the digital environment. The engineer said, "It took me one year to understand the new software within this context. To shorten this, one has to know what needs to be rebuilt [as a request for a guideline]." "It takes a while to learn how to rebuild a process in another environment, in this case a year in the digital environment." The project manager quotes refer to the engineer's activity, as well as their interaction. He refers to many situations, while the engineer explains his approach in using the MES application for visualising a Sequence of Events: "… , he [the engineer] always clicks back and forth and that is the solution for him. But I don't understand anything." The project manager also reflected on the project in general and claimed that: "Transformation of a work process is a rethink. Writing down before rebuilding a process. Maybe it is not relevant which software system [related to the MES] we use, but working with it will show you what you really need. There is a process to gain structure." (Chapter 10.1.1. Material from AR1).

When discussing the manual pages with the project manager, he said, “Always ask yourself, what does a person see, who is a freshman. Also, the roles must be clearly distinguished through different use of text, style and depth of content. Look through a freshman eye.” After the first versions of the chapter, he realized, that “before I only ever clicked somewhere unconsciously. Now I make almost every step much more conscious.” He also comments on his attitude towards visualisation that “I like to sketch. If I look at it, I reflect and learn. I guess I am a visual person.” (Chapter 10.1.1. Material from AR1).

In my role as design expert I reflected, that “After a while, it became obvious, that I am working with people, who are significantly showing signs of tacit knowledge along the issues of being unable to explain what they know and do.” While time and momentum were things I was looking for, I recognized that “It takes time to access the complexity of the project, but also to grasp the skills of the people.” In addition, “In knowledge workers, there is no patience. Their working goal is important for them. All these things become clear when they start to write them down.” (Chapter 10.1.1. Material from AR1).

Theory says that the retrieval of long-term memory takes at least two weeks. I realized that “design skills are only available at various moments of the process. To find the structure, one need relentless investigation in the understanding of the expertise”. Regarding the appearance of shape, I noticed that “the shape of the knowledge is unknown until there is in-depth retrieval of content based on team negotiation and active retrieval work. It needs patience and courage.” (Chapter 10.1.1. Material from AR1).

The special momentum takes place, when “mirroring the skills of each other supports the finding of expression. The person with communication skills meets the person with project based skills”. In general, “visualisation has a strong impact when using simple colour codes.” And “skills relate to various levels (people activities vs. digital systems’ automatic functions). Diagrams can play an important role in finding a structure, hence there is tacitly meaning liked to the visual and explicit level. It needs flexibility in creating different versions with different meaning.” What a designer or a manual expert needs seems to be “a fundamental interest in complex settings and the topic itself.”

Interpretation of the Engineer's and the Project Manager's quotes: The egineer clearly indicated that he needed guidance by rebuilding an example or by a description. This meant that the necessary activities for reproducing a work process could be shortened by adding some form of assistance. The Super-Key-User, on the other hand, had trouble understanding his colleagues' embodied clicks. He used text first of all to rethink rather than transform through failure. There is a process and a structure to be followed within the system, this helped him to rethink. The roleplay is important for reflection and defining content and appearance. The reflection helps to leave the unconscious state and move towards a conscious understanding. Sketches supported reflection and learning.

Interpretation of the design expert quotes: It needed time to see tacit knowledge and what people know. When knowledge workers started to write a process down, the knowledge became accesible. The use of design skills was required at certain points in the process. Mirroring skills is co-creative and results in a form which can be shared. The quality of the service supported the application of the design skills. Diagrams gave structure as they are authored by tacit knowledge. The fundamental interest and the flexibility of the design expert had its outcome in the different versions of the manuals.

Critical Interpretation: Time is a very important aspect in discovering the tacit knowledge the workforce has. Some said, that they needed about a year to understand the new system and its context. Equally, the design expert needed time to gain an understanding of the workforce's tacit knowledge in order to tackle it and record it effectively. The inability to explain one's actions is a sign of tacit knowledge and automotor memory. Simply imitating it does not support the truth of a working process. The process is structured by a rethinking of some activities and by rebuilding the process through several iterations. The design expert's visualisations to externalise this tacit knowledge changed what were unconscious actitivies into actions that were reflected upon. The visualisation in the manual enabled the existing staff as well as freshmen to test its validity and practicability. The educational quality of the externalisation by means of text, diagrams and other visual means would be evaluated through a freshman's eye. The process of developing the visualisation, based on the reflections of the participants, was a long one. It was based on iterative reflections of the visual representations, where diagrams played an important role. The duration is structured by reworking and reflection. From the client's side, it seemed, there was a high demand for the educational support offered by design practice.

Given the fact, that knowledge workers usually have little patience in explaining their skills, it becomes very difficult to access tacit knowledge. Within the team, there were different people with different skills. The Key User was not able to explain his expertise, but the Super-Key-User had the task of understanding him in order to develop the manuals. Therefore a certain relationship was needed in order to get access to the knowledge and to rebuild it in the manuals. Without the Super-Key-User, the development of the manuals against this background would not have been possible. The Super-Key-User needed about 2 weeks to understand certain working processes and to rebuild them as well as visualise them in a draft. This whole process was structured by relentlessly shaping and reshaping his findings in a visual way as well as reflecting on them. Once the working process between the design expert and the Super-Key-User started to be fruitful, it took two to three weeks to develop one manual sub-topic. From earlier investigations with students to understand the impact of visual design skills, the diagrammatic way of expressing expertise seemed to be very appropriate. To develop an educational visualisation takes time and flexibility in applying visual means, as well as a fundamental interest in the complexity of a topic.

Evaluation Interpersonal Communication: During the months of collaboration, a culture of cooperation was developing between the paperless team members and the design expert. It became clear that the resulting chapter of the SOE guidelines was helping to drive the digitization process forward. The chapter served as a clarification tool between the team members as well as between the team and other employees in the company. The document developed into a clarification document due to its numerous iterations. This clarification helped all participants to better understand the topics being visualised, and also to make different levels of working knowledge visible. The nature of the working knowledge that became visible was on the one hand embodied and on the other hand of embedded. It was accompanied by explicit elements, such as already-defined processes within the paper-based production regulations.

- ➔ The culture of communication and sharing documents supported the project's progress.
- ➔ Using the document as support for reflection helped to detect working knowledge.
- ➔ The document iterations gave a voice to people who had difficulty expressing themselves.

6.2.3.2. Interpretation of Interaction with Material from Templates (both rounds of testing)

The results showed that the production employees prefered templates 2 and 3, using pictures and exploded views as needed. I also recognised that the information clusters representing one single work step containing picture, text and number elements needed an additional visual support. We decided to background the cluster with a light gray area to create a visual link between all the elements in the work step Within the second testing round, we used the choosen template and method to question the comprehensibility of a use case. We choose one event divided into 11 work steps displayed on five screens and tested two layouts.

In the second testing we observed whether the visualized tasks could be easily understood and accomplished. It called for the observer to have a better understanding of each processto detect issues within the visualisation. Steps 3, 7, 8 and 9 indicated some issues. By interviewing the production employees we established that the production employees had problems with the exploded views, mainly connected to the fact that this kind of visualisation was unfamiliar to them. We decided to keep the layout method and use this last prototype. The Key User and I then started implementing the templates into the MES application. In parallel, I started documenting the visual system.

Evaluation Screen Templates: Through the employee surveys, fundamental themes emerged for the visualisation and the development of the screen layouts. The presentation of the work steps within the SOED helped the production employees to visualise the goal of the paperless project. They could express their concerns, but at the same time indirectly shared their experiences in the context of work. The nature of their reflections also made clear the diversity of perception. Testing led developing the screen layout templates in the right direction, whilethe visual skills of the design expert helped the layout templates to emerge faster. Changes on the screen layout affecting the software supplier's interface were not implemented.

- ➔ Production employees shared their concerns more by showing than by explaining.
- ➔ Their perception and reception was different from the people in the paperless team.
- ➔ Visual design expertise was welcome in the team as it supported imagination.

6.2.3.3. Interpretation of Document Material

At this stage of the development, there are three kinds of page types focusing on *corporate design*, *visualization explanation* and *application explanation* page types.

Description of screenshots of page types (below)	**Page intention and use of graphical elements**
Page Type 1: Corporate Design Page – Explaining how the CD elements shall be applied in developing the visualisation of SOE within the MES application.	Intention: directive. Elements: CD elements, headline, descriptive text, caption
Page Type 2: Visualisation Explanation Page – Pages guiding how to visualize SOE using photography, templates and the MES application.	Intention: informative-integrative. Elements: screenshots, photos, explanatory text, caption
Page Type 3: Application Explanation Page – Content explains interface, functionality, workflows within the MES application.	Intention: directive. Elements: screenshots, headline, descriptive text, caption

Table 16: Page-types in visualization chapter of SOE guideline

Corporate Design page example 1 *Corporate Design page example 2* *Corporate Design page example 3*

Visualization Explanation page example 1 *Visualization Explanation page example 2* *Visualization Explanation page example 3*

Application Explanation page example 1 *Application Explanation page example 2* *Application Explanation page example 3*

Figure 29: Sample pages

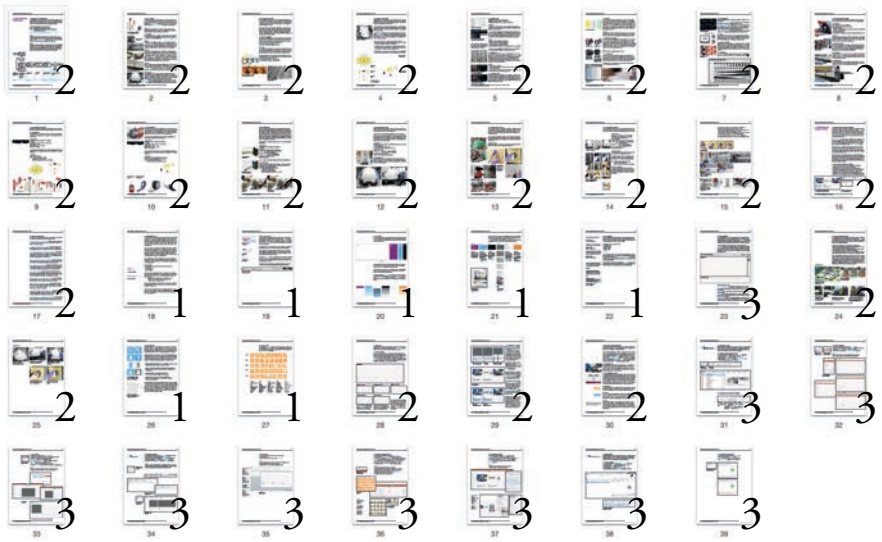


Figure 30: Collection pages of Visualization Chapter

Page types used in the Visualization Chapter	**Page intention**	**Value**
Page Type 1: Corporate Design Page	Intention: directive	7/39
Page Type 2: Visualisation Explanation Page	Intention: informative-integrative	22/39
Page Type 3: Application Explanation Page	Intention: directive	10/39

Table 17: Share of page-types in visualization chapter of SOE guideline

In the course of the first phase of the project, it became clear through the work in the document that it was not primarily a matter of applying the corporate design to the MES application. The guideline evolved from its initial focus on pure screen design to a chapter within the SOE guideline that deals with the creation of visual content in the templates, and the use of the templates in conjunction with the MES application. It also became clear that it can be used as a medium for reflection, filtering and making available the design expert's expertise on visualisation.

Critical Interpretation: It became clear in the first week that the design specifications would be difficult to implement in the MES application, mainly because the software company did not support this. Therefore, the application later focused only on the corporate design colors in the templates. The specially developed icons, whose style is based on the corporate design specifications, were also implemented, but are rarely used. This also shows how difficult the topic of visualisation is in the everyday life of engineers. Without experience in visualisation techniques, they fall into old visualisation patterns. The templates developed limit the freedom of variation somewhat and the explanations about the visualisation principles should offer support here.

Evaluation Documentation (SOE Guideline): It also became clear that the development of a corporate design manual for the MES system is not needed in this context. Only a few parts of the official corporate design find their way into the application's backend. The guideline in the delivered form was accepted, since the presentation quality of the document follows the general corporate design guidelines. Besides, it is recognized that the guideline, through its visual and its didactical structure, can also address subjects other than purely design topics for the MES backend.

- ➔ Corporate Design is just a side effect, but it supported general acceptance of the document.
- ➔ The *Visualisation Chapter* changed towards instructing non-designers to work visually.
- ➔ The visual and didactical structure provided a good basis for more and different content.

The development of pages dealing with visualisation was important, as it showed non-designers how to approach visualisation, addressing a new kind of perception. The chapter on visualisation therefore deals mainly with the specifications of how to represent work processes within a MES system. Through the instructions on how to operate the design of the SOE, it became clear that the first and most important aspect of the paperless project was to prepare work processes for the digital instructions, and to understand what could go digital from the real work settings.

- ➔ Instructions for non-designers addressed the differences in their perception.
- ➔ Engineers also showed a different perception and lacked the ability to explain their expertise.
- ➔ Understanding and analysing real work settings before going digital with regulations.

6.2.4. Conclusion Phase on First Objective

Based on the prior analysis phase, this phase reflects on the first objectives and its sub-question followed up with a general conclusion and a proposal for further activity.

How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?

(a) How does visual design practice support individuals within an organisation to (re-)define their knowledge, when they are not able to explain it by words nor visually?

(b) How does creating layout templates and explaining their use and application to non-designers support employees in visualising their work?

(c) How does a reflective practice add up in an iterative process so that employees should be able to redefine work procedures and express themselves?

The visual templates were required for a structured display of the sequential work steps (SOE) at the workstations. The templates were part of the visualisation implementation in the MES application. The *Visualisation Chapter* of the SOE guideline documents and explains the visualisation and the templates. A visual system was needed because production workers should be supported to understand the production controls on the displays at the workstations. Therefore, the development of the templates supported the process of execution. The documentation, on the other hand, enabled the engineers to develop meaningful information clusters and visualisations for production, and was thus largely responsible for the success of the transformation project.

➔ The design expert was therefore important when it came to developing a visual system and providing various appropriate formats for it. The design expert provided a specific solution or result when there was no internal competence to do this.

The development of the visualisation system and also its explanation in the guideline was the responsibility of the external design expert. The design expert relied on input and active reflection from the production staff and other team members to develop a working system and well-reflected guideline pages to ensure that the templates and the *Visualisation Chapter* worked.

➔ In order to develop the templates and the eesign expert depended on an active exchange between the team members. This exchange needed to take place constantly.

Prior to working with the design expert, the workflows and regulations were documented using MS software, i.e., MS PowerPoint and Word, specifically any guidelines or other documents were written using MS Word. Implementing the templates into the MES application allowed the engineers to visualise the work sequences as they can use PowerPoint within the MES environment. The policy itself was written and designed in Adobe InDesign, which was largely foreign to the staff.

➔ The closed document type (Adobe InDesign) allowed the Design expert to control the process and also set timed highlights.

Most staff and the software supplier graded design guidelines as impractical, and the internal corporate communications department had little involvement in the project. Visualisation culture was fed from CAD drawings or employees used simple drawing tools from MS PowerPoint or Word. Thus, the environment was predominantly characterised by technical representations. Corporate Design specifications were usually not applied in technical documents, or only in a rudimentary way and the documents reflected industry-standard information categories. Prior to the paperless project, run cards and paper-based production instructions were used for work step documentation. The instructions were developed by engineers and then used by production workers.

➔ The technical environment, which is not very inclined to design, lacks access to the free use of visual techniques. It is precisely then that experts become important: firstly, when they can explain something visually at the moment when words are missing; secondly, when the visual culture does not practically allow for visual experiments and, thirdly, visual experts become important when they point out things that were not visible before.

When testing the screen templates, production workers had to be interviewed. They had to go through the tests twice. With the introduction of the MES application, the engineers had the task of integrating all previous paper-based and the later new production rules into the digital *Visual Lean* concept. Therefore, the guide was tested with the production staff to ensure comprehensibility. The project manager supported the development by organising the intern in the creation of the different screen masks and making sure that both the production staff and the engineers had time for the tests and interviews. He was also responsible for setting up the accounts in the MES application.

➔ The design expert visualised different levels of work and, by conducting interviews and incorporating the results, enabled the manuals to be improved for all stakeholders.

Conclusion: The visual layout templates had an impact on the visualisation. On the other hand, the use of PowerPoint for layouts, which is not typically used by design experts, enabled the engineers to use and implement visuals in the new system. The technical mindset speaks a different visual language, but the effect of the templates and some icons were recognised. Detailed design work could not be done by an engineer or the project manager, but the templates allowed users to design the SOE experimentally, as they tended to struggle to visualise what they were doing. Therefore, the templates offered them a way to reflect on their visualisations multiple times. At any of the moments described above, the team was grateful for the visual support the design expert brings to the table. Production employees welcomed their involvement, even if they had difficulty explaining their impressions. Results from the tests showed a different perception than the design expert or engineers. This became even more evident when the production manual was tested at a later stage. The development of the instructions on how to create a visualisation using photography, templates, icons and colors developed differently than expected. While the corporate design aspects became ancillary, the explanations formed the bulk of the content in the *Visualisation Chapter.* By respecting the technical visualisation culture, the instructions needed to be clear and simple. The culture required more effort and there was a great need to support engineers who lacked the ability to visualise. The iterations of the chapter gave a voice to the engineers who had difficulty expressing themselves.

How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?

(a) How does visual design practice support individuals within an organisation to (re-)define their knowledge, when they are not able to explain it by words nor visually? **It became apparent during the development of the manual that presented visual proposals and iterative reflection helped to express and make visible what was difficult for the engineer to express.**

(b) How does creating layout templates and explaining their use and application to non-designers support employees in visualising their work? **The design expert and the templates were supportive for employees, when the use was explained iteratively, slow and visible.**

(c) How does a reflective practice add up in an iterative process so that employees should be able to redefine work procedures and express themselves? **The *Visualisation Chapter*, and more generally the document as such, had a knowledge visualisation character through its use. Afterwards, it would be considered as a final manual document and the reflective character would be experienced again at any time when the document was edited.**

The need for further activities: These answers provided the ground for deeper investigation and understanding of people who can redefine their knowledge capabilities and find their values within an organisation. The established communication and document sharing culture supported the progress of the project. Using the document as a reflection layer helped to indirectly capture each engineer's experience. On the one hand, the applied corporate design supported the general internal acceptance of the document design, even if it was not relevant in the MES application. On the other hand, the visual and didactic quality provided a good basis for further different content, especially in the context of a complex system.

This led me to continue the investigation about the nature of the document within the team setting and focus on the diverse information structure. Especially in this highly technical environment and the different work levels with different capabilities, it was about understanding how different the communication and work structures were. In this relationship, it was therefore also essential to ask what a visual designer needed to know about this complexity and diversity in order to be helpful as a support for the transformation process.

As part one of the paperless project was successful, I was able to establish a follow-up contract to continue the work with the team and the forming of more manual content.

6.3. Action Research Cycle 2

6.3.1. Planning Phase

I planned this second cycle by updating the basic project outline, the participant roles and, departing from my second research inquiry, I described my study design and the timeframe. Based on the findings and conclusion from the first AR cycle, I aimed to understand how the document development supports the process of expressing knowledge to understand routines and approach knowledge management. Based on my second proposition, I assumed that facilitation by using iterations of the guidelines supported the employees by reflecting their declared and undeclared knowledge. The overall purpose of this second AR cycle was to understand and enhance the practice of a knowledge sharing culture within the complexity of the project environment and to understand knowledge sharing, reflecting and expressing. By using the guidelines as matter for reflection, it was seen as a boundary object between project members, as well as a boundary with the design expert. It became necessary to update my role, expanding my technical communication skillset to meet the new tasks, and the development of the SOE guidelines.

Project task: The tasks in the project were extended in such a way that I became responsible for the development of all guidelines. Four different guidelines were defined, each for different user groups. The SOE guideline for the industrial engineers, the production manual for the production employees, the product assurance manual for the quality assurance engineers, and a system configuration manual for project managers.

Project context information: The installation and testing of the application had already been underway for many months. The first test phase in the so-called Productive System was in process, i.e., the first steps had been implemented in the application and could be tested in production with production employees via their portal, the FMBD/VFPT (manufacturing portal). The goal of the second phase of the project was to filter the results from the tests and incorporate them into the SOE guideline. In parallel, a manual for the production staff should also be developed. For this, the design expert was further commissioned, beyond the development and description of the screen templates. In the course of the second phase, it turned out that already developed guideline chapters have to be rewritten, since adjustments were necessary in the application. In many cases the rewriting included several reflection meetings with the client. The adjustments were made based on various decisions as well as findings about routines.

Project participants: In this second phase, I worked mainly with the same people, but the order and focus shifted to interacting with the project manager (Super Key User), industrial engineer (Key User) and the production employee (User). My assignment was to further develop the SOE guideline that would serve as a reference for engineers to create the production documentation for the production employees using the MES application from scratch. Based on numerous conversations with the Key Users of the software, I iteratively created a guideline, which was primarily based on the knowledge and experience of the first intensive examination of the program in the company. The production manual was also more than just a software user manual, as it included the experience of Key Users of the company, who started the project and settled the software in its production environment. I understood that my work was documenting organisational knowledge and that I actually started to visualise the expertise of these Key Users. My role changed due to this contextual setting and therefore, the role of the design expert was redefined and described.

Design Expert (me):

Based on a good working relationship, I was able to build trust with the local staff. During the first phase, I became interested in technical communication for the development of manuals. I learned about the standards relevant to this type of document and was able to familiarize myself with a new field. My role as an expert changed and I was able to apply my years of experience from working in higher education teaching. The combination of technical communication and didactic experience gave me the opportunity to bring both into this phase.

Experience in lecturing: approx. 20 years

Experience in the development of manuals and design guidelines: approx. 25 years

Experience in technical communication (TC): none, only information design, which has tended to be perceived as a rather marginal area in technical communication. Today, the focus in the field is more on the area of user experience.

Definition of Situation: There was no competence nor time in the team to deal with the description of the program operation. The project team recognised my ability to write guidelines and present them in a way that helped the team position itself well internally. The guideline, or rather several guidelines and manuals for different user groups, were to serve the users but were also proof of work. The experience using the application gained by the Key User was mainly linked to only one person. However, this person had difficulties in explaining and presenting his knowledge. The project manager, the Key User and I decided upon various manuals to be developed. The manuals had to be written to technical communication standards following basic corporate design rules and should be tested with the various user groups while being developed.

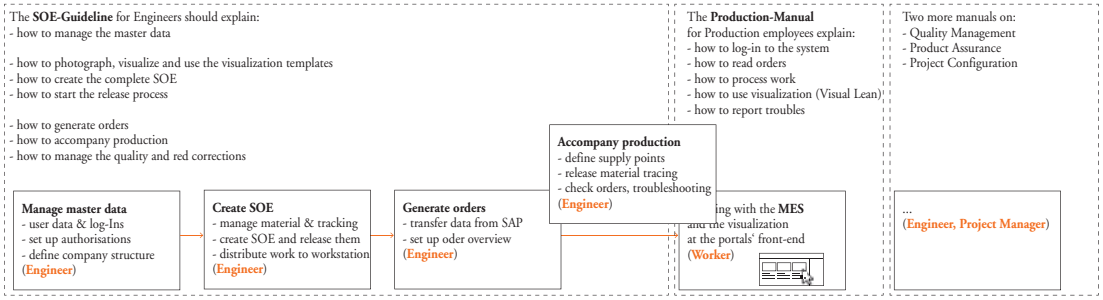


Figure 31: Showing the extended tasks and the defined guidelines to be developed

Problem space: The existing work procedure descriptions in form of the production instructions and the run cards for traceability were to be replaced. This was to be achieved through the MES application and there was a need for manuals, as the software company did not offer detailed manuals. In addition, the team decided that they wanted to use detailed manuals compared to the existing commented screens from the pilot project.

Futhermore, the attempt for detailed manuals was important to the project manager, as it had an impact on a number of other issues. He believed that by resolving the complexity, the project would see a fundamental clarification of the implementation processes in the long term. In addition, without any outside help developing the manuals, the company would only have created MS Word documents. The project manager told me that “the Word files would simply get lost in our digital clutter and no one would be able to find them again. Also, we would have no evidence of our work and no way to store or communicate our experience and skills” (Chapter 10.1. Selected Material from Participants). This was also a concern for the Key User, who also recognised the problem of not being able to explain his routines in software use well enough.

Yellow picture represents a running cards system, pages to the right are page examples of a production instruction manual – both represent the system which was used until the paper-less project started (Figure 32).

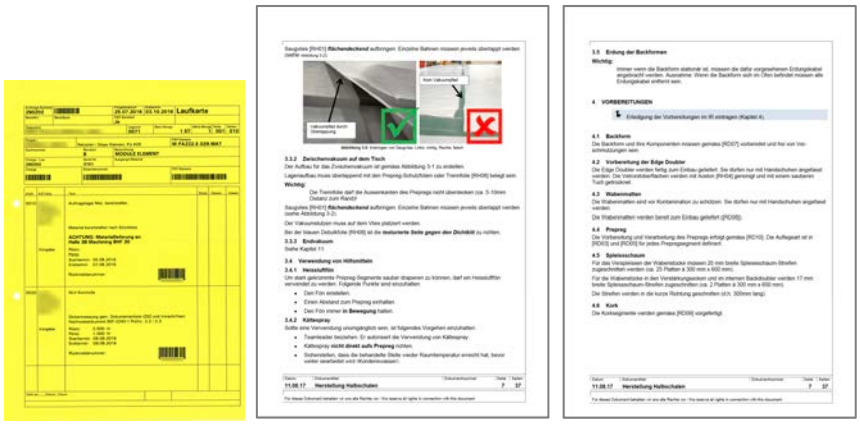


Figure 32: Runnig card (left) and sample pages from production regulations (right)

Dark screens produced in the pilot plant show an attempt to explain the MES interface. The white screen shows an example from the software companies earlier projects (Figure 33).

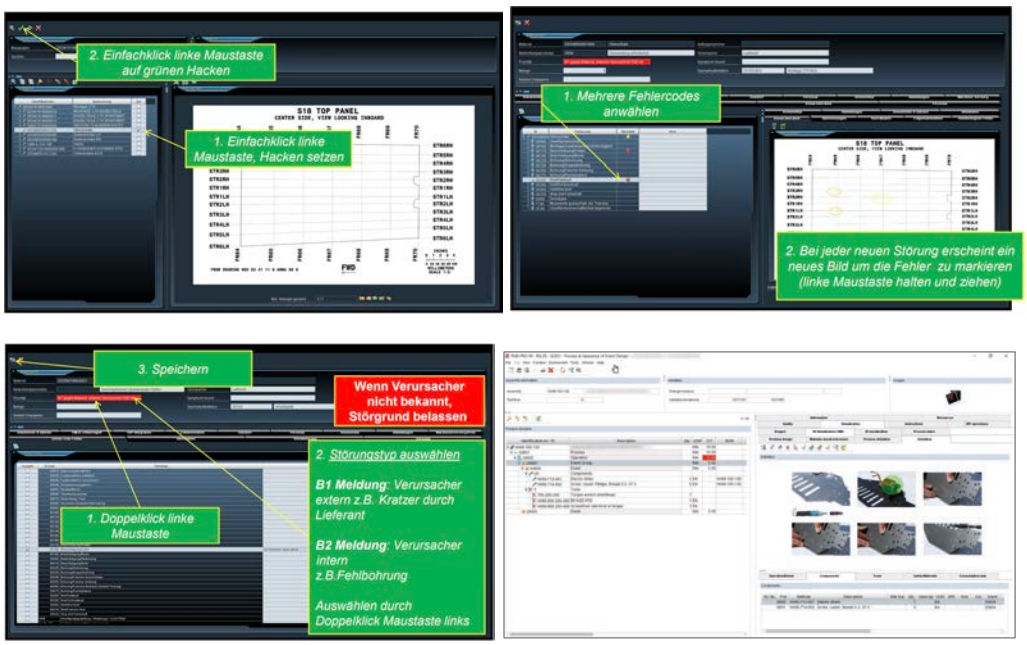


Figure 33: Dark screens from pilot plant and white screen from the software supplier

It became clear that a very detailed explanation was needed on how to operate the MES application, its portals and related activities. The Key User (Engineer) had by now gained experience with the application for about two years, but he still struggled with explanation. It turned out that he already had deeper routines or tacit knowledge and needed support in explaining the functions. He called for outside support to be able to reflect deeply and document the operation of the portals. The challenge

on my side was to understand the different levels of knowledge in order to be able to convey these for the different software user groups. The complexity of the information followed from the levels of knowledge about production, overall process knowledge, management knowledge, and software usage knowledge.

The Key User began by explaining various processes in the application in hopes that it would be understood. Most of the people who started working with the application and asked him for help could only partially follow him. This was now not only criticized by the project manager, but also by other engineers who started to deal with the new application, as they became dependent on his help. In addition, his explanations were partly individual solutions, and could not be used for generalisation. Reflective, abstracted, and generalised approaches were needed to write instructions in a way to provide clear understanding. All the industrial engineers needed a guide to understand how to use the application in general and what to do to properly set up virtual production operations. In addition, production staff needed guidance on how to get started with the application. The project manager needed someone to analyse and present the Key-User's knowledge. This knowledge should be valid for the processes in the company, but also for the use of the application by all stakeholders.

As shown in the literature review, this type of process documentation refers of knowledge management. Scholars claim that the regular use of knowledge and experience strengthens the values of the individual employees and the company, especially if it is deep and anchored knowledge (Nonaka & Takeuchi, 1995) (Nonaka & von Krogh, 2009). Storytelling has often been mentioned to solve the problem of sharing tacit knowledge (Nonaka, et al., 2000). In this case, storytelling was not enough, as the story with its tacit knowledge must be made available to many in a formal way.

Extended problem area: The manuals must reflect the different roles and levels of processes in the production as well as the use of the software. Due to the complexity of the paperless project, the various manuals could not all be completed at the same time. The guidelines for the industrial engineer and for the production employee were directly related to each other in terms of SOE design and its visualisation. The software implementation had been taking place in parallel with the development of the guidelines. Each adjustment in the software automatically entailed an adjustment in the description. In parallel, the first production employees started using the software and needed a manual to support them.

Challenges on the macro-level of developing the manuals were:

- The company needs manuals with reflected and applicable content. This can only be developed by an intense discourse of dialogue between the design expert and Key User.
- It involves a long period of time and financial backend.
- It is used as a learning manual for employees taking up new assignments related to paperless projects in various departments. The same applies to the employees in production, especially when they start using the software from scratch.
- It involves the use of different visual and verbal language reflecting the needs for communication from different perspectives and attention spans.
- The manuals serve as documents in the form of proof of work. These documents take a large part in shaping credibility and project responsibility to strengthen individual profiles.

Challenges on the micro-level of developing the manuals were:

- One core problem within the process of developing a manual derives from the fact that people sometimes cannot easily (or not at all) explain what they actually do. This is related to their experience and long-term memory as embodied working processes. The routines sit deeply in the memory and are stored as automated processes, also called tacit knowledge.
- Technicians or engineers are generally not happy using wordy explanations for what they do and why things work out or not. Drawing and writing are not their key skills, therefore important knowledge gets lost and mostly it is not documented at all.
- The problem of communication weakness in relation to embodied knowledge refers not only to the engineer or production employee, but also to the reference of knowledge. Again, we consider three references: production knowledge, process and organisational knowledge, and software usage knowledge.
- The manual and the content serves as a boundary object, becoming an epistemological object through iterations of reflections, reworking and interpretation. It involves disciplined co-creation, patience and will, which is usually a challenge, as employees do not get lots of hours during regular working days for documenting their work, nor to spend time with externals for the same reason.

6.3.1.1. Research Sub-question 2

My second objective is to understand how this reflective and iterative process can be used for developing a document structure to cover the complexity of all related work profiles and roles. Moreover, how working iteratively with manual fragments, page types, and introducing corporate and technical communication access the various workflows that they become adaptable. In addition, how the use of the comprehensive manual fragments in combination with the process eases the understanding of the knowledge architecture to create a system the design expert can rely on.
The second sub-question is: **What does a design expert need to understand about the working environment in order to systematise and simplify complexity?**

Study design and inquiry: The project started by carrying on the SOE guideline development. I observed the Key-User using the software more attentively and he provided commented screenshots in MS Word or PowerPoint for discussion. By writing notes actively during the observation and some question-and-answer situations, I developed parts of the manual for revision later in my office. The plan was to visit the company regularly to discuss the prepared pages or chapters. Most of the time I only interacted with the project manager and the Key User, who made up the team core. Later, I reviewed the SOE guideline and the production manual with the emplooyees, after they had used it without personal help. Collection of evidence took place by making notes during the observation and structuring the various topics on organisational, conceptual and operative levels. I also took notes after the meetings and documented the comments of the first unwitting users.

To understand the complexity of project environment, I used a set of questions, which derived from the actitivy system. I applied them to my objective to answer the questions in the conclusion phase:
Why is there a need for manuals and knowledge documentation now?
What does the manuals and knowledge management (KM) mean for the participants?
Who is involved with the project and indirectly with KM?
What tools and methods are used in KM?
Where and when does KM take place and where is it shared usually?
What rules or cultural norms govern KM today?
Who is doing the work in KM?

Timeframe: The second part of the project started in August 2018 and ran until December 2019.

6.3.2. Action Phase

Within this second action, I understood my role differently and I also reflected differently on the aspects of the process. The distinction of the collected material was kept as in AR 1.

My attitude and comprehension: I now understood that the expansion of the project led to another challenge – understanding how to convey what was happening within the team, and their internal clarifications during the implementation phase of the application in the company. The adjustments to the software that emerged in this process, as well as the adjustments in the new processes, if necessary, had to be understood, comprehended, and moderated as well as mapped. The main challenge was to understand and reproduce what the Key Users told me. I had to re-engage with their work in detail in order to understand their skills using the software.

Description of what happened:

My activity: I started work by developing a rough list of content. While sitting together with the Key-User when working with the software, I also used the software myself. In general I did not understand any of what the Key-User and the project manager have talked about. The topic was very unfamiliar to me and technical, but I made my notes, as I thought to focus only on organising the information. During the meeting sessions, often, the Key-User stated that when he started to explain a certain process, then he would understand more of that, what he did. I tried to transcribe what he explained, rewrote the notes for myself, and paraphrased it into an instructional language. I slightly changed the way I was used to working and also started to construct simple charts or diagrams to support the conversations. Sometime it helped and sometime we just needed to go throught numerous iterations of reproduced manual pages and corrections. For the first 2 months I was still correcting the developed templates, but I was able to quickly start building the SOE guideline and other chapters. The development of the document structure was based on the technical communication standards.

Process – General Settings: While the first tests and the implementation of the applications were going on in production, we discussed in the team that four guidelines were needed: SOE guideline for industrial engineers, production manual for production employees, quality assurance guideline for industrial engineers and a configuration manual for project managers. The following figure shows how the users typically work together and how the interaction between project participants is set.

The colour orange denotes where the reflection based on the manual development takes place. In part, there is the influence of activities related to the software company, as they are responsible for the functionality and updates of the software.

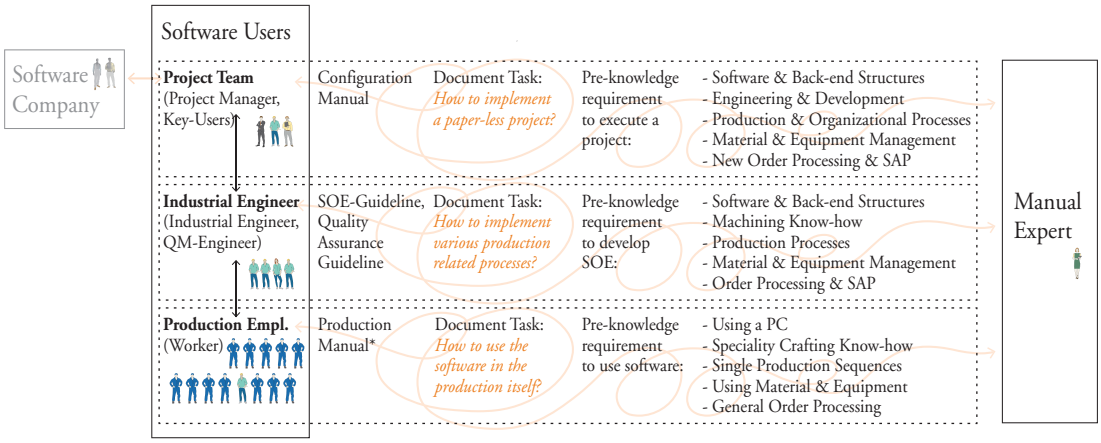


Figure 34: Participants and elements in the paper-less project

It became clearer within the team, that I was now taking on an expanded area of responsibility. I started visiting the company more often and also working on site to log into the system and use the software myself. Our schedule was tight and we were supposed to complete the SOE guideline by the end of 2018. We started with the structure and the instructions, and overall it took longer than we thought, but during the summer of 2018 (Augugst, September), we developed a common understanding of our goal and working remotely was possible. However, numerous conference calls were necessary to clarify details in the document and develop a common comprehension. Nevertheless, the best discussion results turned out to be achieved through live conversation in person. Moreover, we all realised that the manual pages served to find the common space.

I began to use film clips the Key User had prepared, in which he visually and verbally explained his work flow within the system platform. At this point, we had already collected numerous iterations of the SOE guideline. The document was originally going to be created in MS Word, but I was able to convince the team that we would continue to work in Adobe InDesign. It was clear to all, that only I would do this work and also make corrections, even at a later date.

After the 15th iteration, we started giving the manual to in-house interns for testing and later to other engineers who joined the team. The guideline was not ready then, but we needed feedback from other users. Numerous corrections were necessary from their point of view. In the fall, I began to set up the production manual and review the first pages directly with the Engineers.

Process – External forces: During the implementation of the application in production, it became clear that the use of templates in the creation of the SOE was absolutely necessary. However, the programming work could not be migrated overnight as a small intervention in the running operation. For the software company, it meant a deeper intervention in the programming. Therefore, the editing and development of the guideline was paused from January 2019 until work could be resumed from August onwards. The SOE guideline was completely restructured again, based on the software adaptations.

In addition, the number of guidelines was reduced to three, i.e., the guideline for the SOE and the quality management were put into one document – this essentially corresponded to the role of the industrial engineers. However, the production manual was only marginally adapted, as the changes mainly only affected the Sequence of Events Design (SOED). Therefore, the production manual could be finalised by December 2019.

Process – Results: To develop the guideline content, we also started to use film clips prepared by the Key User in which he visually and verbally explained his activity using the system platform. At that time we collected already around 12 iterations of the first manual. The film clips helped to understand the interaction from the engineer's perspective, but the quality of the clips was challenging, as the organisation did not offer good film processing software.

The document initially should be delivered in MS Word, but I stated that a proper manual needed to be done in a design software. So I started to use Adobe InDesign and after the first pages had beed presented, the result impressed the project manager. After the 15th iteration, we started to hand out the manual pages to Iinterns for testing and later on unwitting engineers who joined the team. There were numerous corrections necessary based on their experience. At the same time the company accepted the proposal not to use MS Word-Files for this purpose anymore. At the end of this second

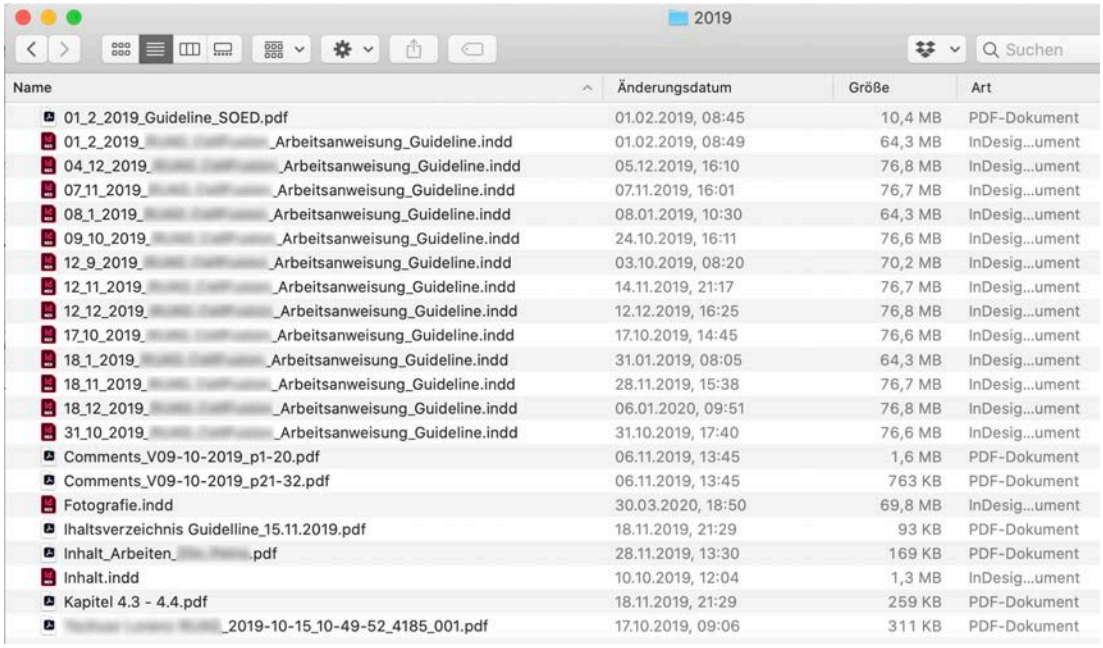
phase, the SOE guideline had about 80 pages, but the document also includes the information about visualisation and the templates with about 20 pages, but without photographs.

Process – Consequences: Due to the reprogramming, the schedule was strongly influenced. Furthermore, it became clear there was much more work than was expected at the beginning of phase two. It also dragged on, mainly because the clarifications took time. This meant that each revision in the manual was read and counter-tested separately by the Key User and the project manager. Some of them were also discussed with other people. As a major consequence of this second phase, it became clear that even more intensive cooperation was needed if the content was to be developed in a consistent and concentrated manner. This meant that there was another extension of my contract. On the other hand, we also decided that we would work on the pages together in regular working meetings. oint reflection was found to be the most effective working approach in the course of the second phase. Finally, it became clear that the development of the third manual, the configuration manual, would require further time and intensive work.

6.3.2.1. Evidence from interaction with material from the documents

The implementation of the workflows had to be done in such a way that a consistent quality of traceability was achieved. The manual described how to digitally build and place all information and media with the application from the perspective of an engineer defining the Sequence of Event Design (SOED). For many implementation steps, a film clip (Figure 37) supplemented the textual and visual explanations and a corresponding reference was given in the manual. The Production Manual was also further developed and both documents were tested by the relevant target groups.

The handling and use of the SOE guideline was described in it's preface. The guideline explains the background to paperless communication and how all information must be prepared. The guide explains basic screen structures, basic elements and information distribution, and uses numerous examples to show how the arrangement of images, texts and symbols should look in order to present the individual work steps clearly. The development of the SOE guideline actually took until 2020. When the application went into build status between January 2019 and summer 2019, core elements had to be reprogrammed and the content developed by January 2019 had to be almost completely revised. The screenshot of the 2019 folder content shows about 10 iterations of the file, but this does not reflect the reality of the changes made, which were much more (Figures 35-36).

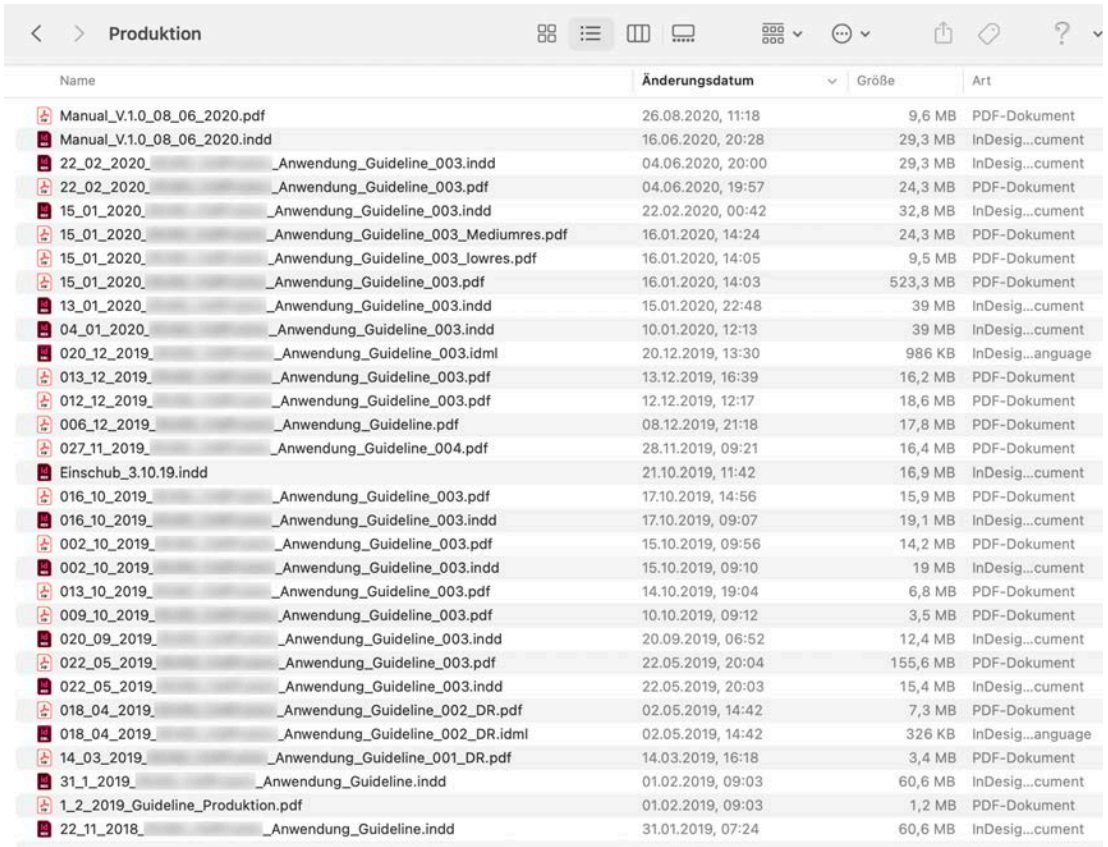


2019

Suchen

Name	Änderungsdatum	Größe	Art
01_2_2019_Guideline_SOED.pdf	01.02.2019, 08:45	10,4 MB	PDF-Dokument
01_2_2019_[redacted]_Arbeitsanweisung_Guideline.indd	01.02.2019, 08:49	64,3 MB	InDesig...ument
04_12_2019_[redacted]_Arbeitsanweisung_Guideline.indd	05.12.2019, 16:10	76,8 MB	InDesig...ument
07_11_2019_[redacted]_Arbeitsanweisung_Guideline.indd	07.11.2019, 16:01	76,7 MB	InDesig...ument
08_1_2019_[redacted]_Arbeitsanweisung_Guideline.indd	08.01.2019, 10:30	64,3 MB	InDesig...ument
09_10_2019_[redacted]_Arbeitsanweisung_Guideline.indd	24.10.2019, 16:11	76,6 MB	InDesig...ument
12_9_2019_[redacted]_Arbeitsanweisung_Guideline.indd	03.10.2019, 08:20	70,2 MB	InDesig...ument
12_11_2019_[redacted]_Arbeitsanweisung_Guideline.indd	14.11.2019, 21:17	76,7 MB	InDesig...ument
12_12_2019_[redacted]_Arbeitsanweisung_Guideline.indd	12.12.2019, 16:25	76,8 MB	InDesig...ument
17_10_2019_[redacted]_Arbeitsanweisung_Guideline.indd	17.10.2019, 14:45	76,6 MB	InDesig...ument
18_1_2019_[redacted]_Arbeitsanweisung_Guideline.indd	31.01.2019, 08:05	64,3 MB	InDesig...ument
18_11_2019_[redacted]_Arbeitsanweisung_Guideline.indd	28.11.2019, 15:38	76,7 MB	InDesig...ument
18_12_2019_[redacted]_Arbeitsanweisung_Guideline.indd	06.01.2020, 09:51	76,8 MB	InDesig...ument
31_10_2019_[redacted]_Arbeitsanweisung_Guideline.indd	31.10.2019, 17:40	76,6 MB	InDesig...ument
Comments_V09-10-2019_p1-20.pdf	06.11.2019, 13:45	1,6 MB	PDF-Dokument
Comments_V09-10-2019_p21-32.pdf	06.11.2019, 13:45	763 KB	PDF-Dokument
Fotografie.indd	30.03.2020, 18:50	69,8 MB	InDesig...ument
Ihaltsverzeichnis Guidelline_15.11.2019.pdf	18.11.2019, 21:29	93 KB	PDF-Dokument
Inhalt_Arbeiten_[redacted].pdf	28.11.2019, 13:30	169 KB	PDF-Dokument
Inhalt.indd	10.10.2019, 12:04	1,3 MB	InDesig...ument
Kapitel 4.3 - 4.4.pdf	18.11.2019, 21:29	259 KB	PDF-Dokument
[redacted]_2019-10-15_10-49-52_4185_001.pdf	17.10.2019, 09:06	311 KB	PDF-Dokument

Figure 35: Screenshot of folder content showing SOE guideline versions in 2019



Produktion

Name	Änderungsdatum	Größe	Art
Manual_V.1.0_08_06_2020.pdf	26.08.2020, 11:18	9,6 MB	PDF-Dokument
Manual_V.1.0_08_06_2020.indd	16.06.2020, 20:28	29,3 MB	InDesig...cument
22_02_2020_[redacted]_Anwendung_Guideline_003.indd	04.06.2020, 20:00	29,3 MB	InDesig...cument
22_02_2020_[redacted]_Anwendung_Guideline_003.pdf	04.06.2020, 19:57	24,3 MB	PDF-Dokument
15_01_2020_[redacted]_Anwendung_Guideline_003.indd	22.02.2020, 00:42	32,8 MB	InDesig...cument
15_01_2020_[redacted]_Anwendung_Guideline_003_Mediumres.pdf	16.01.2020, 14:24	24,3 MB	PDF-Dokument
15_01_2020_[redacted]_Anwendung_Guideline_003_lowres.pdf	16.01.2020, 14:05	9,5 MB	PDF-Dokument
15_01_2020_[redacted]_Anwendung_Guideline_003.pdf	16.01.2020, 14:03	523,3 MB	PDF-Dokument
13_01_2020_[redacted]_Anwendung_Guideline_003.indd	15.01.2020, 22:48	39 MB	InDesig...cument
04_01_2020_[redacted]_Anwendung_Guideline_003.indd	10.01.2020, 12:13	39 MB	InDesig...cument
020_12_2019_[redacted]_Anwendung_Guideline_003.idml	20.12.2019, 13:30	986 KB	InDesig...anguage
013_12_2019_[redacted]_Anwendung_Guideline_003.pdf	13.12.2019, 16:39	16,2 MB	PDF-Dokument
012_12_2019_[redacted]_Anwendung_Guideline_003.pdf	12.12.2019, 12:17	18,6 MB	PDF-Dokument
006_12_2019_[redacted]_Anwendung_Guideline.pdf	08.12.2019, 21:18	17,8 MB	PDF-Dokument
027_11_2019_[redacted]_Anwendung_Guideline_004.pdf	28.11.2019, 09:21	16,4 MB	PDF-Dokument
Einschub_3.10.19.indd	21.10.2019, 11:42	16,9 MB	InDesig...cument
016_10_2019_[redacted]_Anwendung_Guideline_003.pdf	17.10.2019, 14:56	15,9 MB	PDF-Dokument
016_10_2019_[redacted]_Anwendung_Guideline_003.indd	17.10.2019, 09:07	19,1 MB	InDesig...cument
002_10_2019_[redacted]_Anwendung_Guideline_003.pdf	15.10.2019, 09:56	14,2 MB	PDF-Dokument
002_10_2019_[redacted]_Anwendung_Guideline_003.indd	15.10.2019, 09:10	19 MB	InDesig...cument
013_10_2019_[redacted]_Anwendung_Guideline_003.pdf	14.10.2019, 19:04	6,8 MB	PDF-Dokument
009_10_2019_[redacted]_Anwendung_Guideline_003.pdf	10.10.2019, 09:12	3,5 MB	PDF-Dokument
020_09_2019_[redacted]_Anwendung_Guideline_003.indd	20.09.2019, 06:52	12,4 MB	InDesig...cument
022_05_2019_[redacted]_Anwendung_Guideline_003.pdf	22.05.2019, 20:04	155,6 MB	PDF-Dokument
022_05_2019_[redacted]_Anwendung_Guideline_003.indd	22.05.2019, 20:03	15,4 MB	InDesig...cument
018_04_2019_[redacted]_Anwendung_Guideline_002_DR.pdf	02.05.2019, 14:42	7,3 MB	PDF-Dokument
018_04_2019_[redacted]_Anwendung_Guideline_002_DR.idml	02.05.2019, 14:42	326 KB	InDesig...anguage
14_03_2019_[redacted]_Anwendung_Guideline_001_DR.pdf	14.03.2019, 16:18	3,4 MB	PDF-Dokument
31_1_2019_[redacted]_Anwendung_Guideline.indd	01.02.2019, 09:03	60,6 MB	InDesig...cument
1_2_2019_Guideline_Produktion.pdf	01.02.2019, 09:03	1,2 MB	PDF-Dokument
22_11_2018_[redacted]_Anwendung_Guideline.indd	31.01.2019, 07:24	60,6 MB	InDesig...cument

Figure 36: Screenshot of folder content showing production manual versions in 2019

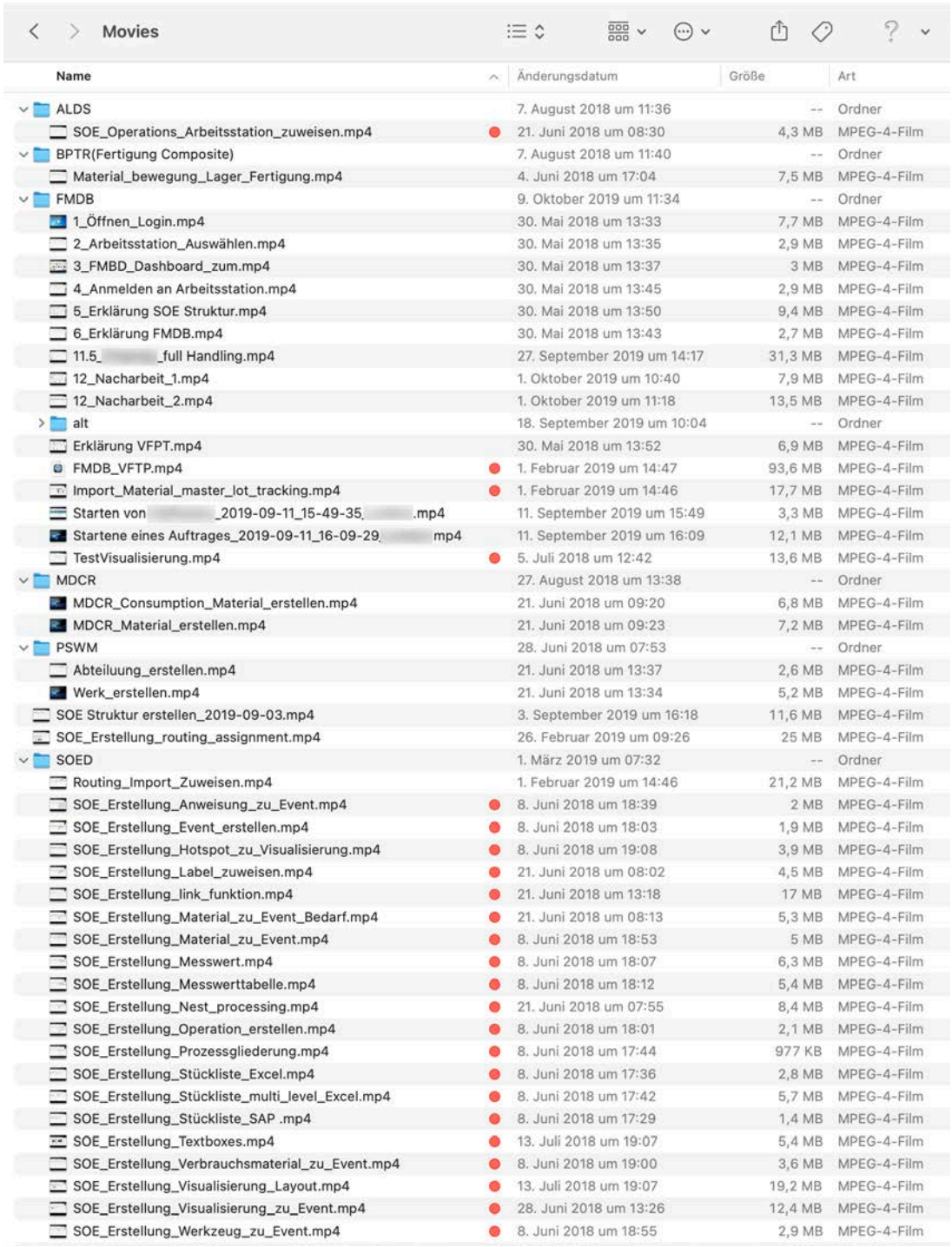


Figure 37: Screenshot showing parts of the folder content from prepared film clips as supplement

6.3.3. Analysis Phase

In the analysis phase of cycle 2, I used the evidence of all key actvities from Summer 2018 until December 2019. Similar to the analysis in cycle 1, I analysed the material coming from personal sources as in-vivo codes, followed by the interaction with material as visual codes from the manuals.

6.3.3.1. Interpretation of Material from In-vivo Codes and Memos

Within the second cycle, the production manual's first pages and various chapters of the SOE guideline had been tested. It became clear, that "the manual offers training for 2-3 weeks, but special knowledge is necessary as a prerequisite" (project manager). "It [manual] has to provide the basics and then it saves time for the learning, or a crash course (engineer)." And the Production Employess stated that "every detail though should be described somewhere, a complete manual". The project manager rated the depth of the information as "it [manual] should not lead to deep dive from beginning. Starting at the top should be a stance." The kind of information in the guidelines "should support learning-by-doing, simple tasks, making mistakes, then checking" (project manager) (Chapter 10.1.2. Material from AR2)

Regarding the reflection on the work processes, the project manager also stated that "the definition of the main milestones in developing an SOE took a while, but we gained clarity." And, that "a change in one part of the setting involves changes in all levels." He also reflected on the project, that "to start from scratch means that a basic frame might be available, but not the content. One needs to familiarize well with new topics. One pattern is, that it is like putting together a puzzle. Then the picture slowly comes to light. It is a puzzle without a template, one might know the dimensions, but not the content." "One needs to know, what is the actual core process and if this can be applied to other working contexts." (Chapter 10.1.2. Material from AR2)

As the design expert, I reflected that a guideline is successful when "the employee can make use of it." In this relation "it became clear, that I had to record knowledge and experience on one hand, and on the other the developed document needed to enable users to learn and gain understanding."

The way, the information needed to be set is, that "the language must be hands-on. Instructions must be short for the shop floor." And, that the "different user perspectives determine the language and the scope of the material are expressed in three kinds of documents. The three levels reflect back

to the content structure. The structure and the hierarchy in the documents [manual] serve the practicability. The manual needs to coordinate practical-physiological, theoretical-principal activity and material with digital set-ups in the application. There is a hierarchy in who is educating who. The Super-Key-User is educating and coaching the Key-User and this level of knowledge is reflected in the manuals as well, but not visibly. The manuals of the project vary in depths as well as in freedom to act and in kind of content." (Chapter 10.1.2. Material from AR2)

The perception of the guidelines was that there is no patience in the knowledge workers, and only to reach their overall goal is important. Therefore there will be expertise of the company work force as well as the skills of the Super-Key-User, as well as the skills of the designer – working expertise–project-expertise–transformation-skills. In general, "online training or other support by the platform would be good. The basic frame and structure can be done in a linear written manual to provide orientation. Due to the technical setting and context of the actual project in the enterprise structure, pure online training is impossible". (Chapter 10.1.2. Material from AR2)

Interpretation of the team member quotes: Participants are aware of what they need in order to get people going on with the new system. Basics are understood as first level information, which leads employees to their first own steps. They know that the manuals will only be understood by employees with special knowledge. By reflecting on the development of milestones, they realised, that it is time-consuming to gain clarity step-by-step. There is an awareness of the impact of a change from one angle influencing the whole system's functionality. To develop the right content [which at the moment of the quote was not clear], there is more than just a *puzzle* needed. The form as a template depends on content and the right information.

Interpretation of the design expert quotes: The main challenge for the designer was to find the right language and content structure for the manuals. The hierarchy of the content was interconnected with the practicability of the manuals, which would coordinate different levels of knowledge. The didactical quality was connected to rules, also understood as principles. The interplay of the knowledge workers was pictured by the learner's internal hierarchy. To get the right information from people who have little patience was difficult, but there were other levels of communication between them. In all levels, the manual needed to support action by activation and facilitation but the learning on processes took place during the development.

Critical Interpretation: For all participants, it seemed that there was a relatively high awareness of the content, the way the manual was produced, and its role in supporting learning. The project manager showed some interest on the process of how the manual was produced from the design perspective, but found it hard to understand the useage of the software (Adobe InDesign). All the participants perceived the relationship between content and learning as very close. As design expert, I relied strongly on the process of producing the manual and on the learning aspect, whereas for the project manager, it was important to produce the content, led by the goal of the manual. All participants were aware of the manual's context and what it will be used for from various perspectives, and therefore the content's appearance was different, but the meaning and the goal were the same.

It becomes apparent, that the design expert grasped the knowledge workers' tacit knowledge through the process of producing the manual. The Super-Key-User knew that he was working with his own experience and that he needed expertise to retrieve the embedded company knowledge, something he compared to a puzzle. As design expert, I realised that my activity was recording knowledge by using the manual as a document to transport knowledge to others – the people who are learning. The manual simply became a recording document on one hand and on the other hand, the produced content needs to be reshaped for the other employees' use. It shows that the client was aware of the various qualities of information and how it felt when starting on a complex issue.

It appeared that there was a huge change to the document through the process of interaction. The challenge remained to gain insight into the expertise of the knowledge workers involved. The content produced from the process was reshaped from the perspective of learning. Therefore, the value of the manual was that it showed the practical-physiological and theoretical-principle activity, and through the transformation of the content by the iterations, hints emerge on how to approach the same hierarchically and didactically. Learning is based not only on activity, but also on principles and transformational skills. It seems that a principle is also a skill.

It also becomes clear that there were different needs in the way the manual was designed. The manuals needed to reflect different perspectives and roles in the organisation, and the different content provides organisational perspectives and possible action areas. The design expert identified what the expectations are, and how the user's actions should be triggered, as well as what kind of communication is needed.

In addition, there was the realisation that these manuals are not only design manuals, but technical communication documents. The term *Technical Communication* here refers to the meaning of *technical* as an expression for procedural or instructional. The literature describes technical communication as a specialised field and, distinct from visual communication, is usually applied by technical writers or psychologists rather than professionals trained exclusively in visual design.

Evaluation Interpersonal Communication: Through the differentiation and the elaboration of the contents, work processes were rethought and analysed beforehand and partly questioned. The documents served as a basis for the common clarification of understanding (boundary object), but still had to allow autonomy for the users and their new learning. The process of understanding in the team, unlearning, and defining the new manual content was a different process than the one that then took place at the user's site. In addition, a discussion arose about whether virtual exercises should be set up. Towards the end of the project it was decided to do this, and film clips were provided in the meantime.

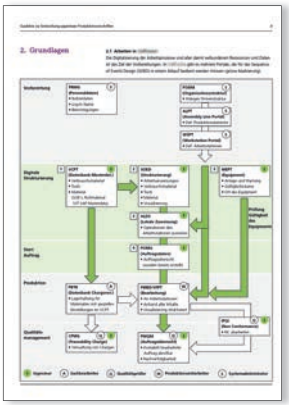
- ➔ The amount of scope developed reflected the depth of engagement.
- ➔ It was most important to differentiate between boundary object and final document.
- ➔ The MES only runs internally, the documentation was delivered as PDF and available.
- ➔ Supplementary clips may be provided to kick-start learning with basic functions at the end.

6.3.3.2. Interaction with material from the SOE guideline

In the following analysis, the situation at the beginning and at the end of Phase 2 was tagged. The pages of the *Photography Chapter*, empty pages, title and list of content pages were left out. The pages focusing on the corporate design were typically of page type 4. During the first and second sub-phases of AR cycle 2, several types of pages emerged that represented knowledge, or made it visible, in different ways. I analysed nine page types used in the SOE guideline.

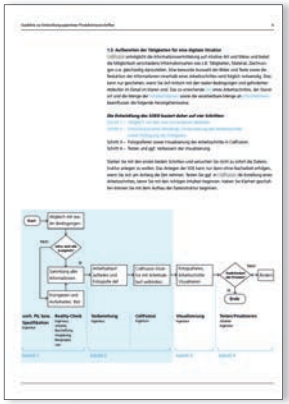
Start-Screen-Explanation-Page

Multiple-Screen-Explanation-Page



Matrix-Page

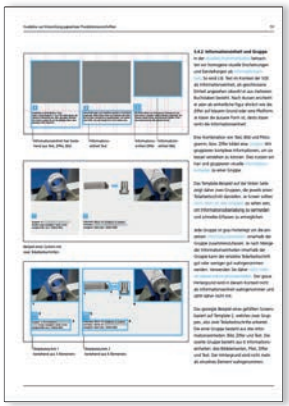
Elements-Explanation-Page



Workflow-Page

Storyboard-Page

Comprehension-Page



Examples-Page

Visual-Comprehension-Page

Figure 38: Sample pages from SOE guideline

Description of figures at following page (SOE Guideline)	**Page intention and use of graphical elements**
Page Type 1: Start-Screen-Explanation-Page – A page in which a screen shot shows the entry panel of the software and text explaining the basic structure of the software platform, which is depicted in the screen shot.	Intention: informative-integrative. Elements: screenshot, structured text, caption
Page Type 2: Multiple-Screen-Explanation-Page – A page in which a screen shot shows the entry panel of one of the portals and text explaining the basic structure of the portal, which is depicted in the screen shot. Both pictures relate to each other but are seen one after the other.	Intention: is informative. Elements: screenshots, structured text, caption, headline
Page Type 3: Matrix-Page – A page in which a matrix diagram shows the relationships between entities, in this case the tasks and responsibilities of employees. The diagram functions by itself and works like a closed unit in the page.	Intention: directive. Elements: matrix, headline, structured text, caption
Page Type 4: Elements-Explanation-Page – A page in which elements of the manual are explained, in order to understand how to use the manual. The pictures have a generic character and can contain everything which can be used as a picture for a certain reason: screenshots, screen elements, text as picture, symbols, colours, etc.	Intention: informative. Elements: generic picture, structured text, caption
Page Type 5: Workflow-Page – A page in which a flowchart diagram introduces the working process of switching from paper-based to digital. The diagram functions by itself but needs explanation, as it describes a new work flow.	Intention: directive. Elements: flowchart, headline, structured text, caption
Page Type 6: Storyboard-Page – A page in which all pictures have a relationship with each other. The order of the pictures shows the order of the activities which need to be done in the software. The several steps are also described in text, step-by-step. Outtakes show important details. Usually these pages also offer a link to a video explanation of the steps to be done.	Intention: directive. Elements: screenshots, structured text, caption
Page Type 7: Comprehension-Page – A page with text only. A hard piece to read, but important. A visual structure supports the reader in grasping the main parts first. Selective reading is possible.	Intention: informative-integrative. Elements: screenshots, text, caption
Page Type 8: Examples-Page – A page with pictures and text, where the pictures show elements of the available options for setting the visualisation inside the software.	Intention: informative. Elements: screenshots, structured text, caption, lines, numbers, shapes
Page Type 9: Visual-Comprehension-Page – A page with mainly pictures and some text. Pictures show examples of visual elements in use and how they need to be placed. A guideline inside the manual for understanding visual structure.	Intention: informative-integrative. Elements: screenshots, structured text, caption, lines, numbers, shapes

Table 18: Page-types used in SOE guideline

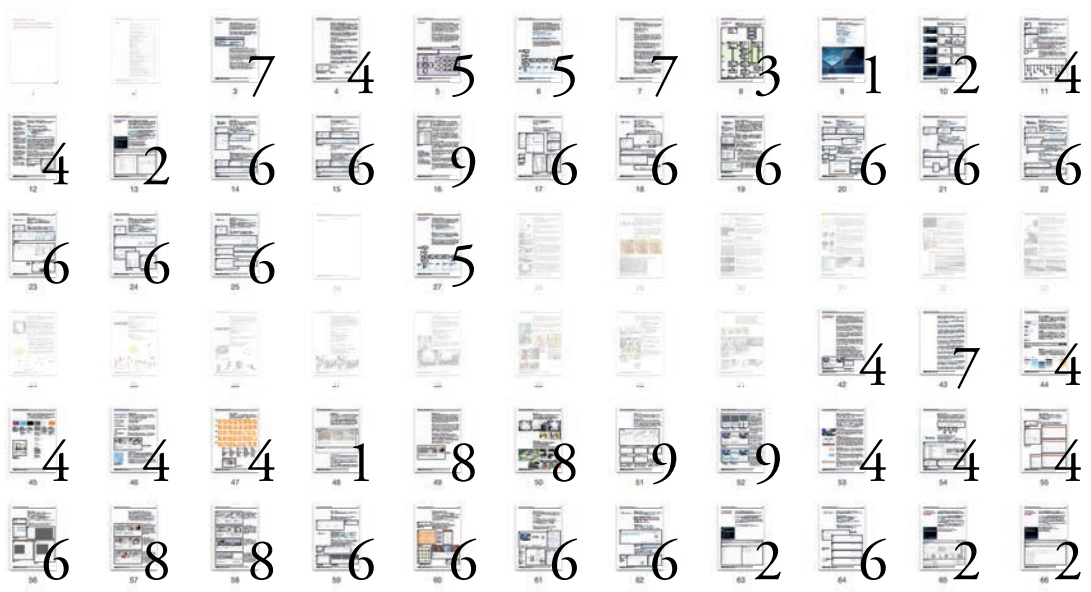


Figure 39: Collection of pages from SOE guideline from beginning

Page types used in the beginning of AR cycle 2	**Page intention**	**Value**
Page Type 1: Start-Screen-Explanation-Page	Intention: informative-integrative	2/49
Page Type 2: Multiple-Screen-Explanation-Page	Intention: informative	5/49
Page Type 3: Matrix-Page	Intention: directive	**1/49**
Page Type 4: Elements-Explanation-Page	Intention: informative	**11/49**
Page Type 5: Workflow-Page	Intention: directive	3/49
Page Type 6: Storyboard-Page	Intention: directive	**17/49**
Page Type 7: Comprehension-Page	Intention: informative-integrative	3/49
Page Type 8: Examples-Page	Intention: informative	4/49
Page Type 9: Visual-Comprehension-Page	Intention: informative-integrative	3/49

Table 19: Share of sample pages from SOE guideline at the beginning of AR cycle 2

Interpretation of interaction with SOE guideline at the beginning: The document showed the largest number of pages were storyboard pages that were directive or clearly instructional in their communication. Followed by the number of pages that had an informative-integrative character to make the activities that are to be carried out understandable as a principle. Pages with a focus on corporate design were no longer prominent here. As the Storyboad-Pages tended to dominate, it became clear that the document had gained a lot of value in directing workers in the use of the new software.

Figure 40: Collection of pages from SOE guideline at the end

Page types used in the end of AR cycle 2	**Page intention**	**Value**
Page Type 1: Start-Screen-Explanation-Page	Intention: informative-integrative	3/73
Page Type 2: Multiple-Screen-Explanation-Page	Intention: informative	3/73
Page Type 3: Matrix-Page	Intention: directive	2/73
Page Type 4: Elements-Explanation-Page	Intention: informative	**12/73**
Page Type 5: Workflow-Page	Intention: directive	2/73
Page Type 6: Storyboard-Page	Intention: directive	**37/73**
Page Type 7: Comprehension-Page	Intention: informative-integrative	6/73
Page Type 8: Examples-Page	Intention: informative	5/73
Page Type 9: Visual-Comprehension-Page	Intention: informative-integrative	3/73

Table 20: Share of sample pages from SOE guideline at the end of AR cycle 2

Interpretation of interaction with SOE guideline at the end: Compared to the beginning of the phase, there was a clear increase in the number of storyboard pages, as these represented and described the use of a specific function within the MES application. The visualisation chapter was defined in its structure. This was followed by the development of further chapters, which related more to the development of the SOE and all associated activities. It became clear that the presentation of the SOE resulted in a significant adaptation in the application. All contents, except for the visualisation chapter, were almost completely rewritten after the adaptation.

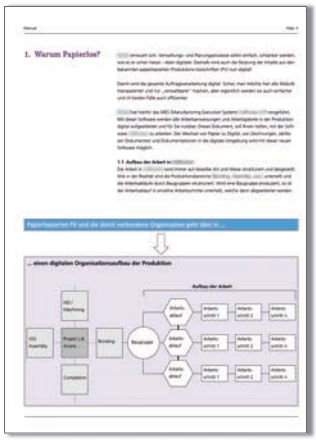
6.3.3.3. Interaction with Material from the Production Manual

At the end of AR cycle 2, I used several types of pages that were also in the production manual.

Testing was based on fewer pages and less content. I analysed nine page types used in that manual.

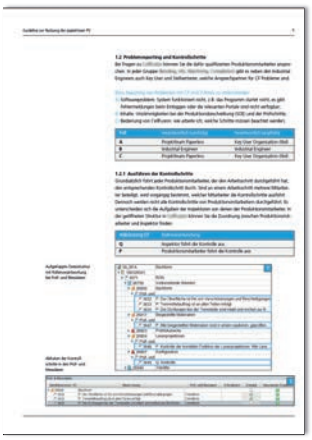
Start-Screen-Explanation-Page

Multiple-Screen-Explanation-Page

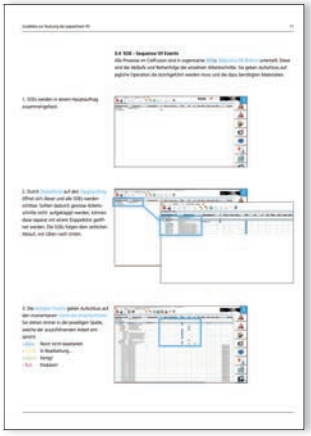


Matrix-Page

Elements-Explanation-Page



Workflow-Page



Storyboard-Page

Comprehension-Page

Examples-Page

Contextual-Page

Figure 41: Sample pages from production manual

Description of figures at following page (Production Manual)	**Page intention and use of graphical elements**
Page Type 1: Start-Screen-Explanation-Page – A page in which a screen shot shows the entry panel of the relevant portal for production.	Intention: informative-integrative. Elements: screenshot, text
Page Type 2: Multiple-Screen-Explanation-Page – A page in which a screen shot shows the entry panel of one of the portals and text explaining the basic structure of the portal depicted. Both pictures relate to each other but are seen one after the other.	Intention: informative. Elements: screenshots, text, caption, headline
Page Type 3: Matrix-Page – A page in which a matrix diagram shows the relationships between entities, in this case the change from paper-based to paperless is shown.	Intention: directive. Elements: matrix, headline, structured text, caption
Page Type 4: Elements-Explanation-Page – A page in which elements of the screen or the manual are explained, as to understand how to use it. The pictures have a generic character and can contain everything which can be used as picture for a certain reason: screenshots, screen elements, text as picture, symbols, colours, etc.	Intention: informative. Elements: generic picture, structured text, caption
Page Type 5: Workflow-Page – A page in which a diagram introduces a working process or a hierarchy of information. The diagram functions by itself but needs detailed explanation.	Intention: directive. Elements: diagram, headline, structured text, caption
Page Type 6: Storyboard-Page – A page in which all pictures have a relationship with each other. The order of the pictures shows the order of the activities which need to be done in the software. The several steps are also described in text, step-by-step. Outtakes show important details. Usually these pages also offer a link to a video explanation of the steps to be done.	Intention: directive. Elements: screenshots, structured text, caption
Page Type 7: Comprehension-Page – A page with text only. A hard piece to read, but important. A visual structure supports the reader in grasping the main parts first. Selective reading is possible.	Intention: informative-integrative. Elements: screenshots, text, caption
Page Type 8: Examples-Page – A page with pictures and text, where the pictures show various situtations occuring within the application.	Intention: informative. Elements: screenshots, structured text, caption, lines, numbers, shapes
Page Type 9: Contextual-Page – Text and picture explain a certain topic depending on a specific situation or context. Usually only specific readers can assign the meaning to a certain situation.	Intention: informative-integrative. Elements: screenshots, structured text, caption, lines, numbers, shapes

Table 21: Page-types used in production manual

In the following analysis, page types and share of the production manual at the beginning and at the end of phase 2 were tagged. Empty pages, title and list of content pages were left out of the analysis.

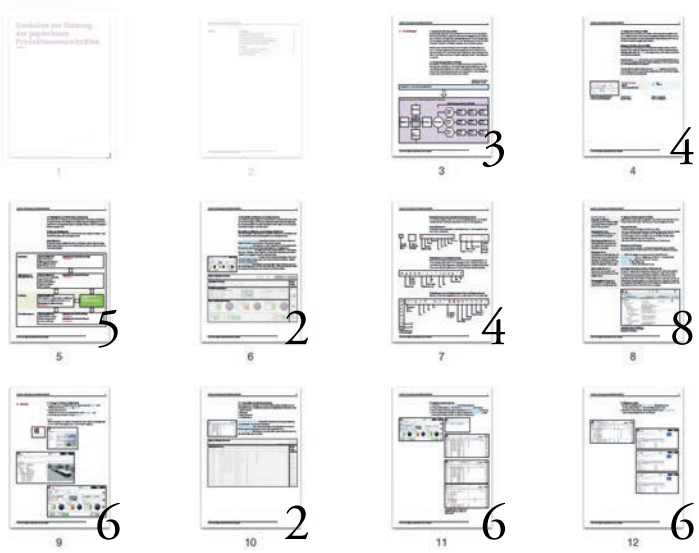


Figure 42: Collection of pages from production manual at the beginning

Page types used in the end of AR cycle 2	**Page intention**	**Value**
Page Type 1: Start-Screen-Explanation-Page	Intention: informative-integrative	0/10
Page Type 2: Multiple-Screen-Explanation-Page	Intention: informative	2/10
Page Type 3: Matrix-Page	Intention: directive	1/10
Page Type 4: Elements-Explanation-Page	Intention: informative	2/10
Page Type 5: Workflow-Page	Intention: directive	1/10
Page Type 6: Storyboard-Page	Intention: directive	**3/10**
Page Type 7: Comprehension-Page	Intention: informative-integrative	0/10
Page Type 8: Examples-Page	Intention: informative	1/10
Page Type 9: Contextual-Page	Intention: informative-integrative	0/10

Table 22: Share of sample pages from production manual at the beginning

Interpretation of interaction with production manual at the beginning: At the beginning of developing the production manual we needed insights into the perception of the production employees. Therefore only some pages were developed and almost all in the first test were representational, whether successive worksteps, explanation of interface situations or responsibilies. With a focus on understanding how to use the interface, therefore *storyboard pages, workflow pages*, and *multiple-screen-explanation pages* were tested first.

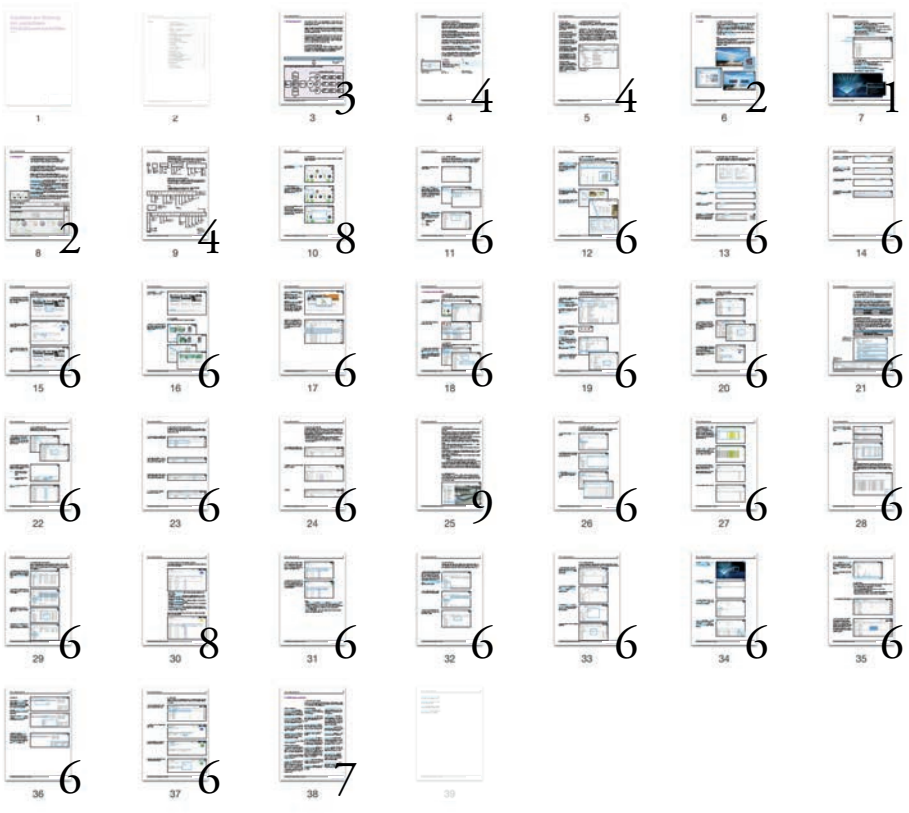


Figure 43: Collection of pages from production manual at the end

Page types used in the end of AR cycle 2	**Page intention**	**Value**
Page Type 1: Start-Screen-Explanation-Page	Intention: informative-integrative	1/36
Page Type 2: Multiple-Screen-Explanation-Page	Intention: informative	2/36
Page Type 3: Matrix-Page	Intention: directive	1/36
Page Type 4: Elements-Explanation-Page	Intention: informative	3/36
Page Type 5: Workflow-Page	Intention: directive	0/36
Page Type 6: Storyboard-Page	Intention: directive	**25/36**
Page Type 7: Comprehension-Page	Intention: informative-integrative	1/36
Page Type 8: Examples-Page	Intention: informative	2/36
Page Type 9: Contextual-Page	Intention: informative-integrative	1/36

Table 23: Share of sample pages from production manual at the end

Interpretation of interaction with production manual at the end of the project: After initial testing, it became clear that the focus in the production manuals should be on large displays with little text, highlighting the sequence of images. So the focus had been on the storyboard pages with respect to these requirements. The presentation of the descriptive texts and the numbering of the screenshots also differs from that in the SOE guideline.

Critical Interpretation: The application of the page structures as shown in the analysis still focuses on too many subtle differences, which does not allow for unambiguity in the evaluation, since the values scatter strongly. As a result, other aspects were emphasised in the analysis in AR cycle 3. Nevertheless, it became apparent that the differences between directive and informative content indicate the way in which the user works with the documents.

Evaluation of both document types: The differences between the SOE guideline and the production manual became very clear during the first tests. The content for production employees should be much less text-heavy and shorter. Concise sections with explained screenshots and without informative explanations were in demand. This also leads, among other things, to the assumption that the documents should be subjected to further critical evaluation before they go into testing. It turned out that the documents were strongly influenced by the way of communication between the team members. They served the purpose of clarification, but were too complex to be practical.

- ➔ The testing should enable the team members to get out of their silo perception.
- ➔ The document itself and its development supported knowledge conversion.
- ➔ The various documents addressed various skill levels and met the users there.

Evaluation page structure: The page structure in the guidelines was different, as it dealt with different topics and levels of interaction with the MES application. The pages for the engineers had to address the operation of different portals, interacting with the development of production rules and they had to explain the visualisation. The pages for the users of the SOE, i.e. the production employees, focused mainly on one or two portals. This resulted not only in different content, but also in how the content is didactically prepared so that it became useful for the target group. While the content for production staff was mainly instructional in nature, the pages for the SOE guideline also contained information and suggestions.

- ➔ Page structures differed in the way they guided, informed and suggested.
- ➔ Pages showed a certain pattern in the way they showed and hierarchised information.

6.3.4. Conclusion Phase on Second Objective

Based on the prior analysis phase, this phase reflects on the second objectives and its sub-question followed up with a general conclusion and a proposal for further activity.

What does a design expert need to understand about the working environment in order to systematise and simplify complexity?

(a) How does the reflective and iterative process be used for developing a document structure which covers the complexity of all related work profiles and roles?

(b) How does the process of using manual fragments (boundary object) as representations, considering corporate and technical communication elements access the complexity to become adaptable?

(c) How does the process of using manual fragments eases the development of a knowledge architecture the design expert can rely on?

Answering the questions from the activity system allows to channel the gained insights from the second action research cycle in a structured way and it prepares the answer of the sub-question.

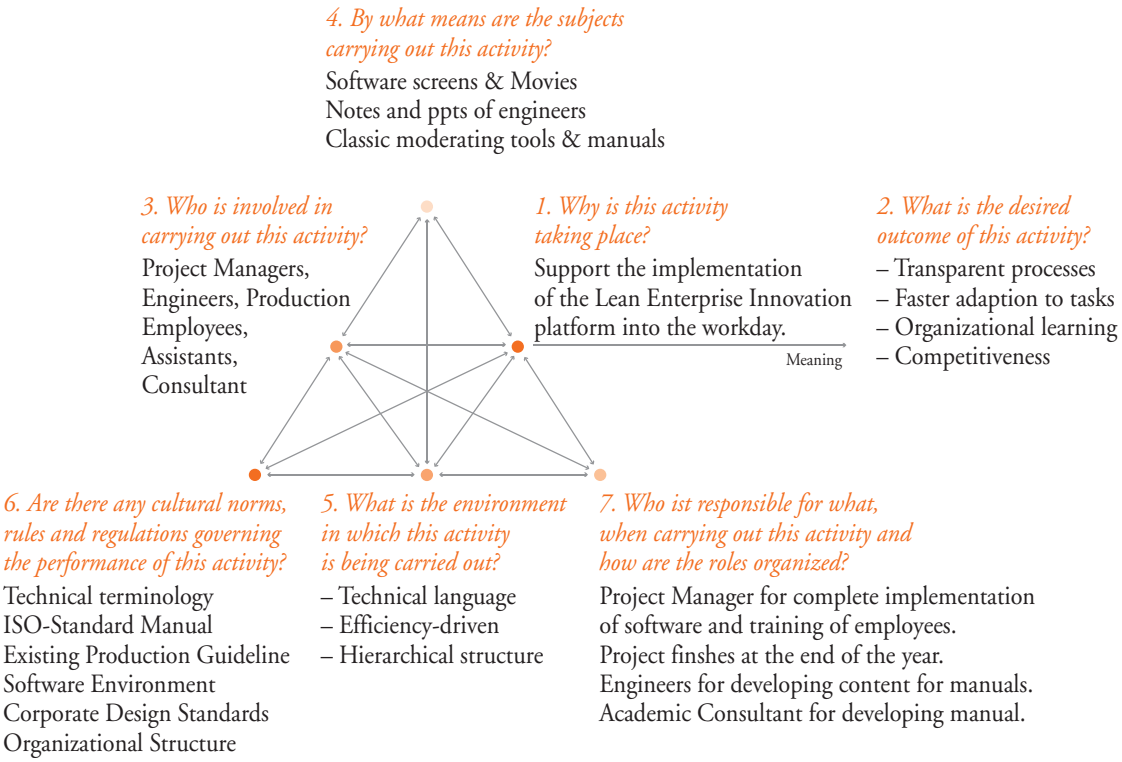


Figure 44: Applied collective activity system on AR cycle 2 based on (Engeström, 1987)

Why is there a need for manuals and knowledge documentation now?

The transformation project and the implementation of the Lean Enterprise Innovation platform calls for activities towards documenting the work and the learnings done. The overall objective of implementing new processes into the organisation demands clarification of old working processes, using new software and learning new routines.

- ➔ The design expert understood the need by looking at the old and new processes.
- ➔ Due to the transformation project, processes needed to be restructured.
- ➔ Implementing a new software, the manuals supported its comprehension for all user groups.

What does the manuals and knowledge management (KM) mean for the participants?

All participants means all employees at the division, especially the teams who started working with the new software months ago needed to start working with the manuals. As the company board took the decision from the top-down to implement the new software, a path was given to be followed by all employees at the choosen division. The project manager's responsibility was high and there was pressure from the board. The manuals seemed to be a small piece in this game, but they proved the project manager's work, and if the manuals were successfully used, they would speed up the implementation in other divisions.

- ➔ The design expert understood the different meanings and therefore the embeddedness of the documents in the organisation.

Who is involved with the project and indirectly with KM?

I started to work with the project manager and the Key-User in order to understand their problems, followed by numerous iterations of the first version of the guideline. The network of knowledge is distributed widely in this complex company environment. In order to develop, test and iterate the manual, all participants swere part of the process: project manager, Key User, engineers, production employees and assistants.

- ➔ The design expert was looking at the developent of the document through the eyes of the different people involved and understood, that there were different ways of working and processing knowledge.

What tools and methods are used in KM?

The only tool used was an internal platform, where documents were stored, but with little regular use. Within the R&D teams, Visual Lean methods were used, which support their research work. In the division where the project took place, there was little experience in using mediating material for conciously managing knowledge. For that reason the company was looking for support, even though they did not expect that the documents would have a double role. The process I went through when I started to develop the manual, relied on work methods I have developed based on the activities from past experience, when I created corporate design manuals. The experience added to the prior approaches, but it also became very clear, that the content and structure of a manual has a strong didactic component requiring a different approach. Even though we were looking at one kind of technical manual with some similarity to a program guide or a software user manual, these manuals are different and relate to the framework of technical communication.

First, the content could only be developed after the expertise had been extracted and understood. Second, for some software, user support can be found online or through video tutorial. For this specific platform solution, there isn't any support available, due to the fact that these applications are too complex and always custom-made. Third, somehow it was accepted that the manual is not constructed in MS Word, but in Adobe InDesign, which made changes for the client less easy, or even impossible. By accepting the manual this way, the company had given away control not only of the manual, but also of the way the manual was developed.

- ➔ The design expert's role changed towards facilitation, and thus expands the perception of a designer's role.
- ➔ These types of documents are not design-related, they are more technically driven, but involved didactic components. They borrowed document standards from technical communications.
- ➔ The page types to be defined were crucial for developing the knowledge levels and areas.
- ➔ If the design expert's role was to be fully responsible for the document, their incorporation into the team was crucial and constant exchange was necessary.
- ➔ The documents had two faces. One as the boundary object and the other as the manual.

Where and when does KM take place and where is it shared usually?

Existing production guidelines had been written in MS Word and were heavy documents. As the company works in high-tech, there was an extremely high amount of technical know-how around and all documents were very technically written. The language and the way topics were adressed and depicted was done according to technical standards. The mind-sets were efficiency-driven and this was further strengthened by the implementation of the digitisation project. For understanding the culture of work and the mind-sets, it was always very valuable to work on the company premises. I got more involved with the dynamics in the departments and how they worked together. There were moments when it became clear to me, that conveying the tacit knowledge to me depended on the different points of view that I encountered, but above all, the neutral or ignorant role allowed me to ask recurring *stupid* questions. As I was the *outsider* in that community, I simply took the freedom of this role and to reflect in my own way. I understood that writing a manual for employees, who use it as support in the gradual acquisition of new knowledge, required knowledge of the field.

- ➔ The design expert understood the knowledge types by expressing the different views.
- ➔ This could only happen, when the participation took place at the company's site.

What rules or cultural norms govern KM?

The pressure of rules, such as the technical constraints and regulations coming from the contract work environment was leading the culture of the community. When I started with my first draft, my approach was based on the assumption that I had to develop a design guideline for using the software. So I started to use the existing *corporate design guidelines*, applying them into the software environment, but as stated, when the project progressed, the objective changed. I also used an industrial standard for technical manuals, determined by the ISO-Standard, which then lead me to the conclusion, that the manual was not a design manual by nature anymore. The use of technical terminology, as well as the semantics of the software itself, coined the style of the written text. The organisational structure and the production processes led the main structure of the manual.

- ➔ It was necessary to accept the technical norms and the standards for technical communication.
- ➔ It was necessary to learn to write technically and in different ways, such as directive, informative or guiding.

Who is doing the work in KM?

It showed that the strategic labour was located in the team consisting of two people, the Key User and the project manager. The operative labour was located at the software company, as well as being a heavy loadon the internal IT department. Further operative labour lay with the engineers and the assistants, who transformed the paper-based production guidelines into the new environment, supported and guided by the SOE guideline. The engineers had to feed the system with the relevant and reprocessed information. The assistants had been responsible for photographing the working sequences, which then were placed into the templates in the visual lean interface of the software. The initial definition of the working routines derived from development and the Production Engineers implemented the workflow into the production environment.

The overall results were the paperless production instructions that were visualised and made interactively available in the system. These would be used by the production employees, as they had their own manual explaining how the system works and how to use it. The production employees also took a part in the testing of the screen templates earlier in the project and did some tests with the first draft of the production manual. The design expert was responsible for making the knowledge available in the manuals, for using the software and editing the content in the appropriate way, from all perspectives.

- ➔ Understanding of who is in charge of defining the ground routines.
- ➔ Saw the different responsibilities, the various views, and how people read and see.

Conclusion: One of the main tasks in the project was to manage the significance of the manuals against the background of the digital transformation and the various user groups and their practices. This also raised the question of the type of knowledge that should be organised in the documents and the manuals. Based on the team setting and the project task, four types of explicit and tacit knowledge could be identified in this case:

Practitioner (production employee): embedded know-how, but strong embodied practical skills;
Planner (engineer): embedded know-how as well as anchored knowledge about the application;
Manager (project manager): embedded know-how as well as embodied communication skills;
External Expert (design expert): embodied visualisation and embedded communication know-how.

What does a design expert need to understand about the working environment in order to systematise and simplify complexity?

(a) How does the reflective and iterative process is used for developing a document structure which covers the complexity of all related work profiles and roles? **Recognising, that the design expert deals with complex technical knowledge structures. Doing a separate first analysis of what the situation offers and how the distribution of tasks and roles, the timing, the way knowledge management has been done so far and who is responsible, would be appropriate.**

(b) How does the process of using manual fragments (boundary object) as representations, considering corporate and technical communication elements access the complexity to become adaptable? **Integrating other levels of expectation is crucial and accepting that the fragments are only a path to the final manuals. Discussions support the understanding of the complexity by numerous iterations. The process is only useful when different roles and mindsets are included by letting them develop their view on the information architecture.**

(c) How does the process of using manual fragments eases the development of a knowledge architecture the design expert can rely on? **When the manual is almost finished, the chapter Hints and Tricks should be done by someone who has more than process- and production-related skills. This person can not only be used to re-test manual content. Employees with such a profile can be used to confirm the developed information architecture in their role as new specialist, knowing the work arounds but also how it all comes together.**

The need for further activities: In this last cycle, I had been looking at complexity, documenting existing expertise and tackling embodied knowledge. The challenge was to find the right system, which encourages the development of the right information architecture. My basic conclusion was that fragments do work, when an in-depth process generates them and the expert considers various perspectives by a good integration into a team. The reflection provided the starting point for a deeper exploration of how people redefine working principles. Subsequently, it is to explore the interaction between the project manager holding embedded know-how as well as embodied communication skills and a design expert holding embodied visualisation. It is a question of what role the design expert takes on here, what kind of working culture is created, and to what extent the results can be used in other projects. The developmnet of the configuration manual will be especially interesting, as it aims to document a complete project from back- to front-end of an implementation focusing on principles and scalability.

6.4. Action Research Cycle 3

6.4.1. Planning Phase

My planning in this last cycle looked at all aspects, except the project participants. They did not change, but one new role was added and described.

Project task: In this third and final action cycle, I focused on the development of the Configuration Manual, as a higher level of reflection, and the corresponding resulting document for project managers. Nevertheless, there was further work to be done in the SOE guideline and the production manual. I worked mainly with the project manager, but did test runs of the guidelines with all team members. This work should have been completed by the end of 2019, but the work needed to continue until around mid-2020 as the customisation effort was not predictable.

Project context information: The adjustments to the software enabled employees to enter production specifications in the SOED portal more quickly. In parallel, the production department started actively using the MES application. The connection to other internal processes took its course, with all the obstacles and need for clarification. From this point on, the project was classified as partially implemented, as it was only used for pure traceability in production. The software company was already less involved to no longer involved, and the initially active production engineer (Key User) was already working on other projects. This last phase in the project was now solely the responsibility of the project manager. He still had to achieve his set goals and these included the documentation and workup of the project from a Super Key User's point of view.

Project participants: Project Manager, design expert, employees for selective testing, Assistant.

Assistant:

The assistant had been engaged by the design expert to help with the final adjustments in the manuals. He was not engaged in the project and could only follow direct instructions. Nevertheless, he was enabled by the company for the internal MES application system, so that he could follow the steps described. At the beginning of his work, he confirmed that he had already worked with a similar system in a different context. He also knows how to use and apply Adobe software.

World perception: hands-on, practical, design-oriented

Average age: between 25 and 30

Profession: Industrial designer with some years of professional experience in the field.

Definition of Situation: In order to formulate the project as an overarching structure and recommendation for action, all levels of work had to be traceable. A project manager was usually responsible for clarifying the internal structures and generating the data flow within the MES application. He defined roles with their responsibilities and had to know how issues were handled. All this had to be reflected in the digital structure. The manual to be developed was more like a policy, since there are fewer directives than in the other two manuals.

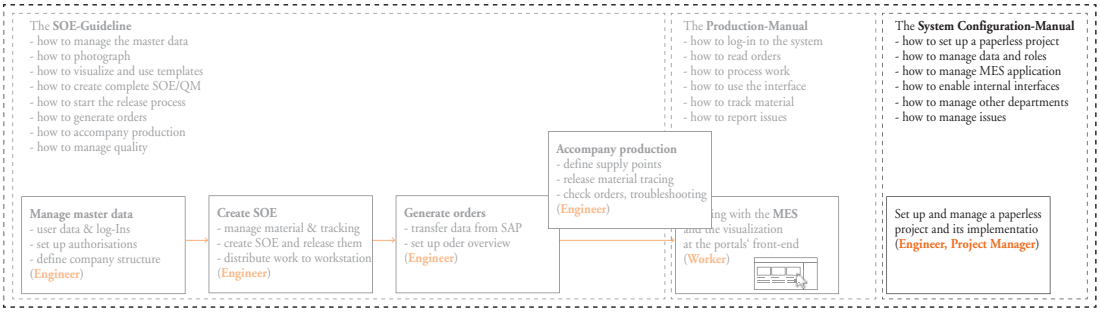


Figure 45: Showing the given taks and working context

Problem space: The project manager had been with the project since the beginning and had gone through and experienced all stages of implementation. Abstracting to a more general valid level was a challenge and he had no starting point for how to collect, sort, structure and make sense of the collected knowledge. The past years have showed that the cooperation with the design expert had always been very helpful, but there was uncertainty about whether the scope could be achieved in the intended timeframe, especially given that past activities have always taken longer than planned. He could not define a clear deadline because he was not clear about the workload. Nevertheless, he knew that he must use the collaboration and the joint reflection to be able to conclude the final processing of all manuals.

In addition, many employees had already completed the reappraisal phase in their minds and the constant reworking seemed to have become a burden. The engineers used the templates, but urgently needed help with visualisation, as they were sometimes not satisfied with the results. They were interested in a training conducted by the design expert, but could not fit the time for it into their daily workflow. These different aspects shaped the context and the work with the project manager formed an island activity.

Extend problem area: The third manual, the system configuration manual, described and reflected the entire project from start to roll-out and documented the entire procedure for introducing a paperless organisation in the company. The development of this manual required all the experience and expertise of the project manager and the first long-term users of the software, so there would be a high level of expertise that would need to be externalised.

Challenges on the macro-level of developing the manuals are:

- The company needed a clearly defined action statement for this sort of projects.
- It involved another round of energy and calls for a deep breath and patience.
- This framework addressed all issues that need to be resolved in the implementation of such a project.
- All manuals serve as proof of work, and they needed to be virtually perfect, as the project took a long time to be implemented. This would strengthen the project manager's profile.

Challenges on the micro-level of developing the manuals are:

- The third manual needed to tackle management skills and should enable all employees, who are situated into this role, to set up projects hands-on.
- The hierarchy of information was most important to be met here, as there was a focus on principles rather than directive information.
- The project manager needed practical support in understanding his own comprehension of the project and this envolved multiple reflections on what he did.
- The three different knowledge levels were to be managed in appropriate relationship to each other.

6.4.1.1. Research Sub-question 3

My third objective is to explore how this system of interaction between the design expert and the employees establish principles that are hidden in the transformational process. And, how regular on-site team participation, negotiation and co-creative problem solving form a foundation for trust and reliability so that almost unsolvable issues could become detachable. Additionally, how the presence of the design expert and fluent support will enable employees to deep dive into their knowledge structures to integrate new pathways and using the new system becomes manageable.
The third sub-question is: **How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?**

Study design and inquiry: I started the work with the project manager by giving the finalisation and partial revision of the SOE guideline and production manual to the assistant. This was to give us time and space to tackle the difficult task of the third manual. I also planned to conduct interviews with all stakeholders to reflect their understanding of the past process and to pick up the current value of the developed manuals. Collection of evidence in this cycle therefore took place via recorded semi-structured interviews with selected production engineers, the Key-User, and the project manager. In the working meetings with the project manager, I was able to record all the time, regardless of what was said. In addition, I took notes during and after the work meetings, which took place weekly and biweekly. I was able to photograph the work setting and the working environment.

Timeframe: The third cycle took place between autumn 2019 and mid-2020.

6.4.2. Action Phase

The activity in this third cycle was structured by the fact that production was now actively using the new application and that the team process was taking place partly as a group working on its own.

My attitude and comprehension: At this point, I was already known by all employees as the design expert. Depending on the role and perception, my value was rated differently. Since I was in a very technical environment, and my work therefore seemed foreign to most, I tried to be as transparent as possible. From the project manager and some engineers my work was seen as meaningful. I myself now understood the basic functions of the application and understood the software as well as the organisational operations. I sensed, that I now have to use all my experience from the last years, to support the project manager in creating the configuration manual.

Description of what happened:

My activity: The weekly work setting was situated at the organisation in a room with desks and a large screen. During sessions I displayed the page layouts as results from the Manager's correction files or from the prior week on the screen. The Manager could view the document at the same time as I showed it,and also work in it. The interaction was fueled by equal input and reflection on output. The weekly or biweekly working meetings went on for 5-6 months, with some breaks. My activities were manyfold and I discussed with the Manager about what I understood, and we negotiated what should be written in the documents. I also moderated by using post-it notes and sticking them on the nearby wall. I wrote notes in an Excel sheet to show him, what he said and to develop a content structure as well as an information hierarchy. All this was accompanied by constant recordings, which only paused when we went for lunch. In addition, I was supervising an assistant, who made the corrections in the Adobe InDesign files.

Process – General Settings: The team decided to reduce the number of manuals from four to three – SOE guideline, production manual and system configuration manual. The main focus remained on the SOE guideline, as it had a key function in the ongoing implementation. The production manual was only intended to help workers familiarise themselves with the system and take the first steps towards being able to operate the basic functions. The system configuration manual was therefore still the icing on the cake, but nevertheless was important.

Process – External Forces: External influence was low at this point, as the massive adjustments to the MES application had been implemented. The software company only worked on small adjustments, which nevertheless resulted in improvements in the manuals, but this had already became a habit. A stronger influence was the financing, since the work on the configuration manual was interrupted again and again by rework in the SOE guideline, this last phase lasted approx. 4 months longer than planned.

Process – Results: The project resulted in around 450 hours of working time together and separately, distributed over around 2.5 years. There had been 29 versions including a partial rework of the SOE guideline with approx. 130 pages, 13 versions including a complete rework of the production manual with approx. 46 pages and 6 versions of the system configuration manual with approx. 60 pages developed. Within this last cycle, the last reworks of the SOE guideline and the production manual took place. The iterations of the system configuration manual always included a major rework. The reviewed documents had been released to the official filing system at the beginning of June 2020.

Process – Consequences: As a result of this last phase, the SOE guideline and production manual are in use. The system configuration manual has not been followed up to date and to my knowledge. The project manager has put his focus on other projects. I am aware that there should be adjustments to the manuals and this is also desired by the engineers. The new organisational structure has not yet taken any steps in this direction.

6.4.2.1. Evidence from interaction with project manager and design expert

Photographs that follow show the workspace in the organisation, where the paperless team had its home for about 2.5 years. At the beginning of the project, employees of the software company also had places there. The pictures show the room with desks, PCs, one large screen, the working setting in the last cycle, and the wall with the post-its and notes.

Further pictures show typical notes from discussions and how the MES application software is displayed. The screenshots show the filing of the interview recordings conducted in the beginning of cycle 3 and the recordings of the working sessions at the team space as well as other material filed.

Remark: Labels and names are removed from pictures and screenshots due to non-disclosure policy.

The large screen displays the design expert's display for discussing content. Project manager and design expert worked together at the table during the working sessions (Figure 46-47).

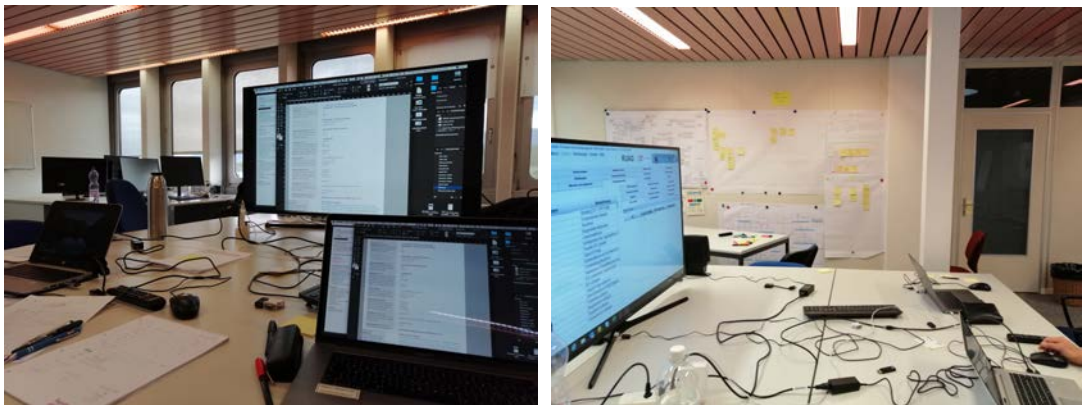


Figure 46: Paper-less team office at site.

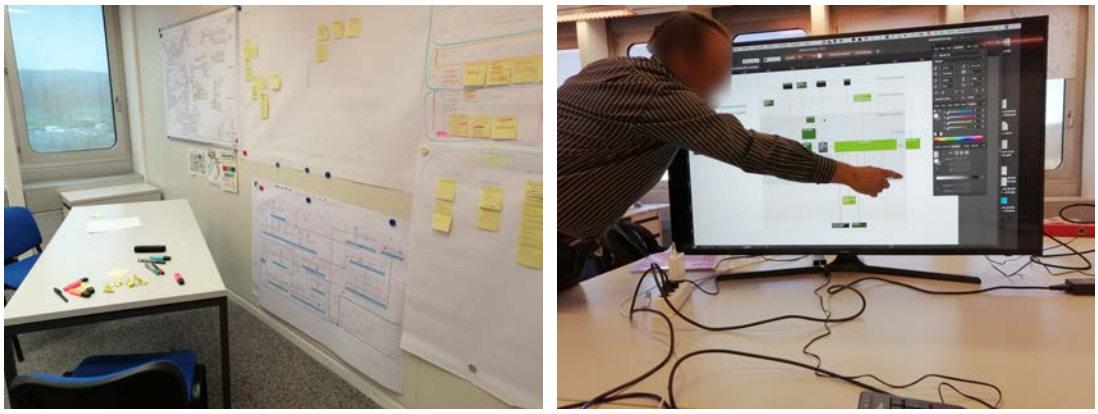


Figure 47: Wall besides the table served as pin-board (left). Project manager pointed towards a diagrm (right).

The interface is pure and functional, brand design elements were not applied (Figure 48 left). Simple notes were made on paper, before they turned into the document (Figure 48 right). Pin-board and paper content changed multiple times, before transformed into guiding information.

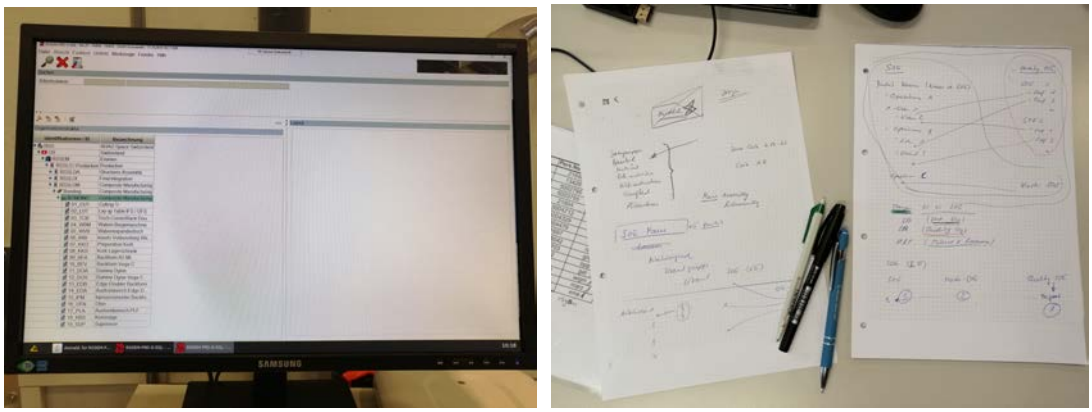


Figure 48: The MES interface was screenshot before it turned into the documents (left). Paper notes (right).

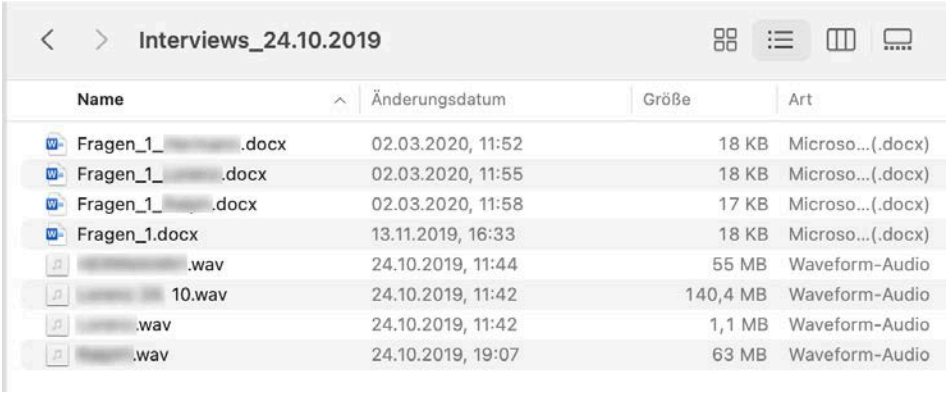


Figure 49: Filing of interview recordings taken in October 2019

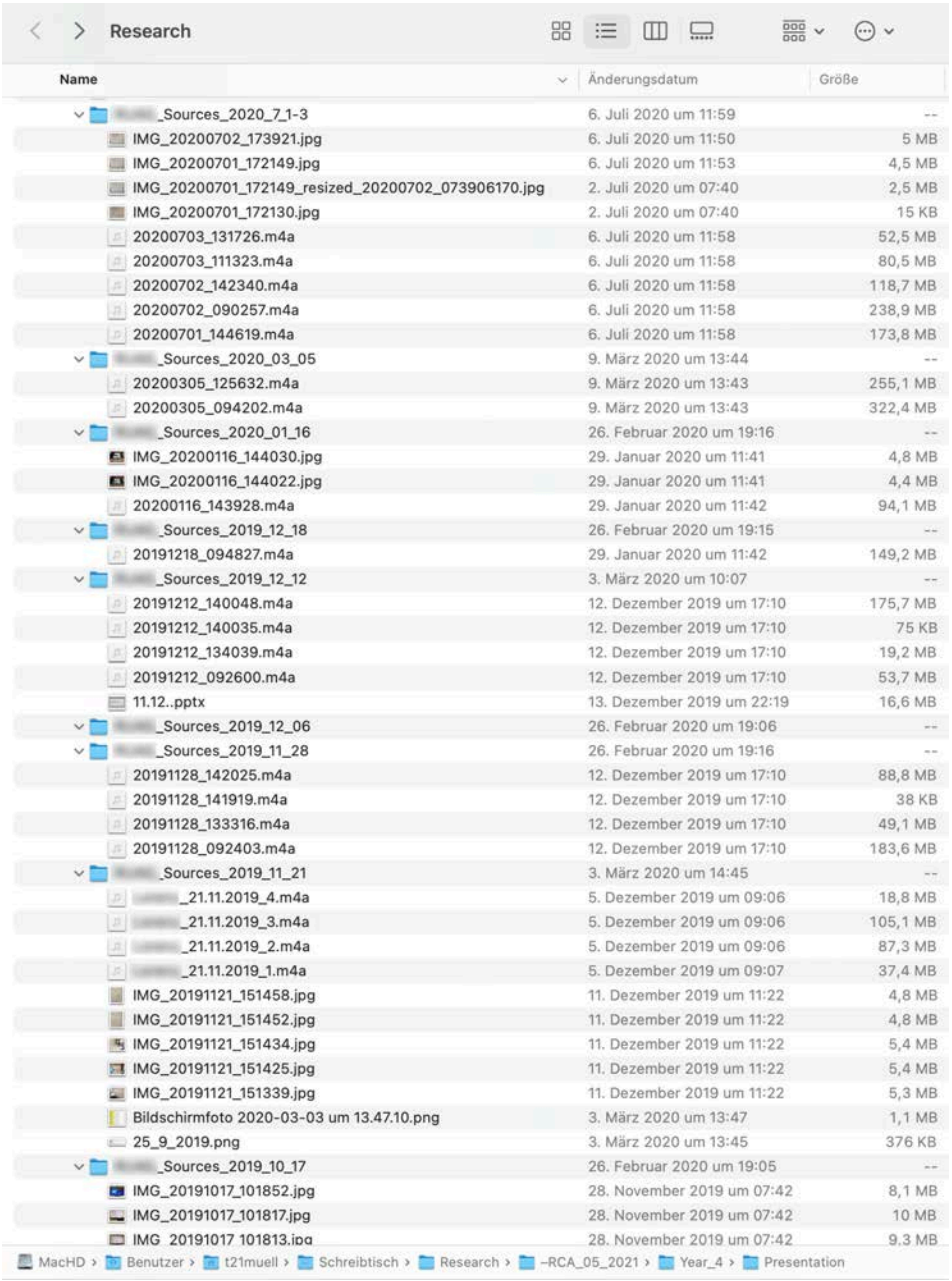


Figure 50: Filing of recordings and material produced in work sessions from October 2019 til mid-2020

6.4.2.2. Evidence from interaction with manual material

Material is documented in filing of all manual versions. The second picture shows a table, where the project manager and the design expert discussed the characterisation of the Configuration manual text type being descriptive, operational, or principled. This approach helped to develop a 3-point rating system to understand where what type of information needs to be described in the manual, and how.

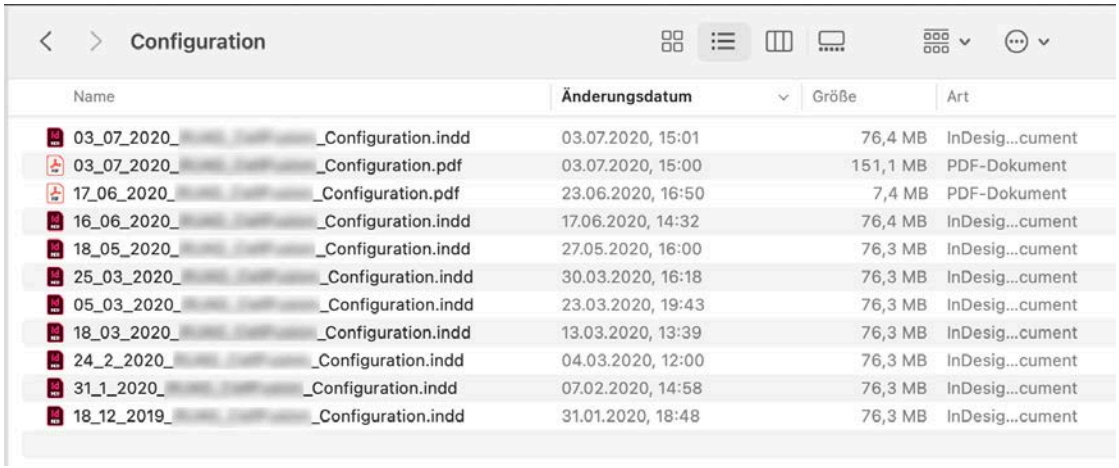


Figure 51: Configuration Manual versions. Naming and date indicate more versions, not separately saved.

	Anwendung	Begründung	Prinzipien	Tätigkeiten als Vorbereitung	Anwendung	Begründung	Prinzipien
					wie	techn. Waru	grunds.warum
SAP / MES erklären			3	abgleichen mit SOE	operativ	taktisch	strategisch
SOE generell (papierbasiert, digital)		1	2		manual-ch.	Guideline-ch	Policy-charakter
FMDB / VCPT Zusammenspiel			3				
Visualisierung VCPT		1	2				
Systemkonfiguration	2	1		abgleichen und komplettieren			
Übersicht der Portale		3					
Daten erfassen (Stucklisten Materialien)	1	1	1				
Stücklisten / Bauteile			3	abgleichen mit (Stückliste in SOE)			
Rohmaterialien	3			neu			
Tools (xxxx)	3			neu			
Equipment (Tools zu Equipment macher	1	1	1	neu			
Messmittel-Tool	3			neu			
Werkzeug-Tool	3			neu			
Vorrichtungen-Tool	3			neu			
Hilfsmaterial	3			neu			
Fotografien (ablegen)	3			zur SOE-Visualisierung			
Mitarbeiter	3			neu			
Massendaten importieren				neu			
Stammdaten			3	neu			
Batch	2	1		neu			
Erfassen	2	1		neu			
A/R	2	1		neu			
optional	2	1		neu			
Chargenpflicht, Serialpflicht	2	1		neu			
Prepreg							
Benennung (Nesting)	2	1		zu SOE-Stücklisten			
Consumption	3						
Out-time calculator (shop life)	3						
Prepreg Rollen (Rollen Management)	3						
Freigabe von SOEs		1	2				
Versionierung		1	2	abgleichen			
Negativ-Fälle	1	2		Neu			
Login/logout at work station			3	neu			
SAP Schnittstelle	1	2		was wird gelesen, was wird zurückgeschrieben (Aufträge, BOM, Zeichnungen, F			
Routing	3			neu			
Aufträge lesen	3			neu			
abgeschlossene Aufträge rückmelden	3			neu			
Stücklisten lesen (Dummies)	1	1	1	neu			
Zeichnungen lesen	3			neu			
Aufträge							
Aufträge erstellen							
Flow ID							
Aufträge ändern				Aufträge werden jeden Tag von CF gelesen --> ein Auftrag kann geändert werd			
Verantwortlichkeiten (Rollen)			3	neu			
Produkt bezogene Rollen	2		1	neu			
Herstellung bezogene Rollen	2		1	neu			
Rollenfunktionene aktuell	2		1	neu			
Berechtigungen	3		1	neu			
Prod Auswertung			3	neu			
Prod Fortschritt		2	1	neu			
Minor Rework		2	1	neu			
Qual Meldungen		2	1	neu			
Firmenstruktur	3			neu			
Arbeitstationen (virtuelle Arbeitstation)	3			neu			
Supply Point	3			neu			
Freezer	3			neu			
Label Printer	2	1		neu			
Einbinden							

Table 24: Table in Excel helped to structure content and how information can be characterised.

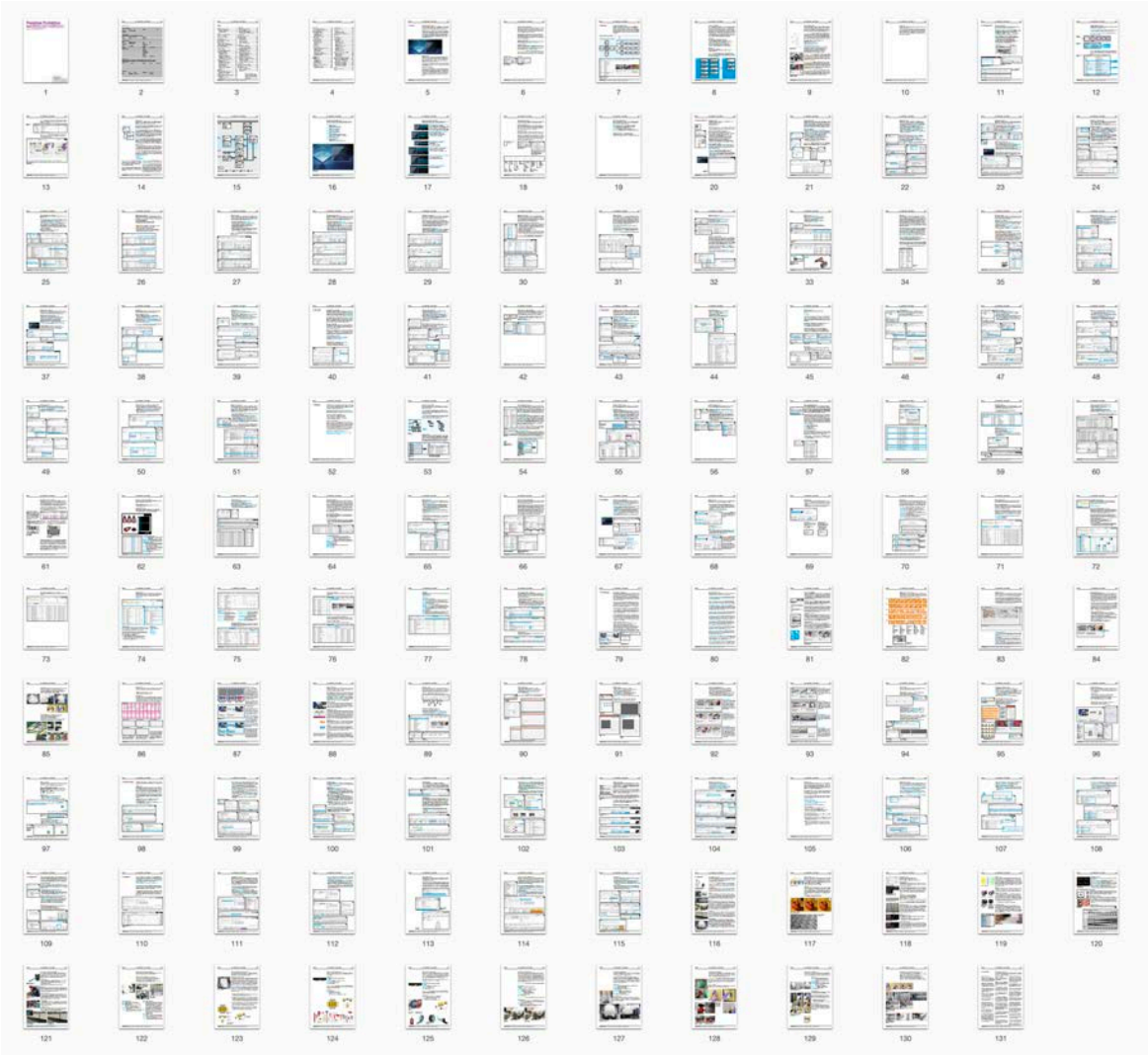


Figure 52: Final document of SOE guideline June 2020

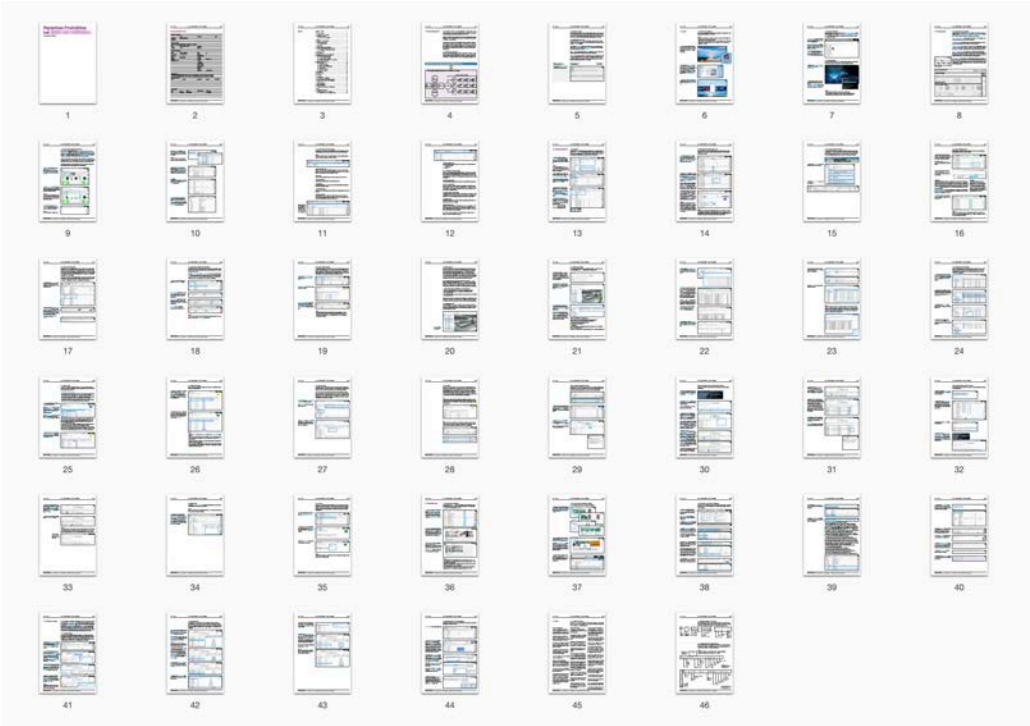


Figure 53: Final document of production manual June 2020

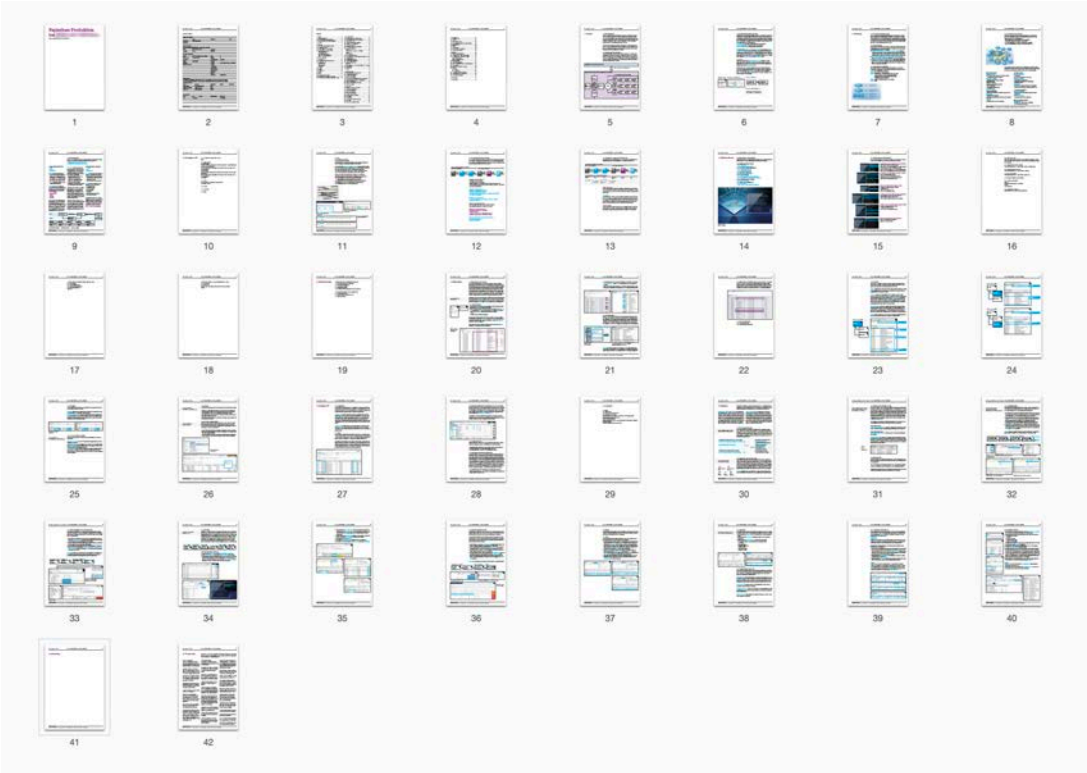


Figure 54: Final document of Configuration Manual June 2020

6.4.3. Analysis Phase

In the analysis of cycle 3, I use the evidence of all key actvities from December 2019 until July 2020. Similar to the analysis in cycle 2, I analysed the material coming from personal sources as in-vivo codes, followed by the interaction with material such as the manuals. In this last analysis, the examination of the visual material from all three documents, SOE guideline, production manual and configuration manual will be examined in detail.

6.4.3.1. Interaction with Material as In-vivo Codes and Memos

The engineer interviewed said, that the hired "expert should know the context, the digital context and he should have worked with a MES before." I also understood from the interview, that from his perspective, the complete project could have be done with less useless effort, when I would have entered the team after the major adjustments. (Chapter 10.1.3. Material from AR3)

The project manager at the opposite pole said, that "it (my contribution) is a support, because I have to think about what the design expert has understood. The external reflection is important, otherwise one just does something for oneself. You [the expert] have skills, which I do not have." He related this to design skills but added that, "your work helps me a lot to understand my understanding of the matter. I see what I understand when I see how you interpret my inputs." He rated the documentation, "if we document all of this project by the manuals, we might raise more awareness for other people, and then maybe more support from management will come." And "you know, people who like change and are interested in knowledge and learning, they will support our project. But in general, nobody wants change, you have to take people along." (Chapter 10.1.3. Material from AR3)

The design expert recognises that "I become aware of what I do, my own skills as a designer but use it as an design expert." And "I transform the given content into the syntax relevant for their needs." Depending on the personality [of the knowledge workers], the expression of their thinking is different. Specialists have trouble "thinking" because they are locked into their know-how activities. Intensive experience about a pilot project supports the logic of the processes, which is deeply rooted in the activity "but not much in reflection." (Chapter 10.1.3. Material from AR3)

The challenge in the design expert's view is that "the entire company is technically structured and the MindSet is not so much aesthetically oriented but rather process-functional. Softskills and how the company works are needed for implementing the MES. There is a high demand on patience and reflection. It is the most important setting, that the project manager looks at a live document and can investigate in the visualisation based on his contribution. The interplay of client and design expert is productive, when both core professional skills overlap, mirror each other, applied to a certain task or question. The knowledge moves from vessel to vessel - memory, medium, application by another person. The interplay depends on both performance and honest reflection. Both have to work hard in reshaping the content." (Chapter 10.1.3. Material from AR3)

It contributes significantly to the mutual understanding that the different perspectives need to be reflected critically. It is easy to see when a text structure and visual layout needs to change, when the view is questioned and critically reflected upon. If this is stimulated from the role of the design expert, "critical moments in the relationship can occur, since the intervention is often accompanied by stronger emotions as changes require effort that affects both sides." And there is always "uncertainty, due to the new role. I had to develop a strategy as I had not done a project before, such as the one described. This ever-changing role of the expert-designer-user and its fulfilling turns of the profile and the active relationship to the Manager turns into a professional, knowledge-intensive and relational service." (Chapter 10.1.3. Material from AR3)

Interpretation of the interviews and the team members quotes: On the client side, especially from the engineering perspective, there is the expectation that the design expert's value drives from an expertise about the software or application, in order to more efficiently document the content within the manuals and be supportive in the implementation. In contrast, the Super-Key-User does not focus on the lack of knowledge but rather emphasises the supportive character by always fluently integratingthe discussed content into the document. The relationship is determined by the understanding of information and by interpretation via the documents on the other hand. It is actually a kind of give and take, which behaves reciprocally until both are decided to have represented the right thing. The potential awareness of the manuals may result in more support by the management. The dynamics of organisational learning are seen in the dependency on the interest on the employees. Change is usually not popular and therefore employees must be brought along.

Interpretation of the design expert quotes: As an design expert, the designer needs to change the range of activity expanding the *skills as a designer* by transforming content into new syntax and at the same time moderating the process and managing different perspectives. There is a *constant need of* transformation of information into usable information for prospective readers and reflection on a neutral perspective. There are softskills, comprehension of the company structure, and knowledge about the MES needed. The profile demands a large amount of patience and involvement. The relational quality is driven by equality, co-creative contributions, investigation into visualisations and authorship. The relationship is productive when both parties perform and reflect as well as negotiate. The designer needs to open his mind to technical mind-sets and to uncertainty as new skills are required. The ever-changing role crosses the borders of well known terrain. The professional and knowledge-intensive support is *creating a facilitative profile*.

Critical Interpretation: Participants' interaction basically rests on double-sided support, understanding, and reflection. The interaction depends on the ability of the designer's transformation of visual content for specific needs. The power structure therefore depends upon the feedback-loops of the designer, but also on the designer as expert giving a constant critique on the input given. The relationship between the participants is two-sided and the design expert's skillset rests on moderation, understanding the context, and team dynamics, as well as visual design skills. Given the situation that at the beginning of the project the task was different, the design expert needed to learn about the new requirements but also used design skills to capture the challenges. The manuals are a proof of work within the company and the mindset of the company is functionally-oriented. They show that the project's goal is fulfilled, based on the given circumstances. They represent design leadership, as without the design skills and the role understanding, the manuals would not exist.

Evaluation Interpersonal Communication: The mindsets of the company's employees are process-functional and usually there is no space for aesthetics. Hence, there is little acceptance in the operative manpower for work which is related to design or visual art. The contract was initated by one engineer, who was educated in design on a further education basis. Acceptance from more employees developed only through a long process of interaction (more than 2 years) and a declaration of commitment until the end of the project.

- ➔ The designer is adapting to the situation with all skills available.
- ➔ By adapting to new working requirements, the designer starts to form a partnership.

The challenge generally is based on the fact that knowledge workers usually are too busy doing their work and do not like to spend much time explaining what they do. They are practitioners and do not reflect visibly on their actions. The interaction between knowledge worker and design expert therefore needs patience and relentless interest. The interplay is productive, when skills from both parts mirror each other. This enables the knowledge to move from one person to another person. This transformation is characterised by the retrieval of the tacit from the memory, its reshaping to the medium "manual" and the use and the application of its content by some other person.

- ➔ The designer needs not only patience but also resilience and courage.
- ➔ The retrieval of knowledge can be mirrored, independent of how deeply its is rooted.

The design expert's role is manyfold and ever-changing. Successful moments arise, when there is a real discussion and intervention from both sides. The intensive interaction occurs when both sides have the need to negotiate their position. It takes trust and flexibility from both. The power structure and the interaction only works because a relationship of trust has developed.

- ➔ By being open and understanding that both sides take their part, there is an interplay.
- ➔ The involved participants need to be clear about their power-perception.

6.4.3.2. Interaction with material from all three documents

In all three documents, there are different page structures based on the various content and user focuses, while some page structures are the same for all three. In addition, there is a hierarchy in the documents without indicating that one has to use all three in a certain order, but they can be used from different user perspectives relative to their task and to work with the new software system. The three documents are invisibly interlinked and are hierarchised by their users:

System Configuration Manual: used by a project manager for setting up a project such as this.

SOE Guideline: used by engineers, setting up the production events in the system for the shop floor.

Production Manual: used by employees in the shop floor, using the system in the work process.

For example, the configuration manual needs to explain structural and organisational aspects of the software, its backend as well as indirect hints on organisational knowledge about the company departments. Within the production manual, knowledge about material and process procedure is covered. The information displayed in the manuals represents different kinds of knowledge and make processes and organisational structure visual on three different levels.

The visual codes used in the documents' layout are corporate design elements representing the company's visual voice using the brand mark, typeface, type settings, symbols, primary colours and layout. Pre-defined corporate design elements, such as a simple version of the brand mark, icons and colours are used in the software. Visual imagery is covered by diagrams, screenshots from the software systems, and photography in various formats of material, shop floor work and products. All visual elements used in the documents are analysed by qualitative measures of meaning and quantitative measures of prevalence. The documents' content is broken down into: *instructions, rationale* and *principles*. In all three documents these levels appear in differently quality and quantity.

Proportional approach to understand the material: The analysis on distribution of *visual elements* and page types in the three documents show different patterns. To determine the number of elements, I counted the number of diagrams, screenshots and photographs, and I measured the length of the text, respecting the structure of the written content. The proportional distribution of content elements shows that the production manual uses predominantly (63%) sceenshots and less text (36%). In contrast, the system configuration manual uses predominantly text (55%) in combination with some screenshots (35%) but favours diagrams (10%) for explaining a rationale and

principles. The SOE guideline uses text (40%) but fewer screenshots (46%). In addition, it needs photography (10%) to convey the sequence of events. The production manual uses a minority of diagrams (1%).

The distribution of *page types* show that they convey the different uses. The *principle*" are concerned with a general understanding of processes and, if necessary, offer opportunities for decisions. The *rationale* explains facts without directly giving instructions for any kind of activity. The *instructions* give clear guidance of procedures and step-by-step guidance. Accordingly, three types of pages are used for the analysis: *principle pages*, *explanatory pages* and *instruction pages*. As a rule, the subdivision can be made page by page, overlaps occur rarely.

All three manuals are based on the same document layout structure, respecting the corporate design guidelines. For the analysis, I used the existing PDF version of the manuals. As the development status of the manuals was different, the contents of the PDFs served as average examples to define the representative distribution. To get a comparable distribution, I converted the counts into percentages, to avoid misinterpretation by the different stages of development, especially the stage of the system configuration manual. Furthermore, I left out all pages that are the same in every document, such as title, table of contents, index and document framework.

The proportional distribution of page types shows that there is a very dominant use of instruction pages in the production manual (79%) versus an extremely low number of them in the system configuration manual (23%). The principle pages and explanatory pages seem to be almost equally distributed in the system configuration manual (38% to 38%) and the SOE guideline (20% to 26%), but the instruction pages predominate (54%). The small amount of instruction pages (23%) in the system configuration manual is due to the fact that there are cross-references to the explanatory pages of the SOE guideline.

Note: The pie-charts can be found in the chapter 10 (Proportional Analysis of Manual Content).

Qualitative Analysis of Visual Codes: The visual page analysis takes into account qualitative measures such as text-image distribution (layout), message, how the message is conveyed (approach) and what kind of action is associated with it (intention). The way in which visual elements are used in the manuals refers to the meaning and the relationship of conveying instructions, reasoning and principles. From a qualitative perspective, the visual codes consist of different visual essentials within a relational context defining meaning. Text areas can consist of essentials such as headlines, sub-headlines, copy-text, lists and diagrams can be made using tables, schemata or flow charts. Depending on the use of the various elements, they are coded as:

Category for the causal entity; in this context the visual code by the visual element.

Origin refers to where the substance is build of and how it appears. Usually the essential visuals.

Meaning does the coding of the means or the sources of the code. Usually the message.

Relation stands for subordinarity of the category, its reference to real world systems.

Prevalence describes the appearance within the system; usually the quantity by volume.

Note: The detailed document analysis can be found in the chapter 10 (Material Document Analysis).

System Configuration Manual: This manual describes all activities for configuring a project within a company environment. To a large extent, principles explain how the interaction between software and organisation can be established and how departments are coordinated. In the software portals, work must be done practically and this requires a certain number of instructions. Numerous references also refer to instructions that are already available in detailed form within the other two manuals. However, the user of this manual is in the position to work on the meta-level and does not necessarily need to know detailed work processes on the shop floor, but it would be advantageous.

Interpretation Page Types in the System Configuration Manual

Instruction pages are similar in structure to those in the other two manuals. In addition to work-related steps, there are instructions that represent a meta-level of tasks, i.e., combining work steps into one step. Often there are general explanations or principles which are added as a supplement.

Explanatory pages comment on given settings in the software or decisions taken about applied principles. Screenshots can be used to illustrate an explanation, diagrams or charts are used when explaining structures. In these pages and in the Principles pages the project or organisational structure becomes visible. The repeated revision of these pages shows the discovery and visualisation of the hidden processes, or the redefinition of the processes using the software conditions.

Principles pages describe the principles of such a project and set out the framework of action for project managers, without, however, making binding specifications in all details. By explaining the principles, organisational structure is presented on a meta-level and the presentations reflect the meta-level by a degree of abstraction. Schemata or flow charts are used for detailed descriptions

Evaluation System Configuration Manual: The knowledge that is made visible in this manual through iterations is how such a project can be implemented in an organisation. It requires some practical working knowledge and knowledge about the organisation to be able to moderate and control a change of this kind. Especially in technical areas, project managers need to be able to communicate with different mindsets, from workers to engineers to management. This different knowledge is therefore located in different places, and different challenges arise to recognize and use the expertise. The knowledge is therefore generated from the strategic and organisational nature of the work and is also a skill, although it is more about understanding the principles.

➔ The management skill is also a hidden knowledge, which needs externalisation.

➔ Strategic and organisational nature of this kind of work shows by principles.

The interaction during the development is especially challenging, since the groundwork must also make available all insights from the previous process in order to develop, structure and present relevant and appropriate content. The cooperation thrives strongly on the fact that the basis of trust has been developed in advance and both sides must fully contribute their insights and knowledge.

➔ The basic energy of the facilitation lies in the trust developed.

The work with all manuals as visual material supports the discovery of the different expertises through iterative work. But especially here it is important that the designer has strong abstraction skills and understands the topic very well. Mainly beecause no existing representations are used, and the contents have to be developed from zero. The representations developed must also remain on an abstract level, as it is a matter of conveying meta-skills and a pictorial representation with clearly assignable content would possibly lead to incorrect application or interpretation.

➔ The visual means is the transporting system for meta-skills.

➔ The designer has to be able to grasp the abstract thought coming from a knowledge worker.

SOE Guideline: The SOE guideline describes all measures and activities from an engineer which are necessary to set up the work flow for the workers. The digital work flow in the software needs to be developed using the features such as visual lean, material and tools portal, measurement and quality control functions within the sequence of events design. This guideline sits in the middle between production manual and system configuation manual as the settings and activities of the engineer affect the production as well as the project management. To a large extent, explanations and instructions on how to design the SOE make up the content. One specific activity is the set up of the events using visual descriptions and photography. The engineer needs to understand the work flow and details in order to recapture the process and to rebuild it within the digtial environment. The engineer also needs to take photos to use in the visual lean elements, and therefore an active reflection on what is actually taking place at the shop floor takes place.

Most of the unlearning takes place here as the events are the core of the work processes and there is an intense interplay between production employees, engineering and project management. The engineer needs to understand and to communicate towards both ends. He does not know certain parts of the organisational knowledge or the applied working knowledge.

Interpretation Page Types in the SOE Guideline

Instruction pages accompany the description of the exact process of how events must be created in the software. The successive steps and the corresponding texts are numbered accordingly. All additional settings in other portals are described in the same way. These pages also show how to photograph the work process and what to look for. Since the creation of sequences requires many different but defined activities in the software, the percentage of these pages is very high.

Explanatory pages are correspondingly extensive due to the diversity of activities. The defined basics for setting up different processes with and without exceptions must be explained. In some cases screenshots are commented on and the settings are explained by an example. Basic settings about the company's corporate design and their application are explained here. There is a focus on the applied photography in the current working environment and how they are used in the new system

Principles pages explain the principle procedure of how the work processes are transferred to the new system. The principles therefore do not represent any room for maneuver but a basic procedure, so processes in the company become visible. The goal of these pages is to trigger a general comprehension of visualisation using photography.

Evaluation SOE Guideline: Within the guideline it is about transferring the work processes into the digital environment. All processes (events) must first be analysed, reconstructed and documented in images and text. The guideline promotes the process of analysis and implementation in equal parts. The guideline for reprocessing has to be considered, especially in the photographic documentation. Learning the visualisation forces the users of the guideline to reflect on the working processes and promotes un-learning. Step by step the guideline is worked out and understood. It has also been developed step by step. Parallel to the development of the guideline, software settings were adapted and the transparent knowledge was reflected and visible within these adaptations. The new setup of the work steps in the software means the implementation of a reflected process.

➔ The processing skills can be relearned by reproducing them visually.

The interaction between design expert and client during the development of the SOE guideline is highly dependent on both parties continually delivering content. On the one hand, the design expert needs prepared content, which is then converted into text and images in the manuals, and on the other hand, the customer needs a smooth delivery of these representations. The regularity of this mutual exchange is necessary, since the reflection only becomes valuable in terms of content when one intensively exposes oneself to the complexity that arises. This means that the adjustments must therefore be equally fluent and fast, since the inner images or ideas of the topic must be flunently matched with the visual representations.

➔ The complexity of the interlinked processes needs reflection by two parties.

➔ The designer has to be able to reproduce fluently and see the right moment.

The necessary design skills are manyfold due to the fact that they do not focus only on one type of 2-dimensional representation. Skills are required in the areas of document layout, diagramming and developing a hierarchy of content. The visual language in this case must have an abstract, applied and systematic character. In addition to the pure identification with the content, the structure needs to supports the learning process on an organisational and on an individual level. The subdivision of text and images into processable quantities is essential.

➔ The visual means need to be very different and diverse.

➔ The designer has to apply a 3-point rating system to understand the different action areas.

➔ The content needs to trigger learning and transformation of habits.

Production Manual: The production manual guides production employees through the sequence of events in production. The employees are usually familiar with the process, but the manual should also be usable for new employees starting work in the new company in the context of their specific projects. This handbook is central to the execution of all work processes in production, but it is only intended to provide the impetus for the use of the new software. The working knowledge sits in the sequence of events. The production manual is therefore shorter and consists of the most important instructions and explanations necessary to get started. The manual is the only one in which the content has not been worked out together with the employees from the very beginning. This led to a problem during the project, because after the first test it turned out that the language used was too complex and too lengthy, and the visual language did not correspond to the actual need for action. After the manual was tested in another semi-developed version by several people in the shop floor, the adjustments could be made. A major difference between this manual and the other two manuals is that it is not only short, but almost exclusively contains instructions for using the software. In addition, it deals with some special cases concerning material management and quality control. In the area of error handling, the only self-regulation is provided if experienced personnel are close by.

Interpretation Page Types in the Production Manual

Instruction pages mainly show large scale screenshots and short paragraphs of text. The work steps are presented in simple and clearly comprehensible quantity. In contrast to the other manuals, the descriptive texts for the screenshots are handled as border text. The screenshots are in the centre and visually dominating the document. Text has rather a commentary function to the image. The instruction pages are the dominant part of the manual and focus lies on the imagery.

Explanatory pages are rare and always linked to an example picture, which is to be seen in reality as it is shown. The number of explanation pages is very small and this is due to the fact that the main purpose of this manual is to guide employees to clearly defined actions. Pictures must always correspond to what they directly serve in action. Explanations are used above all when it is a matter of presenting understanding for a decision that has already been made. However, the explanations are short and are often integrated into the introductory texts of the instructions.

Principles pages can only be found in this manual in a hidden way. Almost no room for maneuver is presented, with production decisions being made outside the software. The freedom that is available is not officially documented. However, there are things that need to be documented in the system and here the focus is on understanding and the corresponding activity.

Evaluation Production Manual: The knowledge in the production manual is pure process knowledge and hand craft. It is based on the experience of all knowledge workers in the company, from the development to the executing production employee. Here it is especially important to transfer the expertise in the production by the analysis of the engineer to be transfered.

➔ The skills are practical but are the concentrated result of all expertise within the company.

This manual can only be accomplished by testing it with the users on the shop floor. The design expert is also dependent on how the client (project manager and engineer as contact person) communicates the work or enters it into the system. This manual aims to present the events already implemented in a comprehensible way. On the other hand, the design expert can veto this if he believes that the content should not correspond to the user groups and a further test is appropriate.

➔ Testing here is most critical, as the reflection is purely realistic and direct. Yes or No.

➔ The design expert needs to grasp the acceptance or the disapproval, even when hidden.

In the production manual, pure reproduction is most likely to be used. It is about the skillful and stringent application of visual communication. If the content delivered is something that shows an inconsistency in the work process, the visualisation can help to detect errors in the system. In the development of this manual, designers who are not so deeply involved in the complexity of the project can also be used, since their greater distance makes them a better filter for inconsistencies.

➔ The quality of a clear visual language pays.

6.4.4. Conclusion Phase on Third Objective

Based on the prior analysis phase, this phase reflects on the third objectives and its sub-question followed up with a general conclusion and ending the action cycles.

How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?

(a) How does the process of interaction between the design expert and the employee establish principles that are hidden in the transformational process?

(b) How does regular on-site team participation, negotiation and co-creative problem solving form a foundation for trust and reliability so that almost unsolvable issues could become detachable?

(c) How will the presence of the design expert and fluent support enable employees to deep dive into their knowledge structures that learning the new system becomes manageable?

The design expert needs more than visualisation skill, but without it, she barely is able to facilitate the dynamics of a transformation. The visual means is a transporting system for various skill levels and the design expert needs to map out the different levels of the knowledge workers. The abstractness becomes a shape and a rating system supports the tackling of the different content levels.

- ➔ Structure the work and understand the principles by organising visual and text elements.
- ➔ Work with schemata to discuss principles with knowledge and process owners.
- ➔ Use appropriate visualisation for the users and test it.

From management skill to practical skill, all are shown by different language, appearance and guiding depths. Principles, instructions or explanations will support the learning, when the means for reconstructing has been met appropriate to the practitioner. Facilitation in this context embeds transparency in work, co-creation, clarity, no ownership, supportive, transformative visual skills, abstraction, and a sense for practical work. Testing with the most critical participants is crucial.

- ➔ Use the unlearn process to understand embodied / embedded knowledge.
- ➔ Lead the reflection in a discourse in order to understand the knowledge yourself.
- ➔ Deduce and record from the discussion text, which can be used in manuals.
- ➔ Support the visual reflection in a co-creative setting.
- ➔ Differentiate between step-by-step guidance and understanding principles.

How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?

(a) How does the process of interaction between the design expert and the employee establish principles that are hidden in the transformational process? **The role of the designer is redefined through the new challenge and the facilitation of employees struggling with complexity. The design expert needs to take a neutral position and look through a systemic perspective at the same time reflecting the information architecture itself.**

(b) How does regular on-site team participation, negotiation and co-creative problem solving form a foundation for trust and reliability so that almost unsolvable issues could become detachable? **The process is co-creative, visual, imaginative and personal. The offer of professional skills and seeing the problems itself leads to beeing in the context and the presence is holistic.**

(c) How will the presence of the design expert and fluent support enable employees to deep dive into their knowledge structures that learning the new system becomes manageable? **The design expert knows about the different levels of knowledge in the roles distributed. The design expert is involved in the process and understands, that the design is the process and not the form at the end. These two sides are key to understand their scope and their effect.**

7. Discussion

This chapter summarises and addresses the significance, importance and relevance of the findings from the previous Action Research Cycles. The discussion contextualises the findings towards the three objectives with the sub-questions and evaluates them in context to the existing literature. Finally the discussed findings will be set in context to the main research question.

7.1. Summary of Key Findings

I condense the findings on knowledge management, communication, facilitation and co-creation.

7.1.1. Findings in the Area of knowledge management

Challenges in knowledge management: Processes in the organisation are lived implicitly, but regulations are explicit. In its state of transformation, this organisation demanded support, because:

- the sharing of invisible design expert knowledge is missing useful explanations and words,
- the sharing culture does not support employees to express knowledge in new forms, and
- design experts can support the finding of hidden issues by applying their methods.

Learning new routines: The specific profile of the design expert bringing in special skills, see the problems in communication, and being supportive yet courageous are represented by:

- The inquisitive attitude of the design expert regarding explanations, triggers discourse and enables reflection and unlearning.
- Using the new system itself expanded the understanding of the basic routines for the design of the manuals taking into account different ways of reading, working and the roles.
- Appropriate, clear and less *designed* visualisation and a simple structure has been shown in tests to make the content easier to understand and support the learning process.

Long term support: The design expert provided support for a number of years. This continuous participation in the project team revealed in challenges and opportunities:

- Constant care for files and discourse makes the design expert a special point of contact.
- Consistency was important for testing due to internal staff changes within the project.
- The design expert had to independently seek exchanges at times and prepare the content.
- The support and involvement in the dynamics of the teams on site was positively received.

7.1.2. Findings in the Area of Technical and Visual Communication

Information architecture of manuals: The manuals show a mixture of approaches and qualities:

- The content differs between producing, planning and managing work and offers various ways of comprehension in reading, seeing and working.
- The manuals relate to each other supporting all perspectives. There is a mix of technical, design and corporate communication, such as directive, informative and guiding styles.
- The content varies between step-by-step guidance to principles forming in a new format.

The strategic quality: The perception of the manuals in the organisation appears to be new:

- The new format of these manuals are in line with the corporate design of the organisation.
- The templates and their use for the engineers offer a new way of sharing work routines.
- They are not visual design-led but involve didactic and strategic components.
- They combine technical document standards with visual and corporate communication.
- The way the employees are bound into the development opens the discourse culture.

Manual as boundary object: The manual fragments develop at the border of the different perceptions and the discourse and help to structure the project as all participants aim towards one goal. The manuals show specific qualities:

- Due to its dynamic quality, the final manual is often not the focus, but the confrontation with the apparent version of a final product brings out the right form eventually.
- Thus the manuals show two faces. One is the boundary object of the manual fragments and the other is the collection of final manuals.
- The boundary object serves as a fluid representation for discussion and negotiation.
- The documents and their information architecture is managed by the design expert.
- The design expert is constantly incorporating the voices of all employees and understands different meanings of embedded and embodied knowledge through the various roles.

7.1.3. Findings in the Area of Facilitation and Co-creation

Perception of the design expert: The development process is influenced and steered by the working format and visualisation skills that the design expert brings in:

- The design expert gets insights from the employees and facilitates exchange resulting in the recognition of different working knowledge and the creation of an information architecture.
- Describing the routines in the system must be continuous. Facilitation involves the constant change of text and images in the context of a fluidly changing environment.
- There is a constant active exchange between team members and the design expert.

Means for change: The transformation project called for restructuring processes in detail, especially the production and work preparation procedures. The manual fragments became an instrument:

- By looking at old and comparing with possible new processes, key moments emerged.
- Since the design work consists of facilitating the process rather than the final delivery of the manuals, the iterative process enabled the externalisation of tacit knowledge.
- The proactive attitude of testing the content and requesting reactions promoted a steady flow and the realisation that nothing can be implemented quickly in the new system.
- Reflection based on visualisation is the means of changing people's actions. The tests show that users immediately change their actions and reflect them within.
- During the project, the project manager and the Key User began to appreciate the way the design expert worked and instrumentalised it for themselves in discovering the project.
- The manual's visual quality by applying the corporate design guidelines of the company promoted acceptance and the ability to take the documents seriously for detailed feedback.
- The work of the design expert becomes a particular support and enables agency for change, as trust and relationship is in place, building on professional support and work.

Facilitation and co-creation: The design expert changes her role during the project:

- In the study, the design expert becomes a change agent by facilitation.
- She helps by listening and revealing other points of view through exchange of ideas.
- She shapes the discourse and motivates others to engage further in the process.
- The facilitator is skilled, perceptive, courageous, persistent, service-oriented and present.
- This proactive attitude requires confidence in the facilitator and the design expert alike.

7.1.4. Contextualisation with Objectives

(1) How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation? The study showed that visual communication and design practice supports individuals within an organisation to (re-)define their practice. The MES-based visualisation approach helps them by using a known software (PPT) and introducing a less complex and easy to use template. The explanations of examples of visualisation support comprehension, but as all of the template users are engineers and non-designers, they still are challenged by this task. Regarding the utilisation of the application itself, the manual chapter on visualisation underpins the engineers to set up sequences of events in the new application. The use of the new system and the description of the production regulations via virtual work steps and sequences places the engineers in the situation where they have to deal analytically with the processes again, even if the previous paper-based production regulations had already been checked and accepted several times.

In addition, the production employees in the plant already started to experiment with the new application. Overall, the employees stated that the visual approach and the development process is valuable for them in their environment. The Key User supported the suggestion that visualising his explanations made them comprehendable and helped him to understand what he knows. In this individual case, knowledge conversion took place.

It became apparent that visualisation and iterative reflection form a process that help the engineers to express. The design expert and the templates were supportive for employees, when the use was explained iteratively, slow and visible. The first chapter of the SOE guideline had a knowledge visualisation character through its use which could be experienced again at any time by using the templates in conjunction with the instructions.

(2) What does a design expert need to understand about the working environment in order to systematise and simplify complexity? The use of iterative long-term facilitation of knowledge conversion by using the fragments of the manuals that were becoming boundary objects supported the discovery of "nondeclarative-procedural memory" (Carlson, et al., 2009, p. 231) had been confirmed. Including all relevant aspects of the digitisation enabled the definition of knowledge types, which found expression in the three manuals and various content types. Contrary to my expectations, in the end it was even possible to create an information architecture that reflects the complexity of the interconnectedness of roles and processes. Through the consideration of standards from technical communication combined with organisational communication aspects, and using the company's own design specifications for documents, a new manual system as output from the development was created for the organisation.

As a formal, clearly defined document with the help of a design application as well as the compliance with didactic requirements for the content, it offers a new way that knowledge management can be handled in the company. As information becomes available, the knowledge appearing in the manual fragments can be reflected on and criticised. It has shown that in this industrial environment, where knowledge work usually ends with the development of MS Word-based technical documentations, that the various manuals cover different levels of work. The information architecture in the manuals offer ways to organise interaction.

The design expert must realise, that there is a complex technical knowledge system and do a first analysis of how knowledge management has been done so far. The contextual understanding builds up by using manual fragments as a strategic tool and as a boundary object to integrate expectations from all participants to organise a discussion culture. To include a critical double check from new specialists will complete the information architecture.

(3) How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects? The type of facilitation described makes it possible to become aware of one's own knowledge through the process of visually accompanied reflections, which was confirmed by the number of iterations the manuals went through. The use of the iterations of the manual supports organisational learning, individual reflection on one's own knowledge but especially on the embedded knowledge in the organisation. This findings relate to the roles defined in the project and the types and levels of knowledge found (Conclusion Phase on Second Objective). It develops a system of different knowledge types (embedded know-how, embodied practical skills; anchored knowledge about the new system and embodied communication skills) creating a knowledge architecture, which emerges as the information architecture.

Selected employees involved in the transformation initiative drive the knowledge implementation process. Participation, constant activity and the provision of visuals for reflection underpin the working relationship between these staff and the design expert. The development of new methods to trigger knowledge transformation by the design expert proved to be a new opportunity during the project. In addition to the use of the manuals, new methods and principles emerged that represented new ways to support knowledge transformation and make the transformation scalable.

The facilitation needs to focus on declustering complexity by the co-creative, visual, reflective and personal process. Professional skills and seeing the information architecture and its challenges themselves lead to beeing in the transformation space and the presence becomes holistic. The scope of the manual delivery must be juggled so that the value lies in the development of principles which makes the transformation to become manageable and scalable.

7.1.5. Limitations

The study showed that metaphors are part of the conversational discourse when sharing knowledge and expertise. However, it also became clear that this kind of exchange is only open and free between familiar people. Therefore, the sharing of stories took place openly between the project manager, the Key User and the design expert, but less openly between the design expert and the production employees. Furthermore, an external expert is usually perceived as a stranger in the organisational environment, and is treated with caution due to confidentiality and security issues.

The handling of the document management could be different in a different environment. Since the closed IT system in the organisation meant that a layout application the staff were not familiar with was used for document creation, the files stayed with the design expert. Even in the end, the design expert only handed over the finished PDF file. In other cases, the files could stay open and shared from the beginning. The results of the study then might be very different, as the control of the reflection flow depends on the speed of the input from all. A shared file is less dependent on one person's input and the dynamic moments of reflection and discussion change or are not there at all.

The study took place in the context of a well-funded project that ran over a long period of time. This requires patience from everyone, and it is not to be expected that every manual development project will offer the same prerequisites. Furthermore, the expert did not expect the scope to change from pure design delivery to procedural knowledge management work. The new commitment is plausible because the design expert had proven herself, but also because it was highly unusual for the team to work with an experienced design expert. In part, they did not know what to expect.

7.2. Discussion of Findings and Contribution to Knowledge

The following section discusses the findings of the study in relation to the literature of knowledge management, technical and visual communication, facilitation and co-creation as well as how design practice contributed. The research question is answered and the core contribution is set out.

Short Overview of Contribution to Knowledge

Field	Theory	Contribution
Knowledge Management	SECI-spiral (Socialisation-Externalisation-Combination-Internalisation) describes the concept of organisational learning (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006). Impediments in sharing tacit knowledge need the build meta-abilities (Selamat & Choudrie, 2007; Tsoukas, 2009). The BA represents a space, place, or location that is used by multiple people to interact (Nonaka & Konno, 1998; Nomura, 2002).	The thesis supports the SECI-spiral model as basic structure and provides evidence of how organisational learning can be achieved by design practice (Framework p. 211) in the four BAs. The visual sharing and reflection practice of tacit knowledge helps to overcome the barriers and enables the development of meta knowledge. The thesis expands the management literature as the collaboration is based on the applied framework (p. 211) integrated in the spaces of the four BAs (Framework shaping Design-BA, p. 216) and forming specific Design-BAs.
Technical & Visual Communication	Reverse engineering enables knowledge creation in the field of technical communication (Wick, 2000; Watson, et al., 2016). Styleguides in the age of technology (Bright, 2005) and corporate identiy are holistic (Regenthal, 2009). Knowledge design and visual rhetoric in science communication (Susanka & Kramer, 2021).	The re-creation of production regulations by the means of design practice enables process analysis not only by the use of visual tools but by the process of the manual development itself. The emphasis on a manual-creation approach coming from the design field, especially starting from the corporate design perspective, working in a technical environment is new. Additionally, the final information architecture offers a unique format for tactical and strategic use in similar contexts (Contribution to Manual Architecture, p. 201).
Facilitation & Co-creation	Joint value creation through dyadic problem-solving process (Aarikka-Stenroos & Jaakkola, 2012). The change agent in innovation management is a facilitator and changes roles on demand (Tann, 2021; Freytag & Storvang, 2016).	The work of the design expert has an impact through an integrated approach, where the role of the design expert changes to that of a facilitator who solves problems collaboratively and co-creatively. It broadens the scope of facilitation in innovation as this approach takes place before digital transformation but not in the context of an innovation initiative. This integrated approach guides employees through the four BAs of organisational learning and empowers them to find their own solutions within transformation and adds to the field of knowledge design.

Contribution through Design Practice

- Using PPT-templates in this context enables non-design practitioners to visualise and communicate.
- Using manual fragments for unlearning as well as active learning.
- Turning manuals into a new format by combining technical-, corporate- and visual communication.
- Iterative facilitation by fluent set-up of document fragments while they record knowledge externalisation.
- Using fragments, knowledge mapping and 3-point-system as tools for dynamic facilitation.
- Using manual fragments as boundary objects and representations for clarification.
- Working on files together supported reflection and negotiation, which is unusual for that industry.

Table 25: Short Overview of Contribution to Knowledge

7.2.1. Contribution to Knowledge Management and Learning

Challenges in knowledge management: Knowledge management is handled very differently in different organisations. Frequently, documentation of work processes is sitting in files, accessed via internal drives. In some cases, Visual Lean approaches (Valente, et al., 2016; Singh & Kumar, 2021) are pursued and experience is shared between employees. But the kind of visualisation applied in the project does not reflect the intentions of lean approaches. To start with, in principle the distinction between embodied as individual and embedded as organisational knowledge (Nonaka, 1994; Lam, 2000; Dalkir, 2005; Tsoukas, 2009) has been confirmed in the study. The distinction shows that both knowledge types exist in parallel (Lam, 2000), as the project is undergoing a cross-departmental transformation from production to planning to management.

The implementation of the new system (MES) called for re-organising all routines: the running cards, the production regulations and how the order system (SAP) is handled needed to be reflected before being implemented. As the existing document types are per se explicit, the embeddedness is represented by the actively executed routines. To this effect, the study findings contribute to the SECI-spiral, stressed by Nonaka and Takeuchi, (1995) and aligns with the model in which knowledge situated in individuals transforms via socialisation, externalisation, combination and internalisation in favor of organisational learning (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006; Tsoukas, 2009).

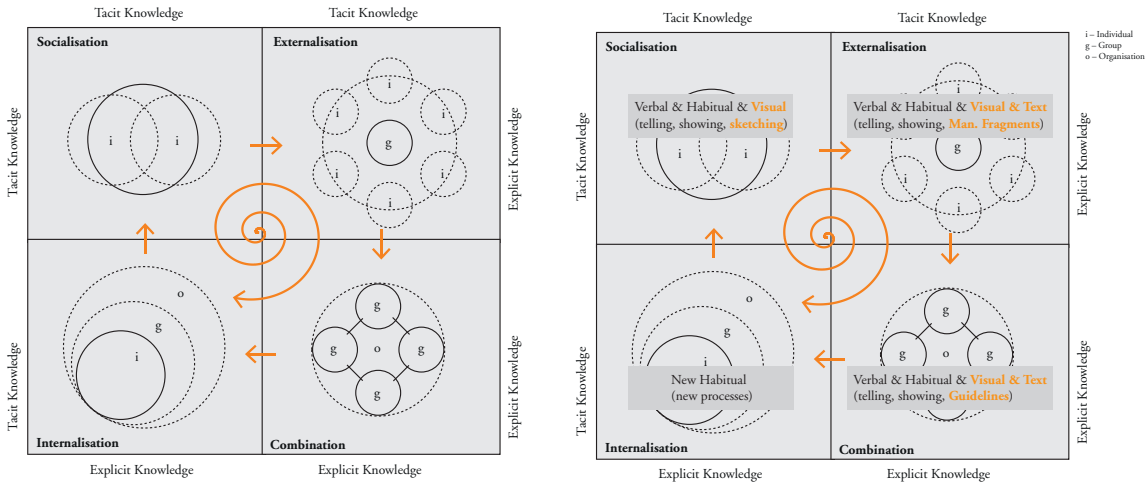


Figure 55: SECI-spiral (left) (Nonaka & Takeuchi, 1995) and project placement (right, own illustration)

In the project, the **socialisation** and **externalisation** of invisible expert knowledge was missing good explanations and the transition of expertise to the group was a challenge. While Nonaka and Toyama found that showing, metaphor, or sharing by explaining (Nonaka & Toyama, 2003), are ways to express the auto-motor routines, the templates and the visual approach in the manual fragments help the individual person to better share the expertise, especially in the technical environment, where the sharing culture does not support employees to express their knowledge in new forms other than CAD drawings or MS Word documents. The availability by visualisation, schemata and the expression of the processes by structured text passages supported the reflection of the employee. Active exchange with the team members and the recording of experiences through observation and joint reflection of manual fragments, maps these stories or metaphors in a new format. These ways of sharing add to the argument of Choudrie and Selamat that knowledge, especially that of experienced employees, is an object of individual impediments due to different reasons (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007; Tsoukas, 2009). The study gives an example of how facilitative iterative manual development and interaction can bridge the barriers. A central finding of my research contributes to knowledge management by using the manual development to express knowledge on an individual level and the organisational level in teams, as by the development of the manual fragments, the embedded processes and the interlinkedness of hidden issues become aparent.

Learning new routines: The study findings support Kolb's Experiential Learning Cycle (1984) as the content developed iteratively by reflection and testing. The results showed that less *designed* content and a reduction of text supported faster learning. In addition, the manuals' activate different cognitive levels by triggering affective and sensory aspects of Active Learning coined by Bloom et al., (1956), as well as Action Learning by Revans (2014). This practice based approach is well received by newcomers supporting self-learning principles, as the manuals as a final product are a deliberate practical accompaniment until the new routines become implicit again. The finding that the demand for external help to find words for the underlying mechanisms (Berry & Broadbent, 1984) is also supported by the demonstration of Carlson et al., (2009), that tacit knowledge as perceptual and procedural long-term memory represents stored information on a near-permanent basis. It explains the duration of the project and that it took a long time (approx. 2.5 years) to create useful manual pages which explain the topics in a way to be shared. The collaborative joint problem solving for developing the manual content drives on the meta cognition abilities by Kaiser et al., (2018) of all participants, who were part of the development and testing. The long-term memory situated in the

individuals reacted to the new suggestions and the ability to interpret and label activities triggered meaning. This also supports the finding of the design expert's attitude, that there is no pre-knowledge on the designer's side. It provokes a discourse on the other side and fosters reflection and unlearning. This finding aligns with Reason and Bradbury (2008) on the unlearning of routines, as the constant reflection triggers critical reflection and options for improvement as a state of *dynamic knowing*. It underscores the realisation that transformation usually involves restructuring, and key moments emerge when comparing old processes with possible new ones. Moreover, perception and reflection is the means for changing people's actions and the study embraces that facilitation by design practice is not about delivering manuals and guidelines, it is about using the process of creating them.

Contribution through design: The manual fragments supported the process of learning, as they shaped as means of *knowing* (Reason & Bradbury, 2008) and by developing principles especially within the development of the system configuration manual, the meta-cognition (Kaiser, et al., 2018) of the project manager developed. The developed 3-point-tool supported his reflection and enabled him to give certain processes names and categories. The re-learning of routines by iterations of reflection by active learning and reading the manual fragments (Revans, 2014), as well as the perceptual and prodedural memory, had been accessed to be transformed by the decoding of chunks and rules (Anderson & Schunn, 1997; Carlson, et al., 2009; Houdé, 2019). At the end of the manual development, the study contributes to the **combination** process, when a group starts to share on a broad base, and the knowledge arrives at an explicit status in the released documents, where the fragments are finally combined. There is an approach to ambiguous knowledge (Holford, 2020), and by the general approach of the project various levels of skills, knowledge, abilities and social knowledge can be brought into the discourse.

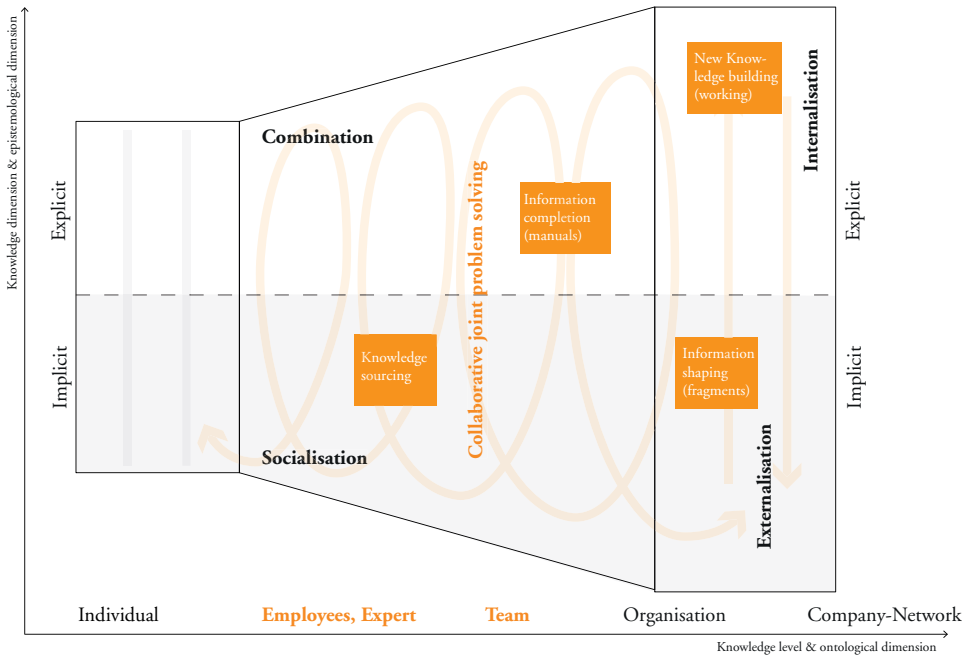


Figure 56: Based on the SECI-spiral and organisational learning (Nonaka, 1994, p. 20) (own illustration)

The schemata (Figure 56) shows, how the design expert's activities move in the various fields of knowledge dimensions and how the project developed from *source* to *fragments* to *manual* and *working*. The design expert does not need to have domain expertise to spiral into organisational knowledge creation. The finding, that the work of the design expert becomes a particular support and enables transformation is possible, when trust and a relationship is in place. It happens when the design expert also sees himself as a facilitator (Tann, 2021) and the design work moves away from the delivery of a finished file. Trust is placed in the professionalism of ground skills. Professionalism is provided by applying basic design skills such as Gestalt principles according to Metzger (2008), as well as a broad understanding of information visualisation basics as detailed by Ware (2020), and builds design authorship by developing writing skills such as those promoted by Rock (1996). The design expert contributes to organisational learning by using all these skills in the context of co-creation and jointly solving the problem of developing learning material, which evolved through the process of constant reflection, testing and consolidating (Experiential Learning). In doing so, the design expert contributes to experienced employees' enhancement, especially against the background of digital information management emphasised by Hlatshwayo (2019). Given this setting, the study takes on a further degree of importance, as a single person who mastered the digital skills of the new system at the beginning – the fragment development served to move from **socialisation** to **externalisation** towards **combination**. Since the manuals are mainly used for beginners, **internalisation** is an individual process, which, however, was subsequently confirmed as successful.

7.2.2. Contribution to Technical and Visual Communication

Manual's information architecture: The scholarly community of technical communication conducts research on how manual development impacts on knowledge mangement. Their sources derive from the development of technical instructions. Content of the information is focusing on the explanation of how to operate a system or a machine. Instructions follow a cognitive approach and as technology is changing rapidly, today they mainly focus on the explanation of software and interfaces. My study adds to knowledge in technical communication by extending the scope of technical instructions and complements the knowledge management framework by Wick (2000) in which he relates various impacts of knowledge management on the levels of how people are working together, what the value means, where the liability is appointed to, and what is captured.

Levels of meaning	**Document-centered Knowledge Mngmt.**	**Technological Knowledge Mngmt.**	**Socio-organisational Knowledge Mngmt.**	**Knowledge Organisation**
Artefacts	documents	software files	communication	financial impact
Focus	documents (codified K)	technology	interaction	source for advantage
Connection	Individual & documents	people to technology	people to people	knowledge economy
Capuring	formal process plus review process	captures KN informal and as created	leverages tacit KN, fosters innovation	mission-critical, affects all organizaional level
Value	by leveraging existing K	by using KM apps	rewards KN-sharing	metrics for intellet. capital
Liability			communities of interest	appoints executives

Table 26: Relation of meaning. Based on Progression to knowledge management (Wick, 2000, p. 520)

The manuals developed extend the format by borrowing technical document standards and combining them with elements from design-oriented communication and corporate text styles, such as directive, informative or guiding styles. As result, the developed manuals create a new document format. Therefore the evolved information architecture provides a variation of comprehension options and page-types between step-by-step guidance to the offer to follow principles. This distinction is providing a liability to producing, planning and managing work for different user types. The new manual architecture built on Wick's framework (Table 26) is illustrated in detail and the categories are interpreted and redefined (Table 27). *Artefacts* are the flux documents and forms of information during the manual development. *Connection* links to the relevant user roles working with the various artefacts and the final manuals. *Capturing* captures the relevant activity in the production process and the use of the new system. *Value* leads to the meaning of the applied learning by developing the manuals as well as by applying them. The *Liability* is linked to the final manuals'

content, as they are responsible for the outcome, when applying them and using them for learning. The three colors below the *Manual (Liability)* indicate what manual elements refer to corporate design (orange), corporate communication (purple) and technical communication (grey).

Contribution to Manual Architecture				
Level	**Indiviual**	**Technology**	**Group**	**Organisation**
Artefacts	*Documents*	*Visualisation, PDFs, videos, MES*	*temporary manual fragments and single manual pages*	*during development and change requests software-side*
Connection	*production employees with printed documents*	*engineers with templates and PDFs*	*engineers and, Super-Users and Super-Key-Users*	*Super-Key-Users and supplier and other departments*
Capturing	*production process, traceability, embodied*	*visual lean production, embodied*	*Production, Work planning, embedded*	*Rules and institutionalised routines, embedded*
Value	*learning to operate*	*Sequence of event design*	*learning to stear & plan*	*learning to manage*
Manual *(Liability)*	***Production Manual*** *(production employees)*	***SOE Structure*** *(PPT templates)*	***SOE Guideline*** *(engineers)*	***System Configuration Manual*** *(project manager)*
Manual Chapters	• *Purpose* • *Audience* • *Reasoning* • *Document visual appearance* • *Guidance of main functions of a system* • *Troubleshooting* • *Further help* • *Glossary, Index, FAQ*	• *Templates* • *Dos and don'ts* • *Visual principles*	• *Purpose* • *Audience* • *Document visual appearance* • *Visual basics* • *Concept of Visualisation* • *Scope and reach* • *Reasoning* • *Mission* • *Guide of system functions* • *Hints & Tricks* • *Troubleshooting* • *Glossary, Index, FAQ*	• *Purpose* • *Audience* • *Document visual appearance* • *Scope and reach* • *Organisational structure* • *Vision and Value* • *Principles* • *Links to backend functions* • *Troubleshooting* • *Glossary, Index, FAQ*

Table 27: Contribution to Manual Architecture after project (based on Wick, 2000, p. 520)

The strategic quality of manuals: The new compilation of the *Manual Chapters*, shown in Table 27 *Contribution to Manual Architecture,* illustrates a new structure. The mixture of content in the manuals varies in visual and text styles in a unique combination. Technical communication is occupied with straightforward guidance (Blake & Bly, 1993; Baehr, 2013), similar to the descriptions on how to use visual templates in design manuals. While technical communication focuses on the communication and guidance on how to use a product, software or an interface, visual communication focuses on the communication, visualisation and guidance of a visual system. Corporate communication is strongly text based and focuses on strategic use of language and masters styles of text to emphasise strategy. The manuals use elements from all three disciplines. As these

discipline-based approaches can also aim to drive the transformation of an organisational culture, the manuals developed offer a unique combination to make transformation through digitalisation efforts as comprehensible as possible. More obvious and visual challenges to develop such documents are the construction of the comprehensive information architecture and content hierarchy, independent writing skills and visual documentation abilities, furthermore an appreciation of didactics and experience in analysing the appearance of learning outcomes are relevant. When the manuals are finished, one valuable aspect needs careful attention and that is the documentation of Hints & Tricks. They represent a high level of embodied knowledge and mètis (Holford, 2020) as stated by Clarke (2010) of someone who knows a system blindly, goes beyond process and model knowledge. This information is difficult to get and supports the statement of Gallardo-Gallardo et al., that it means a lot to knowledge owners realising as interpersonal capital (Gallardo-Gallardo, et al., 2013).

The developed manuals format stretches between the perspective of knowledge management of scholars in technical communication and scholars in the design community. The findings support Bürdek's statement, that content in design guidelines, corporate brand manuals and instructions in technical context are often overlapping (Bürdek, 2015) and represent reference systems of organisational structures. The manuals add to it by referencing different levels of working knowledge and challenge the visual culture and the values of the individual employee. Adding to the findings of Eisenberg et al., that organisational communication should balance between constraint and creativity to promote change (Eisenberg, et al., 2010). The manual development, it's unique structure (Table 27) is the contribution itself, as usually organisations apply strategically controlled communication top-down. Consequently, the balance between directions and creative action should be present in manuals to promote sustainable change, linking into the way these manuals have been developed. The effect in the company is shown in such a way that the manuals are in use.

Contribution through design: The design expert's challenge lies in understanding the complexity of the project objective, the organisational environment, and the different roles involved, as well as the various levels and sorts of knowledge, before settling the document information architecture. In the study, the tasks relating to people's roles are changing. The knowledge owners are changing their analogue routines to become digital. This affects the different roles and working knowledge such as operative producing (production employees) and strategic planning (engineering & design) work processes as well as tactical managing resources (project management). The existing routines in

operations stay at first, but they will need to be analysed, before they get settled as routines in the new digital environment. A design expert can support by enabling staff to consciously analyse work routines, with implicit routines only emerging after several iterations of reflection. A manual can serve to facilitate the reflection on old routines, as emerging errors or optimisation opportunities become visible. However, this process of iterating the fragments requires patience from all involved.

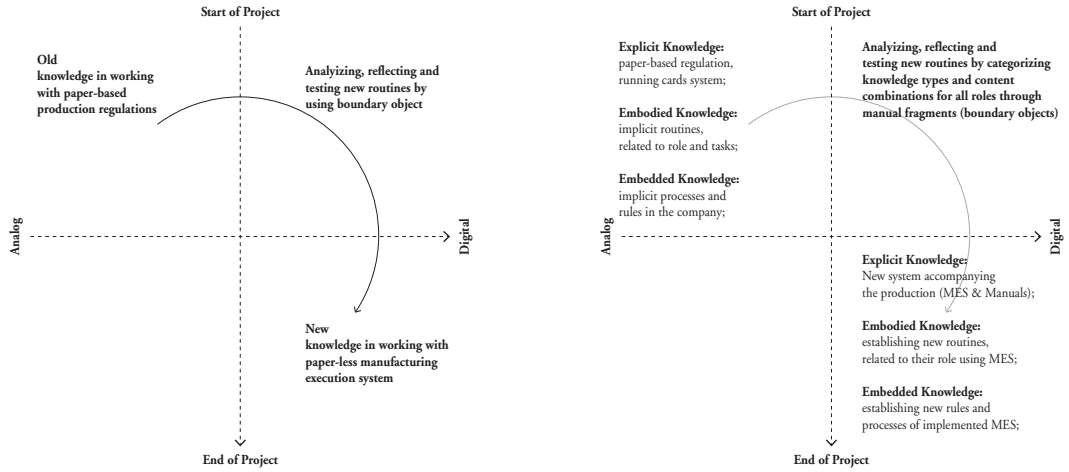


Figure 57: Transformation of knowledge from start of project from analog to digital

The design expert addresses the different knowledge types and workers by different means through using the boundary object, i.e., the manual fragments. The design expert facilitates the trial and error of using the new system and results are consolidated in the combination of the fragments, resulting in three different document types for three user groups:

Production Manual – how to operate the system front-end – Production Employee

SOE Guideline – how to on plan & design work steps at the system back-end – Engineer (Key User)

System Configuration Manual – how to implement a system into an organisation – Project Manager

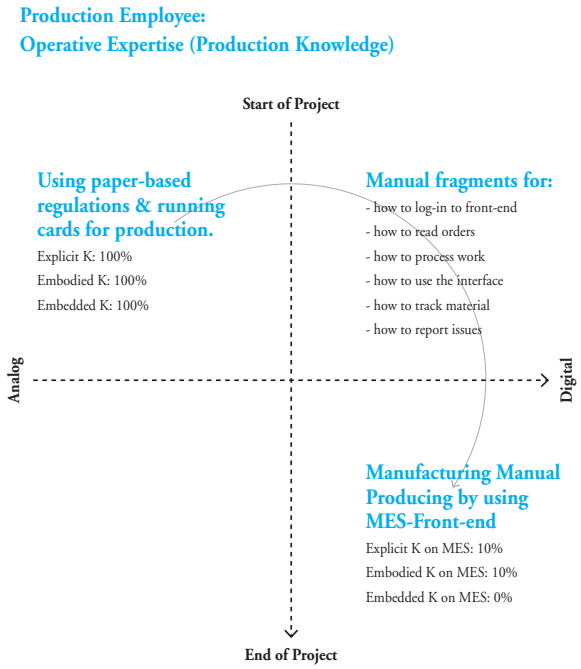


Figure 58: Transformation of operative knowledge in the course

Production Employee: By developing a visual design system for the front-end and explaining how to use it, the production employee begins to work with the new system. Production staff have extensive anchored analogue knowledge and practitioners explain that they do not like to read lots of text and that representations should be presented very clearly. To know a supervisor structure is important to know a contact person in every situation. The practitioner is a typical storyteller and many insights and hints for the manual can be drawn from the conversations. However, the manual as such is perceived as less important, as the production employees usually know their work well and mostly automatically. New staff will find it easy to get used to the new system and use the manual as a kick-starter document for the new work-accompanying system. The engineer carries embodied knowledge about the new system and know the routines on the shop floor. The project manager and the engineer accompany the development of this manual and reflect on the working routines with the production employees, before it is turned into digital events. The engineer is the contact person for the production employees.

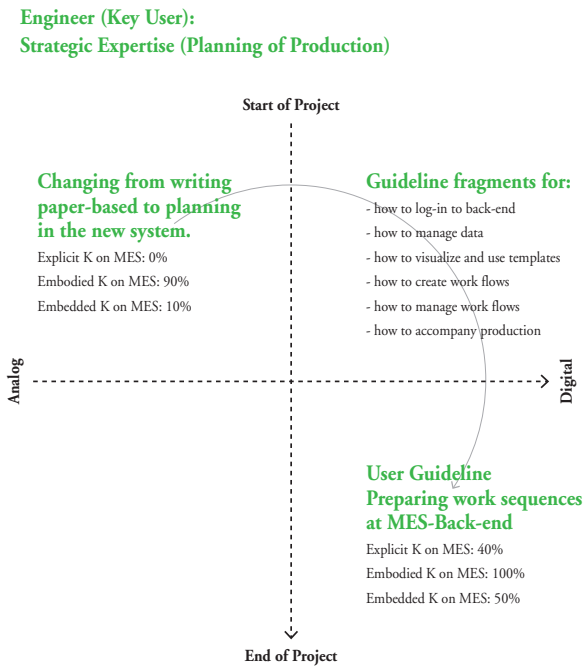


Figure 59: Transformation of strategic knowledge in the course

Engineer (Key User): The Key User developed embodied skills using the new system for a long time, as he was part of the project team from the beginning. He is a Key User but also represents the group of industrial engineers, who are usually planners and lay out the working sequences in the system. They work at the back-end of the system and represent planning knowledge on the way, how products are manufactured in line according to the order requirements, and the detailed design of the product. They also need to understand how to visualise the working routines within the system. During the development of the guideline, this special Key User as test person was not helpful, as he knew too much already and he had developed work-around strategies in the system.

To understand how the guideline works, several tests with non-designerly mindsets and newcomers are useful. The different visualisation culture challenges the assessment power of the design expert. Especially in this manual development, the sharing culture of the extended and large scale document helped the information architecture to develop. At the end of the project, therefore, not only the Key User had the most knowledge, but through the joint reflections with the production employees and the project management, the understanding of the processes also grew on their side, although they are not the target group of the final guideline. Within this guideline, the differentiation of directive, informative and guiding quality of text, illustration, and page structure evolved in detail. It settled the rules for the complete information architecture for all three manuals.

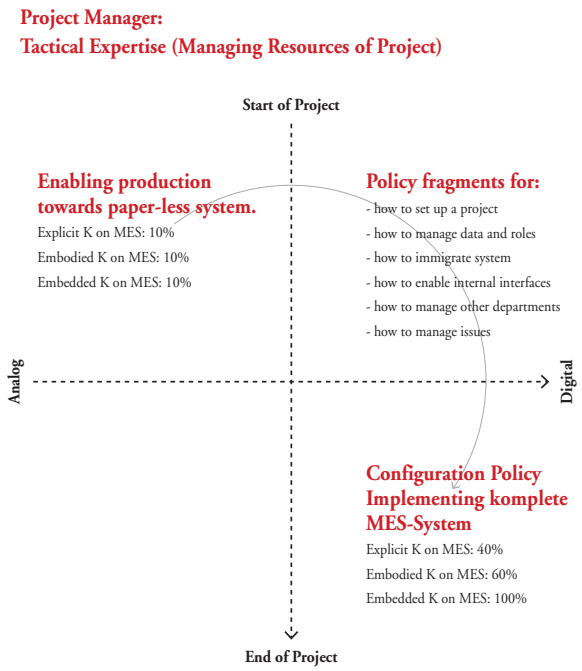


Figure 60: Transformation of organisational knowledge in the course

Project Manager: The manager knows organisational routines and roles tacitly, along with all the problems. He develops and defines the resources at the back-end with other departments of the organisation. Tactical knowledge on how to resource a project such as this requires in-depth knowledge of organisational structures, ways to implement change, the flexibility of departments and their sub-systems, and overall organisational business development. As the project manager, just like the Key User, had been working on the project for a long time, he knew about the difficulties that had to be overcome. The experience of working on the project for about 3 years shaped the project manager and in the beginning it was difficult to define the content for this document with policy character. Unlike other knowledge workers, his experience shapes his perception and he best reflected on his deeper-rooted knowledge via conversations.

Manual as boundary object: The verbalisation as one way of sharing tacit knowledge in **socialisation** towards **externalisation** is the first means for attaining a common understanding and a presetting to visualisation. In the study, the manual fragments are representations of knowledge and support the Key User, the project manager and the employees in the production department to share what they understand about the new system. The concept of the boundary object (Star & Griesemer, 1989; Carlile, 2002; Star, 2010) fits the process of how the manuals were developed. They emerged in a process of clarification and transformation. A complement to the existing literature is that the recognition of ambiguity became clear through the concept of boundary objects. The manual fragments are in flux and do not represent the finished manual. The finished manuals were created later, and are a combination of different process results. Between the team members, especially between design expert and production employees, everything that is created at the intersection of knowing and not-knowing is a result of the collaboration. Thus the study aligns with Evenstein and Whyte (2007), that the objects as manual fragments add to a list of documents, sketches, notes turning into epistemic objects enabling reflective **externalisation** as artifacts of knowing (Ewenstein & Whyte, 2009).

The design expert is constantly improving the quality of the documents by incorporating the voices of all employees and understands different meanings of embedded and embodied knowledge through the various roles in the organization. It becomes clear that the documents show two faces. One is the boundary object and the other is that, what usually is seen as guideline. A boundary object supports the finding of the manuals final content and must be distinguished dynamically. By using the manual as flux object for reflexion, the documents and it's information architecture is owned, aligned and processed by the designer, as inhouse capacity of using the layout software is not available. The design expert is responsible for the file and the involvement into the teams' process is crucial. The findings in the study support the argument of Täuscher and Abdelkafi (2017), that visual tools support the development of busienss at a cognitive level, but the development of the manuals effects the cognition of employees on operating the new system. The way how the designer acts is very dynamic, firstly describing activities of operating a system and changing the desciptions frequently.

7.2.3. Contribution to Facilitation and Co-creation

Perception of designer: Organisations search for support when special qualities are not present and hinder the development process. More often, organisations search for clarification by contracting business consultants in the context of transformation. In the study, the main challenges drive from difficulties around core meta-abilites (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007), such as cognitive skills, self-knowledge, emotional resilience and personal drive, as they are juggled at different levels within the project team. It is rather seldom, that designers are called in to solve issues in this specific context. The reason for hiring designers is their expertise in visualisation and to ease visual complexity and they are brought in rather at the end of a project. In this project, the design expert was also brought in for the same reasons, as it was thought that the interface design framework in the software context was considered final. However, this perspective changed and it can be said, that the scope of the study and its course of action aligns with scholars such as Buchanan (2008) or Steen (2013) who claim that the design discipline extent by process-oriented thinking and working in change management (Rill, 2016). It turns out that design focuses on facilitation becomes more valuable and not only reduces visual complexity but also resolves process and content complexity.

Typically, a design expert is brought in on corporate design projects at the end of an identity project. In our case, however, it turned out that this approach was not applicable, as the design expert was hired when the project was still running and the designer's tasks also changed during the project. It becomes clear that the client's expectations were confirmed, but also the understanding of what a design expert can contribute changed. Therefore, the time aspect had implications on the reason for the engagement and changed from spot-oriented to a process-oriented work. The design expert is a professional in writing design manuals, but yet uses her expertise to facilitate the understanding of existing working routines. Within the course of the work setting and over a long period of time of about 2.5 years, the visual skills became secondary and were taken as a given supportive activity.

Through insight building methods such as testing, the design expert understands the user's perception regarding the process of cognition. The approach of using the development of a manual to do this adds something unique and new to the methods offered. The barriers to sharing expertise are manyfold and the knowledge owners each carry an individual set of these, which need to be treated with respect. The study is in line with the argument that discussions and conducting open interviews support the process of comprehension of complex facts and situations, as in Dreyer and

Brown (2017), and adds that moderation accompanied by the manual fragments are an empathic and respectful way of going through this process together in a one-to-one situation, representing the process of **externalisation** of knowledge (Nonaka & Konno, 1998; Tsoukas, 2009).

Long term support: The time aspect has to be considered in particular, as the study is not aligned towards a management-oriented change program by asking employees who have decided to leave the company about their expertise and experience in a questionnaire such as promoted by Lane's Tacit *Knowledge Questionnaire* (Lane, 2008). It is rather a companionship, as discussed in the prior subchapter, and supports the argument of Hu (2016) that triple-loop learning helps to make better decisions. The valuable aspect in my study lies in the fact that there was always a single contact and continuous support (Tann, 2021) leading to improved organisational effectiveness as an approach of empowerment (Turner, 1982). While Nonaka and Teece discuss the management of industrial knowledge on the background of innovation, technical findings and managing patents (Nonaka & Teece, 2001), the focus in the study is on developing principles to use and implement a new system. The findings support the approach of Turner (1982), Muller and Zenker (2001) and Kotter (2007), that the facilitation support the employees to learn to solve problems in the future.

Facilitation and co-creation: The study widens the role of the design expert becoming a strategic facilitator and by negotiation as well as testings with the employees achieves smooth integration (Tann, 2021). As the design expert ist there, to be talked to, and helps to uncover other points of view by exchanging thoughts, this finding adds to the notion of a relationship and interaction between design expert and project partner as stressed by Aarikka-Stenroos and Jaakkola (2012). Through the intensive use of skills and expertise the document fragments are the result of co-creation and negotiation. The process alignes with a co-creative framework by Aarikka-Stenroos and Jaakkola (2012) as the approach of positioning the manual development process is a joint problem solving (Figure 60) and the value developed is not transferable but intangible represented by the flux character of the fragments. Through teamwork and iterative open reflection, valuable solutions are found by the process itself. The fragments emerge from mutual interaction, reflection and the visualization support and ease the knowledge **externalisation**.

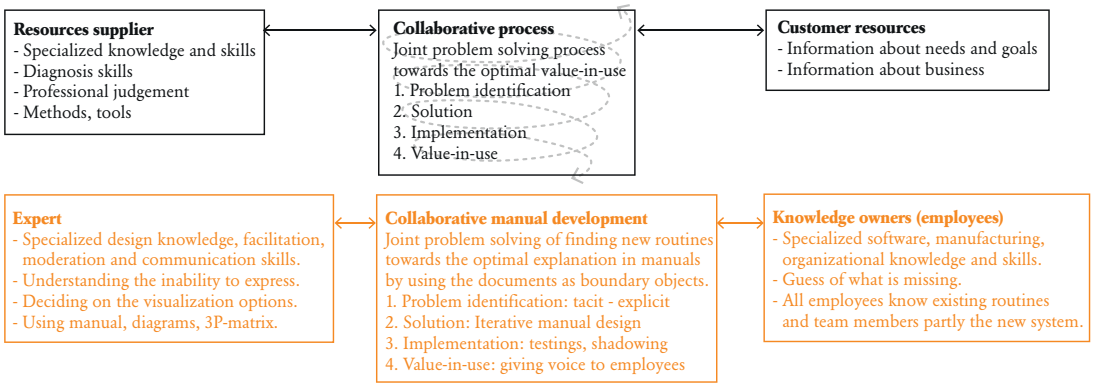


Figure 61: Application (orange) of joint value co-creation (black) (Aarikka-Stenroos & Jaakkola, 2012)

The overall progress within the project also corresponds with Kotter's 8-step-model (Kotter, 2007). Although management started the project (urgency), the project team was very motivated (coalition) and the project manager was able to moderate further pressure from management (vision). The design expert was able to quickly generate success through the first documents developed at the beginning (short-term wins) and thus inspired the management as well as the team members. Credibility developed through the long collaboration over the entire duration as well as through the constant support and attitude of the facilitating design expert (more change). The testing and implementing of the project served a long-term behavioral change and this through the development of the manuals as such (institutionalise).

Contribution through design: In the study the different knowledge types needed differentiation between text structure, visual elements and layout options. The information architecture grew by elaborating the various roles and the knowledge types in relation to their depth, which needs to be analysed, rearranged, and relearned. It is a lengthy process and also includes the reorganisation of the system, based on the findings in the team. From the view of the design expert, the move from analogue in the beginning to the project's goal, the use of the new system is made accessible by manual fragments. The fragments get their value when the content has distinct text and visual character based on numerous iterations. Later, when fragments went through the co-creative process of iterations and relearning, they form a final document. The co-creative framework consists of interaction, relfection, comprehension, testing (fragments), redefining, handing over (final document).

There are sequential steps in this **framework** and co-creation mainly takes place in steps I. to V., and step VI. defines the final document in use:

I. *Listening*, recording and clarification of **actions** (**socialisation** by interaction with employees)
II. *Sorting* and *listing* the different kinds of **activities** (**externalisation** by understanding roles)
III. *Defining* variants of **visual/text combinations** (**externalisation** by testing appearance)
IV. *Coordinating* the **roles** to the activities (**externalisation** by redefining work, 3-point-tool)
V. *Assembling* according to **role** and **combining** fragments (**combination** by testing roles and almost final versions of manuals)
VI. *Defining* complete content of **manual** and *transforming* new knowledge (**combination** by hand out and **internalisation** through constant use by employees)

This framework contains a 3-point-tool which differentiates first between activities, the way it will be visualised by means of text and visual elements and setting up the 3 roles representing operating, planning and managing work. The combination is a unique set of text styles and visual elements and focus on the communication of *Using*, *Reasoning* and *Principles* the various features of the new system. *Using* means to operate the system and this is mainly visualised step-by-step. *Reasoning* means that the feature or the activity needs to be understood and this is mainly visualised by explaining styles of text and some schemata. *Principles* explains a certain approach by describing it and usually a combination of lots of text and diagrams are used. The 3-point-tool serves to understand what the 3 roles need to know, what, and how they work. As a result, the content for the three manuals evolve by assembling the using-reasoning-principles-combinations.

Topic and Activity in System	Using	Reasoning	Principles	Actions needed	
System explanation	1	1/2	3	*adjust with sequence*	
what is …		1	2		
Interplay with Organization		2	3		
Goals		1	2		
System konfiguration	2/3	2/3	3	*adjust and complete*	
Portals	1	2/3	3		
Data acquisition	1	1	1		
Parts lists			3	*adjust with parts list*	
Raw material	3			*new*	
Tools	3			*new*	
Equipment	1	1	1	*new*	
Measuring equipment	3			*new*	
Instruments	3			*new*	
Devices	3			*new*	
Support material	3			*new*	
Photography	2	3	2/3	*to chapter visualization*	
Employees	3	2		*new*	
Import of mass data		2		*new*	
Master data			3	*new*	
Batch	2	1		*new*	
2nd person verification				*adjust*	
Prepreg					
Naming Nesting	2	1		*to parts list of sequence*	1 = Worker
Consumption	3	3	3		2 = Engineer
Out-time calculator (shop life)	1/2/3	2/3	3		3 = Manager
Material Management	3	3	3		

Table 28: Examplary table section of 3-point-tool appointing roles (using, reasoning, priciple)

Depending on the field of activity, this tool iteratively visualises organisational work processes, which are embedded. Craft-related working principles as well as organisational working principles, are both embedded routines. The knowledge is drawn from the disembedding and reflecting on the document fragments as boundary objects. This also helps to define new forms of technical, strategic, visual and organisational information, shaping the combinations. In the end, all three guiding documents (manual, guideline, policy) support the learning of how to apply the new system.

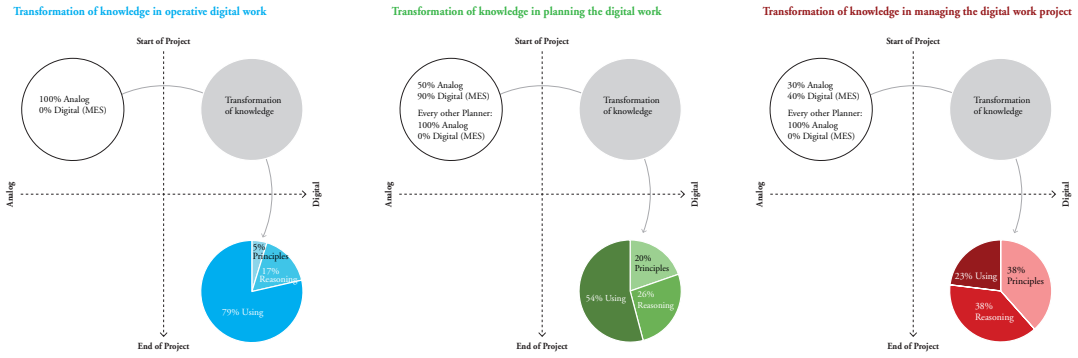


Figure 62: Transformation of knowledge in all three areas (own illustration)

At the end, all the manuals are located in the lower right sector, where the explicit knowledge is located and most roles do claim to understand and know the new system to their relative extent. The more the new system can be used automatically, the more the information becomes routine and habitual and the manuals are not needed anymore.

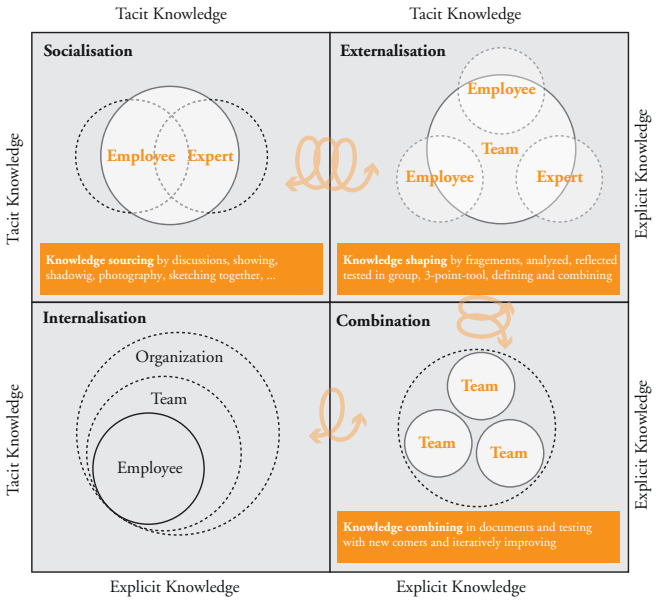


Figure 63: SECI-spiral on organisational knowledge transformation through facilitation (own illustration)

The concept of "BA": As the "knowledge is embedded in ba" (Nonaka & Konno, 1998, p. 40), the design expert is part of the socialisation and supports the externalisation of the intangible knowledge by visualising thoughts and processes, or depicting situations that can only be understood through visualisation in reflection. The concept of BA stands for a space in which relationships are created, and since relationships between people are invisible, they can take place in spaces via activities. According to Nonaka and Konno, these spaces can be "physical (e.g., office, separate business premises), virtual (e.g., email, telecommunications), mental (e.g., shared experiences, ideas, ideals), or any combination thereof" (Nonaka & Konno, 1998, p. 40).

Taking part in BA, such as being in the project working meetings or in the production department, involves and "transcends one's own limited perspective or boundary" (Nonaka & Konno, 1998, p. 41). The design practice is part of the ba-interaction and provides a voice to people's imagination and teams' consciousness of their routines. The framework (p. 211) supports employees in highly specialised organisations to expand their perception and process of sharing. After the knowledge is shared or "separated from ba, it turns into information" (Nonaka & Konno, 1998, p. 41), this information is independent and can be shared, residing in media such as the manuals and internal networks. The progess of the study aligns to the four BAs and shares the characteristics of the four interconnected fields of the SECI-spiral by the way the space is used in interaction.

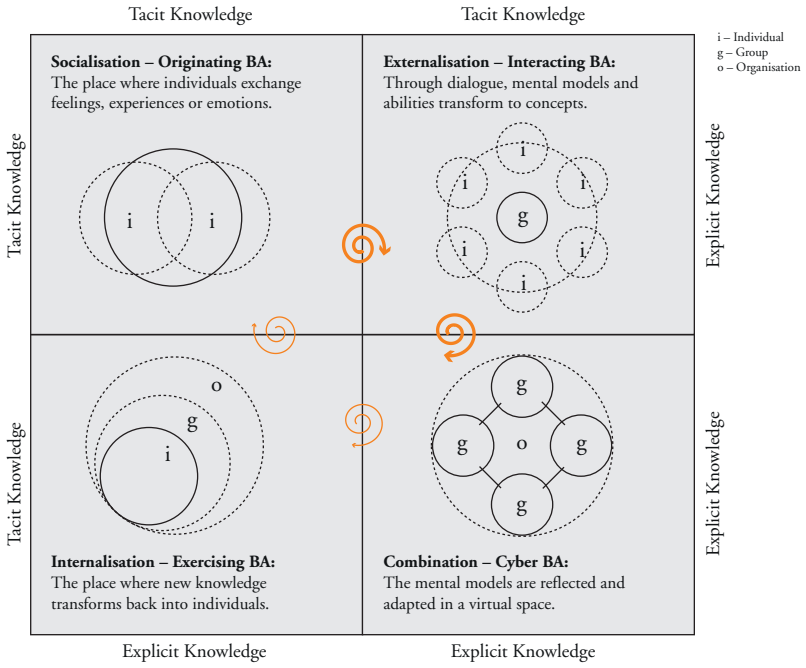


Figure 64: SECI-spiral on organisational learning by BA (Nonaka & Konno, 1998) (own illustration)

While **Socialisation** is the place for the **Originating BA**, where individuals exchange feelings or experiences, **Externalisation** is the **Interacting BA** where through dialogue, mental models and abilities transform into concepts. **Combination** stands for a **Cyber BA**, where the models are reflected and adapted in a virtual space, such as a common and conscious activity. **Internalisation** is the place for **Exercising BA**, where new knowledge transforms back to individuals (Nonaka & Konno, 1998). Nomura (Nomura, 2002) proposes a strategic design of BA work that addresses the current situation and different work styles as he found that there is no general approach to the interaction in the BAs.

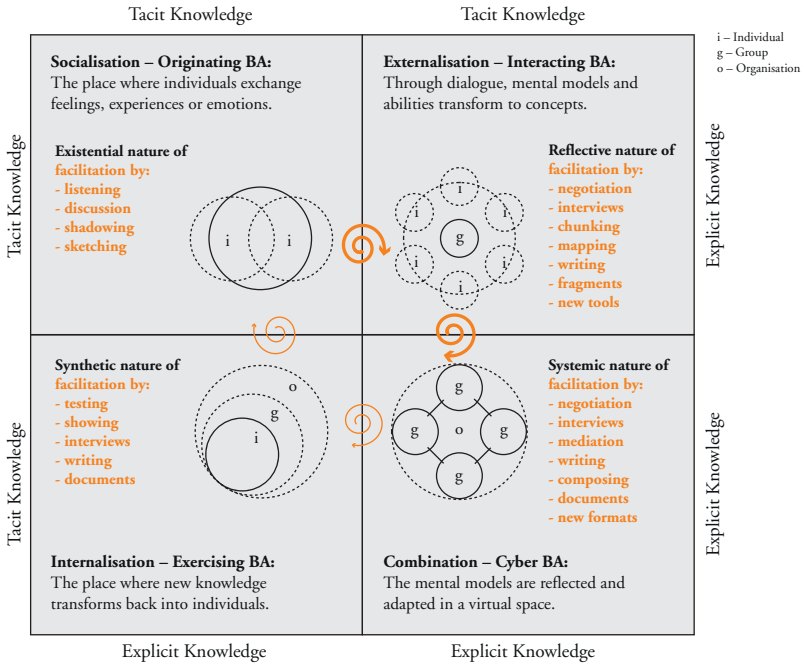


Figure 65: SECI-spiral with concept of BA and facilitation by design practice (own illustration)

The characteristics of the four BAs are coming from face-to-face interaction, going to a reflective peer-to-peer BA. Moving from the reflective space to group-to-group, the knowledge forms as synthetic, when it is transported onto the site. The **Originating BA** has an existential character and the facilitation of the design expert in face-to-face interaction varies between listening, discussing, and shadowing, to sketching. In the **Interacting BA**, which is characterised by reflection, the facilitation takes place by negotiation, interviews, chunking information, mapping, writing, and developing document fragments and new tools as a withdrawal from that space. Within the **Cyber BA**, the systemic character influences the facilitation by negotiation, interviews and mediation, but also the writing and composing of fragments to prepare documents and new document formats to

move into the last BA. The **Exercising BA** is characterised by its synthetic nature, as all will slowly move to the individual skills and testing, showing, interviews, writing in the way of correcting, and final documents are facilitating the new knowledge building. Reflecting on the design practice itself, categories of knowledge supporting facilitation vary from explicit declarative (what) to the implicit procedural (how), situational (when) and strategic (how to) knowledge, which is practically embodied. Based on the *Categorisation of knowledge* by Venselaar et al., (1980) and Wong and Radcliffe (2000), the differentiation between domain-specific basic and domain-specific design-knowledge describes the what, how, when, and how to of a specific field. Whereas the general process knowledge touches the what, how, when and how to on a meta level.

KN-Type	Domain-specific basic knowledge	Domain-specific design-knowledge	General process knowledge
Declarative knowledge	Knowledge of facts and formulas	Knowledge of design and methods	Knowledge of methods to optimise the process
Procedural knowledge	How to use these facts and formulas	How to use these design facts and methods	How to use general optimisation methods
Situational knowledge	When and where to use this basic knowledge	When and where to use this design knowledge	When and where to use this process knowledge
Strategic knowledge	Knowledge of algorithms and heuristics of relevant domains	Knowledge of heuristics in solving design problems	Knowledge of algorithms and heuristics in problem soliving

Table 29: Categorisation of knowledge by (Venselaar, et al., 1980) applied in (Wong & Radcliffe, 2000, p. 499)

While the categorisation (Wong & Radcliffe, 2000) offers a structure to understand practical knowledge, the study also complements the fields of technology and strategic management by design practice. Analysing the various activities in the four spaces, design practice also shows different knowledge types.

While **procedural** and **situational** knowledge is needed in the **Originating BA**, the **strategic** knowledge types become more important in the **Interacting BA**. The highest activity of developing withdrawals are on the edge there, as well as between **Interacting BA** and **Combination BA**. Moving towards the **Exercising BA**, the employees are again more left to their own experiences and the re-learning process. The different knowledge types are needed, as different dynamics and qualities within the interactions are taking place.

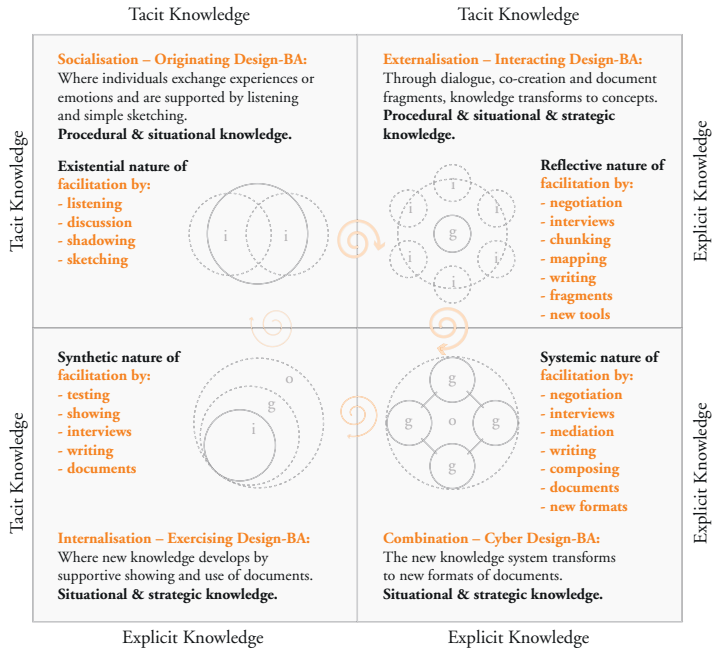


Figure 66: SECI-spiral with facilitation in the four Design-BA's (own illustration)

Shaping the Design-BA:

Hence, where employees exchange experiences and emotions, they get support by facilitation such as listening and sketching or shadowing. This represents an **Originating Design-BA** as mainly **procedural** and **situational** design knowledge facilitates the space. (Framework step I.)

Turning into the interaction, reflective facilitation takes place through dialogue, co-creation and document fragment development transforming into new concepts. This forms the **Interaction Design-BA** where also new tools and facilitation approaches are developed by **procedural**, **situational,** and **strategic** design and process knowledge. (Framework steps I., II. and III.)

Taking the negotiated fragments into the cyber BA, they transform to new formats and shape an information architecture representing a knowledge system. The systemic facilitation takes place in the **Cyber Design-BA** where **situational** and **strategic** design and process knowledge is needed. (Framework steps IV.and V.)

Finally testing these new formats and their new knowledge system, means synthetic facilitation by documents, showing and testing in the **Exercising Design-BA**. The design knowledge here is usually **situational** and **strategic** and supports the employees in iteratively developing their own tacit knowledge in the relevant application fields again. (Framework steps V. and VI.)

7.3. Response towards the Research Question

The remainder is concerned with answering the research question: **How does manual design practice act for facilitation in organisational transformation within digitisation initiatives in highly specialised technology ventures?**

In the course of the study, it became apparent that visualisation as parts of manuals and iterative reflection form a **process** that help the engineers to overcome their barriers in sharing tacit knowledge. The design expert is supportive for **employees**, when the use of a design system (templates) or the use of a new application (software) is explained iteratively, slowly, and visibly. When this quality is kept in the manuals, the active learning effect could be experienced again at any time.

This **process** offers new opportunities for knowledge management and can be employed as a valuable strategic tool in the context of organisational transformation and releasing knowledge and information architectures. The design expert must get in touch with the existing knowledge **system** to gain **contextual understanding**. To move within an increased complexity, the process's representations such as manual fragments serve to affect a reflection culture. In doing so, the representations promote discussion, the realisation of explicit and tacit knowledge, and are a living but dynamic **output** of a co-creative process, which is very different from the mere delivery of a finished product (manual).

The design expert as facilitator acts as co-creative in ways that are visual, skilled, perceptive, reflective and personal. Applying professional skills and seeing the challenges within the **organisational** knowledge and information architecture themselves lead to being in the transformation space and the presence becomes holistic. Designers can move into non-design related areas and provide strategic support through this profile and support the development of **principles** which makes the transformation become **manageable** and **scalable**.

7.4. Consolidated Contribution to Knowledge

The SECI-spiral and the concept of BA are recognised in management literature mainly, but this thesis provides evidence of how organisational learning can be achieved by design practice **(Framework p. 211).** My study supports Nonaka and Konno's (1998) endorsing the call for a strategic approach to BA (Nomura, 2002). It deals with knowledge on an operational level, while it breaks down barriers of tacit knowledge sharing (Selamat & Choudrie, 2007; Tsoukas, 2009).

To access and visualise knowledge by the means of design has been shown by innovation and business management literature such as Elsbach and Stigliani (2018), Steen (2013) or Täuscher and Abdelkafi (2017), demonstrating an integrated use of design tools and methods. In the field of visual management in conjunction with lean management literature, the concept as Visual Lean approach is well known in industry for increasing efficiency and the value of constuction projects (Valente, et al., 2016; Singh & Kumar, 2021). The contribution is based not only on the use of visual tools but the process is at least equally important, and the manual development is beyond a finished product. In technical communication various kinds of instruction manuals have been discussed (Bright, 2005; Maylath & Amant, 2019) as means of communicating in knowledge management (Watson, et al., 2016). A clear emphasis on a manual-creation approach coming from the design field is missing, especially starting from the corporate design perspective, working in a long-term change project in a highly specialised industry. In addition, the final information architecture is unique and offers a new format for use in similar contexts **(Contribution to Manual Architecture, p. 201)**.

Finally, the thesis expands the management literature as the collaboration based on the framework (p. 211) is integrated in the spaces of the four BAs **(Shaping the Design-BA, p. 216).** The impact of the design expert's work on organisational learning only takes place through this integrated approach. It is the professional design activity with a change agent's stance as facilitator (Tann, 2021), solving problems co-creatively (Aarikka-Stenroos & Jaakkola, 2012) together **with employees in digital transformation,** but not within a product-related innovation initiative. Participation in the transformation project over a long-term period is in line with Kotter's 8-step model for creating lasting change (Kotter, 2007) by developing a process for achieving initial successes, a system for devising solutions to complex challenges, and creating principles to make the transformation scalable and manageable. This integrated approach guides employees through the four BAs of organisational learning and empowers to find their own solutions within transformation.

8. Conclusion

8.1. Introduction and Background

This chapter draws on the main objective of my study and how its findings answer the research question. It looks at the role of a designer and her activities in a complex digitisation project within a technical organisation. I will discuss the challenges that the project presented and how the designer interacted with the staff to understand routines as well as learn new routines. I will show how the conclusions inform the literature and build new knowledge, as well as where new implications lie for designers and their practice. I will discuss the limitations and further research potential in this area.

From November 2017 until July 2020, I supported a space technology company in a digitisation project (Chapter 5.1.4 The Digital Transformation Programme), which had been launched to change paper-based production regulations to introduce a manufacturing execution system (MES) instead (Chapter 5.1.5 Technical Environment of the MES Software). During the project and while the software was customised, programmed, and implemented, I supported the employees to understand their existing workflows and how to introduce them into the manufacturing execution system (MES). The outcome of my work and the scope of this project resulted in three user manuals for three user groups (Chapter 10 Material Document Analysis). One manual for the employees at the production level to explain how to use the new MES. One manual for employees who feed the work sequences into the new environment and make it applicable at the production level. And finally one manual for employees who set up a digitisation project using the choosen execution system at another of the organisation's sites. I supported various employees in their roles as production worker, engineer and project manager, to investigate and help them to reflect on their routines and processes. These routines and processes were mostly tacit and embodied in the individual employee and embedded in organisational workflows. My support took place through iterative development steps of the manuals and working with the employees in the project team (Chapter 6 Action Research).

From the study perspective, I applied *Participatory Action Research* (Chapter 4.3.1 Action Research), as I was part of the project team throughout the whole time. The *Research Through Design* approach (Chapter 4.2 Research Strategy) structured the study setting as the development of the manuals formed the design practice with a following detailed document analysis and the interaction created a starting point for interviews and observation.

8.2. Aims and Objectives

Based on my experience as an expert in corporate design manuals, the study focuses on the role of a designer coming from visual communication, working in a technical environment and developing manuals that need to address different levels of knowledge and roles. The aim was to understand how co-creative facilitation supports organisational learning and the shift from previous routines to routines in a new digital environment. Consequently, there were specific objectives to support the main research question: **How does manual design practice act for facilitation in organisational transformation within digitisation initiatives in highly specialised technology ventures?**

The objectives are in conjunction with sub-questions (Chapter 3 Research Objectives):
(1) To understand how visual communication and design practice support individuals to (re-)define their knowledge, as they have barriers to explaining it or using visual tools. Furthermore, to explore layout templates, explaining their use for non-designers to support the visualisation of work. And how this reflective practice adds up in an iterative process so that employees are able to redefine and analyse their workflows, leading to the first sub-question: *How does visual communication help non-designers with a technical mindset to reflect their knowledge through the process of visualisation?*

(2) To understand how this reflective and iterative process can be used to develop a document structure and how working with manual fragments makes the complexity of different workflows and roles accessible so that they become adaptable. And how using the fragments as representations of knowledge facilitates finding a knowledge architecture and a system that the design expert can rely on, which leads to the second sub-question: *What does a design expert need to understand about the working environment in order to systematise and simplify complexity?*

(3) To explore how the collaboration establishes principles that are hidden in the transformational process. And how participation, negotiation and co-creative problem solving form a basis for Facilitation by Design. It also explores how the design expert as change agent enables employees to deep dive into their knowledge structures to enable new ways of doing things and make the new system manageable, leading to the third sub-question: *How can the design expert facilitate the employees to understand the principles concealed in the transformation and scale them for long-term effects?*

8.3. Key Findings

The findings of the study show that organisational transformation can be supported through design-led activities in respect to the three objectives. Designers provide value to the scope of the project described in the study, they understand how to navigate through complexity in topic as well as workload, and they are able to mobilise employees by trustbuilding and human-centred approaches. The findings to the three objectives form the answer to the main research question.

8.3.1. The Value for Internal Knowledge Management

The added value that a design expert brings to a transformation project and technically oriented employees in a company lies in two key aspects: **practical support in the development of user manuals and, secondly, the way in which this is done by offering document fragments to employees in an iterative and fluid manner, thus creating a culture of sharing.**

The design expert develops the manuals in the form of digital documents and PDFs for the organisation, which are then used by all employees in the appropriate roles. The documents are developed in a layout application (Adobe InDesign) that the staff can't handle and don't have the time allocated for. Typically, documentation of this type is written internally as MS Word documents. Engineers are responsible, and the files are stored on a central drive. In this case, the team members did not want to set up the documents themselves from the beginning. There was a discussion that the Adobe InDesign documents would be made available later as MS Word documents. However, this did not happen; instead, they used the final PDF files as they were submitted by the design expert. The engineers were pleased with the openness of the design expert to develop these manuals for the organisation. It became clear that they were not willing or able to deal with this work. Moreover, the employees, whether workers, engineers or the project manager, barely know what to write and how to present or illustrate. Therefore, it was a very pragmatic support to end up with documents and that there was an external person (me) who was responsible for it. The aspect that they did not edit the documents themselves also clarifies the situation that they do not have to think about the content of the document themselves. In one of the interviews, the interviewee told me of previous experiences when documents had been written by internal staff. The document quality was perceived as predominantly single-sided and less reflected upon.

During the time that the interim versions of the manuals were being worked on, employees who had the opportunity to test the printed versions of them found that the form and content of the information was profound. The manual versions were considered serious, although it was obvious that the content was not quite ready. All involved employees reflected seriously and provided profound feedback on each fragment. The content of the manuals evolved gradually and in numerous iterations for two reasons. The MES software needed to be adapted to the needs of the company and the rounds of reflection between all team members created a need for adaptation. The versions illustrated routines and workflows in the new system, and team members were able to understand which aspects had been revised and where problems arose. The documented processes showed the state of the software as it was being developed at that point in time. Recognising this point in time allowed for comparison between before and how it should be. This recognition, as well as the propositions about processes visualised in the interim versions, supported discussion and reflection on existing and possible new routines and processes. The subsequent partial restructuring of work routines, comparing them to possible new processes, led to these key moments. In these intense moments of the project, a culture of exchange developed.

This emerging culture of sharing and exchange was triggered by the material iteratively developed by the design expert. The procedures presented in the manual therefore showed differences between old and new workflows and helped employees to correct initial and evolving propositions about the manual content. The layout of the sequences in the software referred to the reflected routines as embodied knowledge of the production staff, and the workflow defined in the new software referred to the reflected processes of the organisation as embedded knowledge. The knowledge slowly but steadily transformed over the months into practically-oriented information. During the project, a new information architecture for manuals emerged in the context of this transformation. Although the manuals distinguish different types of work, they are related to each other due to the interconnected processes (Chapter 10.2 Material Document Analysis)

8.3.2. The Expertise in Communication for Manual Development

To achieve the value for the project, a design expert must know three aspects: **the documents must be played tactically between team members, the visual document quality must only follow the company's design rules, and finally, the development of the required content can only be handled by combining and learning fields of work atypical for design.**

One of my most impressive realisations in the role as design expert was that I didn't have to style the manuals, and that the final versions only emerged at the end of a long process. I had to develop patience for the slowness of teams and, more importantly, the need for numerous adjustments. I realised that there are two faces of the manual. The *development face* of the manual of the interim versions, which is a boundary object that moves back and forth between the staff and between the staff and the design expert. However, everyone understood the *development face* to be a partially finished verison. The finished versions of each manual were then to be used by everyone in the company who would be involved with the new software. Interestingly, serious reflection was given when the team perceived the *development face* as final. This meant that I had to tactically use the *development face* as a *finished face* and thus as a tool to trigger serious reflection and feedback. To achieve this perception, the manuals only needed to follow the corporate design restrictions for documents given by the organisation. The project manager had been pleased by the visual quality of the documents. He also recognised the investment in the hired design expert as good value, but at the same time as a representative medium to prove the work of the project team for the management of the organisation.

The different user perspectives of production employees, engineers, and project managers required different ways of presenting information and depth. Workers on the shop floor need direct guidance on how to use the new system during production. The best results in testing this manual with shop floor workers were obtained when very simple and less complex visualisation and short text passages were used. Similar to the workers, the engineers also preferred simple language, but they needed a higher proportion of instructions for their work area in order to understand principles. Developing the manual for the engineers was the most challenging as the scope of their routines changed significantly, similar to that of the project managers. Numerous rationales and explanations of the principles had to be communicated.

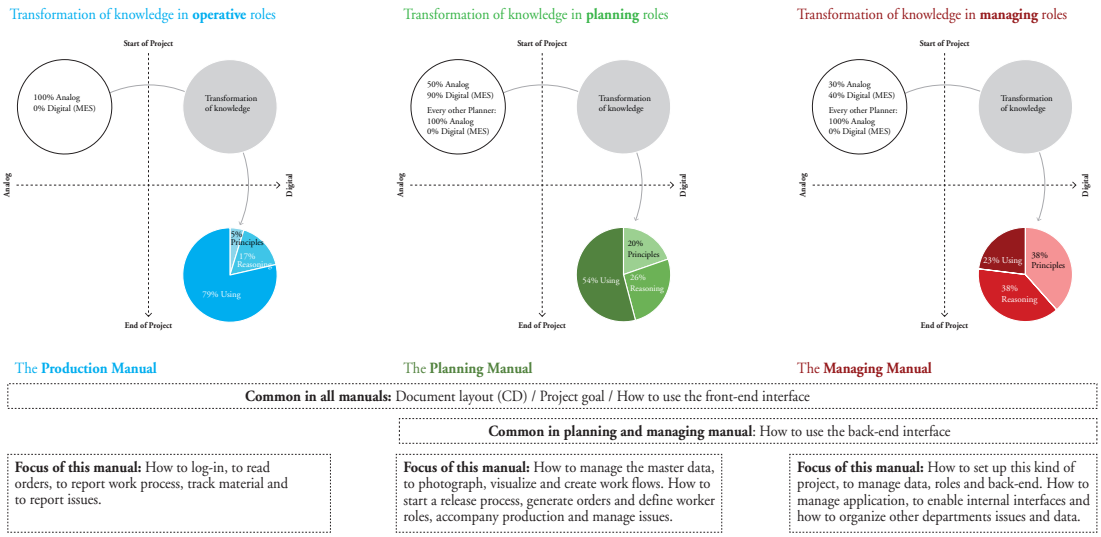


Figure 67: Transformation of knowledge in all three areas (own illustration)

Due to the different roles of the employees, the manuals differed in how they handled information. Since all employees work towards the same goal, the manuals are also networked with each other, and this networking of information could not be realised from the beginning, certainly not by a design expert as an outsider. It became clear that, in addition to didactic goals, strategic corporate goals also had to be covered. This diversity led to a networking of the information, and an unexpectedly complex information architecture emerged. Since the design expert could not initially recognise this complexity, she must rely on the skills and experience she brought to the project as design expert, to manage the unknown. Using the new software itself to understand the new system from the user's perspective is one way to do this. However, to meet the requirements in their entirety, the design expert must deal with technical communication as well as corporate communication. Technical communication is a large area of expertise not normally handled by designers, and there was a learning curve involved. The field of corporate communications is also not usually handled by the designer. The areas of corporate design and corporate identity, on the other hand, are more in the realm of design practice. As it turned out, all three specialties were needed in combination to accomplish the task in this project.

8.3.3. The Co-creative Interaction and Facilitation

In order to recognise the value and ability of a design expert, two things are important for the development of the change capability of employees with different responsibilities and tasks: **the role of the design expert changes from delivering documents to facilitate employees by professional, skilled, long-term, personal support and presence on site in adapting a role as change agent.**

The challenge on the part of the designer was initially to understand her role and the associated expectations of her work. This understanding developed over the course of the collaboration on the part of the design expert and team members. Through constant and active exchange between team members and experts, the scope of the designer's tasks increased, as did the scope of the manuals. The expectation of the design expert changed in that the development of the manuals was not solely the delivery of finished manuals. It became clear that these could only be created on the basis of an intensive exchange with the employees and fast delivery became unsustainable. Furthermore, it became clear that the design expert expands her field of activity not only through support for the instructions, but through the process of developing them itself. Thus, not only did the field of activity grow, but it changed her role in the organisation. Interaction with staff allowed other perspectives to be uncovered, and she became the point of contact for resolving communication issues in the project. This change in role meant that although the manuals were at the centre of communication as the subject of clarification, the manual product took a back seat. Conversation and exchange came to the fore as an activity.

The interaction with regard to organisational learning and transformation lies primarily in the aspects of time and presence. Unlearning and learning new routines as well as identifying potential for improvement within processes takes a lot of time. Here, the long-term support provided by the design expert is particularly noteworthy, as this enabled the development and consistently supported it against the backdrop of frequently changing conditions through the programming of the new software. The long-term accompaniment and involvement in the dynamics of the teams could only be experienced on site, as this was the only way to keep the presence of the new role active. Being present in person then allows for different tactical plays to be used in communication, and it allows supportive tools and methods to emerge within sessions with team members. Purposeful reflection through an interrogative stance, tactically playing manual fragments, or an information evaluation matrix could thus develop and resolve the complexity of the task.

The remainder is concerned with answering the research question: **How does manual design practice act for facilitation in organisational transformation within digitisation initiatives in highly specialised technology ventures?**

In the course of the study, it became apparent that visualisation as parts of manuals and iterative reflection forms a **process** that help the engineers to overcome their barriers in sharing tacit knowledge. The design expert is supportive for **employees**, when the use of a design system (templates) or the use of a new application (software) is explained iteratively, slowly and visibly. When this quality is kept in the manuals, the active learning effect could be experienced again at any time.

This **process** offers new opportunities for knowledge management and can be employed as a valuable strategic tool in the context of organisational transformation and releasing knowledge and information architectures. The design expert must get in touch with the existing knowledge **system** to gain **contextual understanding**. To move within an increased complexity, the process's representations such as manual fragments serve to affect a reflective culture. In doing so, the representations promote discussion, the realisation of explicit and tacit knowledge, and are a living but dynamic **output** of a co-creative process, which is very different from the mere delivery of a finished product (manual).

The design expert as facilitator acts co-creatively, in ways that are visual, skilled, perceptive, reflective, and personal. Applying professional skills and seeing the challenges within the **organisational** knowledge and information architecture themselves lead to being in the transformation space, and the presence becomes holistic. Designers can move into non-design related areas and provide strategic support through this profile and support the development of **principles** which makes the transformation **manageable** and **scalable**.

8.4. Contribution to Knowledge and Design Practice

The contribution to knowledge is rooted in an integrated approach to the work of a design expert who acts as a facilitator within the organisation, supporting staff in organisational learning and providing them with assistance in overcoming their barriers to digital transformation.

Short Overview of Contribution to Knowledge (see also chapter Contribution to Knowledge)

Field	Theory	Contribution
Knowledge Management	SECI-spiral (Socialisation-Externalisation-Combination-Internalisation) describes the concept of organisational learning (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006). Impediments in sharing tacit knowledge need the build meta-abilities (Selamat & Choudrie, 2007; Tsoukas, 2009). The BA represents a space, place, or location that is used by multiple people to interact (Nonaka & Konno, 1998; Nomura, 2002).	The thesis supports the SECI-spiral model as basic structure and provides evidence of how organisational learning can be achieved by design practice (Framework p. 211) in the four BAs. The visual sharing and reflection practice of tacit knowledge helps to overcome the barriers and enables the development of meta knowledge. The thesis expands the management literature as the collaboration is based on the applied framework (p. 211) integrated in the spaces of the four BAs (Framework shaping Design-BA, p. 216) and forming specific Design-BAs.
Technical & Visual Communication	Reverse engineering enables knowledge creation in the field of technical communication (Wick, 2000; Watson, et al., 2016). Styleguides in the age of technology (Bright, 2005) and corporate identiy are holistic (Regenthal, 2009). Knowledge design and visual rhetoric in science communication (Susanka & Kramer, 2021).	The re-creation of production regulations by the means of design practice enables process analysis not only by the use of visual tools but by the process of the manual development itself. The emphasis on a manual-creation approach coming from the design field, especially starting from the corporate design perspective, working in a technical environment is new. Additionally, the final information architecture offers a unique format for tactical and strategic use in similar contexts (Contribution to Manual Architecture, p. 201).
Facilitation & Co-creation	Joint value creation through dyadic problem-solving process (Aarikka-Stenroos & Jaakkola, 2012). The change agent in innovation management is a facilitator and changes roles on demand (Tann, 2021; Freytag & Storvang, 2016).	The work of the design expert has an impact through an integrated approach, where the role of the design expert changes to that of a facilitator who solves problems collaboratively and co-creatively. It broadens the scope of facilitation in innovation as this approach takes place before digital transformation but not in the context of an innovation initiative. This integrated approach guides employees through the four BAs of organisational learning and empowers them to find their own solutions within transformation and adds to the field of knowledge design.

Contribution through Design Practice (see also chapter Contribution to Design Practice)

- Using PPT-templates in this context enables non-design practitioners to visualise and communicate.
- Using manual fragments for unlearning as well as active learning.
- Turning manuals into a new format by combining technical-, corporate- and visual communication.
- Iterative facilitation by fluent set-up of document fragments while they record knowledge externalisation.
- Using fragments, knowledge mapping and 3-point-system as tools for dynamic facilitation.
- Using manual fragments as boundary objects and representations for clarification.
- Working on files together supported reflection and negotiation, which is unusual for that industry.

8.4.1. Contribution to Knowledge

The SECI-spiral and BA are recognised in management literature mainly, but this thesis provides evidence of how organisational learning can be achieved through design practice.

The implementation of the new system (MES) in the study called for re-organising all prior routines and they needed to be reflected upon before being implemented. Because the existing paper-based document types are explicit, the embeddedness of knowledge is hidden in the actively executed routines. To this effect, the study findings contribute to the SECI-spiral, first stressed by Nonaka and Takeuchi, (1995) and align with the model, in which knowledge situated in individuals transforms via *socialisation*, *externalisation*, *combination* and *internalisation* in favor of organisational learning (Nonaka & Takeuchi, 1995; Nonaka, et al., 2006; Tsoukas, 2009). These ways of sharing add to the argument of Choudrie and Selamat that knowledge, especially that of experienced employees, is an object of individual impediments due to different reasons (Choudrie & Selamat, 2006; Selamat & Choudrie, 2007; Tsoukas, 2009). A central finding of my study contributes to these aspects by using the manual development to express knowledge on an individual level and the organisational level in teams, as by the development of the manual fragments, the embedded processes and the interlinkedness of hidden issues become aparent **(Framework p. 211)**. Therefore, the study shows how facilitative iterative manual development and interaction can also break down barriers of tacit knowledge sharing (Selamat & Choudrie, 2007; Tsoukas, 2009).

The scholarly community of technical communication conducts research on how manual development impacts on knowledge mangement. A clear emphasis on a manual-creation approach coming from visual communications and the corporate design field so far is missing, especially starting from the corporate design perspective, working in a long-term change project in a highly technical organisation. My study adds to knowledge in technical communication by extending the scope of technical instructions and complements the knowledge management framework by Wick (2000) suggesting an extended structure and a strategic approach to manual development. The new compilation of the *Manual Chapters* illustrates the new structure and the final information architecture is unique, offering a new format for use in similar contexts **(Contribution to Manual Architecture, p. 201)**.

The mixture of content in the manuals varies in visual and text styles in a novel way. Technical communication is occupied with straightforward guidance (Blake & Bly, 1993; Baehr, 2013), similar to the descriptions on how to use visual templates in design manuals. While technical communication focuses on the guidance of how to use a product or software, visual communication focuses on the guidance of a visual system in conjunction with values and corporate communication while being strategic in its use of language. The manuals in the project use elements from all three disciplines. As these discipline-based approaches can also aim to drive the transformation of an organisational culture, the manuals developed offer a strategic combination to make transformation through digitisation efforts as comprehensible as possible.

Accessing and visualising knowledge by the means of design has been shown by the innovation and business management literature such as Elsbach and Stigliani (2018), Steen (2013) or Täuscher and Abdelkafi (2017), demonstrating an integrated use of design tools and methods. In the field of visual management in conjunction with lean management literature, the concept of a Visual Lean approach is well known in industry for increasing efficiency and the value of constuction projects (Valente, et al., 2016; Singh & Kumar, 2021). The study's contribution is based not only on the use of visual tools, but the process is at least equally important, and the collaborative manual development is beyond a finished product. While Nonaka and Teece discuss the management of industrial knowledge on the background of innovation, technical findings and managing patents (Nonaka & Teece, 2001), the focus in the study is on developing principles for new routines to use and implement a new system based on organisational learning. The findings support the approach of Turner (1982), Muller and Zenker (2001) and Kotter (2007), that the facilitation supports the employees learning to solve problems in the future.

As a consequence, my study supports Nonaka and Konno's theory (1998) endorsing the call for a strategic approach to BA (Nomura, 2002). The thesis reflects this call as the collaboration base on the framework (p. 211) and is integrated in the spaces of the four BAs **(Shaping the Design-BA, p. 216).** After the knowledge is shared or "separated from ba, it turns into information" (Nonaka & Konno, 1998, p. 41), the information is then independent and can be shared, followed by residing in media such as the manual fragments, the final manuals and their use in everyday work and internal networks.

The impact of the design expert's work on organisational learning only takes place through this integrated approach (**Integrated Framework for Facilitation by Design, p. 232**). The design practice adds to change management literature, as it is a professional and skilled design activity with a change agent's stance as facilitator (Tann, 2021), solving problems co-creatively (Aarikka-Stenroos & Jaakkola, 2012) together **with employees in digital transformation** but not within a product-related innovation initiative. Participation in the transformation project over a long-term period is in line with Kotter's 8-step model for creating lasting change (Kotter, 2007) by developing a process for achieving initial successes, a system for devising solutions to complex challenges and creating principles to make the transformation scalable and manageable. This integrated approach guides employees through the four BAs of organisational learning and empowers them to find their own solutions within transformation.

8.4.2. Contribution to Design Practice

Based on the findings in design practice, an integrated framework emerged. The framework supports designers working in specialised ventures and offers potential application in other organisations, where employees need facilitation within the process of sharing, reflecting, and uncovering tacit knowledge. The framework can be applied against the background of industry 4.0 and is applicable for all organisations that are in a transitional phase where knowledge needs to be communicated, analysed, systematised, and relearned through facilitation by design. The *Integrated framework for Facilitation by Design* enables design practitioners to develop from their own skills and adds to knowledge design measures (Susanka & Kramer, 2021). It enables facilitation through procedural, situational and strategic design knowledge regardless of the context or complexity of the task. Thus, the specific Design-BA can be used in the context of design or in other settings where knowledge spaces are actively entered and exited. The spaces enable the focused temporal use of knowledge.

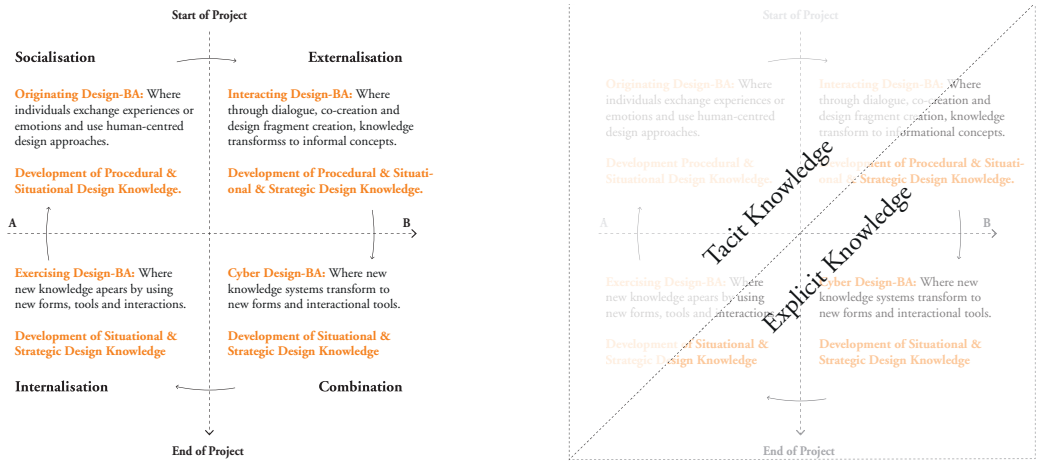


Figure 68: Further development of Design-BA and its relation to tacit and explicit knowledge (own illustration)

The Design-BA is mental as well as physical, as it enables transformation from tacit to explicit to new information with its different qualities. It lives from what the participants bring and how they bring themselves to their own limits within the interaction. Design-BA thrives on participants crossing boundaries to experience the synthesis of rationality and intuition. Facilitation in the Design-BA is active, skilled, analytical, creative, independent and always supportive. By applying design expertise (doing), understanding the issues in a given context (seeing) as well as facilitating by a courageous stance (being) and developing value through a co-creative process, the design expert moves into the role of a change agent. The design expert uncovers by practice and his own skills new tools for facilitation and uses them fluently and even tactically.

The *Integrated Framework for Facilitation by Design* consists of a process (1) to work with individuals and groups (e.g., Framework p. 211) to establish knowledge work. It builds the basis for a system to tackle more complex (2) challenges and to enable full contextual understanding. One result of such a system may be in dealing with information architectures (e.g., Contribution to Manual Architecture, p. 201). The process itself only unfolds its effect if the work takes place in the organisation together with all participants and in defined spaces for knowledge work, such as in the four BAs (e.g., Shaping the Design-BA, p. 216). The framework enables the development of principles for an organisational learning culture that will ultimately enable the organisation to manage transformation to varying degrees and scales (3).

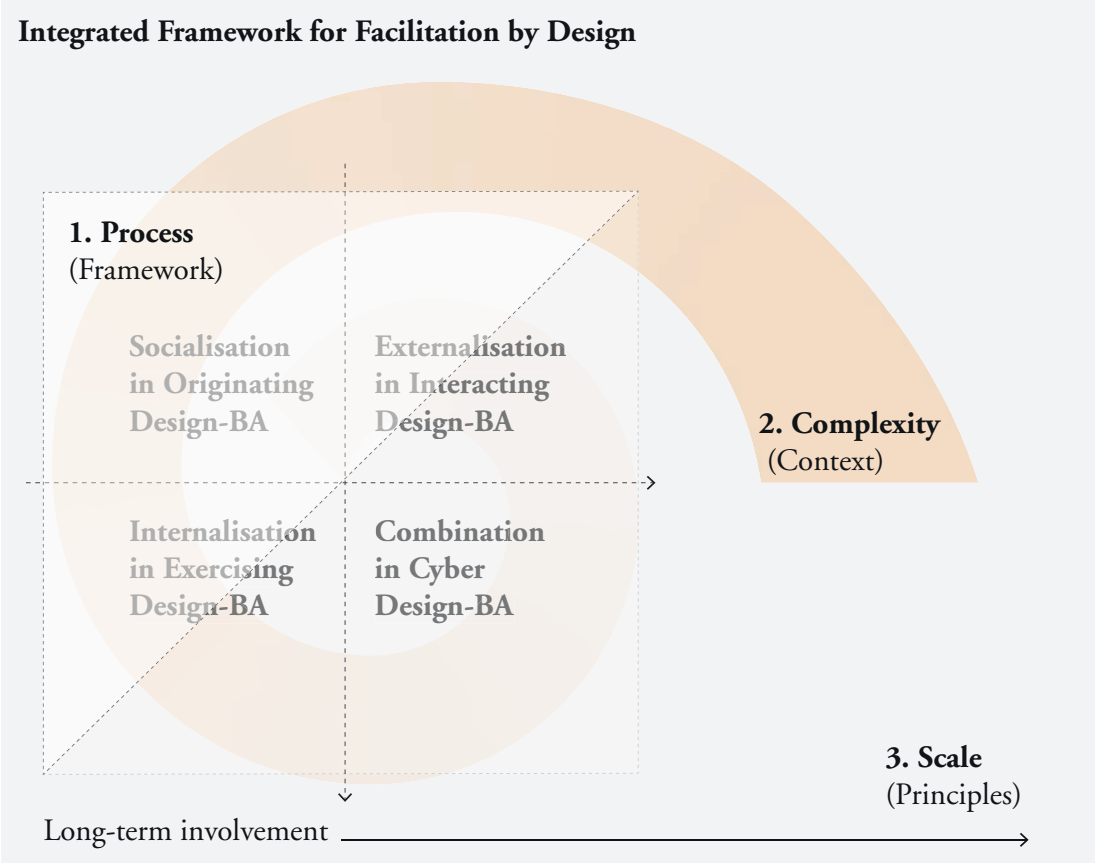


Figure 69: Integrated Framework for Facilitation by Design (own illustration)

8.4.3. Implications to Design Practice

The implications refer to practitioners who work professionally in visual design in the context of organisational transformation. This is often the case when organisations change and need to adapt their corporate design, for example, or when communication measures need to be adapted due to a change in communication strategy. As a rule, visual experts are commissioned to support these types of projects. Taking into account the study results, not only does the potential of the task fields expand, but the *Integrated Framework for Facilitation by Design* enables designers to look at what they can do from a different perspective. The value of design work can experience a major impact by this framework, as it is not just about delivering finished visual products, but accompanying an organisation in a process of discovery through design conducting knowledge management.

8.4.3.1. Mindset and Skills

The design skills required for such interaction and development work lies in engaging with the project and its people. By applying basic operational design skills in the areas of visualisation (drawing, GUI, templates, documents etc.), the design expert supports the implementation with this kind of material. In addition, the design expert needs to understand different visual cultures and their means in practice, e.g., that non-designers use different methods to create visual material. The design professional tries to view the work as process-oriented and consciously interacts and directs the development of artefacts as a representative, and as a facilitator, moderator, and enabler, using these artefacts tactically without calling it so. The facilitation of activities through design skills is characterised by enabling the transformation of the implicit into explicit and reflective material.

Strong abstraction skills as part of basic design skills, various styles of writing creating authorship, a willingness to engage with unfamiliar content in an unbiased way, and the ability to visualise at the right time are essential. The design expert uses professional design software, as well as other software used by staff, to understand its application logic and visual work capabilities, and to see how non-designers practice visualisation. Shadowing, testing, interviewing, and collaborative evaluation provides a new perspective on how ephemeral imagery is used as means of transformation. As the project progresses, the design expert also strengthens his or her own skills as the application takes place in a non-design context. The designer's own tacit design knowledge becomes equally evident and strengthened. The role and therefore the perception of a designer is enhanced and a new perspective of the profession emerges: a profession that generates sustainable value for companies

through its supporting activities, even in complex and abstract contexts, which goes beyond the measure of a deliverable. To facilitate by the use of visual means to support employees is comparable to a service from business consulting, but the integrity has a different quality.

8.4.3.2. Collaboration

The collaboration between design expert and organisation depends on the active participation of all parties and must therefore take place in an open atmosphere, a space in the meaning of the BA. The collaboration can therefore only develop value if the designer's work can be perceived as valuable, i.e., if the work shows something that could not have been represented without the designer's activity. The development of the manuals as co-creative visual products shows that these results become evidence of the process itself. The manuals are living artefacts and illustrate how the exchange took place. The intensity of the exchange is necessary to understand what kind of knowledge is being exchanged and how something becomes visible.

Within the entire team, the relationship is fundamentally based on mutual understanding and trust. However, different types of mutual interaction are necessary. If an already reflected process can be transferred into an instruction, this can also be done as transfer work without depth. But if reflection is to be lived through in a co-creative situation, both sides must bring a professional understanding to the table. Thus, foundational work is needed as a temporal process for developing the co-creative situation and atmosphere. Without the development of this groundwork, understanding, especially against a very complex and technical background, is not possible because mutual acceptance is lacking. The value of the co-creative setting develops over time and forms the basis for a shared story. Although roles are defined differently in a project team and its organisational context, the common goal is known without knowing to what extent the project would fail or succeed. Due to the duration of a project, the availability of the test personel is not always possible due to different scheduling or even leaving the department.

The level of involvement of the design expert in a project depends on the space and where the facilitation takes place. If the design work is done in the studio and there is little or no regular contact with the organisation's employees, it is difficult to establish such projects, as the design practice in the study is neither a corporate design nor a technical communication project. It needs integrative awareness of the people involved and the flexibility to deal with non-design issues and

accept non-design tools and cultures. It requires direct participation, working in the field, eating and drinking coffee together, and sharing other stories, alongside project goals. This level of integrity will ease the relationship. The designer can accept an argument in order to be a stable part of knowledge-intensive situations, where insights and knowledge contributions are brought in from all parties. The study has shown that design has the potential to communicate meaning across borders, to be transparent, to trigger perceptions of other ways of thinking and working. There is a responsibility to understand other fields and other ways of thinking, looking for new forms and meanings to find new ways of thinking, acting and positioning. This responsibility is to adopt a temporary stance of being persistent and ignorant of what is hidden or unknown. Design practice must be self-reflective, able to present itself in other forms in order to be better understood from other perspectives, it must consciously adopt an overview perspective, and it must be able to negotiate. It must be able to negotiate possible meanings and their forms in order to transfer the meanings from different perspectives and working levels – it is a trans-shaping of meaning. It is a co-creative re-purposing of design from the perspective of design practice and a reshaping of core capabilities and core meanings for other fields. In the course of this joint reflective reshaping, design can transform the intangible.

8.4.3.3. Fields of application

The findings of this research can support designers in similar contexts, but also organisations, who work with designers in the forefront of knowledge management and ventures in transformation.

Design Experts – Visual communication can take on a new meaning due to this study. The design expert is an integral part of a co-creative environment within a temporary team of an organisation. The design expert uses design tools as communicative and agile elements and leads the discourse that supports employees in their reflection and their learning. Taking into account the *Integrated Framework for Facilitation by Design*, this will also enable other design profiles besides visual communication to accompany organisations in transformation, be it for the implementation of digitisation initiatives or other objectives.

Organisations – Organisations regard the designer as a change agent who leads towards new insights into their own organisation, being an active player within transformation initiatives. The facilitator is highly integrated and through the design-based skills and the way design can create and open up insights, a broader, human-centred understanding of processes and operations will be possible.

8.5. Future Studies

The results of the study are valuable for the investigation of transformation projects, as it is based on organisational learning in the context of digitisation. It is important to note that the study's findings are based on the change in the role of the design expert and the associated change in their activities and the implications for the questions in the study.

The practicality of the different manuals needs to be further investigated. It should be emphasised, however, that due to the long duration of the study, extensive reflection took place and the different perspectives and learning results were collected and incorporated.

The design expert plays an important role by patiently listening to what the knowledge holder says. These moments took place more often during meetings towards the end of the study. It nevertheless supports the *Integrated Framework of Faciliation by Design*, that the narrative is only the beginning and serves for knowledge sharing in the Originating BA.

8.5.1. Recommendations

A comparative case study could shed light on the effect of the design expert being part of a team in a single role, compared to the actual study in which the design expert was additionally acting as researcher. The researcher in the second study should become only the observer, conducting interviews and analysing the documents, provided that the context is the same, as well as the challenge and the timeframe of the study.

Based on the *Integrated Framework for Facilitation by Design*, further research could focus on the effectiveness of using other tools and media and how different design profiles act in the framework. A study could therefore investigate the influence of design experts with different profiles and skills. As the BA can also be applied to digital spaces, further investigation could look at how digital tools and artificial intelligence (AI) influence the framework and the knowledge transformation.

The expert's involvement not only strengthened but also improved the effectiveness of the organisation through her influence and as part of the team. Facilitation is an activity and not tangible, but the outcome is measurable, as it documents the work of the staff and supports organisational learning at the end. The project outcome offers a new insight into relational services

and co-creation as support for an internal process change and reorganisation of an organisation. While the team is advised by a software company on the basis of a service contract, the relational service between the organisation and the design expert is unclear at the beginning. It moves within indeterminate boundaries at the beginning and only in the first few months does it become clear what new results and insights the collaboration can lead to. Only through a long-term assignment situation, with numerous extensions and iterative collaboration situations, did the project develop and acquire its own flow. A study in relation to the acceptance of design experts, taking into account the development of costs, can provide information about the price flexibility of organisations in such a context and the associated expectations of design experts.

Another aspect is therefore also the organisational framework of the study, as the study described took place in an internationally active organisation that is very technically oriented and regulated by numerous specifications. The potential objective could investigate how design experts achieve impact with the help of the *Integrated Framework for Facilitation by Design* in small and medium-sized enterprises as well as in companies from non-technical sectors.

Inspired by the development in the study, but also by the dynamics of design practice in industry, a general study on whether design professionals change their professional profile in favour of a change agent role by participating in transformation projects and innovation initiatives could be conducted. The study could shed light on the change in the professional image of design and the self-perception of design professionals and show whether designers who intensively deal with this topic could take on the role of design-based change agents and correspondingly narrow professional profiles. However, it could also show how closely these fields are interlinked and whether a completely new recognised and independent professional profile in design can result from this.

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10. Appendices

The appendix contains selected material from interviews, transcribed voice-recordings, notes and the manuals. The origial files with the full-lengths of the interviews, my notes, all recordings and an overview of the process can be made available on request. The project took place in Switzerland and the phrases were translated for this document, the original files contain the text in German. The complete manuals that were developed in the project cannot be made available for open inspection due to the non-disclosure regulation.

10.1. Selected Material from Participants

The coding took place after collecting the material. The codes became a mixture of pre-defined and in-vivo codes. The most often used pre-defined codes were defined by the literature:

Knowledge Management: *knowledge, data, information, individual, socialisation, internalisation, know-how, organisational learning, transfer, reflective, impatience, time, duration, activation, excercising, process, learning, unfamiliarity, knowledge workers, impediments, sharing*
Visual/Technical Communication: *design, Gestalt, technical/visual communication, interdisciplinarity, culture, corporate design, digital, communicative, instructive, codified, authorship, creativity, content, meaning, text, visual, style, balance, solution, documents, manuals, products, process, diagramm*
Co-creation: service*, network, service system, technology, untransferable, intangible, relational, adaptive, communication, knowledge-intensive, stearing, negotiative, collaboration, involvement, facilitation, experience, softskills, moderation, organisational effectiveness, learning, co-creative*

10.1.1. Material from AR1

In the following, there is the flow of notes developed along the way and codes are highlighted.

Selected quotes from all participants:

"It has to provide the **basics** and then it saves time for the learning, or a **crash course**. Every detail though should be described somewhere, a **complete manual**. The manual offers **training for 2-3 weeks**, but special knowledge is necessary as a prerequisite. It should not lead to deep dive from beginning. Starting at the top should be the goal." "It should support **learning-by-doing, simple tasks**, making mistakes, then checking." (Engineer)

"The definition of the **milestones** in developing SOEs took a while, but we gained clarity." "A **change in one part** of the setting involves changes in **all levels.**" "To start from scratch means, that a basic **frame** might be available, **but not the content**. One need to familiarize well with new topics. One pattern is, that it is like putting together a **puzzle**. Then the picture slowly comes to light. **It is a puzzle without a template, one might know the dimensions**, **but not the content**." "One need to **know**, what is the **actual core process** and if it can be **applied** to other working context." (project manager)

"Success is that the employee **can make use of it**.", "It became clear, that I had to **record knowledge** and experience but also develop **documents to enable users to learn and gain understanding**.", "The language must be hands-on. **Instructions** must be short for the **shop floor**." (design expert)

Selected quotes from researcher perspective:

- The **different user perspectives determine the language and the scope of the material** they are expressed in **three kinds of documents**. The **three levels** refelct to the content structure.
- There is no patience in the knowledge workers, but their **overall goal** is important. All these things become clear when they start to write them down.
- The **structure and the hierarchy** in the documents (manuals) base on the **practicability.**
- The **manual needs to coordinate practical-physiological, theoretical-principal activity** and material with digital set-ups in the application.
- A manual should present the **position of the rules**, **support logical understanding** and be **didactical**.
- There is a **hierarchy in who is educating who**. The project manager is educating and coaching the Key-User and this level of knowledge is reflected in the manuals as well, but not visibly.
- Therefore there will be expertise of the company work force as well as the skills of the project manager as well as the skills of the designer **–working expertise–project-expertise–transformation-skills.**
- Online training or other support by the platform would be good. The basic frame and structure can be done in a linear written manual for orientation. Due to the context, pure online training is impossible.
- **It must support action and learning by doing.**

- The **manuals of the project vary in depths of freedom** to act and in content.
- Learning not only base on activity, but also on principles and transformational skills. **Its learning to understand, that a principle is also an activity and a skill at the same time.**
- Manuals need to reflect upond differents **perspectives and roles in the organization**, the different content offers organizational perspectives and prospect activity areas, but the meaning of the project and the manual content is different for its users.

10.1.1.1.Interview Objectives AR1

The list of objectives for the questionaire to employees conducted by the assistant about the developed templates for the visualisation within the SOED:

1. Logic of the sequence
2. Amount of content and instructions on the screen
3. Appropriate placement of texts
4. Visibility of separation of different work steps
5. Balanced overall appearance
6. Length of text lines
7. Font size of texts
8. Comprehensibility of visualizations
9. Size of images
10. Unambiguity of instructions
11. Navigation through the step
12. Proportions of images to each other
13. The work step is made clearer/clearer by the text
14. Comprehensibility of the instruction
15. Simplicity of the instruction
16. Length of the text
17. Visibility of the result to be achieved

10.1.2. Material from AR2

In the following, there is the flow of quotes and notes developed along the way and codes are highlighted.

Selected quotes from all participants:

"… you know, xxx always clicks back and forth and that is the solution for him. But I don't understand anything." **"Transformation** of a work process is a **rethink**. Writing down before rebuilding a process. Maybe it is not relevant which system/process (related to the MES) is used, but **working with it will show you what you really need**. **There is a process to gain a structure."** "Always ask yourself, what does a person see, who is a freshman. Also, the roles must be clearly distinguished through different use of text, style and depth of content**. Look through a freshman eye**." "I realize now that before I only ever clicked **somewhere unconsciously**. Now I make almost every step much more conscious." **"**I like to **sketch.** If I look at it, **I reflect and learn.** I guess I am a visual person." (project manager)

"It took me **1 year to understand** the new software within this context. To shorten this, one has to know **what needs to be rebuilt**." "It takes a while to learn how to **rebuild a process** in another environment, in this case a year in the digital environment." (engineer)

"After a while, it became obvious, that I am working with people, who are significantly showing **signs of tacit knowledge** along the issues of beeing unable to explain what they know.", "It takes time to access the complexity of the project, also to **grasp the skills** of the people." (design expert)

Selected quotes from researcher perspective:

- In knowledge workers, there is no patience. Their **working goal** is important for them.
- All these things become clear when they start to write them down.
- Theory says, that the retrieval of **long-term memory** takes about **2 weeks** at least.
- A finding is that the various **design skills** are only available at **various moments** of the process.
- To find the **structure**, one need relentless investigation in the understanding of the expertise.
- The **shape of the knowledge** is unknown until there is in depth retrieval of content based on team based negotiation and active retrieval work. It needs patience and resistance.
- **Mirror the skills** of each other supports the **finding** of expression. The person with communication skills meets the person with project based skills.

- Design students claim **visualization** as a good mode of operation to **extract** an **expertise**.
- Freshman proved, that the experiments using **visual media supported their learning**.
- Using **movies** to explain a process ease the understanding.
- Using **pen and paper** supports **visual thinking**. (Non-Designers claim this helps for reflection.)
- Visualization has a strong **impact** when using simple **colour codes.**
- Skills relate to **various levels** (people activities vs. digital systems automatic functions.)
- **Diagrams** can play an important role for finding a **structure**, as there is tacit knowledge behind.
- It needs **flexibility** in creating different version with different meaning
- In designers there should be a **fundamental interest** in complex settings and the topics itself.

10.1.3. Material from AR3

In the following, there is the flow of quotes and notes developed along the way and codes are highlighted.

Selected quotes from all participants:

"Is is a support, because I have to think about what the consultant has **understood**. The **external reflection** is important, otherwise one just do something for oneself. **"You** (the consultant) **have skills, which I do not have**." "Your work helps me a lot **to understand my understanding** of the matter. I see what I understand when I see how you interpret my inputs." "If we **document** all of this **project** by the manuals, we might raise more awareness for other people, and then maybe more support from **management will come**." "You know, **people who like change** and are interested in knowledge and learning, they will support our project. But in general, nobody wants change, you have to take people along." (project manager)

"The consultant **should know the context**, the digital context and he should have worked with a MES before." (engineer)

"I become **aware on** what I do, my **own skills** as a designer but use it as consultant" "I transform the given content into the **syntax relevant** for their needs." "During the project, the **scope changed** and a different skill is needed. There was a shift from a **corporate design manual to technial communication** documents and I had to research about technial manuals and the DIN norm." (design expert)

Selected quotes from researcher perspective:

- Depending on the **personality**, the expression of their thinking is different.
- Specialists have **trouble "thinking".** Deep knowledge about a pilot project supports the logic of the processes which is deeply rooted in the **activity** but not much in a reflection.
- It is supportive, when some part of the team comes from a **different department**, as for **critical reflection** the content and for its improvement.
- But the entire company is technically structured and the **MindSet** is not so much aesthetically oriented but rather **process-functional**.
- **Softskills** and how the company works are needed for implementing the MES.
- The mindset of assistants is driven by their availability and **will to deep dive** into a topic such as this. In all cases the deep dive did not take place.
- Restarting with fresh people **demands time and patience** for getting them on board.
- Do not lose **patience**. Ask **questions**.
- The **view** (work setting) to the document enables both participants to reflect equally.
- Client is able to see **a live document** and to investigate in the visualization based on his contribution.
- A lot of knowledge is **at site**, it's practical and the location is important to dive into the **environment**.
- To own the working **document** means, that you gear the process. There is **ownership in the process**.
- The **interplay** of client and consultant is **productive**, when both core professional **skills overlapp**, mirror each other, applied to a certain task or question.
- The knowledge moves from recipient to recipient – **memory, medium, application** by a another person.
- Interplay depends on **both performance** and **reflection**. Both have to work hard in reshaping the content.
- It contributes significantly to the **mutual understanding** that the different perspectives need to be reflected critically. It is easy to see when a text structure and visual layout needs to change, when the view is questioned and critically reflected. If this is stimulated from the role of the

consultant, **critical moments** in the relationship can occur, since the **intervention is often accompanied by stronger emotionality as changes require effort that affects both sides**.

- There is **uncertainty**, due to the new task. I had to **develop a strategy** as I had not done a project such as the one described.
- The **ever-changing role** of the consultant-designer-user and its fulfilling turns the **relationship** into a professional service.

10.2. Material Document Analysis

The existing material is coded as *what is visual* and how it produces meaning and relation. The analysis of the visual codes will then be divided into *relative visual codes* by manual. Visible structures emerged, such as the development and use of page types or the way elements such as text and images were specifically worked with. The meaning of the codes in context are hierarchised as:

Visual Category for the causal entity; usually the classification of a visual e.g., diagram, text, …

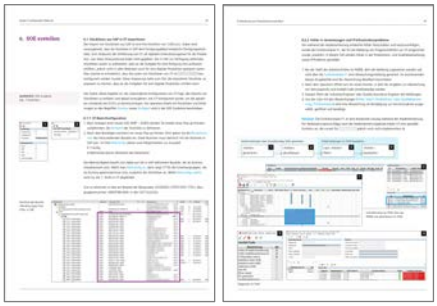
Origin for the used visual material in the category, e.g., schemata, numbers, …

Meaning as category for the effect, e.g., applied process

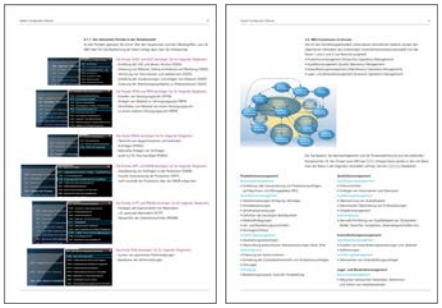
Relation as category for its embeddedness e.g., events in the application

Value as category for the appearing quantity, e.g., 25% of all visual material

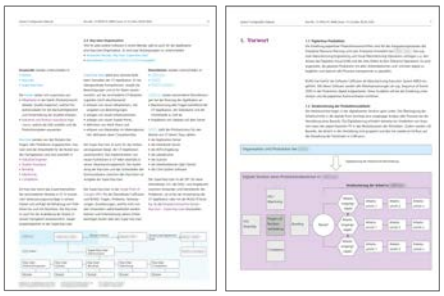
System Configuration Manual: This manual describes all activities for configuring a project within a company environment. To a large extent, principles explain how the interaction between software and organization can be established and how departments are coordinated. In the software portals, work must be done practically and this requires a certain number of instructions. Numerous references also refer to instructions that are already available in detailed form within the other two manuals. However, the user of this manual is in the position to work on the meta-level and does not necessarily need to know detailed work processes on the shop floor, but it would be advantageous.

Specific Visual Codes in **System Configuration Manual – Instruction pages**					24%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Volume*
text	headlines, copytext, lists,links, captions	naming and describing activity	specific work flow in CF		30-50%
diagrams	Abstract schemata	typical process	usage of portals		10%
screenshots	tables, interface, screen segments	CF / SAP content, functions IP of CF / SAP	interface process at backend		30-50%
photography	-	-	-		-

Interpretation: Instruction pages in the system configuration manual are similar in structure to those in the other two manuals. Screenshots are explained and the individual work steps are described. A numbered hierarchy structures the successive work steps. In addition to work-related steps, this manual also contains instructions that represent a meta-level of tasks, i.e. combining work steps into one step. Often there are also general explanations or principles which are added as a supplement.

Specific Visual Codes in **System Configuration Manual – Explanatory pages**					38%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, listings,	naming, explaining, describing principles	CF set-up principles		30-50%
diagrams	Flow charts, matrix	general elements	content management		10 %
screenshots	tables, interface, screen segments	CF / SAP content, functions IP of CF / SAP	Portals of software systems		30-50%
photography	-	-			-

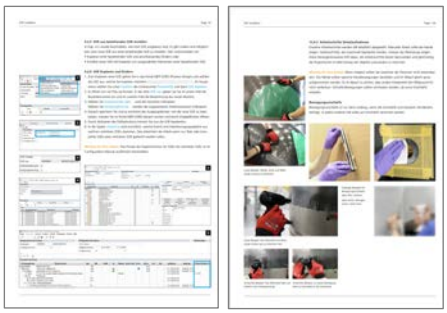
Interpretation: Explanatory pages of the system configuration manual comment on already given settings in the software or taken decisions about applied principles. Screenshots can be used to illustrate an explanation, diagrams or charts are also used when explaining structures or processes. The amount of text in these pages is dependent on how well the visualization can be coordinated with the text. In these pages and in the Principles pages the project or organizational structure becomes visible. The repeated revision of these pages shows the discovery and visualization of the hidden processes, or the redefinition of the processes using the software conditions.

Specific Visual Codes in **System Configuration Manual – Principle pages**					38%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, listings,	naming and describing principles	project implementation		50-70%
diagrams	Abstract schemata	general processes	transformation		30-50%
screenshots	-	-	-		-
photography	-	-	-		-

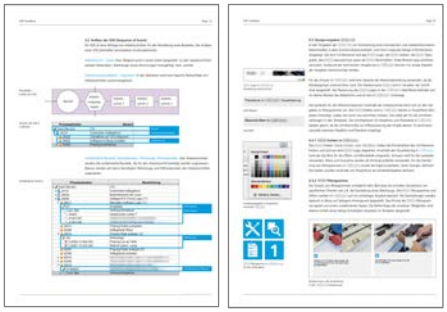
Interpretation: Principles pages describe the principles of such a project and set out the framework within which a project manager can and should act, without, however, making binding specifications in all details. By explaining the principles, organizational structure is presented on a meta-level and the presentations reflect the meta-level by a certain degree of abstraction. Often schemata or flow charts are used for description and the texts are correspondingly detailed.

SOE Guideline: The SOE guideline describes all measueres and activities from an engineer which are necessary to set up the work flow for the workers. The digital work flow in the software needs to be developed using the features such as visual lean, material and tools portal, measurement and quality control functions within the sequence of event design. This guideline sits in the middle between production manual and system configuation manual as the settings and activites of the engineer affect the production as well as the project management. To a large extent, explanations and instructions on how to design the SOE are making up the content. One specific activity is the set up of the events using visual descriptions and photography. The engineer needs to understand the work flow and details in order to recapture the process and to rebuild it within the digtial environment. The engineer also needs to take photos to use in the visual lean elements and therefore an active reflection on what is actually taking place at the shop floor takes place.

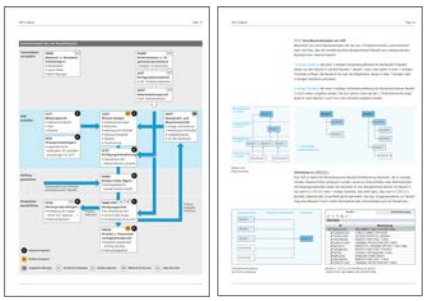
Most of the unlearning takes place here as the events are the core of the work processes and there is an intense interplay between production employees, quality assurance and project management. The engineer needs to understand and communicate towards both ends. He does not know certain parts of the organizational knowledge or the applied working knowledge but it would be advantageous.

Specific Visual Codes in **SOE Guideline – Instruction pages**					54%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, lists,links, captions	naming and describing activity	specific events in CF		30%
diagrams	-	-	-		-
screenshots	tables, interface, screen segments	CF / SAP content, functions IP of CF / SAP	interface of events settings in CF		30-50%
documentatory, detail till half total	hands, tools, material, product	showing work activity	visualizing work process		30-50%

Interpetation: Instruction pages of the SOE guideline accompany the description of the exact process of how events must be created in the software. The successive steps are numbered and the corresponding texts are numbered accordingly. All additional settings in other portals are described in the same way. These pages also show how to photograph the work process and what to look for. Since the creation of sequences requires many different but defined activities in the software, the percentage of these pages is very high.

Specific Visual Codes in **SOE Guideline – Explanatory pages**					26%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, lists,links, captions	explaining applied activies	applied events flow in CF		30-40%
diagrams	applied schemata	applied process	events in CF		10%
screenshots	Marked and annotated screens	CF / SAP content	events setup in CF		30-40%
documentatory, detail till half total	camera settings	how to photograph events	document events		10%

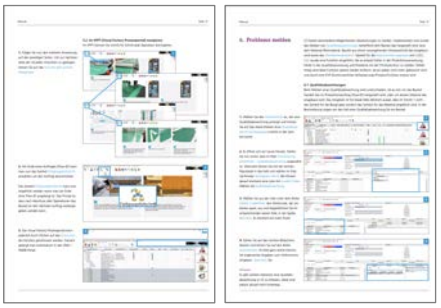
Interpretation: Due to the diversity of activities, the explanatory pages are correspondingly extensive. The defined basics for setting up different processes with and without exceptions must be explained. In some cases screenshots are commented and the settings are explained using an example. The basic settings for the corporate design of the company are explained in this guideline. In addition, the application of the corporate design elements is explained and to what extent they are relevant and used here. The applied photography in the current working environment and how the photographic settings are to be designed is also explained on these pages.

Specific Visual Codes in **SOE Guideline – Principles pages**					20%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, lists,links, captions	naming and describing activity	specific work flow in CF		30-50%
diagrams	abstact schemata	typical event measures	requisites of events		30-40%
screenshots	screen segments	comparison with principles	insight of general settings in CF		10%
photography	-	-	-		-

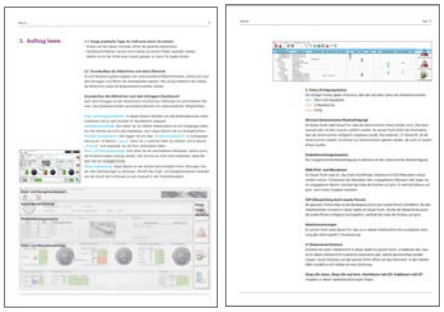
Interpretation: Within the principles pages, the basic procedure of how the work processes are transferred to the new system is explained. The principles therefore do not represent any room for maneuver but rather a basic procedure that is used here. Therefore processes in the company become visible. The same applies to the development of an understanding of photography and the visualization of events. To trigger a general comprehension of visualization using photography is the goal of these pages.

Production Manual: The production manual guides production employees through the sequence of events in production. The employees are usually familiar with the process, but the manual should also be usable for new employees who are starting to use the software, as well as for starting work in the new company in the context of their specific projects. This handbook is central to the execution of all work processes in production, but it is only intended to provide the impetus for the use of the new software. The working knowledge sits in the sequence of events. The production manual is therefore shorter and consists of the most important instructions and explanations necessary to get started. The manual is the only one in which the content has not been worked out together with the employees from the very beginning. This led to a problem during the consulting project, because after the first test it turned out that the language used was too complex, too much text was used and the visual language did not correspond to the actual need for action. After the manual was tested in another semi-developed version by several people in the shop floor, the adjustments could be made.

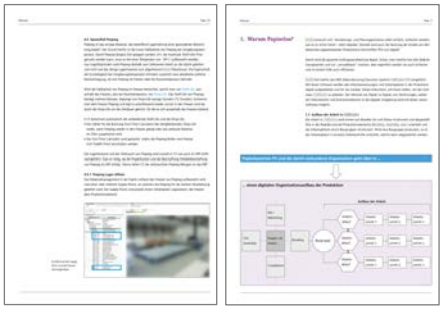
A major difference between this manual and the other two manuals is that it is not only short, but almost exclusively contains instructions for using the software. In addition, it deals with some special cases concerning material management and quality control. In the area of error handling, the only self-regulation is provided, but only if experienced personnel are participating.

Specific Visual Codes in **Production Manual – Instruction pages**					79%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, captions	naming and describing activity	sequences of events in CF		20%
diagrams	-	-	-		-
screenshots	tables, interface, screen segments	CF content	production manag., and SOE		50-70%
photography as in visual lean	hands, tools, material, product	visualizing work step	work process guidance		30-40%

Interpretation: Within the instruction pages mainly screenshots and short amount of text are shown. The work steps are presented in simple and clearly comprehensible quantities in text and pictures. In contrast to the other manuals, the descriptive texts for the screenshots are handled as border text. The texts are no longer in the center of the layout and screenshots are in the center and visually dominating the document. Text has rather a commentary function to the image. The instruction pages are the dominant part of the manual and focus lies on the imagery.

Specific Visual Codes in **Production Manual – Explanatory pages**					17%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext, captions	explaining sceens	screens in CF		30-40%
diagrams	-	-	-		0%
screenshots	screens as in use (e.g. portal)	digital work environment	CF		30-40%
-	-	-	-		10%

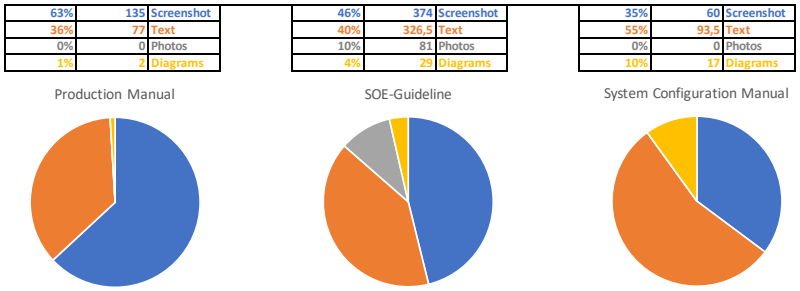
Interpretation: Explanations are rare and always linked to an example picture, which however is to be seen in reality as it is shown. The number of explanation pages is very small and this is due to the fact that the main purpose of this manual is to guide employees to clearly defined actions. Pictures must always correspond to what they directly serve in action. Explanations are used above all when it is a matter of presenting understanding for a decision that has already been made. However, the explanatory texts are short and are often integrated into the introductory texts of the instructions.

Specific Visual Codes in **Production Manual – Principles pages**					5%
Category	*Origin*	*Meaning*	*Relation*	*Examples*	*Vol.*
text	headlines, copytext	naming and describing activity	specific work flow in CF		50-80%
diagrams	-	-	-		3%
screenshots	screen segments	comparison with principles	insight of general settings in CF		20%
photography	-	-	-		-

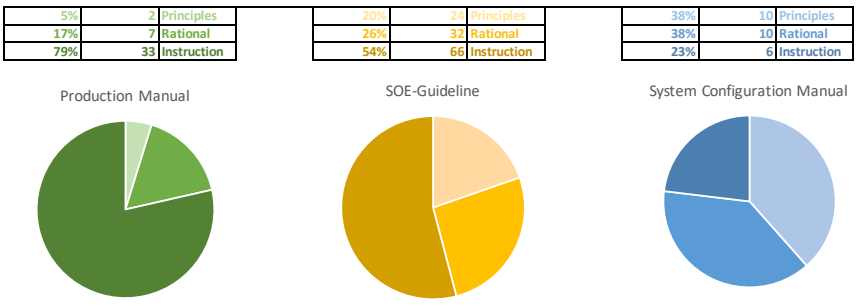
Interpretation: Principles can only be found in this manual in a hidden way. Almost no room for maneuver is presented, with production decisions being made outside the software. The freedom that is available is not officially documented here. However, there are some topics which have to be documented in the "system" and here it is important to understand the principle of the process and to trigger or document an action accordingly. The amount of principles clearly visible in the manual is extremely small and includes e.g. the introduction page, which is available in each of the three manuals.

10.2.1. Proportional Analysis of Manual Content

Distribution of content elements show, that the production manual uses dominantly sceenshots (63%) and some text (36%) to convey the message. In contrast, the system configuration manual uses dominantly text (55%) in combination with some screenshots (35%) but favours diagrams (10%) for explaining a rational and principles. The SOE guideline uses text (40%) almost in the same quantity as the production manual but less screenshots (46%). In addition to the other manuals, it uses photography (10%) for content layout of the sequence of events. In contrast the production manual does not use photography and only a minor amount of diagrams (1%).



Distribution of page types shows, that due to the various intentions the content structure differs. The principle pages explain the why of the procedure, explanatory pages explain the defined elements and the what of the procedure and the instruction pages describe the how of the step-by-step procedure. The distribution of the page types shows a very dominant use of instruction pages in the production manual (79%) versus an extreme low amount of them in the system configuration manual (23%). The relation of principle pages and explanatory pages seem to be almost equally distributed in the system configuration manual (38% to 38%) and the SOE guideline (20% to 26%), but the instruction pages predominate (54%). The small amount of instruction pages (23%) in the system configuration manual are due to the fact that there are cross-references to the explanatory pages of the SOE guideline.



10.3. Coding by pre-defined Keywords

This chapter supports the reflection in the Analysis and Conclusion Phase of the Action Research Cycles. Although the main discussion on literature takes place in chapter 7 (Discussion), these reflections helped me to understand the meaning of the findings and their relationship to existing theories. I formulated several subquestions to understand the various aspects. The following table highlight the key-theories from literature.

Key-theories on Design Practice	Key-theories on Organizational Learning	Key-theories on Services and Co-creation
Process-oriented thinking and working Ability to **commuicate the invisible** Digital and transformation **skills** **Authorship** evolves through content and meaning Visuzalizing needs application of **Gestalt principles** **Understanding** of the content **Human-computer Interaction** (HCI) is part of technical communication (TC) TC is an **interdisciplinary** field of design and technology Guidelines and **templates** are documents for **reference systems of knowledge** Design communicates, **values**, technology, work and culture Organizational communication should **balance constraint** and **creativiy** to **promote change** Content in technical communi-cation is strongly **text-based** Content in corporate design is **visual** Content from **organizational communication** base on **text**, but variable in **style**.	DIKW-pyramid **hierachized** data, information, knowledge, wisdom **Meaning** and **relationship** between hierarchies Information management is not knowledge management Distinction is made between the **individual** (IN) and the **organisational** (OR) knowledge There is explicit knowledge such as regulations (OR) and metaknowledge (IN) There is **tacit, embodied** (IN) knowledge and **tacit, embedded** (OR) knowledge **Organ. Learning** (OL) circulates **socialisation, externalisation, combination, internalisation** (SECI) Memory building depends on the **duration** and activation of a stimulation Knowledge workers have **troubles** in **sharing knowledge**, there are **impediments** Long-term memory represents stored information on a **near-permanent basis** **Embodied knowledge** is a central asset of companies and **leaves** with employees **Templates** or knowledge management systems represent embedded knowledge	Service differenciates between **services and goods logic** **Value** is crated through **co-creation** in various steps of a customer journey Services basically works with **relationship** and **collaboration** **Value** takes place and is not transferable, as services are **intangible** There is always a **network** involved **Facilitation** for client learning base on **communication** In **customer-dominant** logic the customer is **involved** in the service delivery **Knowledge-intensive** services can base on **relation** There is an exchange of KN and **empowerment** and improve organizational **effectiveness** **Collaboration** takes place at the border/intersection of actors Documents **record** collaboration, negotiation leads to clarification via **boundary objects**

10.3.1. Reflections on Design Practice

What kind of design practice and skills are relevant?

Visual design skills and rewriting supports iterative extraction of information structure – Tranformation

The client needs external support with visualisation as they cannot operate the design software. They want to communicate as little as possible and have little patience, visualisation helps here. The visual quality of all three manuals underlines the importance of the team in the organisation. All staff involved understand the visual revision as a didactic enhancement. Diagramms help to distinguish between principles and operational activity (3-point tool). The manual serves as illustrative material for learning on both sides. The complexity of the project required a learning time of one year from team members. Newcomers learn the same with the manual in weeks. The documents illustrate the reality of what has been understood and what not. The document fragments are a living thing, changing through constant reflection. The fragments serve as medium for the client to reflect, to see what has been understood. The depth of visual detail depends on the ability achieved. The process is accompanied by ups and downs. The ideal manual should focus on important parts and be supported by videos. Creating training material would help to shorten the learning phase when starting anew.

The practice needs skills in traditional visualization, layout and also codification. These are pre-requisites and should be used at the right time with the right content to create meaning. The meaning will rise through the relfection of the users perspective and hence the design develops co-creatively. Strong mediation and facilitation skills support the development and may be an add-on to the design practice, as these skills do not mean process-orientedness using preshaped tools or methods. Appraoches develop in action and are reactive by nature, as the designer should see his/her role as facilitatior and mediator but using his fundamental skills in desinging. Authorship can develop, when the basic skills of the designer, the transformative qualities of the imagination are always available but not the main focus. So it is not about placing the design skills in the front, but to have them available as a basis for document development in combination with an attitude that develops in the relationship with the customer. This relationship enables the externalization of knowledge and makes it available or changeable. The documents are a means to an end.

What kind of visualization support the discovery of tacit knowledge?

Customer needs support for visualization, as software interface lacks quality – Design, software skills

Visual hierarchy helps customer to distinguish between principles & operations – Design skills

Visual quality depends on situation in the process and skill externalized – Aesthetic terminology

As practice has shown, diagramms, text, 3-point-tool for structuring content serves the discovery of TK in an interative way. In addition theses elements need to be properly placed in a formal document, so that they receive seriousness and reflection can be implemented accordingly. In some situations, the live-work of the development supports the co-creative and communicative process, shapes content and establishes meaning.

How does the design practice linger to educational aspects?

All employees involved understand the visual revision as improvement. – Visual learning

The manual serves as visual matter for learning at both sides – Visual learning

The new system requires learning +1 year, the manual shortens it to weeks – Actice Learning

The manual serves the client to reflect, he sees what he has understood. – Boundary object

The balance of constraint and creativity should be present in manuals to promote lasting change. As technical communication as well as corporate design manuals serve the implementation but also the change of an identity and hence support organizational transformation. Technical communication is occupied with straigth forward guidance, similar to the descriptions on how to use visual templates in design manuals. Organizational communication focus on strategic use of language and masters styles of text to emphasize on strategy. All fields focus on strategy but in various means, matter and expression. While TC focuses on the the communication and guidance on how to use a product, software or an interface – VC focus on the communication and guidance of culture, values and identity. While TC focus on writing, VC focus on visualizing. OC supports the development of human attitude. All together shape a design practice within a service context focusing on transformation within organizational learning. The overall process is lengthy, iterative and needs active support from all participants. As the discovery is part of the manual development, it is not an exeption. It should be repeatible to understand its principles and options for shortening the development of other manuals or documents with similar requirements.

10.3.2. Reflections on Knowledge Management and Information Architecture

How is the process of TKN discovery and what time does it take?

Process is iterative for a long time – this is a sign of embedded KN

Process is like sorting a puzzle, you know the frame but not the content – embedded / implicit KN

Process is unlearning and learning of rules – Part of Transformation

Process is accompanied by ups and downs. – Un-/Learning cycle

For the client it became more reluctant, there is another approval phase, who reflects critical on the content and therefore it it an asset to the process. – boundary object, professional service

All employees interviewed, declared, that the manuals are valuable for their understanding. The chosen MES application is interchangeable, the preparation of work processes is independent of software. The manuals reflect knowledge from all levels of the company (Project Management-Work Planning-Production). The documentation of the knowledge embedded in the manuals enables a re-implementation. The manuals also document explicit knowledge, but this is re-evaluated based on the process of reappraisal through organizational processes. The development of the content is a learning of new skills and an unlearning process of existing knowledge. All three manuals reflect the network of activities in the different departments – embedded and domain-specific KN. Manual development is iterative for a long time – this is a sign of implicit KN. “Starting with this project is like a puzzle, you only know the frame but not the content.” (project manager) – embedded and implicit KN. Some types of knowledge workers have little patience, but they accept the need for manuals. – KW workers. The extracted knowledge shows different levels of skills and types of knowledge.

Are manuals a documentation of tacit knowledge (TKN)?

Process reflect KN from all company levels (MNMT-AVOR-OPS). – SECI

Process also document explicit knowledge, but this is re-evaluated based on the process of reappraisal through organizational processes. – Unlearning

Process record tacit/embedded KN and transfer it into information – DIKW

Manuals document TKN, but only after storytelling, observation and reflection. – TCBOK

All three manuals reflect the network of activities in diff. depmts – embedded & domain-specific KN

Manuals are a living thing, constantly changing through usage and reflection. – Boundary object

Knowledge only takes place through action and manuals are not representing knowledge, but information to trigger action and learning. The manuals are an important part in documenting the externalization of tacit knowledge on the individual as well as on the organizational level. When the manuals have reached a level in everyday business and use that the templates, routines and principles are no longer perceived as new and unknown, they show what can be understood as tacit knowledge of a company, but only in the form of a reference system.

What is the content of manuals and what are they used for?

All knowledge, skills and expertise must be transferred to manuals – Transformation

Software usage knowledge (MES) must be transferred – Transformation

The extracted knowledge shows different levels of skills and types of knowledge – OL / Unlearn

The chosen MES application is interchangeable – TCBOK

The preparation of work processes is independent of software. – Unlearn

Manuals illustrate what has been understood and what not. – Visualization

The manuals need to support and trigger the usage of a new platform software in a technical environment. All manuals base on technical communication rules, in addition they communicate values and principles by incorporating identity through corporate design and wording insired by corporate communication approaches. The content design of the MES-software uses partly the corporate design, but stays basically very technical and software supplier driven. There are numerous screenshots of the platform application, schemata, descriptions, links to short video clips and files. In sum, the manuals represent the content for three different scenarios and learning depths by balancing regulations and creativity through technical, design and corporate communication. The manuals are not user manuals, except in parts the one for the production employees, but rather handbooks for actively implementing a transformation.

Do manuals support learning and impact on organizational learning?

Documentation of the embedded knowledge enables a re-implementation – Manual

Manuals should focus on important parts and be supplemented by videos – Media

Training would shorten the learning phase, starting from zero – Visual storytelling in socializing

According to literature, embedded knowledge in organizations through knowledge management systems such as runnig card systems or other templates in use are hard to be replaced, as it takes a long time for the company memory to be installed first hand. It is hard to unlearn it or let it go and use a new system. The manual development supports an unlearning process and can trigger new learning. Using a manual for mapping embedded knowledge iteratively out of the company memory, from the perspective of design and not from a technical perspective becomes an enrichment in the field in knowledge management.

For whom are these three manuals? (context)

All envolved employees of the company declared, that the manuals are valuable for their comprehension and how to start using the new system. – Re-embedding of Knowledge

Knowledge workers have little patience, but accept the need for manuals. – Knowledge workers

Visual quality of all manuals underline their importance in the organisation – Proove of Service delivery for Management and Organization

Manuals' information is made for users to turn them into knowledge based on applied processes in production, work planning and project management. In addition, obstacles in sharing knowledge on the base of self-learning principles need to be recognized. When sharing documents with users while creating them, it supports attachment to the transformation process, supports knowledge-workers communication and enables unlearn and learn. Employees with a high level of embodied as well as embedded knowledge not beeing part of the manual development, will have a hard time to change due to the new system. Therefore the manual for production employees is only set as a starter kit (basics) as these employees know their working routines and just need to get used to the click-through-documentation of their work. The manuals for the work planning and project management strongly intends to familiarize the users with the software and the relevant backend in detail.

10.3.3. Reflections on Facilitation and Co-creation

How is the interaction of people involved?

The interaction of client and expert is domain-specific and knowledge-based on both sides – Interaction on content level, professional and knowledge-intensive service

The interaction base on an co-crative and collaborative process. – Value-based / relational service

The Manual expert, constantly needs to reflect as a freshman – Didactical approach (HCI)

The interaction of client and expert is domain-specific and knowledge-based on both sides. There is a demand for didactical support, as it helps the knowledge worker as well as the project manager to understand what he cannot express. The client showed interest in learning design skills, which is a sign of the mutual exchange of skills. The interaction was based on an equal self-image and both learned from each other and over time, the customer gains insight into how to create a manual. The designer acts in a triple role and brings value to the technical environment. The contract mutated from design-oriented to technical and organizational manuals, and the designer had to adapt and learn new skills as well. The designer is the owner of the documents and leads the process by constantly updating the manual documents. The work flow depends on the feedback loops of the designer's work and was not used as a control element in the process. In the process, the designer, as a expert, constantly needs to reflect as a freshman in order to understand a neutral position. In order to play a role in such a project, the designer needs stable design and writing skills, patience, no intention of self-realization, interest in learning about non-design-related topics and, due to the complexity of the project, a constant effort to facilitate a flow.

Over time, the perception of the role from the company's perspective changed as the value of the work increased over time. In contrast, the role of the designer always is the devil-part, because he reflects, whether the delivered information is externalized enough or not. The designer uses his critical and outside view to give feedback. It also shows, that design-work is always based on understanding and reflecting content and its meaning in a defined use case. For the client it became more reluctant, there is another approval phase, who reflects critical on the content and there for it it an asset to the process. The process moved from a more or less unintersting area for technicians into a field, in which they could see value and applicability in their allday routines.

Its about a relational service for an internal process transformation project for processes reorganization. While the paperless project implementation is done by a high-end technology company, the client is supported and consulted by a software company based on a service contract, which is a typical almost standard service, although the contractor had to reprogram and modify the application to the client needs. The relational service between client and designer moved further towards undefined borders at the beginning. What was needed to be done, had been completely unclear at the beginning and needed to be developed iteratively. The interaction evolved, when project manager and concultant started to have on-site sessions on a weekly basis. In between the

sessions, both worked on their tasks. The client retrieved information at the software and company level and the expert developed and extended the manuals. Within the session, both working results were discussed and jointly reflected upon.

What kind of relationships drive the power structure?

The client showed interest in learning design skills – exchange of skills and relationship

The relationship was based on an equal self-image, learning from each other. – Value-based service

The power structure depends on the feedback loops of the designer's work – Productive authorship

Time is a very important aspect in respect to discover the tacit knowledge. Therefore the relationship also needed time to develop and set the right tone and quality for the interaction. Some employees said, that they needed about 1 year to understand the system and the context. Similar to the relationship building in this very technical environment, although the mind-set is process driven, we all did not know, how the interplay works best. Only by a long-time contracting situation with numerous extentions and iterative co-working situations the procuct evolved and became its own story and identity. Only thought this open, trust-based and dynamic supportive process the value developed co-creatively and the manual content was formed. The manual itself formed its own identity at the end.

What kind of role does the designer play in this context?

There is a demand for didactical support, as it helps the knowledge worker to understand what he cannot express. – Visualization, Boundary object

Over time, client gains insight into how to create a manual. – Empowerment, relational setting

The designer acts in a triple role and brings value to the technical environment – Roles

The contract mutated from design-oriented to technical manuals – Changing roles

In order to play a role in such a project, the designer needs stable design and writing skills, patience, no intention of self-realization, interest in learning about non-design-related topics and, due to the complexity of the project, a constant effort to facilitate a flow. – TCBOK, learning

The role of the designer always is the devil-part, as he reflects, whether the delivered information is externalized enough or not. The designer uses his critical and outside view to give feedback. It also shows, that design-work is always based on understanding and reflecting content and its meaning in a defined use case. – Transformation and content, negotional

The designer is the owner of the documents and leads the process. – Design authorship
The designer has ownership in the content to the same extend as the client, as the content was developed co-creationally and iteratively – Co-creation

In contrast the expert claims to need time for gaining sensibility on tacit knowledge in order to tackle it. The process is structured by a rethinking of some activities and by rebuilding it. The designer mind-set needs a restart as the complex situation challenges new skills and the need for process-driven design work with a focus on support rather than aethetics.

It supports internal processes and feeds into the development of internal documents for transformation. The experts input empowers but also improves organizational effectiveness by his knowledge and by the outcome of the teamwork. The service is there to be used in action as well, the service is intangible, but the result is measurable as it documents other peoples work and by supporting organizational learning at the end.