DIPLOMARBEIT

LEAN IN KNOWLEDGE WORK: DESIGNING A FRAMEWORK TO ENABLE STRUCTURED WASTE REDUCTION

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ABSTRACT

Knowledge Work (KW) lacks a structured approach to identifying and reducing Waste, as Lean methodologies have traditionally been applied in manufacturing and service sectors. Existing studies on Lean in KW rely on context-specific adaptations, limiting their generalizability. This research aims to develop a holistic and universally applicable Waste framework for KW, incorporating a Variation-based perspective to address root causes of inefficiencies.

Following the Design Science Research (DSR) methodology, this study integrates Lean Lenses and Principles, Knowledge Management (KM), and Organizational Learning (OL), as well as Problem-Solving to define three major Waste categories: *Team Dysfunctions, Poor Knowledge Management Practices, and Poor Work Methodologies.* The framework was operationalized into an assessment tool, supported by defined Dimensions, Indicators, and a qualitative workshop format.

The artifact was evaluated through structured workshops with team leaders, facilitated in a one-on-one setting using the collaboration tool MIRO. Results confirm that the framework effectively identifies the intended Wastes. Participants found the format clear, relevant, and useful, with Likert Scale ratings averaging 4.33 across all evaluated aspects. Not only team specifics and characteristics were detected, but also structural issues could be identified. Thereby, the results highlight issues on department, business unit, as well as on site level, bringing deep insights to the overall organization and related improvement possibilities.

This research contributes to Lean Thinking in KW by introducing a generalizable Waste framework and Lean KW Practices, thereby, offering a structured assessment method for continuous improvement. Future work should further formalize Lean KW Principles and Practices, expand the Work Methodology dimension, and refine more independent assessment metrics.

KEY-WORDS

Lean, Knowledge Work, Waste Reduction, Waste Framework, Organizational Learning, SECI, Knowledge Management, Continuous Improvement, Problem-Solving, Assessment Tool, Team Functioning

TABLE OF CONTENT

1. INTRODUCTION

This chapter outlines the motivation and problem domain, distilling them into specific problem statements, objectives, and research questions addressed for the thesis. It concludes with an overview of the research methodology and the thesis structure.

1.1 MOTIVATION AND PROBLEM DOMAIN

MOTIVATION

In the early 1990s, Peter F. Drucker foresaw a pivotal challenge looming over developed nations: the imperative to enhance productivity within the sphere of KW. This prognosis stemmed from a significant shift toward a service-based economy, marked by a dwindling emphasis on direct manufacturing.

This transition had already seen the majority of the workforce in developed countries gravitating toward roles within the realms of KW or the broader Service sector. Drucker emphasized that this shift necessitated a redefined economic priority: the elevation of productivity within knowledge and service-oriented endeavors. Consequently, Drucker's assertion remains pertinent: “The chief economic priority for developed countries, therefore, must be to raise the productivity of knowledge and service work.” (Peter F. Drucker, 1991)

During the era when Drucker emphasized the necessity for white-collar productivity enhancement, a disruptive shift was underway within manufacturing systems. Traditional models, rooted in economies of scale and mass production, faced disruption as the Lean narrative gained momentum.

Originating as a Western interpretation of the Toyota Production System (TPS), the Lean narrative emerged from the research conducted by the International Motor Vehicle Program at MIT, which delved deeply into the principles of TPS. Between the 1980s and 1990s, initial awareness revolved around Just-In-Time (JIT) techniques and cost efficiencies (Modig & Ahlström, 2021).

However, from the 2000s onward, attention shifted towards building capabilities at a systemic level. It was during this period that the translation of Lean principles and practices expanded beyond manufacturing, infiltrating the service industry. This evolution marked a pivotal phase where lean principles extended their application beyond their manufacturing origins (Hines et al., 2004).

According to Hines et al. (2004), the evolution of Lean methodology is intricately linked with the process of OL, progressing through distinct stages: from the initial "knowing organization" to the advanced phases of the "understanding organization," "thinking organization," and finally reaching the pinnacle of a "Learning Organization". This evolution, as proposed by Hines et al. (2004), signifies a shift from a tool-centric and prescriptive approach prevalent in the "Knowing Organization" phase towards a more mature, adaptive state—the "Learning Organization". This transition involves a greater emphasis on adaptability and contingency within the Lean framework.

This transition of Lean to the Service industry brought major improvements, for example within Hospital and Care Services and proved the application of Lean outside the manufacturing contexts. Further, modern approaches in Software Development, like Scrum or Kanban, made use of Lean Principles and Practices to increase productivity within this domain (Anderson, 2010; Ellis, 2020; Larsson & Ratnayake, 2021; Poppendieck & Poppendieck, 2007; Sutherland et al., 2019).

Finally, the applicability of Lean within highly knowledge driven contexts is now at the heart of research and focuses on least repetitive and highly collaborative contexts. Thereby, it is of high interest to prove its application, where knowledge is used for creating customer value, where problem solving and the use of knowledge is at the core to create new things, and where work is strongly based on expert knowledge and competence (Kropsu-Vehkapera & Isoherranen, 2018).

This aligns with the development of Lean and its link to OL and the development towards a “Learning Organization”. For organizations, it is therefore of high interest to make use of Lean within KW, as it opens possibilities to increase productivity and drives learning (Ballé et al., 2019). As stated by Bowen & Spear (1999), the organizational impact of Toyotas approach is to form a community of scientists at all levels.

Finally, “solving knowledge workers’ productivity challenges would lead companies a competitive advantage over others due to the increasing excellence of their knowledge operations. Operational excellence in knowledge intensive activities, like strategic management, design, and research could be a way for a company to differentiate itself from competitors”. (Kropsu-Vehkapera & Isoherranen, 2018, p. 441)

PROBLEM DOMAIN

Despite the potential of Lean for KW contexts and the intrinsically link between Lean and OL (Ballé et al., 2019), previous research on Lean in KW setting is scarce. Thereby, studies use Service and KW synonymously, which adds ambiguity to the research topic, as “Lean Service”, as well as “Lean Office”, is well studied and focuses on work, more related to repetitive and standard work (Kropsu-Vehkapera & Isoherranen, 2018).

In this sense, Lean in KW context should focus on the knowledge process and related practices, not recurring operational processes. Therefore, future work should focus on new approaches to Lean and knowledge processes and information handling. Especially, case examples for improving the knowledge process would benefit Lean KW literature (Kropsu-Vehkapera & Isoherranen, 2018).

The core approach to organizational improvement (also see 2.3.5 Perfection) within Lean is the Continuous Improvement paradigm and its implementation (Fadnavis et al., 2020). Thereby, the continuous practice of reducing Waste in favor to increase customer value drives an organization towards perfection (Womack & Jones, 2003).

But on the other end, two thirds of Lean implementation programs fail in North America due to the inability of organizations to achieve cultural change, such as to motivate people to adopt new behaviors or the continuous improvement of daily practices. Where the most challenging part is to understand the concept of Waste (Larsson & Ratnayake, 2021).

Further, Lean Scholar indicates that Waste reduction wasn’t a goal within KW settings, despite its fundamental role in the narrative. More emphasizes was given to increase Value, as the constraining ambiguity of KW was said to be the primary contradiction (May, 2005). Existing research on Waste reduction in KW is scattered and focuses on defining highly specialized Waste categories, according to the respective Case Study Company and their specific domain.

Furthermore, seeking obvious Wastes within processes, often neglects the root causes of Variation and their systemic issues. Therefore, the “Lenses of Lean” should be applied to understand Variation at its core (Hopp & Spearman, 2021).

As demanded by Kropsu-Vehkapera & Isoherranen (2018), the Variation of KW must first be understood, before any improvement can be applied. In this sense, a more holistic and strategic Waste definition was demanded by Scholar (Santhiapillai & Ratnayake, 2018), where a first approach was presented by Ellis (2020). Despite this existing approach, there is no evidence for its scientific validity and needs further investigation.

1.2 PROBLEM STATEMENTS, OBJECTIVES, AND RESEARCH QUESTIONS

Based on the previously described problem domain, the following problem statements were derived and related objectives and research questions were developed for this thesis.

PROBLEM STATEMENTS

P1: *Research on Lean in KW is scarce and should focus on the knowledge process and information handling itself, seeking a new approach to the subject.*

P2: *Case examples, especially for the improvement of the knowledge process, are broadly missing.*

P3: *Waste reduction wasn't a goal in KW for a long time and existing studies define the Waste categories domain-specific, indicating the lack of a universally applicable framework. A first approach was delivered by Ellis (2020), which applicability and validity stays open.*

P4: *The understanding of the concept of Waste is a major obstacle to Lean implementation. Especially in KW contexts, the concept of Variation must be understood in relation to the nature of KW itself.*

P5: *Often, the root causes of Variation are neglected, instead reducing obvious Wastes within processes, or treating symptoms.*

Starting with the problem statements derived from literature gaps (3.9 Academic Void), the following objectives were developed for this thesis. In sum they seek to address the problem statements and enable formulation of the research questions.

OBJECTIVES

O1: Develop a structured and universally applicable framework for Waste categories in KW. Address the limitations of highly context driven approaches and show its theoretical validity by comparison with the framework proposed by Ellis (2020).

O2: Build upon the concept of Variation to tackle root causes of Waste in KW.

O3: Emphasize knowledge processes and information handling as key areas of focus in KW.

O4: *Operationalize and apply the framework to gather practical insights.*

Based on the previously define gaps in Lean scholar and the derived objectives for this thesis, the following research questions are developed for this work. There relations are presented in Figure 1.

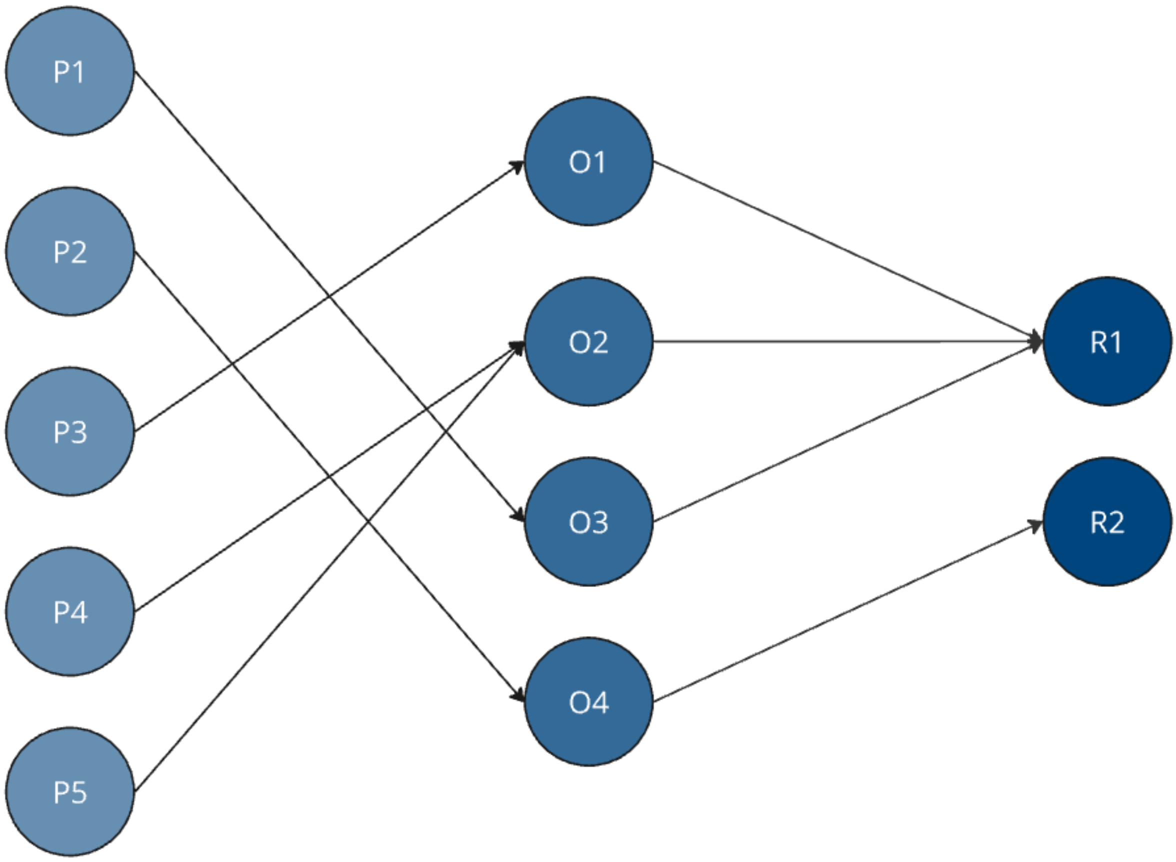


Figure 1 – Relation of Problems, Objectives, and Research Questions

RESEARCH QUESTION

R1: *How can a holistic and universally applicable Waste Framework be defined for the KW domain to enable structured Waste reduction from the Lean Perspective?*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

> *R2a: What are the Dimensions and their Attributes to evaluate the identified Wastes from the Lean Perspective for KW?*
>
> *R2b: Which Indicators serve to assess the occurrence of the Wastes?*
>
> *R2c: What format serves to conduct the assessment and how is it applied and facilitated?*
>
> *R2d: How well does the developed format serve to identify Wastes?*

To address the beforementioned problems, an artefact in the form of a comprehensive framework and a corresponding assessment tool for the operationalization is proposed. Therefore, the Design Science Research Methodology gets applied, which is outlined in the next chapter.

1.3 RESEARCH METHODOLOGY

The purpose of this chapter is to outline the research design used in this work, the Design Science Research (DSR) methodology. DSR is an established approach in information systems and other fields that focuses on the creation and evaluation of artifacts intended to solve identified problems. This chapter will provide an overview of DSR, its core principles, and how it has been applied within the context of this thesis. Thereby, following the work of Hevner et al., (2004) and additions from Hevner (2007).

Research Methodology: Design Science Research

DSR is a problem-solving paradigm that seeks to enhance human and organizational capabilities by creating innovative artifacts. These artifacts can be constructs, models, methods, frameworks, or installations that address identified problems within a specific domain. The primary goal of DSR is not only to produce these artifacts but also to generate new knowledge that is both applicable and academically rigorous.

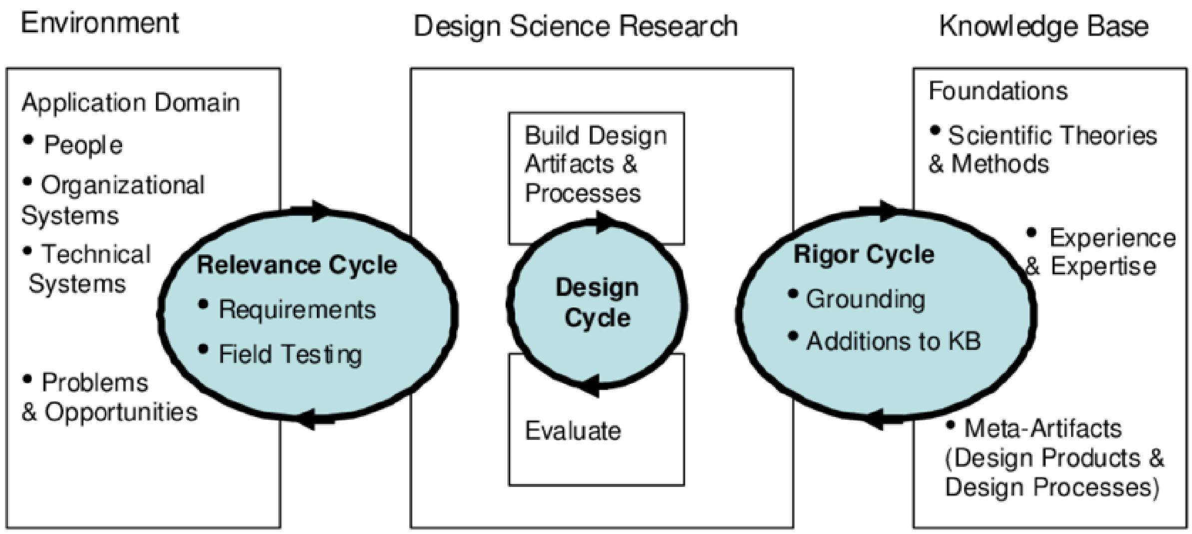


Figure 2 - DSR Framework (Hevner, 2007)

The DSR framework (Figure 2) is built on three foundational pillars, which are **environment**, **design science research**, and **knowledge base**. It operates through three interconnected cycles: **relevance**, **design**, and **rigor**.

The **Environment** represents the practical setting where business needs, challenges, and requirements emerge. It provides the context in which the artifact is intended to operate and improve. Moreover, the environment defines the acceptance criteria used to evaluate the artifact's effectiveness. This connection between the environment and the research process is facilitated by the **Relevance Cycle**, ensuring that the artifact aligns with real-world needs and addresses meaningful problems.

The **Knowledge Base** consists of established scientific theories, models, methods, and tools that inform and guide the design process. Researchers draw on this foundation to create and evaluate artifacts, ensuring that their work is grounded in rigorous academic principles. At the same time, the knowledge base is enriched through new insights and contributions derived from the research. This interaction is governed by the **Rigor Cycle**, which ensures that the selection and application of theories and methods are diligent, and that the artifact's creation and evaluation are methodologically sound.

At the core of DSR lies the **Design Cycle**, which focuses on the iterative construction and assessment of the artifact. This process involves repeatedly generating, testing, and refining design alternatives based on requirements derived from the environment and theories drawn from the knowledge base. The cycle continues until a satisfactory solution is achieved that meets the predefined criteria.

By integrating these pillars and cycles, the DSR framework ensures that research is both practically relevant and scientifically rigorous, bridging the gap between theory and practice to produce innovative, impactful solutions.

Hevner et al., (2004) outlined seven key guidelines for conducting DSR:

Design as an Artifact: DSR requires the creation of a viable artifact in the form of a construct, a model, a method, or a framework.

Problem Relevance: The research must address an important, relevant problem within its context.

Design Evaluation: The artifact must be rigorously evaluated to ensure its utility, quality, and efficacy.

Research Contributions: DSR should provide clear and verifiable contributions in the form of the designed artifact, theoretical insights, or methodological advancements.

Research Rigor: The research process should apply rigorous methods both in the construction and evaluation of the artifact.

Design as a Search Process: The creation of the artifact involves an iterative process of searching for the best solution, which may include cycles of design, development, and evaluation.

Communication of Research: The results and contributions of DSR should be effectively communicated to both technology-oriented and management-oriented audiences.

1.4 STRUCTURE OF THE WORK

In the following, the structure of the work in relation to the applied research methodology is outlined. Figure 3 illustrates the chapters of this thesis in relation to the applied DSR methodology.

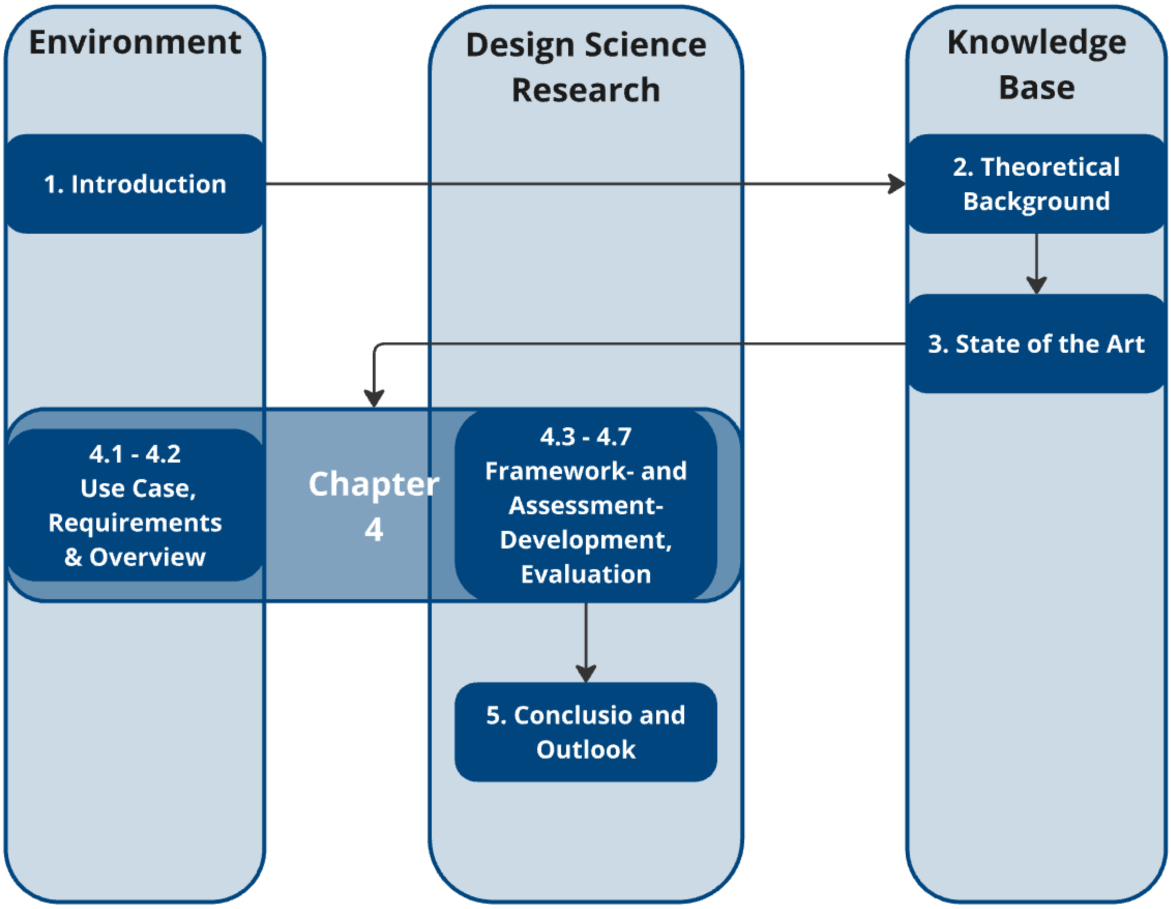


Figure 3 - DSR framework application

The Environment is introduced within chapter 1 and chapter 4.1. Thereby, chapter 1 outlines the context, motivation, relevance, and identifies the problem domain from the perspective of Lean literature. It highlights the need for a holistic Waste framework, dedicated to the KW domain, and its operationalization. Chapter 4.1 introduces the specific use case, its requirements, and goals, for the intended application of the artefact. In this sense, both chapters capture the DSR guidelines **Problem Identification and Motivation** and **Definition of the Objectives for a Solution.**

The Knowledge Base is provided within chapter 2 and 3. Chapter 2 provides the necessary Theoretical Background. Thereby, starting with a definition of the Lean narrative as Efficiency Management with the main goal to reduce Variability by applying the Lenses of Lean. The theoretical fundament is then built up by providing Lean Principles, serving for analysis and interpretation in the later work.

Further, the KW domain is introduced, and its characteristics are outlined. Then, Organizational Knowledge Creation and Learning, as well as the overall connection to the Lean narrative is introduced.

Chapter 3 provides an overview on the State of the Art regarding the current application and interpretation of Lean in KW, thereby, outlining applied methods and models, used within the thesis, as well as literature gaps.

DSR itself is captured within chapters 4 and 5. Thereby, addressing **Design and Development of the Artifact, Demonstration, Evaluation, and Communication of Results**. Based on the specific use case, the objectives, and a review of the relevant literature, the requirements, methods and techniques needed to create an assessment tool are identified, considering the cycles of **Relevance** and **Rigor**.

Within chapter 4, the specific use case is introduced, and a workshop format for Waste assessment is presented as artefact. The main elements of the artefact are presented and evaluated within the chapter.

Thereby, a foundational model of Value creation in KW is derived from the Intellectual Bandwidth Model and SECI Model for the scope of this work, which combines aspects of OL (SECI), Collaboration, and Work Methodology. The model serves as fundament for a holistic Waste framework and is presented in chapter 4.3. Based on this developed model three main Waste Categories were identified: *Dysfunctional Problem-Solving Methodology, Team Dysfunctions, and Poor Knowledge Management Practices*.

It could be shown that the model broadly aligns with the work of Ellis (2020) and is one abstraction level above the model.

Through analysis of the contents of two established assessment tools from the perspective of Lean Principles (Relevance- and Rigor Cycle) as well as the findings from the State of the Art, five distinctive evaluation Dimensions (for the outcomes of the assessment) could be defined, which also serve as a Lean Practices for KW (chapter 4.4): *Ensure Healthy Team Dynamics, Management of the Information- and Knowledge-Flow, Drive Problem Solving Methodology,* as well as *Drive Work Execution Methodology* (where the latter is not included in the scope of this work (O6)).

Based on this, Indicator statements were derived and developed within the Dimensions characteristics, and content of the two assessment tools (chapter 4.5).

Then, a Workshop format was developed as qualitative assessment tool for KW teams. The format is a facilitated focus-group format, that addresses team leaders within a one-on-one session between participant and facilitator (chapter 4.6).

To demonstrate the artefact's ability to solve the intended problem, it gets experimentally tested through overall three runs at the industry partners site, addressing the intended use case. To evaluate the artefact regarding the quality and relevance of the format, a feedback-survey was developed for participants, based on a combined Likert-Scale and open-response questionnaire (chapter 4.7).

Results of the evaluation of the artefact are discussed, as well as the formats relevance, functionality, gaps, and future work is presented conclusively in chapter 5.

2. THEORETICAL BACKGROUND

2.1 LEAN DEFINITION

As Lean is a western interpretation of the Toyota Production System (TPS), multiple definitions from diverse authors exist, where an ongoing and lively discussion is held on the topic, and a general framework is missing (Cusumano et al., 2021; Hopp & Spearman, 2021)

To frame this work, the call from Hopp & Spearman (2021) is followed, to define Lean as "Efficiency Management". Thereby, anything that increases the efficiency of delivering products can be regarded as Lean Practice. This definition fits best with the one of Modig & Ahlström (2021), who define and conceptualize Lean in terms of efficiency and outline a structured view on different abstraction layers.

Modig & Ahlström (2021) define Lean as an operational strategy to maximize efficiency. Thereby, Lean organizations emphasize Flow Efficiency over Resource Efficiency. An optimal Lean state would be to reach a maximum Resource- and Flow Efficiency (Figure 4), by prioritizing flow at first, and increasing resource efficiency along the way.

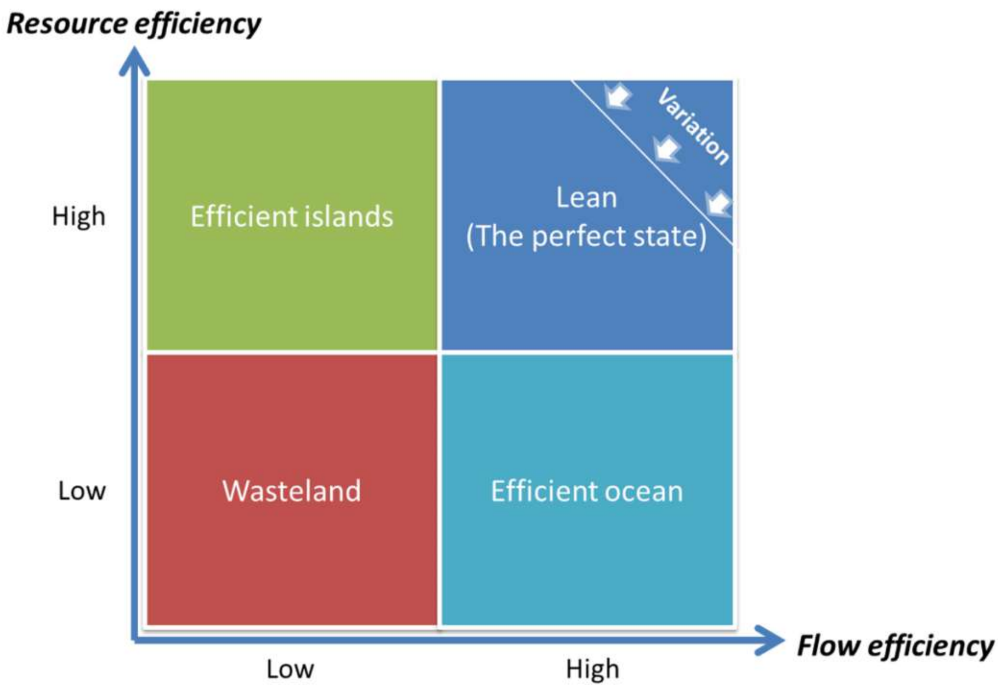
> **Resource Efficiency:** Focuses on maximizing the utilization of resources (like personnel, equipment, and space) at all times. The traditional interpretation of resource efficiency aims to ensure that every part of the organization is operating at full capacity, minimizing idle time. This perspective is often associated with maximizing individual or local efficiencies but can lead to inefficiencies in the overall process if not managed carefully.
>
> **Flow Efficiency**: In contrast, flow efficiency emphasizes the smooth and continuous movement of products, services, or information through the entire system, from start to finish, without interruptions. This approach prioritizes the efficiency of the entire value stream over the efficiency of any specific component. Flow efficiency aims at reducing the total time it takes for a product or service to move from the initial request to the delivery to the customer, thereby increasing value.

Within the "Wastelands", resources are mainly wasted, and customers are not satisfied. A lack of routines, standards, structure, and coordination is prevalent. Mostly a reactive behavior is observable, and resources are wasted to cope with unforeseen problems.

The Efficient Ocean thereby, is characterized by high customer centricity, where customer demand is served as efficient (and fast) as possible. Resources are only used if there is demand, leading to slack and low resource efficiency. The organization prioritizes flow and consists of interconnected parts along the value stream of goods or services.

The area of Efficient Islands characterizes high resource efficiency with low flow efficiency, where the organization is consisting of highly utilized sub-systems (high resource efficiency), not interconnected. This leads to long lead times, inventories, and buffer queues at system boundaries.

Variation in supply and demand reduces the ability to reach a maximum resource- and flow efficiency at the same time (Lean - The perfect State), where Variation can be defined as any deviation from absolute regularity (Hopp & Spearman, 2021).



To fully cope with this Variation, an organization would need full information transparency on current and future demands, as well as fully flexible and reliable resources. Resources would also need to be fully adaptable in terms of capacity, functionality and competences within shortest possible time, to cope with the demand. Therefore, it is impossible to reach the perfect Lean state, as the degree of Variation is limiting the maximal possible efficiency in both dimensions. This leads to an "efficiency-frontier", determined by the degree of Variation an organization is facing and its ability to cope with it. Further, the specific operational strategy of an organization is determining the position within the efficiency matrix.

Modig & Ahlström (2021) further outline a structured approach to understanding Lean by dividing it into several abstraction layers. Each layer is used by means to reduce Variation. These layers, arranged from the highest level of abstraction to the most specific, are:

Values: This layer represents the foundational beliefs and underlying philosophies that drive an organization. It forms, how people and the organization behave, to reduce Variation. Examples from Toyota are e.g., Teamwork, and Respect for People.

Principles: Principles are the guidelines ("how we should think") that inform individuals and the organization, how to reduce Variation and increase flow. Toyota has Just-In-Time (to create flow) and Jidoka (to see and remove obstacles to flow) as main principles. Within this work, the principles from Womack & Jones (2003) are used, that enable a broad perspective on Lean.

Methods: Methods are the specific approaches ("how we should act") used to reduce Variation, as they guide employees and ensure consistency and standards in what they do. Value Stream Mapping (VSM) is an example for a Method, Toyota uses to optimize processes.

Tools & Activities: This layer includes the practical tools and activities that are used to apply certain methods to reduce Variation. E.g., Visualization Dashboards as transparency tools.

According to Modig & Ahlström (2021) the specifically applied means on each level are context specific to the organization and its environment. Often, Toyota is tried to be copied on a Methods and Tools level, which leads to misconceptions of Lean, as Toyota developed those means for their specific problems, they encounter. Therefore, an organization must carefully consider, which Values, Principles, Methods, and Tools are appropriate to its context and facilitate Lean as operational strategy.

This approach aligns with the perspective of Hines et al., (2004), who conceptualize Lean as a framework, where the Principles facilitate a strategic perspective to understand "Value" (see later) and Methods & Tools are used on an operational level to reduce waste.

In conclusion, Lean is found on the challenge to utilize resources most efficiently, while optimizing for a lowest possible lead time (time from customer request to fulfilment). While Variation causes an efficient frontier, it is most important to reduce Variation.

2.2 THE LENSES OF LEAN: COPING WITH VARIATION

2.2.1 WASTE AND VARIATION

As outlined earlier, Variation is the primary contradiction of a perfect state that facilitates a maximum flow and resource efficiency. Beside Variation (Mura, as described above), Toyota has defined Waste (Muda, wasteful activities that need to be eliminated) and Overburden (Muri, overloading machines and personnel) as main distractions to producing Value: "Muda, Mura, and Muri are terms often used together in the Toyota Production System (and called the Three Ms) that collectively describe wasteful practices to be eliminated" (Lean Enterprise Institute, 2024).

The 7 Wastes (Muda), as defined by Toyota, are as follows:

1. Overproduction
2. Inventory
3. Defects
4. Motion
5. Over-processing
6. Waiting
7. Transport

The 3Ms, thereby, are interrelated: For example Variability in Process availability can cause Waiting and built up Inventory, whereas overburdening of workers occurs to cope with that Variability in peak demand, may leading to Defects (theleansuite.com, 2022). Therefore, the interrelations are manifold.

Waste reduction, thereby, distinguishes three types of activities (Womack & Jones, 2003):

(1) Value-creating activities as perceived by the customer

(2) non-value-adding but necessary activities

(3) non-value-adding activities as perceived by the customer

The priority is to eliminate type (3) activities, while type (2) activities are addressed subsequently, leveraging the principles of flow, pull, and perfection.

2.2.2 THE LENSES OF LEAN

Hopp & Spearman (2021) introduced four "Lenses of Lean" to frame research and to provide a holistic perspective on Efficiency Management or Lean. Those perspectives serve to understand how Lean can be viewed and guide direction by a framework for researchers and facilitate a problem-solving perspective for practitioners. The overarching goal is to cope with Variation, as main contradiction to Efficiency.

By applying those perspectives, the interrelations of the above mentioned 3Ms can be delaminated and addressing Variation can be better framed and understood on different levels of abstraction.

THE PROCESS LENS

The Process Lens stems from the pursuit of Lean to reduce Waste within processes and seeks to eliminate non-value-adding activities. This perspective focuses on obvious Wastes that can be directly observed within processes and frames the application of the 7 Wastes (see above) to specific process steps. To drive out these Wastes, various Lean Methods & Tools can be applied. The Process Lense is also a good starting point for Lean transformation, as the focus is on obvious Wastes, but lacks applicability to assess and eliminate Waste that stems from activities or by-products outside the process.

THE FLOW LENS

This perspective addresses Variability induced Waste, that stems from fluctuations in supply and demand. "Because the effects of variability are manifested in the flows of people, materials, dollars or other entities, we term this second lens the Flow Lens". (Hopp & Spearman, 2021, p.5) It facilitates a perspective to trace the causes of Variability.

As the occurrence of Variability is a natural process, it will always be buffered by either Inventory (e.g., have goods on stock to cope with peak demand), Capacity (e.g., provide additional workers to cope with demand), or Time (e.g., deliver later).

To optimize overall efficiency and reduce the total cost of buffering, either Variability must be reduced, or the mix of Variability-Buffers must be altered (optimal cost/benefit trade off). Therefore, predictability plays a significant role, as predictable Variability can be addressed by e.g., AI supported predictive systems, where unpredictable Variability must be buffered continuously.

To cope with Variability, the so called "Buffer-Flexibility Corollary" is applied: "Flexibility reduces the amount of variability buffering required in a production system" (Hopp & Spearman, 2021, p.7). As flexibility facilitates Variability pooling and enables the synchronization of supply and demand.

THE NETWORK LENS

Where the first two Lenses facilitated Waste reduction, the Network Lens steers direction to where and how Waste should be attacked, to achieve a maximum cost efficiency. Thereby, a holistic perspective is applied, acknowledging the circumstance that a company's service, or production system is an interconnected network of flows (also see 2.3.3 Flow).

This induced the need for efficient management of bottlenecks (applying the queueing theory) in production or service systems, as they produce most backups and delays (inventory and waiting Waste, or better said, Inventory and Time Buffer).

THE ORGANIZATION LENS

This perspective steers the focus on organizational culture and human aspects of an organization: “Although a physics focus might be sufficient for a production or service system run entirely by machines (e.g., a true “lights out” factory), the reality is that all business systems involve people. To account for this, we require the fourth and most expansive perspective on Lean which we term the Organization Lens.” (Hopp & Spearman, 2021, p. 10) The Organization Lens therefore, accounts for human behavior, as previous literature on Lean barely incorporates psychological aspects of work.

According to Hopp & Spearman (2021), scholars of cognitive science and decision making must be included, accounting for System 1 and System 2 thinking (Kahneman, 2011) and related System 1 biases, like Hindsight Bias (judging decisions by outcome, not soundness of method), Confirmation Bias (looking for evidence to confirm own beliefs), and Loss Aversion (avoidance of loss is greater than the motive to achieve gain).

The authors claim, that Lean implementations struggle, as “Lean implementations failed to take into account the way real people think and behave” (Hopp & Spearman, 2021, p. 12).

Finally, these are only examples to guide direction, where “The Organization Lens draws on behavioral science to anticipate human reactions to Lean policies and to guide designs that work with human tendencies rather than against them” (Hopp & Spearman, 2021, p. 15).

2.3 LEAN PRINCIPLES

The core Lean principles used to facilitate a holistic perspective on the Lean narrative are derived from the work of Womack & Jones (2003). Other authors with different principles could have been used (e.g., 14 Principles from Jeffrey K. Liker), but those defined by Womack & Jones (2003) are abstract enough to form a correspondingly holistic understanding and detailed enough to capture the core aspects of Lean thinking.

2.3.1 VALUE

Value must be defined from the customer's perspective, reflecting what the customer is willing to pay for. This definition of value should be expressed in terms of a specific product (or service) that the customer is seeking. To derive this value, direct dialogues with key customers are essential, with a focus on new solutions rather than old products.

Furthermore, it is crucial that this value definition is universally applicable across the entire Value Stream, avoiding discrepancies caused by concentrating on isolated products or specialized tasks. This necessitates engaging in conversations with value stream partners to ensure alignment.

Redefining Value from the customer's perspective along the entire Value Stream demands a shift from the status quo and a comprehensive reevaluation of existing processes. By adopting a holistic view, as perceived by the customer, opportunities for improvement become apparent, enabling the elimination of waste. Once the initial rethinking is completed, it is imperative to continually revisit and refine the value definition as part of an ongoing process of continuous improvement and the pursuit of perfection.

This definition of value serves as foundation to eliminate Waste. Waste, therefore, is everything, a customer is not willing to pay for and what is not needed to produce that value.

2.3.2 VALUE STREAM

The value stream needs to be managed as a whole, embracing value stream thinking. This means to focus on “all the specific actions required to produce specific products to see how they interact with each other” (Womack & Jones, 2003, p. 44).

To achieve operational excellence and eliminate Waste, it is imperative to start by mapping the entire value stream comprehensively (by Value Stream Mapping (VSM), a technique to draw a comprehensive map of the value creation process), encompassing all steps involved in creating a product or service. This serves as the foundational step in the pursuit of perfection.

The value stream map should categorize all activities into three distinct types: (1) Value-creating activities as perceived by the customer, (2) non-value-adding but necessary activities, and (3) non-value-adding activities as perceived by the customer. The priority is to eliminate type (3) activities, while type (2) activities are addressed subsequently, leveraging the principles of flow, pull, and perfection.

Recognizing that local optimization at the company level has its limitations, true efficiency can only be achieved through collaboration and joint optimization with upstream and downstream partners. In the realm of product development, fostering long-term relationships with value stream partners and maintaining a relentless focus on generating customer value collectively is paramount.

To guide organizational efforts, the North Star should be the pursuit of a perfect state. This involves competing against this ideal and eliminating waste (muda), with a key emphasis on optimizing how value-creating steps are organized.

2.3.3 FLOW

When products are produced or services are provided, commonly a dominant part of total processing time is waiting for other steps within the process. Flow then, is a steady and continuous state "with no wasted motions, no interruptions, no batches, and no queues" (Womack & Jones, 2003, p. 52).

Flow is then a state, where a maximum resource and flow efficiency is achieved (the Lean state).

To achieve flow, three essential steps are proposed by Womack & Jones (2003):

(1) After defining value and the complete value stream, the focus should constantly lie on the specific order and the product itself, from start to end.
(2) Traditional boundaries of jobs, careers, functions (often departments), and companies needs to be ignored to form a lean enterprise that removes all forms of impediments to continuous flow.
(3) Work practices and tools needs to be rethought to eliminate backflows, scrap, and stoppages, to continuous processing.

A lean approach is to form small, enabled, and cross-functional product teams, "with all the skills needed to conduct value specification, general design, detailed engineering, purchasing, tooling, and production planning […]." (Womack & Jones, 2003, p. 54) This approach reduces dependencies and increases flow, as all necessary functions are available.

Capable workers and machines are necessary, as flow systems immediately get interrupted and stop in the case of occurring errors. Therefore, also production teams need to be cross-functional in every task, to cope with variances in availability.

Further, the fragile nature of flow systems induces the need for highly standardized tasks, that are defined and constantly improved by the work teams who perform the work.

Finally, the objective of flow thinking is to reduce the stoppages of any process to zero, by constantly designing the right tools and removing waste.

2.3.4 PULL

"Pull in simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it […]" (Womack & Jones, 2003, p. 67). The pull system is the key-enabler of flow across a value stream and aims to eliminate batch production and queuing inventories (which are regarded as waste).

A pull system typically is introduced by kanban (signal cards that indicate the need to produce goods for upstream steps in a process) or similar computer-based approaches, which signal upstream steps the necessity to produce goods, based on downstream demand. Visual control thereby enables responsiveness and transparency. The guiding principle is to "Don't make anything until it is needed, then make it very quickly" (Womack & Jones, 2003, p. 71).

Where "The ability to get parts resupplied very quickly from the next level of the system, and therefore the ability to reorder in small amounts, is always the secret to reducing total inventories in a complex production and supply stream" (Womack & Jones, 2003, p. 79).

To achieve a smooth-flowing value stream, the pull system needs to be expanded across the whole supply chain, starting from the customer request (pull-signal) up to the provision of raw materials. The customer must be integrated, as predictions in customer demand enable precise planning.

The optimal state is to massively decrease lead-times and inventories, "so that demand is instantly reflected in new supply […]" (Womack & Jones, 2003, p. 88), triggered by the customer directly pulling value.

2.3.5 PERFECTION & CONTINUOUS IMPROVEMENT

Perfection is the pursuit of an ideal state through countless small improvement steps (evolutionary), aware that it is fundamentally impossible to achieve that state. The fundamental approach often used is termed as "kaizen" ("change to good"), which utilizes incremental, evolutionary improvement to achieve higher value through continuous removal of waste. This is also commonly known as Continuous Improvement.

Therefore, Problem-solving needs to be conducted by cross-functional teams along the value stream, enabling collaboration and growing together of formerly isolated people of all functions.

To effectively apply improvement, two Lean techniques are required:

(1) First, a clear definition of perfection needs to be established by applying the four lean principles of value specification, value stream identification, flow, and pull.

(2) Second, it needs to be defined, which forms of waste get attacked first

Despite an ideal state of perfection cannot be reached, as it constantly develops, "the route is the goal" and in this sense, the rout "provides inspiration and direction essential to making progress along the path" (Womack & Jones, 2003, p. 79).

The underlying key-principle to a lean-thinking transformation is transparency, and general change management practices, facilitating a human-centered transformation journey.

2.4 KNOWLEDGE WORK DEFINITION

As KW faces a definition challenge itself, relevant definitions and aspects for the scope of this work are provided. Further the role of variation and uncertainty in KW is outlined.

2.4.1 KNOWLEDGE WORK CONTINUUM

KW is a dimension of work involving activities such as finding, creating, packaging, and applying knowledge. All employees may engage in KW to varying degrees, both within and across occupations. Thereby, the use of knowledge in organizations is discretionary, shaped by employees ability and motivation, which are influenced by factors like leadership, job design, social interactions, and organizational culture, including expectations and rewards (Kelloway & Barling, 2000).

Further, KW centers on the handling and processing of information, with knowledge as its primary output. It is inherently multidimensional, characterized by variations in the nature of knowledge, the degree of routines and standards, and the individual's role in the work. Thereby, KW must be regarded as continuum, distinguishing between routine, lower-complexity tasks (Office Work, OW) and more complex, innovative, and knowledge-driven work, classified as KW (Kropsu-Vehkapera & Isoherranen, 2018).

Beside those characteristics, other distinctive features need to be mentioned, that generally separate the application of Lean in KW from its roots in manufacturing:

KW is characterized by high task uncertainty compared to manufacturing, as it often involves late-stage changes from customers or uncertainties arising from technology or the external environment. Unlike manufacturing, the processes and connections in KW are mostly invisible, as critical elements may reside in individuals minds or within symbolic representations in computer systems, making early problem identification challenging. Additionally, KW is more explorative, encompassing both high-level system thinking and detail-oriented problem-solving, focusing on creating new knowledge rather than merely applying existing knowledge (as seen in more routine office work) (Staats et al., 2010).

Within this thesis, the distinction between KW and OW is used to indicate, that the focus is on complex, innovative, and knowledge-driven contexts, such as Research and Development (R&D).

2.4.2 VARIATION AND UNCERTAINTY IN KNOWLEDGE WORK

De Meyer et al., (2002) categorized projects according to four different types of uncertainties, namely: variation, foreseen uncertainty, unforeseen uncertainty, and chaos. Each type requires specific means and approaches to manage uncertainty. These characteristics are introduced in the following, as KW often comes in the form of projects (e.g., new product development, scientific research projects), as well as it introduces the needed understanding of variation, waste, and uncertainty.

Variation arises from minor, cumulative factors that lead to slight deviations in project outcomes, such as cost, timeline, or specifications. Effective management of variation involves incorporating buffers into the plan and closely monitoring progress to ensure these deviations remain manageable. This definition and the way to mitigate possible risks, aligns with the stable conditions in Lean manufacturing, where variability is buffered.

Foreseen uncertainty involves risks or events that are identified during planning but remain uncertain in their likelihood and impact. These risks can be anticipated, and contingency plans are typically developed to address them if they occur. Managing foreseen uncertainty requires structured tools like decision trees and predefined alternatives to respond effectively when these risks materialize.

Unforeseen uncertainty refers to unexpected events or outcomes that were not anticipated during planning. These "unknown unknowns" often result from unforeseen interactions or entirely new conditions. Managing this type of uncertainty requires learning, adaptability, regular reassessment of progress, stakeholder incorporation, and a willingness to modify strategies in response to emerging circumstances.

Chaos describes project uncertainty where fundamental goals and assumptions are unstable and subject to frequent change. These situations often arise in highly innovative projects: "Even the basic structure of the project plan is uncertain, as is the case when technology is in upheaval or when research, not development, is the main goal" (De Meyer et al., 2002, p.62). Often the project ends up with final results that are completely different from the project's original intent.

The focus shifts completely to learning, iterative planning, and flexibility: "Tracking is less focused on the current status of the project relative to its target and more on the current status of learning about basic project assumptions. The need for flexibility and iteration obliges project managers to cope with constant change" (De Meyer et al., 2002, p.66). In a broader sense, one might think that the Buffer-Flexibility Corollary is applicable, as flexibility facilitates Variability pooling and enables the synchronization of supply and demand.

In conclusion, KW might deal with *Unforeseen Uncertainty,* but most expectably, operates in the domain of *Chaos*, as introduced through the KW definition.

2.5 ORGANIZATIONAL KNOWLEDGE CREATION

2.5.1 BASIC DEFINITIONS

DATA VS. INFORMATION

Data itself "is a set of discrete, objective facts about events" (Davenport et al., 1998, p.2). Within organizations this relate to recordings of transactions, as for instance customer purchases (amount of goods purchased, when, prices, …). The difference between Data and Information is, that Information has meaning and purpose. Thereby, Data becomes Information by adding value through contextualization, categorization, calculations, corrections, and condensation. (Davenport et al., 1998)

INFORMATION VS. KNOWLEDGE

"In short, information is a flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. This understanding emphasizes an essential aspect of knowledge that relates to human action" (Nonaka, 1994, p. 15).

The theory of knowledge creation interpretates knowledge "as a dynamic human process of justifying personal beliefs as part of an aspiration for the "truth" (Nonaka, 1994, p. 15).

KNOWLEDGE DEFINITION

"Knowledge derives from information as information derives from data" (Davenport et al., 1998, p.5). Humans are at the center when it comes to the transformation of information to knowledge. This transformation happens through comparison (comparison to other situations), consequences (implications of the information for decisions and actions), connections (relation of the gained knowledge to other knowledge), and conversations (opinions of other individuals). Knowledge is further, often defined as "justified personal belief" (Davenport et al., 1998).

INNOVATION

As outlined by Nonaka (1994), innovation is a key form of organizational knowledge creation and cannot be explained sufficiently in terms of information processing or problem solving. Innovation can be understood as a process in which the organization creates and defines problems and then actively develops knowledge to solve them.

EXPLICIT (CODIFIED) KNOWLEDGE

A major distinction must be drawn along a continuum, which distinguishes explicit and tacit knowledge, as introduced by Michael Polanyi.

Explicit knowledge refers to knowledge that can be articulated, codified and stored in some form and media. Therefore, this type of knowledge can be transferred to others (Nonaka, 1994).

An example is a Standard Operating Procedure, which can be learned by reading and internalized by application.

TACIT KNOWLEDGE

Tacit knowledge refers to the knowledge, embedded in individuals and is difficult to articulate, as it "is deeply rooted in action, commitment, and involvement in a specific context" (Nonaka, 1994, p. 16). It further contains cognitive and technical elements. The cognitive element refers to the "mental models" of a human being, which are formed working models of the world through creating and manipulating analogies in the mind. The technical aspects refer to concrete know-how, crafts, and context specific skills. A key role to create new knowledge is the articulation of tacit knowledge and the interaction between individuals (Nonaka, 1994).

2.5.2 SECI MODEL: ORGANIZATIONAL KNOWLEDGE CREATION

According to Nonaka (1994), knowledge is created through an epistemological process of knowledge conversion of tacit and explicit knowledge. The four relating processes are *Socialization, Externalization, Combination, and Internalization*. Further, knowledge creation is amplified through different ontological levels of interaction between individuals, to groups, and to the whole organization (sometimes interorganizational). The dynamic and continuous interaction between the epistemological and ontological dimension creates a spiral conversion process, that expands organizational knowledge both, qualitatively and quantitatively.

This suggests that an organization seeking to expand and transform its knowledge should simultaneously promote a variety of diverse policies and related practices that support all modes of knowledge conversion, ensuring that the cycle remains active and doesn't diminish or come to a halt.

Four modes of knowledge conversion can be distinguished (Figure 5). The conversion from tacit-to-tacit knowledge, from explicit-to-explicit knowledge, the conversion from tacit to explicit knowledge and the conversion from explicit to tacit knowledge.

The SECI Model (Figure 5) starts with the process of *Socialization (tacit to tacit)*, which is the sharing of tacit knowledge between individuals through shared experiences. The key to acquire tacit knowledge are shared experience, as they allow to share the thinking processes of individuals. This can be realized through side-by-side working with a mentor and the observation, imitation, and practice, as this sharing process isn't driven by language, rather by action ("how to do certain things").

Second, *Externalization* functions as the conversion from tacit to explicit knowledge, where essentially concepts, images, documents, and other artefacts are created. Individuals thereby rely on dialog, metaphors, and team confrontations to make tacit knowledge explicit and codifiable. As outlined by Gherardi (2000), key to success of this mode is to dis-embed knowledge by reflection on the action, which adds distance between the individual and the action. The outcome of this formalization and crystallization process of knowledge is the organizational memory (Farnese et al., 2019). By formalizing knowledge, new information is created that becomes accessible for future use and available to other colleagues. This captures the essence of "synthesizing," where new meta-knowledge is generated through selection and connected to the organization's established knowledge system, allowing for the emergence of new models or mental maps (Nonaka et al., 2006).

Within the *Combination* mode, explicit knowledge is converted to other explicit knowledge of higher order through merging, editing, and processing towards more complex and systematic knowledge (Farnese et al., 2019). This includes for instance the formalization of process knowledge into a handbook or SOP.

Finally, the *Internalization* mode acts to embody explicit knowledge and to enrich one's tacit knowledge. Thereby, formal knowledge is connected to personal experience, to make use of it in practical situations (Farnese et al., 2019). This mode relates to "classical learning" and is deeply connected with action and practicing (Nonaka, 1994).

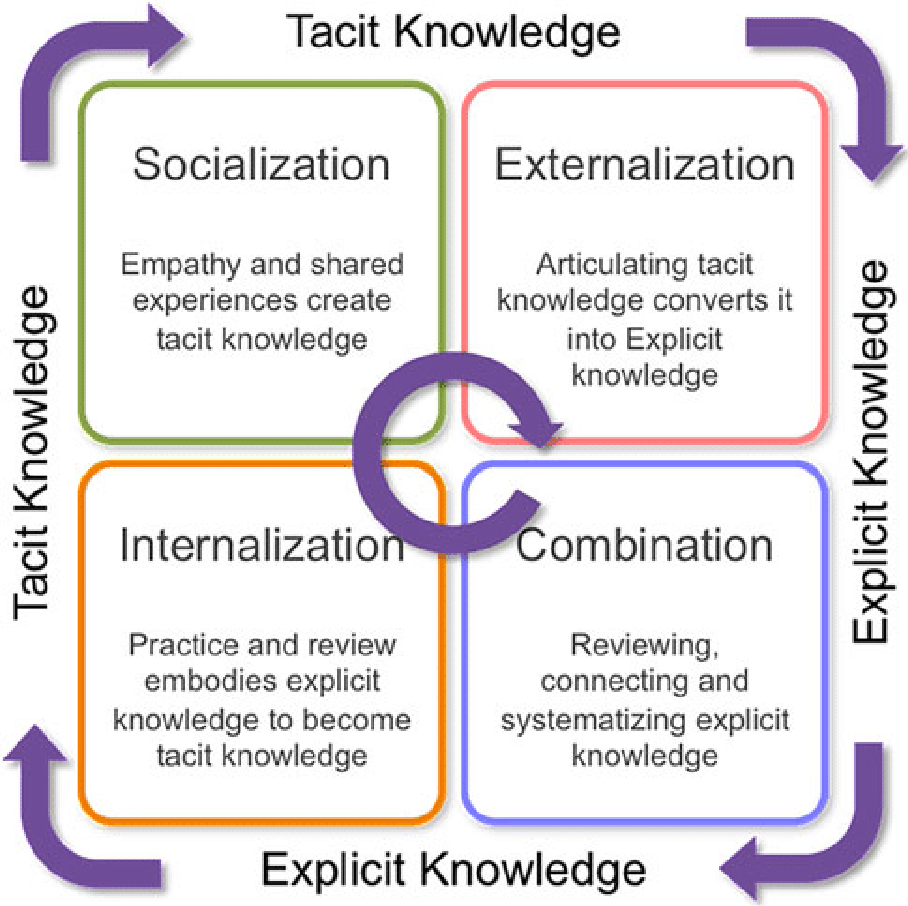


Figure 5 - SECI Model - adapted by Menaouer & Nada (2020)

2.5.3 THE ROLE OF THE CROSS-FUNCTIONAL-TEAM

As Lean strongly builds upon the self-organizing, cross-functional-team (Womack & Jones, 2003), its role in OL and knowledge creation is outlined in the following. Further, this thesis seeks to develop an artefact, applied within such teams.

According to Nonaka (1994), the organizational knowledge creation process is initiated by the increase of an individual's knowledge, those gained perspectives must be articulated and thus, amplified, through socialization among others. Therefore, a field must be given, to enable those interactions.

The self-organizing team acts as such a field, where individual members cooperate to create new concepts by articulating individual perspectives and resolving conflicts through formation of higher-level concepts. Thereby, "*commitment* is one of the most important components for promoting the formation of new knowledge within an organization" (Nonaka, 1994,p. 17).

Self-organizing teams thereby enable the creation and transformation of knowledge in two ways:

First, through *Socialization* and *Shared Experience*, the understanding of different perspectives among the members and the creation of a common implicit perspective as tacit knowledge, the *Shared Understanding,* is formed. "Various forms of tacit knowledge that are brought into the field by individual members are converted through coexperience among them to form a common base for understanding" (Nonaka, 1994, p. 24).

The enabling factor for this process is *Mutual Trust* between the members of the team, as this forms the foundation for constructive collaboration. Conductive to build trust is the sharing of ones' own experience, allowing others to understand the perspective. Further, individual commitment of team members must be given. According to Lencioni (2002), mutual trust is the fundament to constructive conflict, as opinions and different standpoints can be freely expressed. Constructive conflict, in turn, enables individuals to commit, as they feel regarded and heard.

Second, by a continuous dialog between team members, the *Shared Understanding* is constantly articulated by the process of *Externalization*, converting tacit to explicit knowledge.

This necessitates good communication practices, allowing for revision and negotiation, expressing ideas freely, and encouraging constructive criticism while discouraging negation. Finally, this process must continuously happen.

Further, a redundancy of information (e.g., cross-training) must be given, as "Making and solving new problems are made possible when its members share information by obtaining extra, redundant information which enables them to enter another person's area and give advice" (Nonaka, 1994, p. 25). This also functions as a mechanism to control the degree of diffusion of the *Shared Understanding*.

Both mentioned processes appear simultaneously or alternatively in a team's knowledge creation process. Besides that, the facilitation of the process plays a significant role:

Effectively managing how team members interact—specifically, how their ideas spread out (diverge) and come together (converge)—is crucial for speeding up the creation of new knowledge. In a team setting, different ideas and discussions develop at varying speeds and intensities. These ideas first grow separately but eventually start moving toward a common understanding or concept. The key responsibility of the team leader is to balance this process of ideas diverging and converging during conversations and shared experiences.

"In sum, the cross-functional team in which experience sharing and continuous dialogue are facilitated by the management of interaction rhythms serves as the basic building block for structuring the organization knowledge creation process" (Nonaka, 1994, p. 24).

2.6 LEAN, KNOWLEDGE CREATION, AND PROBLEM - SOLVING

This chapter outlines the overarching connection between Lean, OL, and problem-solving. Further, basic concepts on problem-solving methodologies are shortly outlined.

2.6.1 LEAN AS A LEARNING SYSTEM

According to Ballé et al., (2019), Lean can be understood as a learning system itself, as it emphasizes experimental learning. Thereby, first a solution is implemented to an unknown problem by trial and observation (single-loop-learning) and then, the changes and outcomes are studied to find the possible best solution (double-loop) (Argyris, 1976).

As described by Toyota itself, they see their organization as an ensemble of dynamic PDCA (Plan, Do, Check, Act, so called Deming Cycle, see later) cycles, rather than a static organizational chart. As stated by Spear & Bowen (1999, p. 105): “In the long term, the organizational structures of companies that follow the Toyota Production System will shift to adapt to the nature and frequency of the problems they encounter”.

“Lean is a system to continuously develop people and create a culture of problem-solving; a strategy to face challenges by engaging and involving all problem solvers into exploring issues and forming unknown solutions by learning experientially from practical countermeasures” (Ballé et al., 2019, p. 3).

Thereby, Lean’s culture and its principles, methods & tools lay out the conditions, conductive to a learning organization and innovation: “Lean tools are techniques to create the conditions for such experiential learning and the lean approach turns management upside down by turning the chain of command into a chain of help: challenge and support, rather than command and control” (Ballé et al., 2019, p.3).

As mainly misinterpreted by western companies that try to copy Toyotas methods and tools, Toyota views tools as temporary “countermeasures,” not fundamental to its production system. These tools address specific problems until better solutions arise, evolving or being discarded as improvements are made. “They’re referred to as “countermeasures” rather than “solutions” because that would imply a permanent resolution to a problem” (Spear & Bowen, 1999, p.104).

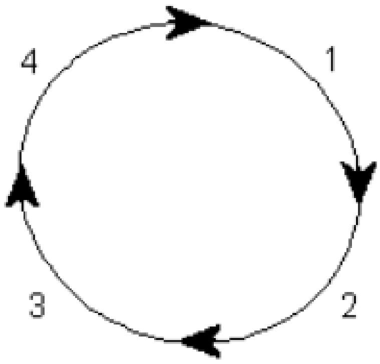
In conclusion, the TPS, and Lean as derivation of it, is a learning system itself, as it continually develops and trains people in problem-solving, empowers them, and drives continuous improvement, according to the problems, the organization is facing.

2.6.2 PROBLEM SOLVING METHODOLOGY AND LEARNING

The role of problem-solving within Lean was highlighted excessively within beforementioned chapters. Now, basic theory on the problem-solving methodology, manifested in TPS and Lean, is outlined. Thereby, focusing on the previously mentioned PDCA cycle, or better, the PDSA (Plan, Do, Study, Act) cycle, as its role within the TPS is foundational.

Heavily influence by the work of the American pragmatist Irving Lewis (1883 – 1964), Dr. Walter A. Shewhart introduced the so called “Shewhart Cycle”, consisting of *Specification, Production, and Inspection.* Those steps refer to making a hypothesis, carrying out the experiment, and testing the hypothesis, and constitutes a dynamic process of acquiring knowledge.

Influenced by this work, W. Edwards Deming modified the cycle to account for a constant interaction between design, production, sales, and research (Figure 6). He introduced this cycle within his seminars on statistical quality control to the audience of Japanese managers and engineers (Moen & Norman, 2009).



1. Design the product (with appropriate tests).
2. Make it; test it in the production line and in the laboratory.
3. Put it on the market.
4. Test it in service, through market research, find out what the user thinks of it, and why the non-user has not bought it.
5. *Re*-design the product, in the light of consumer reactions to quality and price.

Continue around and around the cycle.

Figure 6 - Deming Cycle 1951, (Moen & Norman, 2009)

This cycle was then modified by those Japanese executives to the PDCA cycle (Figure 7). The problem-solving process follows a four-step cycle: plan (identifying the problem and hypothesizing causes and solutions), do (putting the plan into action), check (assessing the outcomes), and act (revisiting the plan if results fall short or standardizing if they succeed). The PDCA cycle focuses on preventing errors from recurring by creating and continually refining standards.

Figure 7 - PDCA cycle, (Moen & Norman, 2009)

Ultimately, Deming introduced the PDSA cycle, which explicitly accounts for “Study”, as “Check” refers to “hold back” in English language, which is an incorrect representation. He called it the Shewhart cycle for learning and improvement. Emphasizing the purpose to create new knowledge (Moen & Norman, 2009).

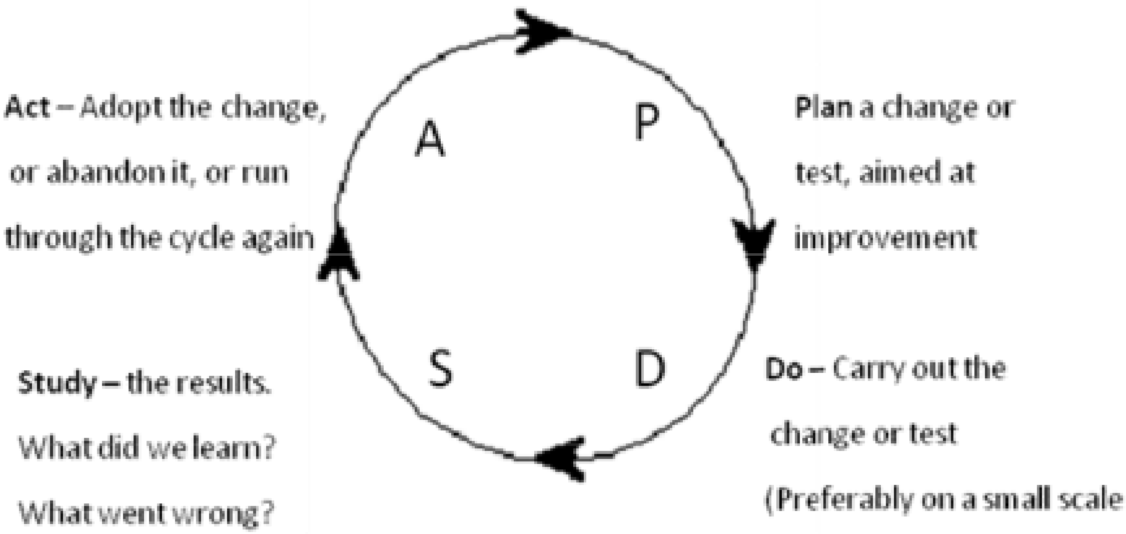


Figure 8 - PDSA Cycle, (Moen & Norman, 2009)

3. STATE OF THE ART

Concordant with the objectives and research questions introduced in 1.2 Problem Statements, Objectives, and Research Questions, this chapter summarizes the state of the art regarding Lean in KW contexts. Thereby, drawing a status quo on Lean in KW, as well as previous attempts in Waste reduction, as well as it highlights the academic void.

The literature analysis is structured into key thematic areas, which are Waste reduction, Lean Principles for KW, Value Creation in KW, KM Practices, as well as Problem-Solving Methodologies within the Perfection Principle. Additionally, the literature study identifies relevant methods for the development of the artefact of this thesis, as well as it works out the academic void.

3.1 Lean and Knowledge Work: The definition Challenge

Highlights difficulties in previous attempts in KW and issues in defining KW adequately. Furthermore, it outlines literature gaps and thereby works out the focus for this thesis.

3.2 Waste Reduction in Knowledge Work

This chapter draws a status quo on Waste reduction in KW contexts and outlines previous attempts, approaches and related literature gaps, to set the focus of the thesis. Further, relevant frameworks for the creation of the artefact are introduced.

3.3 Value Principle and Value Creation in Knowledge Work

Explores the Value Principle in KW and necessary distinctions to manufacturing contexts, as well as a foundational model for Value Creation is introduced, which is used later in the developmental work.

3.4 Knowledge Management Practices

This chapter outlines KM practices along the SECI model, which are used to develop the artefact of this thesis. Its general role and importance are shortly introduced, with respect to the scope of this work.

3.5 The Knowledge Value Stream Principle

This chapter briefly outlines viewpoints on the Value Stream Principle for KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

3.6 The Information and Knowledge Flow Principle

This chapter briefly outlines viewpoints on the Flow Principle, and its interpretation for KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

3.7 Pull Principle in Knowledge Work

This chapter shortly outlines different viewpoints on the Pull Principle in KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

3.8 Perfection and Continuous Improvement for Knowledge Work

This chapter outlines the state of the art regarding continuous improvement, problem-solving methodology and overall perfection principle for Lean KW. Further, a model is introduced to assess a team's problem-solving capabilities, which is used later within the development of the artefact.

3.9 Academic Void

Briefly summarizes the academic void, based on the findings from the State of the Art.

3.1 LEAN AND KNOWLEDGE WORK: THE DEFINITION CHALLENGE

This chapter highlights difficulties in previous attempts in KW and issues in defining KW adequately.

As mentioned earlier, Lean is evolving into a holistic, system-thinking, and adaptive school of thought that moves beyond the focus on tools and methods, and extending beyond the confines of manufacturing (Hines et al., 2004). However, a mere distinction between manufacturing and service is also too narrow, where the term service often leads to misconceptions.

According to Kropsu-Vehkapera & Isoherranen (2018) the term KW is often used synonymously with service in related publications, leading to an inaccurate representation of KW, as further distinctions are necessary. Therefore, “Future research should indicate what type of knowledge work is being studied and what kind developmental methods are usable in certain contexts, since the ways we develop basic office work are different from how we handle knowledge- intensive work” (Kropsu-Vehkapera & Isoherranen, 2018, p.441).

These distinctions are needed due to the nature of work itself and the role of knowledge, differing significant across various jobs within service sector: “A typical flaw in many lean service studies is the assumption that all service work is knowledge work, even work that is repetitive and simple in nature […]” (Kropsu-Vehkapera & Isoherranen, 2018, p.435). Thus, a clear definition, that captures the whole KW continuum is necessary, leading to a finer differentiation between KW and OW, as introduced earlier.

In this sense, Lean in KW context should focus on the knowledge process and related practices, not recurring operational processes. Therefore, future work should focus on new approaches to Lean and knowledge processes and information handling. Especially, case examples for improving the knowledge process would benefit Lean KW literature (Kropsu-Vehkapera & Isoherranen, 2018).

The Literature Review conducted by Kropsu-Vehkapera & Isoherranen (2018) shows, that earlier research and studies in the field of KW is scarce, and often falling short in defining KW adequately, mixing it with highly repetitive Services (often OW). Therefore, a clear picture of Lean in knowledge intense contexts cannot be drawn, as most of the conducted studies are of qualitative nature and treat single case-studies.

“To better understand lean approaches in knowledge work, more detailed case studies are required to comprehend how to implement lean in knowledge work, as well as to gauge which practices are especially applicable” (Kropsu-Vehkapera & Isoherranen, 2018, p. 442).

Later contributions in the field of Lean KW gained attention towards the definition challenge, highlighting the complexity of the domain and the need for differentiation (Ellis, 2020; Larsson & Ratnayake, 2021; Santhiapillai & Ratnayake, 2018, 2023), where only one explicitly builds upon the distinction between KW and OW (Sousa & Dinis-Carvalho, 2021).

3.2 WASTE REDUCTION IN KNOWLEDGE WORK

This chapter draws a status quo on Waste reduction in KW contexts and outlines previous attempts, approaches and related literature gaps. Further, relevant frameworks for this thesis are introduced.

3.2.1 BACKGROUND AND CLASSIFICATION

According to May (2005), Waste elimination isn't a primary goal of Lean in KW, as the Waste is foremost hidden due to the invisibility challenge of KW, which makes it much harder to detect. Therefore, increased value creation should be emphasized.

Later contributions in the field of Lean in KW contrasted this assumption. Ellis (2020, p.51), for instance argues, that "we should start not by increasing effort, but rather by cutting waste".

The primary assumption stays, that most waste is hidden, but in fact, it hides within sub-processes of KW (Ellis, 2020; Staats & Upton, 2011). Examples of sub-processes are e.g., approval processes, progress reports, formal problem-solving, KPI tracking, and customer service contracts. The higher the degree of standardization and routines (more related to OW than KW), the better Waste is recognized (Kruger, 2014; McDermott & Venditti, 2015).

To apply Waste reduction, the Wastes of Lean manufacturing (2.2.1 Waste and Variation) are adapted to the domain of application, to make them understandable to the people working in the system (Douglas et al., 2015).

Several authors presented different approaches to adapt the Lean manufacturing Wastes to specific domains, such as software development, engineering services or even public services like police (Bicheno & Holweg, 2024; Poppendieck & Poppendieck, 2007; Rachman & Ratnayake, 2016; Santhiapillai & Ratnayake, 2018, 2023). Where those studies mostly facing the KW definition challenge.

Those analogies, such as from the software development industry, are mostly defined and applicable to their domain. An approach to define Waste in general KW settings would therefore be most suitable, as it would be decoupled from specific domains (Ellis, 2020).

"A common mechanism in lean writing is to create knowledge work equivalents: for example, Inventory is changed from stored goods to open projects" (Ellis, 2020, p. 67). Where this can, for sure, be useful, certain challenges exist, as the analogy might confuse knowledge workers who might not want to compare their work to a factory.

Klein et al., (2023) for instance, proposes a framework of "knowledge waste" which are over specialization, underused talent, waste of explicit knowledge, and retention of tacit knowledge. Other approaches, addressing KM related wastes, where analogies to the TPS wastes were undertaken (Pan et al., 2023).

Unlike physical work, defining KW clearly is challenging due to the need to consider multiple dimensions when investigating Waste. In KW, such as product development and R&D, waste often arises from human factors because these tasks involve human activities, tacit knowledge, learning, and collaboration (Ellis, 2020; Santhiapillai & Ratnayake, 2018), which specifically highlights the role of the Organization Lense as a whole, as well as OL, and collaboration aspects.

In conclusion, waste reduction is scattered and highly context driven definitions are undertaken to account for the individual situation of the respective field of application. Whether the domain is manufacturing, service, or KW, or different to that, the procedure is always the same. Further, the focus was set to be on sub-processes, more related to OW and the Process Lense.

It is not a problem in itself to reduce direct waste (obviously the Process Lense) but the approach is prone to neglecting the root causes of Waste, namely the underlying source of variation. "It is unfortunate that so much press has been given to the 7 types of waste and specific practices such as Kanban and 5S. Neither categories of waste nor individual practices lead to an understanding of the underlying causes of waste" (Hopp & Spearman, 2021, p. 624).

In this sense, a holistic perspective is necessary, as well as a more formal and theoretical Waste description should be found by researchers (Santhiapillai & Ratnayake, 2018).

Therefore, more investigation of value creation in KW itself, and the understanding of variation (uncertainty) is necessary, to cope with the underlying root causes of waste. Thus, applying the Flow-, Network-, as well as the Organization Lens. As demanded by Kropsu-Vehkapera & Isoherranen (2018), the variation of KW must first be understood, before any improvement can be applied.

3.2.3 LEAN KW WASTE FRAMEWORK

Ellis (2020) proposes a holistic Waste framework for Lean in KW. In sum, it addresses inefficiencies in knowledge workflows, waste that occurs through biased thinking and work practices, people related topics, and organizational settings. An overview is presented as follows, as this thesis introduces a holistic framework itself, and will refer to the following approach in later sections (4.3.3 Waste Framework Alignment).

DISCORD

Discord is "the waste from people who don't align to the organization as a whole or to individuals within" (Ellis, 2020, p.109). It captures the waste of many types of team misalignment. Examples are misalignments with team leaders or team members, to the organization's leadership, to other functions within the organization, and even to the customer. Thereby, teams may work without coordination or in opposition to each other and/or the larger organization. Further examples are personal conflicts between individuals or missing dialogs between departments, which causes silos between people, functions, or even parts of a global concern.

INFORMATION FRICTION

Information friction occurs when information is available but not accessible or accurate (content, representation, and communication) for those who need it, leading to errors, delays, and wasted effort. Indicators of this issue include poor decisions, missed opportunities, and repeated requests for the same information. This often stems from how information is stored, managed, and shared within an organization. Common root causes include limited access to information, cumbersome processes, lack of standardization across teams, and insufficient communication.

MORE-IS-BETTER THINKING

More-is-Better Thinking describes the waste that occurs when employees become overly absorbed in tasks without a clear plan for achieving success, prioritizing busyness over value creation. Indicators include constant activity with few measurable outcomes, and projects that take longer than planned without delivering the expected value. This mindset is often caused by a lack of prioritization, unclear definitions of success, and a fear of being perceived as unproductive.

INERTIA TO CHANGE

Inertia to Change is the resistance to change, even when such change is necessary. Signs include a reluctance to adopt new ideas, clinging to old habits, and rejecting improvement suggestions. This often stems from fear of the unknown, comfort in the status quo, or lack of trust in the change process. People may resist change because they feel comfortable in their current environment or fear the uncertainty that comes with new directions.

NO-WIN CONTESTS

No-Win Contests arise when employees are given tasks that cannot realistically be completed within the available time or resources. Signs include overload, frustration, and frequent reports of "almost done" without significant progress. These situations are often caused by unrealistic expectations, poor prioritization, missing workload management, or insufficient resources such as time, budget, or personnel.

INFERIOR PROBLEM SOLVING

Inferior Problem Solving occurs when problems are not thoroughly addressed, leading to recurring issues that waste time and resources. Signs of this type of waste include recurring problems, short-term fixes, and frustration. The root causes often include inadequate problem analysis, treating symptoms instead of root causes, and a lack of communication.

SOLUTION BLINDNESS

Solution Blindness occurs through biased thinking, such as people remain attached to a solution even after new information shows it to be ineffective. This can happen due to emotional attachment or fear of admitting failure. Indicators of solution blindness include clinging to a solution despite poor results, ignoring warning signs, and rejecting alternative approaches.

HIDDEN ERRORS

Hidden errors are mistakes that remain undetected until they cause significant issues later in the process. These errors often surface late in the project cycle, leading to high costs, quality problems, or customer dissatisfaction. The root causes of hidden errors include the complexity of processes, lack of transparency, inadequate testing and problem-solving, and a culture where errors are not openly acknowledged.

3.3 VALUE PRINCIPLE AND VALUE CREATION IN KNOWLEDGE WORK

This chapter explores the conditions for value creation in KW, as to mitigate overly “treating symptoms” in the form of reducing obvious wastes, stemming from the Process Lens. Thereby, models, used later to create the artefact are outlined.

3.3.1 CLASSIFICATION AND VALUE DEFINITION

In Lean manufacturing, value is everything a customer is willing to pay for and value creation, what is needed (value-adding and supportive activities) to produce those goods or services. Within KW, those definitions my lack direct applicability, and the value delivered is often hidden, and cannot easily be defined (Kropsu-Vehkapera & Isoherranen, 2018).

As the customer might not be served directly, the next receiver of the outcome of KW (the value receiver) should be defined as customer, which might be an internal customer downstream (Anderson, 2010; Christelis & Smit, 2012; Ellis, 2020). Therefore, the value definition differs, according to the domain and receiver and must be well understood (Christelis & Smit, 2012).

To narrow this, “the primary customer for knowledge work is probably the person who determines when the work product has met the need” (Ellis, 2020, p. 42).

3.3.2 VALUE CREATION: THE INTELELCTUAL BANDWIDTH MODEL

Distinct to manufacturing, KW value creation differs. Within KW, information handling and processing is a core task, and the main outcome of work is knowledge. Therefore, “It is necessary to find research that focuses on information and knowledge processing to support value creation” (Kropsu-Vehkapera & Isoherranen, 2018, p. 439). This is also generally the fact, when discussing the transition from a production to a knowledge economy, where a new emphasis lies on the infostructure (Adriaenssen et al., 2017).

Following the Intellectual Bandwidth Model *(Nunamaker et al., 2001)*, an organization’s potential to create value is determined by its intellectual assets related capabilities and the one of collaboration:

> *The effectiveness with which an organization can create value is bounded by its intellectual bandwidth, which is its collective potential to acquire information, make sense of it, and take action with respect to a goal. The intellectual bandwidth of a team or an organization represents its potential to do meaningful work through the minds of its members. Intellectual bandwidth can be increased either by increasing a team's ability to assimilate information or by increasing the ability of its members to collaborate. However, multiple gains may be obtained by increasing both (Nunamaker et al., 2001, .p.12).*

The bandwidth thereby represents a potential, not actual realization. To create value, “people must go through a value creation process where they become informed, reason together, make a plan, and take action” (Nunamaker et al., 2001, .p 13).

Finally, only action can create value, where the work process methodology leverages available intellectual bandwidth to create value. The work processes input is Information, where group dynamics are the building blocks of the work process.

Therefore, groups must have sufficient intellectual bandwidth that derives from

1) their access to the necessary information and communication support to provide content for the reasoning process
2) their ability to create, sustain, and then change their patterns of interaction, or group dynamics

In sum, the building blocks for value creation are *Information Assimilation, Collaboration (Group Dynamics), and Work Methodology* (see Figure 9). The latter is concerned with structured collaborative reasoning processes, such as Problem-Solving Methodologies like PDSA, and structured and coordinated action related processes, like Project Management Methodologies (e.g., Scrum, Kanban, Classic Project Management).

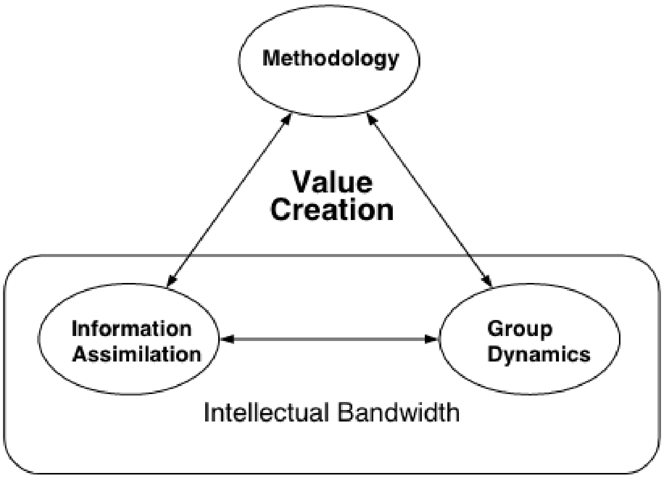


Figure 9 - Value Creation Model (Nunamaker et al., 2001)

Information Assimilation, Collaboration (Team Dynamics), and Work Methodologies can also be seen from the perspective of OL and KM, as these are building blocks of it.

Therefore, the assumption is that value creation is leveraged by *OL Capabilities* and *Work Methodologies* (reasoning and action).

The role of *Work Methodology*, especially the reasoning process and related methodologies (such as PDSA), is highlighted, as:

> *In the information processing paradigm, a problem is simply given, and a solution is reached through a process of combining relevant information based on a preset algorithm. But this process ignores the importance of problem setting-defining the problem to be solved. In reality, problems do not present themselves as given but instead have to be constructed from the knowledge available at a certain point in time and context (Nonaka, 1994, p. 28)*

In this sense, also innovation can be aligned with value creation and the overall principle: Innovation is a key form of organizational knowledge creation and can be understood as a process in which the organization creates and defines problems and then actively develops knowledge to solve them (Nonaka,1994).

Therefore, the process of *OL and Work Methodology* (reasoning and action) aligns with it: Organizations with a greater capability for creating knowledge are likely to have superior innovation performance (Zelaya-Zamora & Senoo, 2013).

3.3.3 DELIMITATION AND CLASSIFICATION: WORK METHODOLOGIES

Work Methodologies regarding “action”, like Agile Project Management, are not directly in the scope of this thesis but are mentioned explicitly here, as the artefact addresses agile, cross-functional teams. Further, their contributions to KW productivity are presented incompletely in this work.

Nonetheless, they are highly relevant to the topic, as unpredictable uncertainty (Chaos) dominates KW, where value creation often arises through iterative processes, particularly in collaborative projects where professionals work together on a product or service. Their collective contributions enhance the final outcome through repeated refinement in cycles of learning and problem-solving.

Agile work methodologies like Scrum explicitly incorporating iterations with so called “Sprints”, within a team focused, collaborative mode, orchestrating action towards goals (Sutherland et al., 2019).

“In general, agile project methods are also lean because they are intent on increasing project value delivered, over time, and minimizing waste. However, agile project management is distinguished by its emphasis on maximizing earned value by exploiting change – while simultaneously minimizing the waste associated with change” (Cavaleri et al., 2012, p. 130).

This is also valid from the standpoint of the value principle, as agile work methodologies incorporate the customer continuously and early on in development, focusing on value, as defined by the customer (Sutherland et al., 2019).

In this sense, also agile work methodologies, practices, and values, and related project management frameworks (e.g., Scrum, Kanban) are termed as Lean Methods (Bicheno & Holweg, 2024).

3.4 KNOWLEDGE MANAGEMENT PRACTICES

This chapter outlines KM practices along the SECI model, which are used to develop the artefact of this thesis. Its general role and importance are shortly introduced, with respect to the scope of this work.

3.4.1 DEFINITION AND RELEVANCE

As previously outlined, the SECI process must be managed according to nurture OL. Therefore, several Practices must be applied within each transformation stage, to keep the cycle moving (Nonaka, 1994; Nonaka et al., 2006), which was earlier introduced as KM.

Actively practicing KM is key to a learning organization and overall success, as "an effective knowledge management strategy encompassing knowledge acquisition, creation, capture, and ease of sharing valuable knowledge tied to organizational goals, leads to improvements in innovation, performance, and transformation" (Gleason & Prietula, 2022).

Further, "there is a need for a KM system in the form of applications, decisions support system, and learning a system for processing knowledge so that it can be used for solving problems and producing innovative output" (Anggraeni, 2024, p.21).

3.4.2 KNOWLEDGE MANAGEMENT PRACTICES

In the following, KM Practices are presented along the SECI model, to align with it. Thereby, building upon the work of Farnese et al., (2019), who developed the Knowledge Management SECI Process Questionnaire (KMSP-Q). This questionnaire will also serve to develop corresponding assessment statements later along the SECI model.

MENTORING PRACTICES (SOCIALIZATION, SHARING TACIT KNOWLEDGE)

Mentoring practices involve transferring tacit knowledge from experienced members—such as supervisors and seasoned peers - to newcomers or less experienced colleagues through strategies designed to enhance workplace socialization. This process enables the sharing of tacit knowledge through observation, modeling, and assimilation of the implicit and unconscious skills embedded in professional practice. As a common organizational socialization tactic, mentoring facilitates employee's learning, practical abilities, and personal growth during role transitions. It deepens their understanding of professional skills, organizational politics, and values, leading to various behavioral, attitudinal, and relational outcomes (Becerra-Fernandez, R. S. & Sabherwal, R., 2001; Eby et al., 2008; Farnese et al., 2016).

Beside the use of mentoring programs, information redundancy within teams (Nonaka, 1994) can be fostered by job rotations (change the roles) (Wang & Noe, 2010) or practices like "pair-programming", where colleagues work side by side on the same task (Sutherland et al., 2019).

KNOWLEDGE SHARING (SOCIALIZATION, SHARING TACIT KNOWLEDGE)

Knowledge sharing is defined as the willingness to provide one's own knowledge - such as experiences, best practices, and skills - to colleagues when needed or upon request. The literature extensively acknowledges the crucial role of knowledge sharing in enhancing organizational performance (Van Wijk et al., 2008; Wang & Noe, 2010), where difficulties arise in sharing the knowledge embedded in individuals (Szulanski, 2000). Therefore, to encourage lateral communication and provide access to individuals with relevant knowledge, it is necessary to implement social and motivational systems along with human resource practices (Alavi & Leidner, 2001; Cabrera & Cabrera, 2005).

According to Wang & Noe (2010), team characteristics play a significant role for the willingness of individuals to share knowledge among team members, where team cohesion (mutual trust as main condition) is crucial. Further, social networks, such as community of practices, serve to share knowledge efficiently within the organization.

TEAM REFLEXIVITY (EXTERNALIZATION, CONVERTING TACIT TO EXPLICIT KNOWLEDGE)

Team reflexivity involves the collective process of reflecting on "how we work", critically reviewing and revising goals, methods, practices, and the environment in which one operates, and accordingly planning changes to enhance team effectiveness (West, 2000) as well as overall organizational performance and innovativeness (Farnese et al., 2016; Schippers et al., 2010)

According to Nonaka (1994), organizations consistently generate new knowledge by continually rethinking and reconstructing their existing perspectives, frameworks, or assumptions on a daily basis.

By engaging in dialogue and discussions about their experiences, employees detach themselves from their professional practice. This process allows tacit knowledge to be extracted and made explicit through methods of abstraction (such as creating maps) or symbolization (like using metaphors), leading to heightened awareness and meta-level learning (Gherardi, 2000; West, 2000).

ORGANIZATIONAL MEMORY (EXTERNALIZATION, CONVERTING TACIT TO EXPLICIT KNOWLEDGE)

Organizational memory involves the processes of storing, organizing, systematizing, and retrieving past experiences and events with the aim of reducing forgetting. By disassociating knowledge from individuals and specific contexts - a process known as disembedding - organizational memory lessens the reliance on specific people for knowledge (Szulanski, 2000) and enables team members to access and select relevant knowledge.

This also makes experience accessible over time and to other colleagues. This is facilitated by a crystallization process that connects it to the wider organizational knowledge system (Nonaka et al., 2006; Wexler, 2002).

Corresponding practices to enhance organizational memory are founded on formalization of experience, like best practice collections, manuals, reports and other written documentation (Alavi & Leidner, 2001).

Previous research in the field has shown, that captured and stored knowledge may enhance organizational performance. Thereby, this supports to properly act routines and further increases innovation, as the access to a stock of expertise and core capabilities is provided (Moorman & Miner, 1997).

ORGANIZATIONAL COMMUNICATION (COMBINATION, INTEGRATING EXPLICIT KNOWLEDGE)

This dimension aims at establishing norms and formal practices (streamlined communication channels like e.g., meetings) to share information and news, keep colleagues updated, and to overcome hierarchical levels, as well as boundaries between units of the organization. This also increases a systemic view on the organization. Through the management of "politics of information" and by making information available, the organization forms the cultural conditions, conductive to a fair distribution of knowledge power and trustworthiness among people (Davenport et al., 1998; Ipe, 2003).

Scholars have shown the relationship between organizational information sharing and performance and innovation (Collins & Smith, 2006; Mesmer-Magnus & DeChurch, 2009).

TECHNICAL SUPPORT (COMBINATION, INTEGRATING EXPLICIT KNOWLEDGE)

This dimension refers to Knowledge Management Systems (KMS) and tools that increase useful and fast transfer and access to knowledge (Alavi & Leidner, 2001). This dimension is critical for the success of an organization as KMS and other tools can be used to systematize, improve, and exchange knowledge between internal clients, as well as with those, external to the organization. This enhances the organizations competitiveness (Melville et al., 2004).

It reflects a willingness to employ these tools and to promote collaborative environments founded on reciprocity and knowledge sharing, as well as to facilitate the management of information by enabling its systematization, categorization, or reconfiguration (Goh, 2002; Nonaka, 1994).

HR TRAINING (INTERNALIZATION, EMBEDDING EXPLICIT KNOWLEDGE INTO TACIT KNOWLEDGE)

The human resources training dimension pertains to learning processes designed to help employees assimilate new knowledge and reshape their mental models, whether for decision-making, work procedures, or to support role transitions (Salas et al., 2012). Thereby, training programs strengthen human and social capital and thus, produce an advantage for the organization and helps to stay competitive (Alvarez et al., 2004; Arthur et al., 2003).

HR DEVELOPMENT (INTERNALIZATION, EMBEDDING EXPLICIT KNOWLEDGE INTO TACIT KNOWLEDGE)

Human resources development encompasses all the policies and practices that support the growth of human resources, enabling people to understand the significance of their work, attribute meaning to their professional experiences, and appreciate their behaviors that go beyond formal role requirements.

A learning organization encourages continuous learning and knowledge creation at all levels and defines processes that facilitate the circulation of knowledge and translates this knowledge into changes in internal and external behavior (Senge, P., 1990).

Overall, it reflects the organization’s ability to serve as a context where all members are encouraged to learn and develop their full potential, with human resource development being a core strategy (Argote et al., 2003).

3.5 THE KNOWLEDGE VALUE STREAM PRINCIPLE

This chapter briefly outlines viewpoints on the Value Stream Principle for KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

Within Lean literature, the concept of the *Knowledge Value Stream* (Figure 10) was introduced for product development activities (Raman & D'Souza, 2017, 2021; Sandvold et al., 2018). It withholds the organizations knowledge (explicit and tacit).

The prevalent knowledge (explicit and tacit) to a team thereby enables decision making, problem-solving, and development of products. "In the case of an efficient and effective knowledge value stream, all the relevant knowledge from the BOK is available as prevalent knowledge for the design team to make the decision" (Raman & D'Souza, 2017, p. 3).

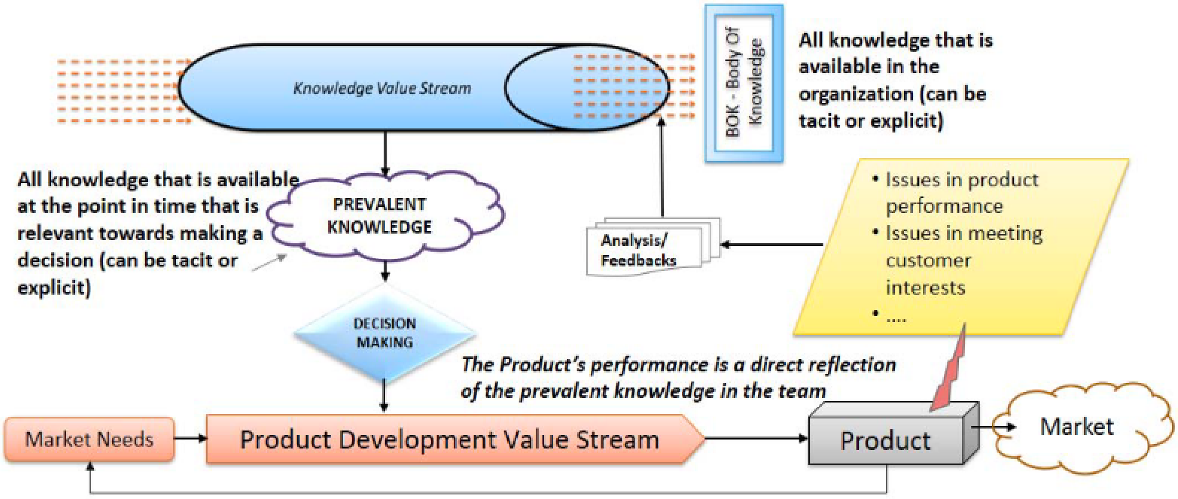


Figure 10 - Knowledge Value Stream (Raman & D'Souza, 2017)

During product development (or more generally, solving problems for customers), new knowledge is created through learning cycles and closing knowledge gaps within the knowledge value stream, which is then transferred to the product value stream, to finally serve the customer (Raman & D'Souza, 2017, 2021). Those streams are both dynamic flows that nourishing each other (Sandvold et al., 2018). Therefore, analysis and closed feedback loops are crucial: "Establishing the closed loop in the knowledge value stream is critical to ensure that the BOK in the organization matures and evolves over a period of time" (Raman & D'Souza, 2017, p. 5).

3.6 THE INFORMATION AND KNOWLEDGE FLOW PRINCIPLE

This chapter briefly outlines viewpoints on the Flow Principle, and its interpretation for KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

The principle of flow and the detection and visibility of such is often hidden within KW, due to the iterative, and cyclical nature, and foremost, the invisibility of KW. As KW focuses on the creation of new knowledge, serving customers with solutions to their problems, and creating services and the like, the flow principle must also be redefined to account for the domain. The following chapter outlines state of the art definitions regarding flow in KW.

3.6.1 INFORMATION FLOW

The beforementioned circumstances has shifted the focus in KW to the *Information Flow ,* as "[…] information is the primary basis of value in knowledge work, and it must flow to the right person in the right form at the right time at the lowest cost with the highest quality possible" (May, 2005).

Information flow also addresses communication practices (such as meeting practices, facilitation, forums for informal connections, …) due to the collaborative nature of KW, which was highlighted as Lean KW practice by Staats & Upton (2011) and termed as "Streamlined Communication". Lean literature gained attention towards the importance of the information flow in KW, thus applying methods to optimize it like Social Network Analysis for information flow improvement (Rachman & Ratnayake, 2018; Raman & D'Souza, 2017).

3.6.2 KNOWLEDGE FLOW

As introduced in Lean literature, *Knowledge Flow* refers to the transformation of knowledge, as introduced in the SECI model (Dombrowski et al., 2012).

In this sense, "Knowledge Management (KM) is understanding the organisation's knowledge flows, and implementing knowledge-related activities such as acquiring, selecting, generating, internalising, and externalising knowledge in order to create value for an organization" (Pan et al., 2023, p.112).

Therefore, knowledge should flow efficiently, particularly the most valuable knowledge (Pan et al., 2023; Raman & D'Souza, 2017).

Waste can be seen as obstacles that hinder the flow of information and knowledge, limiting users ability to access the information and knowledge they need (Pan et al., 2023).

3.6.3 KANBAN: VISUALIZATION AND TASK FLOW MANAGEMENT

Besides that, Lean literature has stressed the importance of the visualization of KW workflows and their related tasks, by applying the agile work methodology Kanban (Anderson, 2010), as it opens up the possibility to manage, steer, and improve the flow of work (tasks flow through their workflows). Further, datafication enables decision making towards effective (work) flow management (Middleton & Joyce, 2012; Power & Conboy, 2015; Staats et al., 2010; Yadav et al., 2018).

3.7 PULL PRINCIPLE IN KNOWLEDGE WORK

This chapter shortly outlines different viewpoints on the *Pull Principle* in KW. Thereby, this chapter outlines definitions, used later to develop the artefact of this work.

3.7.1 KNOWLEDGE AND INFORMATION PULL

Related to the *Information and Knowledge Flow Principle*, *Pull* refers to the delivery of knowledge and information, as it is requested by knowledge users (Chandra et al., 2015; Pan et al., 2023). In this sense, it refers to the ability of a team, to pull the "prevalent knowledge" from the *Knowledge Value Stream*.

3.7.2 KANBAN: VISUALIZATION AND PULL OF WORK

Within KW, several authors build upon the application of the Kanban Method for Agile Project Management, as introduced earlier (Abella & Arvizu, 2019; Ellis, 2020; Ikonen et al., 2010; Middleton et al., 2005; Middleton & Joyce, 2011, 2012; Power & Conboy, 2015; Staats et al., 2010; Yadav et al., 2018).

Thereby, Pull is realized based on the visual representation of workflows and their tasks, where tasks are initiated based on actual demand and team capacity (which is like the mechanism in manufacturing settings).

This also potentially prevents the overburden of workers and introduces manageability of the "work in progress" inventory (tasks in work) and the overall flow of work (Anderson, 2010). The same mechanisms (but partly other realization approaches) can be observed in other agile Work Methodologies, like Scrum (Sutherland et al., 2019)

3.7.3 PULL AS MEDIATOR FOR TEAM AUTONOMY

Finally, one can abstract Pull also to a higher level and build an analogy to autonomy and the self-organizing team. As the Pull Principle steers production by signaling demand, in KW this could mean to only signaling demand and let people organize themselves to cope with it, which is core to agile work methodologies (Anderson, 2010; Sutherland et al., 2019).

3.8 PERFECTION AND CONTINUOUS IMPROVEMENT FOR KNOWLEDGE WORK

This chapter outlines the state of the art regarding continuous improvement, problem-solving methodology and overall perfection principle for Lean KW. Further, a model is introduced to assess a team's problem-solving capabilities, as it is used later within the development of the artefact of this thesis.

3.8.1 PERFECTION AND CONTINUOUS IMPROVEMENT IN KNOWLEDGE WORK

Within KW settings, the application of continuous improvement (kaizen) is realized by the application of hypothesis-driven methods of problem-solving, like the Deming Cycle (PDSA, Plan, Do, Study, Act) (Kruger, 2014; Maruta, 2012; May, 2005; Staats & Upton, 2011). Thereby, no differences are present, as the principle of perfection is universally applicable and at the core of Lean and its origin, the TPS.

This is also elementary to general Lean implementation, as it is a journey of continuous improvement, that helps an organization to improve its current state towards a better future state. "Thus, one can consider the capability of an organization's teams to routinely practice structured problem solving as a core requirement for successful lean implementation" (Fadnavis et al., 2020, p. 32).

In addition, problem-solving processes serve as an excellent foundation for improvement processes such as OL, and KM (Pan et al., 2023).

Knowledge is critical to effective problem solving as it forms the foundation for developing more effective solutions. Therefore, encouraging a project team to adopt a more active approach to learning and knowledge processing enables greater agility and openness in solving problems, while also enabling the development of higher quality solutions to problems (Cavaleri et al., 2012).

3.8.2 PROBLEM-SOLVING IN TEAMS

According to Hung (2013, p.381), "coordination and communication are the two critical interactive mechanisms that make a group of people a functional team, a cognitive problem-solving system, or an effective learning system".

As stated by Sohrab et al., (2023), low-performing teams discussions are centered around solution exploration and assessment, instead of gathering and analyzing the information required for good solutions. Those teams frequently became fixated in pitching solutions. Further, encouraging everyone to share information in the team is crucial. As over three decades of research provide strong evidence that information unknown to some team members is far less likely to be brought up during team discussions.

Therefore, a skilled facilitator is a key factor for an efficient problem-solving process, as a great inhibitor of idea generation in groups are the concerns of people to be negatively evaluated (Proctor, 2020). This refers to mutual trust as a foundation (Lencioni, 2002; Nonaka, 1994), as well as constructive conflict patterns, that create commitment (Lencioni, 2002).

"When we fail to foster a high quality interaction, we lose out on the benefit of discourse between people who see things differently. The result is a lack of deep understanding, fewer creative options, diminished commitment to act, increased anxiety and resistance, and reduced morale and wellbeing" (Reynolds & Lewis, 2018, p. 5).

3.8.3 PROBLEM SOLVING CHARACTERISTIC FOR TEAMS: TEAM PROBLEM SOLVING ASSESSMENT TOOL (TPSAT)

According to Rotondi (1999) who developed the Team Problem Solving Assessment Tool (TPSAT), nine attributes can be distinguished, that define and assess a team's problem-solving success. Even if the tool is already getting in in years at the time of writing, its elements stay highly relevant.

CUSTOMER'S VALUES

This variable refers to the extent to which the team understands the customer's needs, concerns, expectations, and desires, and considers them during problem-solving. Ideally, the team takes the time to truly understand the customer's values, considering them essential to developing the best solution.

TEAM MEMBER EXPERTISE

This variable measures the amount of domain-specific knowledge within the team. The ideal state is when the team has both theoretical knowledge and practical expertise. Especially from those persons closely involved with the process on a day-to-day basis, regarding the problem.

TEAM INTERACTION STYLE

This variable describes how team members react to opinions and perspectives that differ from their own. Ideally, the team engages in in-depth, win-win discussions that reveal the rationale behind each member's opinions and perspectives. Members make a genuine effort to understand each other's ideas, searching for insights in opposing views to develop a synergistic and superior solution. Ideas are debated to reveal their strengths and weaknesses.

SYSTEMATIC PROBLEM EXPLORATION AND SOLUTION DEVELOPMENT

This variable pertains to the process the team uses to explore the problem and develop a solution. In the ideal state, the team breaks the problem into manageable parts and thoroughly explores each one to identify the customer's particular needs and the root causes of problems. Where appropriate, data is used to explore problem root causes. The team assesses potential issues resulting from the interaction of the parts with the whole, then develops a solution to address the identified needs and causes of each part of the problem.

MEETING FACILITATION

This variable concerns the facilitation of each meeting. Ideally, a facilitator skilled in problem-solving and team meeting techniques runs the meeting.

PRESSURE TO SOLVE THE PROBLEM

This variable reflects the importance of the team's efforts in solving the problem. In the ideal state, the team has a timetable for action that contributes to their sense of the importance of each meeting.

PROBLEM DEFINITION

This variable represents how much the team knows about their meetings and what is expected of them during those meetings. Ideally, the purpose of each meeting is clearly defined ahead of time. Each meeting is planned and structured, including providing background on the problem and indicating what the team should accomplish. An agenda has been developed, and each member understands what is expected of them and what to anticipate during the meeting.

TEAM MEMBER PARTICIPATION

This variable indicates the degree of involvement of members in the team's problem-solving efforts. The ideal state is when all members are actively involved in the problem-solving process.

WRITTEN LOGS OF MEETINGS

This variable refers to the team's thinking and deliberations being recorded for all to see during their meetings. Ideally, a written log is kept during meetings, visible to the entire team, to record the rich diversity of ideas generated. This ensures that no idea is overlooked because of who contributed it or because it was not reiterated frequently.

3.9 ACADEMIC VOID

Existing research on Lean in KW is scarce and often fails to distinguish KW from repetitive OW, leading to misconceptions, particularly in relation to knowledge processes and information handling.

Existing studies are predominantly qualitative single case studies, making it difficult to generalize findings or establish systematic approaches. The academic void lies in the absence of a structured understanding of Lean in KW, particularly regarding knowledge processes and information handling.

Future research should, therefore, find a new approach to Lean in KW, conduct more case studies, and practical applications to address this gap.

Therefore, the following Problem Statements were derived:

P1: *Research on Lean in KW is scarce and should focus on the knowledge process and information handling itself, seeking a new approach to the subject.*

P2: *Case examples, especially for the improvement of the knowledge process, are broadly missing.*

The concept of Waste in KW remains poorly defined and highly context-dependent, mostly adapted from Lean manufacturing without a universally applicable framework. While it was initially argued that waste elimination should not be the primary focus in KW, later contributions emphasize its necessity, particularly in sub-processes with higher standardization. However, most existing approaches remain domain-specific, making them difficult to generalize across KW settings.

Furthermore, current studies primarily focus on process-level Waste reduction (Process Lens), neglecting the root causes of variation that drive inefficiencies, which is generally an issue in Lean Scholar. The emphasis on adapting traditional Lean Waste categories rather than developing a theoretical and holistic framework limits the understanding of Waste in KW. A more structured investigation into variation is necessary to address these gaps, aligning with broader Flow, Network, and Organization Lenses.

As a result, the following problem statements were identified:

P3: *Waste reduction wasn't a goal in KW for a long time and existing studies define the Waste categories domain-specific, indicating the lack of a universally applicable framework. A first approach was delivered by Ellis (2020), which applicability and validity stays open.*

P4: *The understanding of the concept of Waste is a major obstacle to Lean implementation. Especially in KW contexts, the concept of Variation must be understood in relation to the nature of KW itself.*

P5: *Often, the root causes of Variation are neglected, instead reducing obvious Wastes within processes, or treating symptoms.*

4. SOLUTION DEVELOPMENT

The following chapter outlines the development and evaluation of the artefact. Starting with the use case, the specific requirements of the application environment are first introduced. Then, an overview on the whole artefact is provide, where components and their development are outlined in following sub-chapters. The chapter closes with the evaluation and its results from the experimental field testing.

4.1 USE CASE AND REQUIREMENTS

USE CASE

The industry partner is anonymized within this thesis for sensitive data protection purpose.

In February 2023, the industry partner established its own department for processes and methods. The purpose behind this initiative was to provide an internal service for Lean and Agile Work Methodologies and their implementation.

The department specializes in three key areas of expertise: Agile, Lean, and Human Factors. In its transformation and optimization projects, the department operates mostly within the KW domain, such as Research and Development (R&D), and finally aims to establish scaled Agile Working Methodologies, to overall increase KW productivity, "[…] whereas agile methods mainly focus on team level development activities, Lean is often viewed as a platform upon which to scale agile methods because it focuses on the whole value stream and on enterprise-level processes and behavior" (Karvonen et al., 2012).

Therefore, it is essential for the intended projects to develop a well-grounded "Lean perspective" that emphasizes a holistic view on the current situation, indicating inefficiencies that can be addressed within a Continuous Improvement approach, facilitated by a Lean Process Specialist. In this sense, a starting point for optimization must be obtained out of the Lean narrative, capturing the status-quo and guiding direction for improvements.

Upon engaging with a client, it becomes essential to comprehensively understand the existing issues, that hamper KW efficiency in the team's daily business. However, the absence of a standardized Waste framework for KW, as well as a missing approach to assess the occurrence of the Wastes, hampers the effectiveness of planning and implementing optimization measures.

SPECIFIC REQUIREMENTS

As defined by the department, the artefact developed in this thesis should be used to assess cross-functional, agile, teams. It should serve as a qualitative assessment tool, facilitated by a Lean Specialist. The tool, thereby, should serve to identify a status quo of a team regarding the occurrence of KW Waste, as well as it should be used regularly afterwards with the purpose to recognize a trend (e.g., to estimate the success of certain applied methods to encounter the Waste).

Further, the tool not only should practically identify Waste in KW settings, but also provide a holistic Lean perspective. Additionally, it should practically guide the Lean Specialist towards explicit measures for optimization.

The following objectives were identified in recurring talks within the department. They complement the overall objectives for this thesis by additional environmental requirements (Relevance Cycle):

O5: Possibility to assess the occurrence of Wastes in agile and cross-functional teams by a holistic, universally applicable framework, which facilitates a Lean perspective for KW, and practically guide practitioners towards explicit measures.

O6: As the teams already work with agile frameworks, distinct dimensions should be focused on to gather a holistic picture.

O7: The solution is provided as qualitative Workshop format, which delivers team-specific insights on the individually perceived situation.

O8: The artefact should enable a fast and lightweight application, so that results can be obtained after a maximum of 2h assessment.

4.2 ARTEFACT OVERVIEW

Central to the artefact is the development of a holistic Waste Framework through the conditions, conductive to create value from KW and therefore, if dysfunctional, generate Waste (4.3 Waste Framework Development). The holistic Waste Framework consist of:

1. *Poor Work Methodologies*
    a. *Reasoning: Problem-Solving Methodology*
    b. *Action: Work Execution Methodology (e.g., Agile Project Management Framework / not in scope of the thesis)*
2. *Team Dysfunctions*
3. *Poor Knowledge Management Practices*

To define a set of Practices for Lean in KW (4.4 Evaluation Dimensions and Lean Practices for KW) that collectively mitigate the introduced Wastes, an analysis of the practices and characteristics of two established assessment tools (KMPS-Q and TPSAT) with respect to the findings from the State of the Art, was undertaken (Relevance and Rigor). These Practices are:

1. *Ensure Healthy Dynamics and Functioning*
2. *Management of Information- and Knowledge-Flow*
3. *Management of the Knowledge Value Stream*
4. *Drive Problem-Solving Methodology*
5. *Drive Work Execution Methodology*

An overview is presented in Figure 11 as follows:

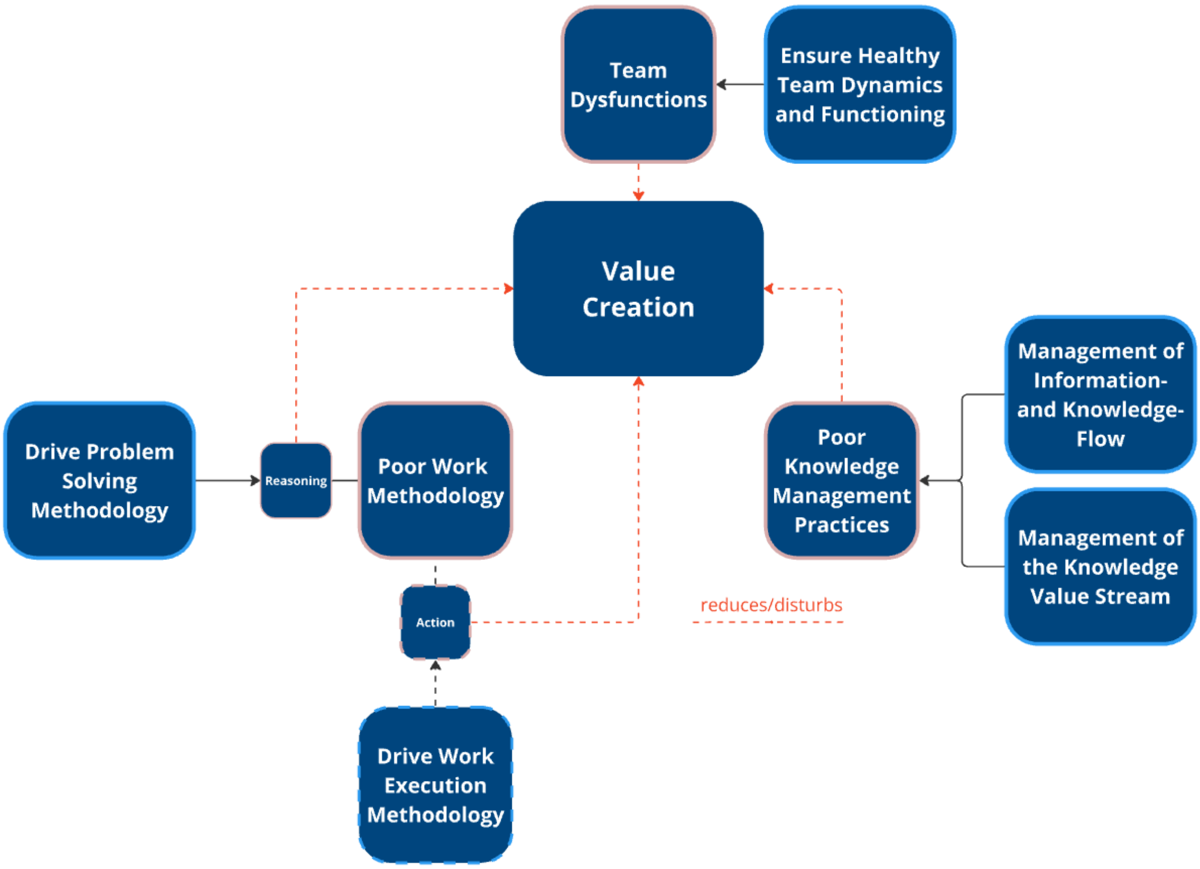


Figure 11 - Artefact Overview

Further, those Practices and their characteristics will serve as Lean KW perspective to evaluate the outcomes of the assessment tool, the artefact of this work, and guide Lean practitioners in Continuous Improvement towards Perfection.

Therefore, the contribution is twofold: One, serving as evaluation dimensions for the assessment according to their specific characteristics, and two, provide a Lean KW perspective to guide practitioners by actionable Practices.

For each dimension/practice, indicators were developed to show a "worst case", enabling workshop participants to identify their occurrences and abstract to similar situations (4.5 Indicator Development).

The proposed solution is a qualitative, team-specific workshop assessment format, designed for team leaders (or team coaches, e.g., agile coach, SCRUM master). Facilitated by a Lean Specialist, the workshop is conducted in a one-on-one setting to provide psychological safety and encourage honest insights from participants. The final workshop is delivered digitally using the online tool MIRO, allowing for interactive and engaging sessions (4.6 Workshop Design).

Despite the introduced Waste Framework, participants get assessed in two main categories for facilitation and framing purpose of the Workshop: *Team Problem-Solving and Knowledge Management Practices*. *Team Dysfunctions* are excluded as main category in the workshop and hidden within the two main categories.

The artefact is experimentally tested within the intended field of application with overall three runs, where the results are evaluated regarding the objectives of this thesis (4.7 Evaluation and Demonstration of the Artefact).

4.3 WASTE FRAMEWORK DEVELOPMENT

Based on the findings from the State of the Art, a holistic Waste Framework is developed in the following chapter, as basis for the artefact of this work.

First, a model for value creation in KW is derived from the findings of the literature work, which depicts the foundations, conductive to define the Waste Framework. Then, the Framework is defined, and its characteristics are explained from the perspective of the Lean Lenses (2.2 The Lenses of Lean: Coping with Variation).

Further, it is shown, that it aligns broadly with an existing model, proposed by Ellis (2020), and offers an even more holistic perspective, potentially the main components for Lean KW.

Thereby, this chapter addresses *Research Question No.1*.:

R1: *How can a holistic and universally applicable Waste Framework be defined for the KW domain to enable structured Waste reduction from the Lean Perspective?*

4.3.1 A MODEL FOR VALUE CREATION

As introduced in the literature work, the root cause of variation must be understood generally (to avoid treating symptoms instead of tackling the root causes), and especially in KW contexts, as the domain differs significantly to manufacturing. Learning, iterative planning, and flexibility was said to be the main conditions to face uncertainty (chaos) in KW.

This put forth, the importance of iterative work methodologies for work execution and planning, like Scrum and Kanban, was addressed extensively. Further, the role of work methodologies for reasoning processes, such as PDSA (and related practices), was highlighted in the overall context of Lean, learning, and value creation in organizations.

The relations of work methodologies (reasoning and action), information assimilation, and team dynamics, and collaboration were introduced by the Intellectual Bandwidth Model, which explains the conditions, conductive to value creation.

It is now argued that the Intellectual Bandwidth can be replaced by the mechanics and ingredients of OL, the SECI Model, and related aspects, which are KM Practices and the cross-functional team ("as a field"), and its functioning and dynamics (mutual trust, collaboration, constructive conflict, commitment).

Despite the bandwidth is founded on technological aspects and is more inclined to information processing and handling (Information Assimilation), it significantly overlaps (Figure 12), as KM Practices also incorporate technological aspects and emphasize information handling and sharing (*Information and Knowledge Flow Principle*).

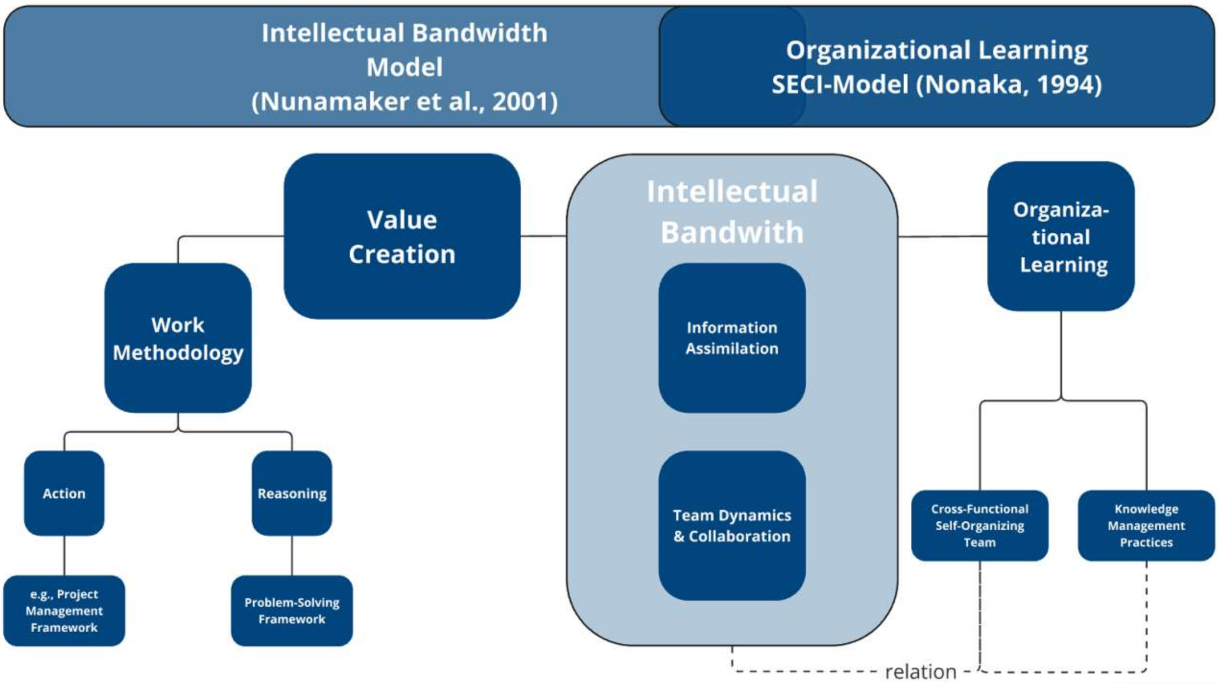


Figure 12 - Value Creation Model

Further, innovation is a key form of organizational knowledge creation and cannot be explained sufficiently in terms of information processing or problem-solving. Innovation can be understood as a process in which the organization creates and defines problems and then actively develops knowledge to solve them (Nonaka, 1994). This highlights the overall connection and supports the newly defined Model, as presented in Figure 13.

This model will serve to trace the main contradictions to KW value creation (and innovation). Or better said, it contains the factors, conductive to create value from KW. Therefore, if those building blocks are dysfunctional, value creation is at risk, which overall diminishes or disturbs value creation in KW, and introduces Waste.

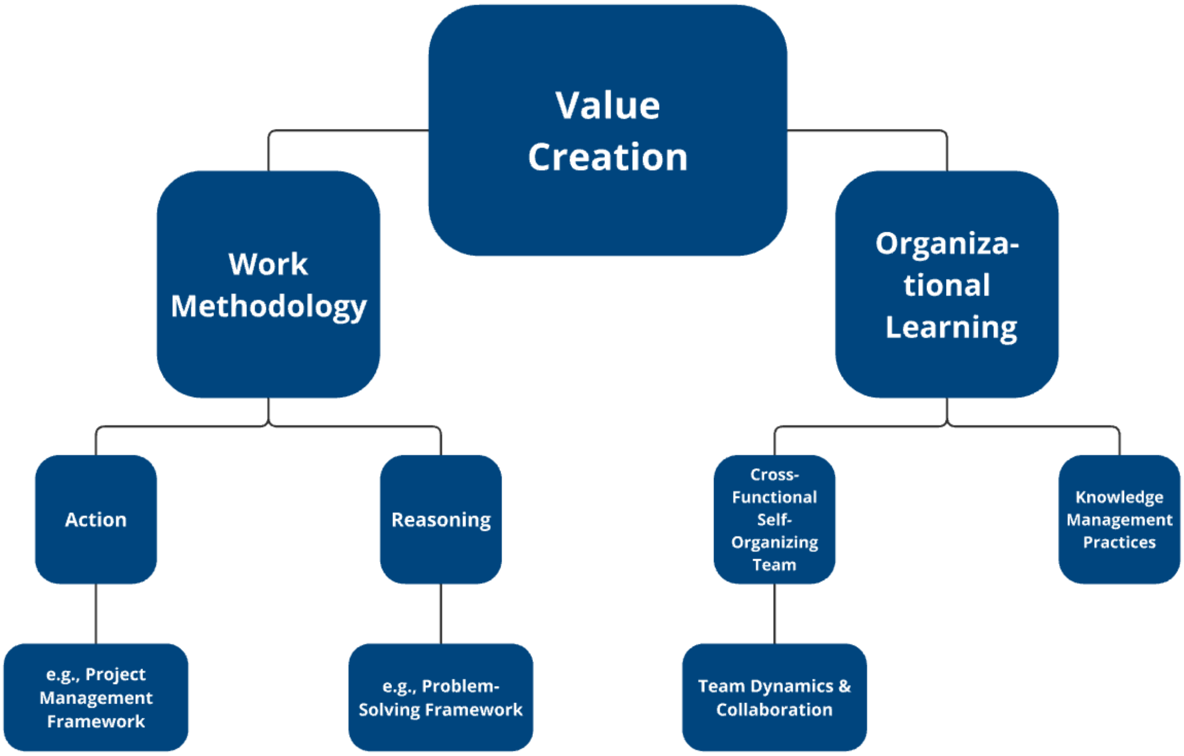


Figure 13 - Reduced Value Creation Model

Figure 13 shows the “Team Dynamics & Collaboration” block underneath the one of the cross-functional team. This was carried out to account for it explicitly, as it is a building block in the Intellectual Bandwidth Model, as well as the SECI model, and contains conditions, such as mutual trust.

4.3.2 THE HOLISTIC WASTE FRAMEWORK

As outlined above, three main categories can be defined, that enable value creation, or otherwise, if dysfunctional, diminish or disturb it. Figure 14 outlines the newly defined Waste Framework.

1) Poor Work Methodologies
   a. Reasoning: Problem-Solving Methodology (problem-solving capabilities and frameworks)
   b. Action: Iterative work execution and planning (highlights the role of agile methods / out of scope for this thesis)
2) Team Dysfunctions
3) Poor Knowledge Management Practices

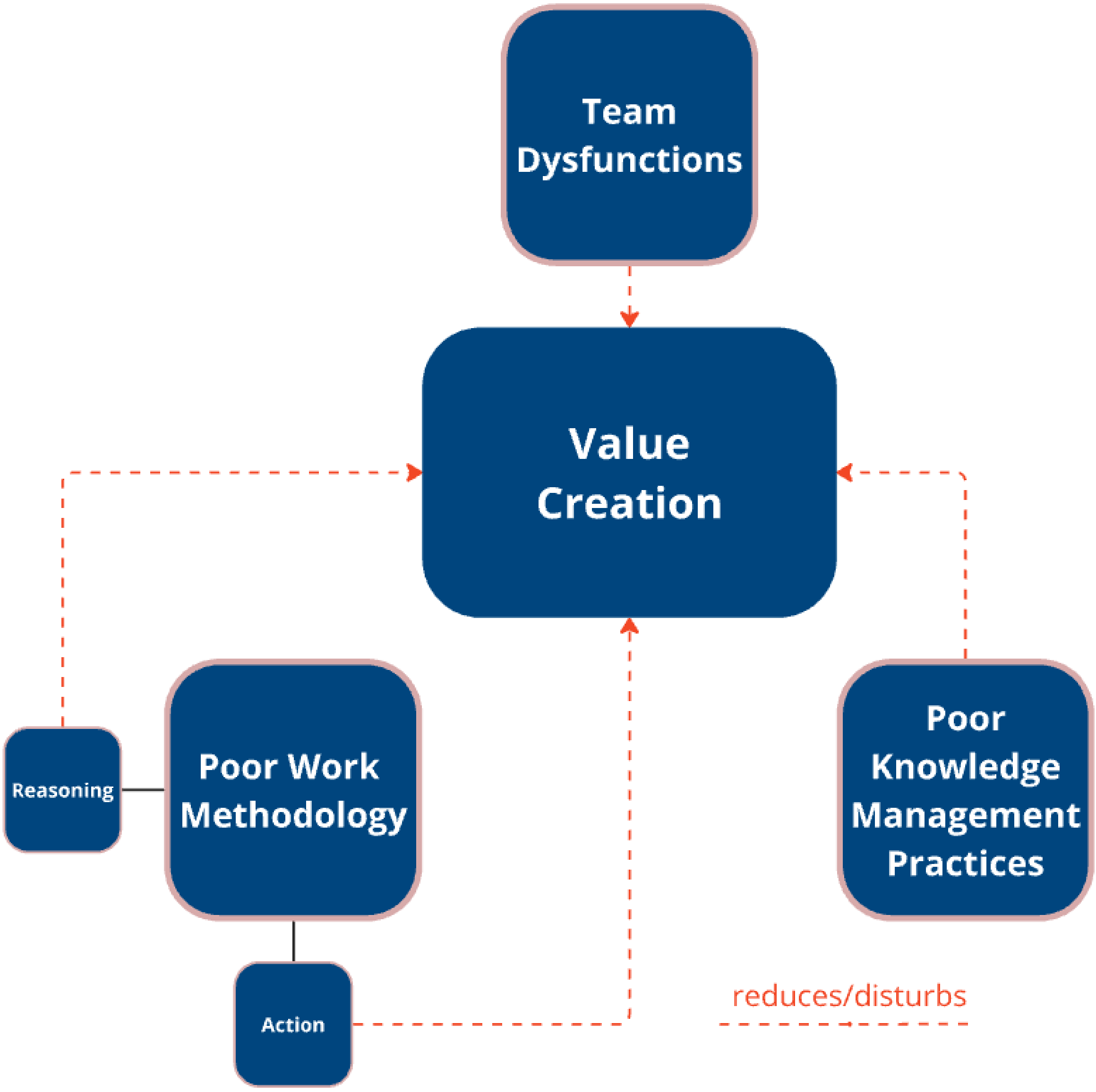


Figure 14 - Holistic Waste Framework

FLOW LENSE PERSPECTIVE

This model generally introduces a “Flow Lense” perspective on Waste reduction in KW contexts, as it is derived directly from the conditions, conductive to create value and incorporates all necessary attributes, that enable a team or an organization to face uncertainty within KW. Thus, if dysfunctional (not capable in dealing with uncertainty), Variability (Chaos domain in KW, and within Lean manufacturing Variability) induced Waste occurs.

The occurrence of Variability (uncertainty) is a natural process. Within manufacturing systems, it will always be buffered by either Inventory, Capacity, or Time. The following analogy to KW can be drawn:

Buffer	Manufacturing System	KW System
Inventory	e.g., have goods on stock to cope with peak demand	e.g., have applicable knowledge available (tacit and explicit) to cope with demand of solutions to problems (e.g., develop something)
Capacity	e.g., provide additional workers to cope with demand	e.g., acquire new knowledge from external sources to match demand, or ability to generate new knowledge (learn) to cope with demanded solutions.
Time	e.g., deliver later	e.g., deliver later, or reduce demand by incorporating the customer early to better meet requirements (SCRUM (Sutherland et al., 2019))

Table 1 - Buffer comparison

To optimize overall efficiency and reduce the total cost of buffering, either Variability must be reduced, or the mix of Variability-Buffers must be altered (optimal cost/benefit trade off). Therefore, predictability plays a significant role, which is often not the case in KW. Thus, flexibility is all the more important, as it facilitates Variability (Uncertainty) pooling and facilitates the synchronization of supply and demand (Buffer-Flexibility Corollary).

ORGANIZATION LENSE PERSPECTIVE

“Team Dysfunctions” is explicitly highlighted at the top, to indicate the importance of the functional team (main condition), as it expectably diminishes the best Work Methodology and KM practices.

Further, “Poor Work Methodology - Reasoning” addresses biased thinking, introduced by faulty reasoning processes.

NETWORK LENSE PERSPECTIVE

To introduce the efficient management of bottlenecks (applying the queueing theory), the model serves to introduce the “Knowledge and Information Flow Principle” within “Poor KM Practices”, (also see later 4.4 Evaluation Dimensions and Lean Practices for KW). Therefore, enabling practitioners to resolve bottlenecks in knowledge and information flows.

PROCESS LENSE PERSPECTIVE

The outlined framework introduced modularity in a way, that is allows for "Process Lens" Waste categories to be attached to it, according to the domain of application in the best possible way (e.g., defining KM process related Wastes as analogy to Lean manufacturing wastes).

4.3.3 WASTE FRAMEWORK ALIGNMENT

In the following, the Waste Framework of Ellis (2020) is shortly discussed and analyzed with respect to the previously introduced Waste Framework. It can be shown that it almost completely aligns, as represented in Figure 15. Gaps and shortcomings are also addressed.

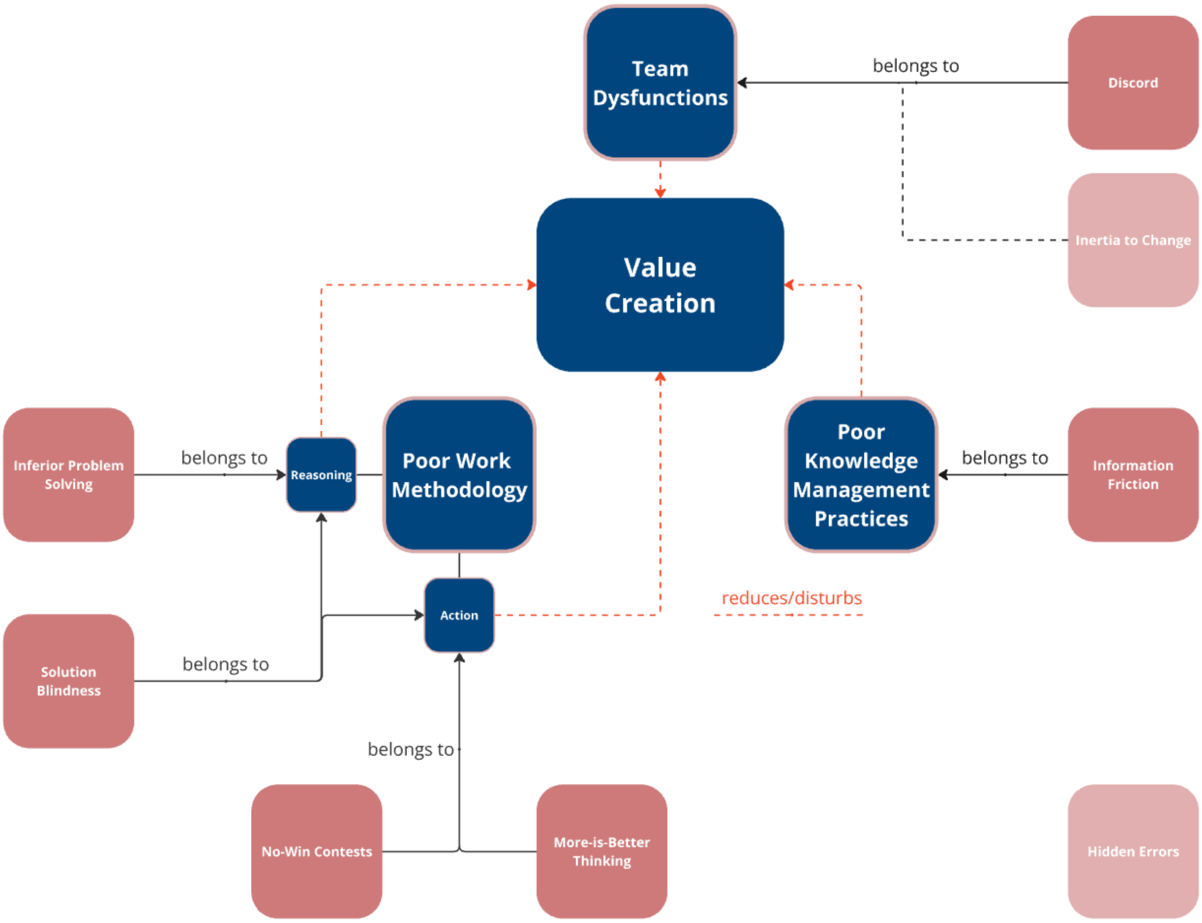


Figure 15 - Waste Framework Alignment

DISCORD

The Waste of Discord addresses a dysfunctional team, which diminishes and or hinders collaboration and productive team dynamics, which lastly diminish value creation. Therefore, Discord belongs to “Team Dysfunctions” and is generally an “Organization Lens” attribute.

INFORMATION FRICTION

This Waste category is concerned with issues related to information and knowledge accessibility, communication practices (knowledge Pull and information Flow and Pull), and issues regarding the representation of information. Despite Ellis (2020) mentions practices to capture tacit knowledge by expert rule sets and checklists, the work falls short in explicitly addressing the whole organizational knowledge creation process (e.g., Socialization by Mentoring Practices), and related practices. In this sense, it belongs to “Poor Knowledge Management Practices”.

MORE-IS-BETTER THINKING

This category is concerned with missing action plans and goal setting, lack of prioritization, and unclear definition of success. This leads to missed targets, extended timelines of projects, and lost opportunities. Therefore, it addresses directly the *Work Methodology* regarding action, thus, aligns with "Poor Work Methodology regarding action/execution".

INERTIA TO CHANGE

This Waste must be seen from the perspective of the Organization Lens, as it is concerned with human behavior. The consequences of inferior or missing change management can be manifold. As Lean is constantly changing an organization and deeply relies on change management, it is highly relevant.

Despite that, this Waste will expectably occur in, more or less, every team and setting, as it is natural human behavior. Therefore, it is attached to "Team Dysfunctions" (pale block with broken line attached) and regarded as a main practice, underlying Lean approaches, but not directly regarded as dysfunction.

NO-WIN CONTESTS

They occur if workers are overloaded due to unrealistic expectations, missing capacity planning, insufficient resources, and missing prioritization. The equivalent of this category is the Waste of overburden workers in Lean manufacturing. As KW has the invisibility challenge of work and its workflows generally, tendencies exist to overload people as the workload is not visually observable, like in manufacturing. Whereas the consequences for workers are dramatic and might lead to mental health issues like burnout.

It is now argued that this Waste is a direct cause of poor Work Methodologies in work execution, like it is the case for "More is better thinking". As, for instance, agile Work Methodologies, like Kanban, explicitly apply mechanisms to avoid the overburden of people and visually represent tasks in workflows, allowing for visual representation of workloads. Clearly, it depends on Leaders to drawing the consequences if overload is permanently observable, but those frameworks clearly open the possibilities to account for it.

INFERIOR PROBLEM SOLVING

Inferior Problem Solving occurs when problems are not thoroughly addressed, leading to recurring issues that waste time and resources. It directly aligns with Work Methodology regarding reasoning processes.

SOLUTION BLINDNESS

Solution Blindness occurs when people remain attached to a solution even after new information shows it to be ineffective. This can happen due to emotional attachment or fear of admitting failure, or more generally, biased thinking and missing Work Methodology to account for it during reasoning and action (by e.g., the availability of a facilitator in reasoning processes, as well as formal approaches such as PDSA).

It is now argued that this is, like "More-is-Better Thinking" and "No-Win Contests", a direct result of Dysfunctional Work Methodologies. Where this category explicitly shows the importance of the interrelations of both, reasoning and action.

HIDDEN ERRORS

Hidden errors are mistakes that remain undetected until they cause significant issues later in the process. These errors often surface late in the project cycle, leading to high costs, quality problems, or customer dissatisfaction.

This is a Waste category of the Process Lense. The connection to the Organization Lens is given by the error culture that must be nurtured by Leadership. Explicitly important to note is, that this Waste derives from the others, as for instance, control mechanisms are missing in work execution (testing) or people hesitate to speak up as they fear to be treated unfair. In this sense, it stands alone as pale block.

4.4 EVALUATION DIMENSIONS AND LEAN PRACTICES FOR KW

So far, a simple and holistic Waste framework was developed for KW, based on the findings of the Literature Work and corresponding objectives for this thesis. Further, it could be shown, that the Waste Framework of Ellis (2020) broadly aligns.

To define a set of Practices for Lean in KW that collectively mitigate the introduced Wastes, an analysis of the practices and characteristics of the KMPS-Q and TPSAT assessment tool, as well as the findings from the State of the Art, was undertaken.

Further, those Practices and their characteristics will serve as Lean KW perspective to evaluate the outcomes of the assessment tool, the artefact of this work, and guide Lean practitioners in Continuous Improvement towards Perfection.

Therefore, the contribution is twofold: One, serving as evaluation dimensions for the assessment according to their specific characteristics that are defined in the following, and two, provide a Lean KW perspective to guide practitioners by actionable Practices.

Thereby, this section addresses Part a of *Research Question No.2.:*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

> *R2a: What are the Dimensions and their Attributes to evaluate the identified Wastes from the Lean Perspective for KW?*

4.4.1 DEFINITION AND OVERVIEW

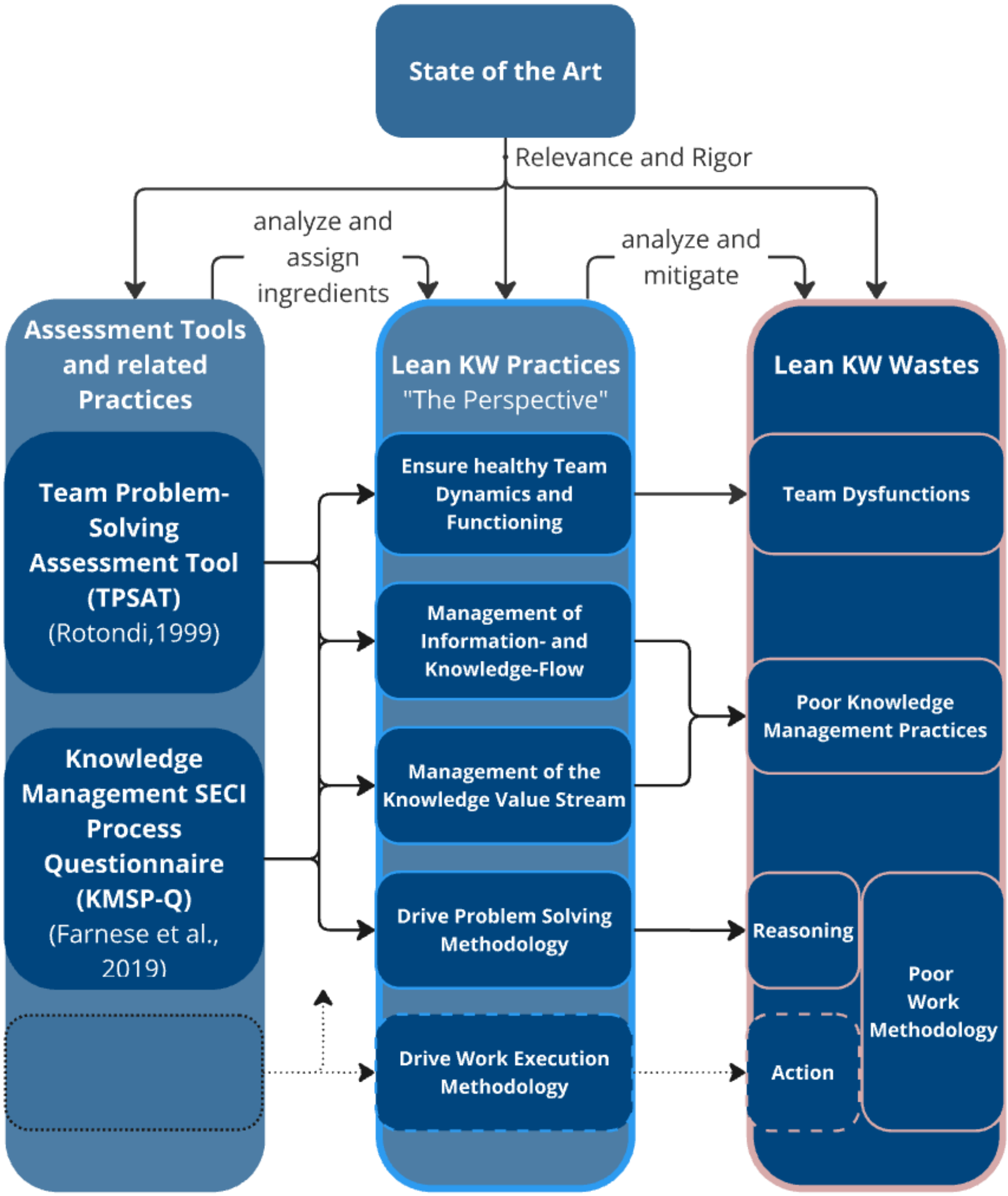


Figure 16 – Lean Practices for KW: Definition approach

Figure 16 shows the applied approach. Thereby, five distinct Lean Practices were introduced by the findings of the State of the Art, building upon the Lean Principles for KW, as well as findings, related to value creation and the cross-functional team (mutual trust, conflict, and commitment) and its role in KM, OL, and problem-solving.

The Pull Principle was excluded, and merges into “Management of Information- and Knowledge-Flow”, as well as “Management of the Knowledge Value Stream” (in the form of knowledge and information availability, and accessibility).

Note: “Drive Work Execution Methodology” is excluded, as it is not in the objectives and scope of this thesis. Therefore, it is show with a broken line, and gives an outlook to future work.

The ingredients of the two assessment tools (the practices and measures they suggest) were analyzed with respect to the introduced practices and assigned to them (indicated by the arrows on the left in Figure 16). This was done because both tools contain different practices that address several of the Lean principles. For instance, “Ensure Healthy Team Dynamics and Functioning” is addressed by Practices/Variables of both tools.

This serves as the Lean KM Perspective to analyze the outcomes of the Workshop Assessment, as well as they collectively address the identified Wastes (excluded is the “Poor Work Methodology - Action”, as it is not in the scope of this work and should be part of future work).

The results are presented in the following chapters in a table form, where the following representation is used:

Practice / Variable	Description	Measure	Origin	Acronym
Refers to the Practice/Variable of the corresponding tool	Describes the Practice/Variable as proposed by the tools	Indicates what is measured within the Waste Assessment Workshop	Reference to the source tool. *Note: Knowledge Management refers to the KMPS-Q tool, where the SECI stage is also explicitly highlighted.*	Indexing for the Waste Assessment Workshop

4.4.2 ENSURE HEALTHY TEAM DYNAMICS AND FUNCTIONING

Practice / Variable	Description	Measure	Origin	Acronym
Knowledge Sharing	Willingness to share knowledge with other team members.	Mutual Trust Conflict	Knowledge Management (SECI - Socialization)	TDF1
Team Interaction Style	Describes how team members react to opinions and perspectives that differ from their own.	Mutual Trust Conflict	Team Problem-Solving (TPSAT)	TDF2
Team member participation	Indicates the degree of involvement of members in the team’s problem-solving efforts.	Mutual Trust Conflict Individual Commitment	Team Problem-Solving (TPSAT)	TDF3

Table 2 - Ensure Healthy Team Dynamics and Functioning

4.4.3 MANAGEMENT OF INFORMATION- AND KNOWLEDGE-FLOW

Practice / Variable	Description	Measure	Origin	Acronym
Communication Practices & Management of Interactions				
Problem Definition	Represents how much the team knows about their meetings and what is expected of them during those meetings.	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF1
Written logs of Meetings	Refers to the team's thinking and deliberations being recorded for all to see during their meetings.	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF2
Meeting Facilitation	Availability of a Facilitator and availability of respective skills.	Management of Interactions	Team Problem-Solving (TPSAT)	IKF3
Pressure to solve the problem	Availability of action plans and follow ups to solve the problem after meetings.	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF4
Transfer of Knowledge, Information & Knowledge Sharing				
Mentoring Practices	Knowledge sharing through Mentoring and Job Rotations.	Knowledge Transfer	Knowledge Management (SECI - Socialization)	IKF5
Knowledge Sharing	Sharing through social networks like Community of Practices.	Information and Knowledge Sharing	Knowledge Management (SECI - Socialization)	IKF6
Organizational Communication	Norms and formal practices to share information and news, keep colleagues updated, and to overcome hierarchical levels, as well as boundaries between units of the organization.	Information Sharing	Knowledge Management (SECI - Combination)	IKF7
Technical Support	Knowledge Management Systems (KMS) and tools that increase useful and fast transfer and access to information and knowledge.	Information and Knowledge Sharing	Knowledge Management (SECI - Combination)	IKF8

Table 3 - Management of Information and Knowledge Flow

4.4.4 MANAGEMENT OF THE KNOWLEDGE VALUE STREAM

Practice / Variable	Description	Measure	Origin	Acronym
Organizational Memory	Practices like producing best practice collections, manuals, reports and other written documentation.	Formalization of Knowledge in KMS	Knowledge Management (SECI - Externalization)	KVS1
Technical Support	Knowledge Management Systems (KMS) (repositories) actuality, standardization, and functionality.	Quality of KMS	Knowledge Management (SECI - Combination)	KVS2
Team Reflexivity	Reflection within the team on own way of working, as well as on encountered issues and gathering of relevant data.	Analysis and Closed Feedback Loops	Knowledge Management (SECI - Externalization)	KVS3
Team member expertise	The amount of available domain-specific knowledge within and to the team.	Information and Knowledge Availability	Team Problem-Solving (TPSAT)	KVS4
HR Training	Learning processes designed to help employees assimilate new knowledge and reshape their mental models, whether for decision-making, work procedures, or to support role transitions.	Availability of trainings relevant to the profession and role transitions.	Knowledge Management (SECI - Internalization)	KVS5
HR Development	Enabling people to understand the significance of their work, attribute meaning to their professional experiences, and appreciate their behaviors that go beyond formal role requirements.	Opportunities to improve the own work, develop own skills, and to creatively participate beyond their formal role	Knowledge Management (SECI - Internalization)	KVS6

Table 4 - Enrichment of the Knowledge Value Stream

4.4.5 DRIVE PROBLEM-SOLVING METHODOLOGY

Practice / Variable	Description	Measure	Origin	Acronym
Customer Value	Refers to the extent to which the team understands the customer's needs, concerns, expectations, and desires, and considers them during problem-solving.	Consideration of Customer Value	Team Problem-Solving (TPSAT)	PSM1
Systematic problem exploration and solution development	The process the team uses to explore the problem and develop a solution.	Problem Solving Methodology	Team Problem-Solving (TPSAT)	PSM2

Table 5 - Problem-Solving Methodology

4.5 INDICATOR DEVELOPMENT

For each evaluation dimension defined in the previous section, indicators are developed as foundation of the artefact. These indicators will be presented to the Workshop participants, where they get asked whether they encounter issues of this kind.

The indicators developed in the following are derived from KMPS-Q and TPSAT assessment tool, where several adjustments were undertaken, to fit the desired qualitative Workshop format.

To support better readability, only an extract is presented in the following. The full list can be accessed in the Appendix (APPENDIX A: INDICATOR).

This section answers Part b of *Research Question No.2:*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

R2b: Which Indicators serve to assess the occurrence of the Wastes?

4.5.1 APPROACH AND METHODOLOGY

As previously outlined, the KMPS-Q and TPSAT assessment tools serve as foundation to derive assessment indicators regarding KM and problem-solving.

The following section will present the applied methodology and examples for deriving the indicators and the adaptions carried out to fit the indicators to the Workshop format.

Generally, the indicators are formulated in a way to indicate a “worst case”, where the participants get asked to identify those, that fit their situation. At best, the formulation of the indicators allows for abstraction, meaning that participants can associate similar situations to the presented one by the indicator.

Further, no weighting will be applied to the indicators, meaning all are equally treated. If the underlying tool has one applied, it is neglected within this thesis, as the Workshop is designed as qualitative instrument to draw a team-specific perspective on the status quo. In this sense, it is only important in the first step to see, whether issues of this kind are encountered by the team.

4.5.2 KMPS-Q DERIVATIVES

This tool provides rough example items along the SECI cycle and its associated Practices, which can be specifically adapted.

For *Knowledge Sharing (Socialization)* the following Item is presented by the authors:

"*Each one's know-how is made available to colleagues to deal with problems that may arise".*

The developed item for this work, reads as follows:

"Colleagues seldom proactively provide their knowledge and experience if someone has difficulty in completing their work".

As the main goal of this statement is to indicate the absence of mutual trust, it is formulated to indicate the hesitancy of team members to proactively provide their knowledge to colleagues. In this sense, the indicator is aligned with the Waste of "Team Dysfunctions", as well as the Lean KW Practice of "Ensure healthy Team Dynamics and Functioning".

4.5.3 TPSAT DERIVATIVES

This tool provides detailed statements on a scale, where participants are asked to identify themselves on it by the statements. Further, the tool has an overall weighting between its categories applied, distinguishing in the importance and contribution of each category to the overall team problem-solving process. This will be neglected within this work.

The category and scale of *Team Interaction Style* is presented as follows:

100: The team will have in-depth win/win discussions which reveal the rationale behind members' opinions and perspectives. The members will make a genuine effort to understand each other's ideas and perspectives during their discussion, and search for insights in opposing views in order to develop a synergistic and superior solution. Ideas will be debated to reveal their strengths and weaknesses.

45: The members will tend to defend their own opinions, but they are willing to listen and debate each other's rationales. This means that the members can be moved some of the time by persuasive arguments.

0: Members' ideas about the problem and its solution will not be explored to reveal their strengths and weaknesses, and there will be little constructive debate. Members will defend their positions to protect their egos. The discussion will rarely go deeper than the exchange of opinions, and there will be little discussion of the rationale behind a member's opinion or perspective.

Based on this scale and the applied framing, to indicate a "worst case" and similar situations, the following statement was developed:

"During Team Problem-Solving activities, team members often defend their own ideas, leading to minimal constructive debate and shallow discussions that do not explore the strengths, weaknesses, or reasoning behind different perspectives".

As can be seen, the formulated statement captures the lowest score statement of TPSAT. Generally, the statements based on TPSAT are aligned with the lowest score items of the source, where adaptions are carried out to increase comprehensibility in the qualitative Workshop setting. Further, some items get split, and some of the mid and low range get combined, to account for different aspects, and to make the statements better understandable and comparable with similar situations.

4.5.4 EXAMPLE: ENSURE HEALTHY TEAM DYNAMICS AND FUNCTIONING

The table below shows the examples from above, within their tabular representation. The full list of all Dimensions and respective indicators can be accessed in APPENDIX A: INDICATOR .

Practice / Variable	Indicator / Statement	Description	Measure	Origin	Acronym
Knowledge Sharing	Colleagues seldom proactively provide their knowledge and experience if someone has difficulty in completing their work.	Willingness to share knowledge with other team members.	Mutual Trust	Knowledge Management (SECI - Socialization)	TDF1
Team Interaction Style	During Team Problem-Solving activities, team members often defend their own ideas, leading to minimal constructive debate and shallow discussions that do not explore the strengths, weaknesses, or reasoning behind different perspectives.	Describes how team members react to opinions and perspectives that differ from their own.	Mutual Trust Conflict	Team Problem-Solving (TPSAT)	TDF2
Team member participation	Not all members are actively involved in the problem-solving process. A minority of the team is running the debate on the problem, where some members don't contribute.	Indicates the degree of involvement of members in the team's problem-solving efforts.	Mutual Trust Conflict	Team Problem-Solving (TPSAT)	TDF3

Table 6 - Indicators: Team Dynamics and Functioning

4.6 WORKSHOP DESIGN

This chapter outlines the design, procedure, and facilitation of the intended workshop format. Thereby, this section addresses Part c of *Research Question No.2:*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

R2c: What format serves to conduct the assessment and how is it applied and facilitated?

4.6.1 DEFINITION AND OVERVIEW

The format is designed as a qualitative Workshop that strives to identify the occurrence of the previously outlined obstacles to KW efficiency. Further, it anticipates gathering a holistic perspective on the team's working reality by providing the possibility to detail the encountered situation.

The solution is a qualitative, team-specific workshop format designed for team leaders. Facilitated by a Lean Specialist, the workshop is conducted in a one-on-one setting to provide psychological safety and encourage honest insights from participants. The final workshop is delivered digitally using the online tool Miro, allowing for interactive and engaging sessions.

For understandability and facilitation purpose, the Workshop will use the two Categories "Team Problem Solving" and "Knowledge Management Practices". Therefore, the previously outlined Indicators that were derived from the KMPS-Q and TPSAT tool get assessed within the anticipated sequence of their authors and analyzed with respect to the Evaluation Dimensions, as introduced in 4.4 Evaluation Dimensions and Lean Practices for KW.

4.6.2 WORKSHOP DESIGN AND FACILITATION GUIDELINE

The Workshop is designed in two phases and provides an interactive setting within the online tool MIRO. For the complete documentation, please access APPENDIX B: WORKSHOP Design.

After welcoming and introducing the participant to the purpose of the workshop and the general procedure, such as privacy conditions (the results are completely anonymized), Phase 1 is introduced.

Within Phase 1, the participant is asked to silently go through a provided list of digital Items, that contain the Indicator Statements (Sticky Notes in MIRO), and to select them if they encounter this situation or a similar one within the team or its environment. Thereby, they are requested to pull them into the intended column to the right (Figure 17). Within Phase 1, the facilitator answers arising questions on demand, if necessary, where participants are encouraged to ask when needed.

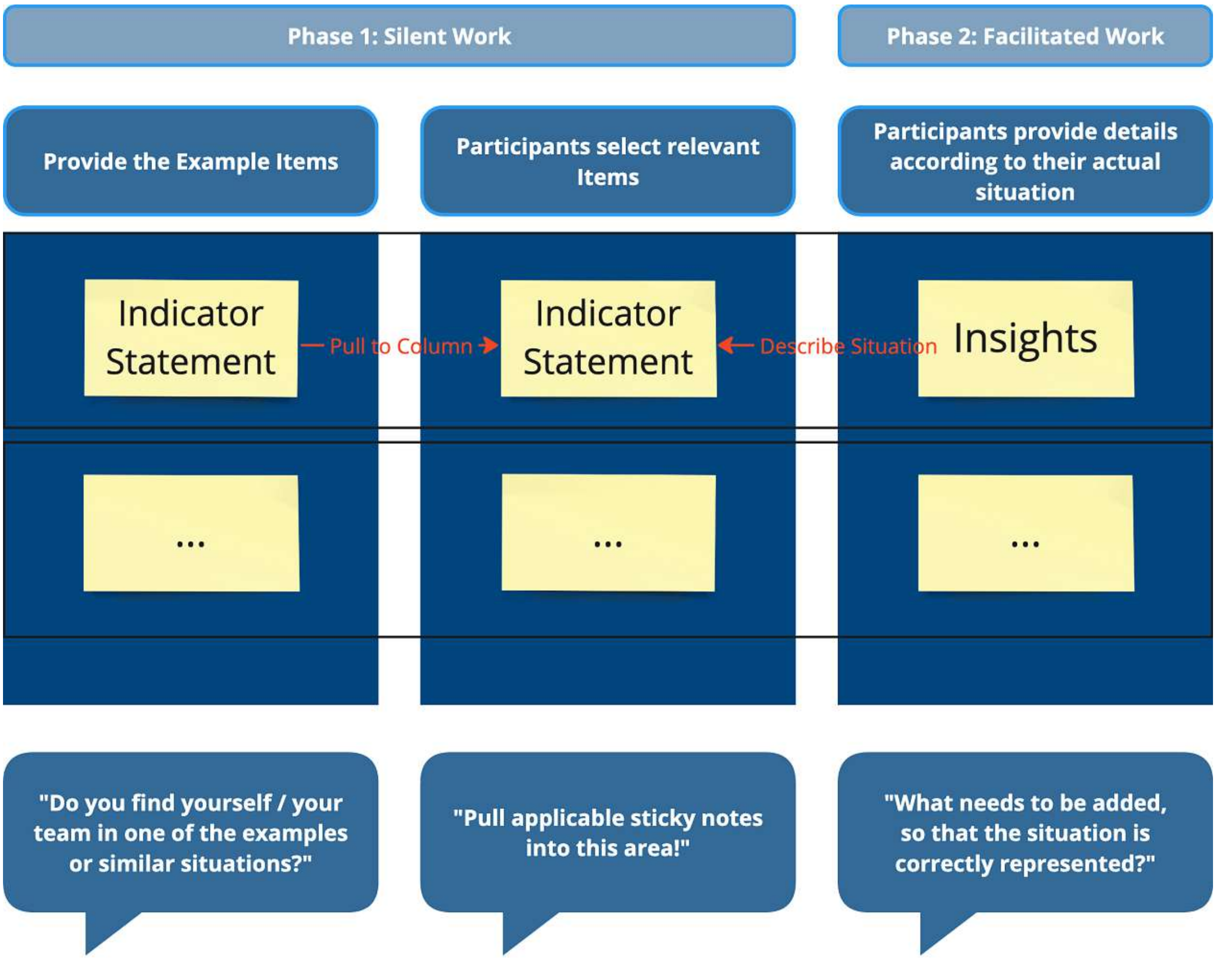


Figure 17 - Workshop Design and Procedure

After all relevant Items were identified, Phase 2 starts with the purpose to provide deeper insights to the situation and to account for similar situations, and as well as to explain them. Within this Phase 2, the Workshop facilitator is more active and guides the participant through the process.

Therefore, the facilitator will guide the participant Item-wise from the first selected Item to the last, by asking open-ended questions on the current situation. They serve to gather the opinion of the participant in the best possible way (Taherdoost, 2022). Examples are:

- "What must be added to describe your actual reality?"
- "Are there any differences that must be explained?"
- "How does this issue impact day-to-day business?"

Within this Phase 2, the responses of the participant are captured on sticky notes in keywords, where the participant and the facilitator work together, to capture them if necessary (as it would disturb the explanations of the participant, if they are asked to capture them in parallel).

Furthermore, to hold the connection between Indicator Item and its open responses, the Workshop template is horizontally divided by "swim lanes", as represented in Figure 17. Further, the Phase 1 and its mechanism to pull Items to a dedicated column, serve to better facilitate and guide through the relevant issues, present at the team.

4.7 EVALUATION AND DEMONSTRATION OF THE ARTEFACT

The following section briefly outlines the approach, scope, and conditions of the empirical evaluation, as well as the methodology to capture qualitative measures of the Workshop format. Also, results are presented within this section. Thereby, this section addresses Part d of *Research Question No.2:*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

R2d: How well does the developed format serve to identify Wastes?

4.7.1 APPROACH AND SCOPE

The Workshop format gets tested as qualitative tool in a team specific setting, where three different team leaders are invited separately to a one-on-one session with the facilitator. Therefore, overall, three runs of the Format are carried out to demonstrate and evaluate the artefact of this thesis.

The results of the Workshops get fed back by analyzing them according to the previously defined evaluation dimensions.

The format itself gets evaluated by a feedback-form, according to test the perceived usefulness and quality of the Workshop format by its participants.

4.7.2 VALIDATION FIELD

The Workshop format gets tested as Leadership-Workshop, conducting Team-Leaders or the agile Coach to assess their own teams.

Leaders of a R&D team, a strategic purchasing team (as they face significant uncertainty and have complex projects, according to the disruption of global supply chains and inflation), and a team from application engineering (which is especially interesting, as it is a multi-cultural setting with colleagues from India, and remotely managed) get invited to the assessment to experimentally evaluate the artefact. This is applied to capture insights from different professions. Each have varying, but significant, share of KW.

It is to mention, that the application engineering team is a sub-team, led by a local engineer, often fluidly working with the broader application engineering team, located in Austria.

Overview:

Team 1: Strategic Purchasing Team

Team 2: Sub-Team of application engineering within an intercultural and remote setting with Indian colleagues

Team 3: R&D expert team, assessment conducted with the agile coach of the team

4.7.3 FEEDBACK FORM

A feedback form is used to evaluate the perceived usefulness and quality of the Workshop format. Therefore, the following questions are developed. A mixed approach is applied with a Likert Scale, and an open response possibility is provided to capture open points. The form can be accessed within APPENDIX C: FEEDBACK F.

1. How comprehensible were the examples? (LIKERT SCALE)
2. How well did you find yourself in the examples? (LIKERT SCALE)
3. Were you able to easily identify similar problems from the list of examples? (LIKERT SCALE)
4. How relevant do you think the problems discussed are to your daily work? (LIKERT SCALE)
5. What has remained open? What would you like to tell us? (OPEN RESPONSE)

4.7.5 EXPERIMENTAL TESTING: WORKSHOP RESULTS

In the following, the results are discussed along the Evaluation Dimensions. The results of the workshop are completely anonymized. Further, a general analysis is undertaken, where similarities between the participants, as well as unique results are explicitly highlighted.

ENSURE HEALTHY TEAM DYNAMICS AND FUNCTIONING

TEAM 1

Results yielded, that within the team no general absence of trust is observable. Different opinions are explored thoroughly, giving rise to everyone's voice. Issues can be observed, when "emotionally" topics (such as collaboration issues with other teams or single persons) arise, shifting discussions on a systemic level, which quickly leads to personal sensitivities coming to the fore and attitudes being defended, which is to be expected.

Within mixed problem-solving meetings (where some members of the team and or the participant attends), the commitment is often low, which is indicated by low participation and a small group leading the discussion.

TEAM 2

In the intercultural setting, members often hesitated to come up with their ideas, which was an aspect, when the team was founded. A steep hierarchy at the Indian site was mentioned as barrier, where the Indian colleagues were not used to work in an agile and flat hierarchy.

Within the broader setting of the overall application engineering team (where the participant is located and leads the sub team with Indian colleagues), members often defend their own ideas, and the overall team leader, exerts a strong technical influence. In this sense, not all perspectives and voices are respected and thoroughly explored. Optimization potentials could be identified.

TEAM 3

The assessment showed that some ideas find less acceptance (feeling of being taken less seriously), where much criticism, talking things down, and less pro-active will to change characterizes the situation in the broader organization's context (mixed meetings to problem-resolution). The team itself, is describe as relatively neutral, but has no real team cohesion, as it consists of experts, mostly working side by side rather than together. This was said to be due to their specialization, making it hard to cooperate.

MANAGEMENT OF THE INFORMATION- AND KNOWLEDGE-FLOW

TEAM 1

The assessment showed inconsistent meeting discipline, with unclear agendas leading to uncertainty about expectations. Meetings often start with a problem introduction but lack clear responsibility or a structured path forward, especially in ad-hoc problem-solving teams (external to the team, where team members participate).

Especially those meetings in the broader organizational context (external to the team), lack clear timelines and deadlines, resulting in low urgency and limited accountability for meeting outcomes and follow-up tasks. Clarity improves after status meetings, but agendas remain inconsistent and vague, where written logs have improved over time.

Further, the lack of a skilled moderator was generally highlighted, but within the team, the role is fulfilled by team members on a rolling basis, which often yields good results in problem-solving and general meeting outcomes.

Role and job rotation are rarely used to facilitate knowledge sharing within the team. Time constraints and limited capacity were mentioned, which prevent regular implementation. A standardized approach is missing. Instead, knowledge transfer happens only on demand in urgent situations, rather than as a proactive and continuous practice.

Further, the team struggles to participate in Communities of Practice or similar formats for sharing knowledge and best practices. No dedicated platforms or structured offerings exist, except in leadership areas. In procurement, local formats are missing, and knowledge exchange happens only on request and in an ad-hoc manner. While a Global Purchasing Community exists, it is broad and mainly for managers, making it too high-level and not focused on practical, daily business needs.

A lack of structured information-sharing across teams, business units, and the organization as a whole was indicated. Meetings or dedicated formats for exchanging updates are either missing or occur irregularly, leaving teams isolated and unaware of activities outside their immediate scope. While there is some exchange with Spanish colleagues, broader technical and professional updates are lacking. It was explicitly highlighted, that this exchange would be very helpful.

There is no broader information sharing within the business unit, and teams struggle to gain an overview of projects, experiences, or supplier management. Deeper insights into the organization only happens when enforced, such as in specific projects.

TEAM 2

The assessment reveals that the team does not consistently document meeting discussions in a structured way, which risks losing valuable ideas.

While brainstorming sessions capture all ideas, general meetings in the broader context to the team lack a standardized documentation process. Meeting results are shared with participants, but in an informal and inconsistent manner (e.g., screenshots, Excel, Word), making it difficult to ensure clarity, accessibility, and long-term tracking of decisions and ideas.

Further, the team lacks an experienced external facilitator with problem-solving skills, and internal moderators often do not have the necessary expertise. Typically, the person who organizes the meeting also moderates it, without a structured facilitation approach.

Clear timelines and deadlines are often lacking, leading to low urgency and accountability for meeting outcomes. Some projects have no fixed deadlines and progress without clear direction. It is rare for meetings to result in concrete action items with deadlines, and tasks often end up in the team backlog without clear follow-up.

While role and job rotation are virtually nonexistent in the team, team members remain in their roles without conscious efforts to rotate professions. While mentoring exists between full-time employees and students, there are no structured mentoring programs for experienced colleagues to pair with less experienced ones at the departmental level. Additionally, as the assessed team is small, mentoring is often informal, with the team leader acting as the sole mentor for all colleagues. This lack of structured rotation and mentoring limits knowledge transfer and learning opportunities within the team, and in the broader departmental context.

TEAM 3

According to the participant, meetings often lack clear purpose, structure, and preparation, leaving participants unsure of expectations and outcomes. This is mostly observable in meetings in the broader context of the team's environment, where participants from different teams come together to address problems. In some cases, background information is missing, and no agenda is set, making it difficult for team members to prepare effectively.

Further the assessment indicates that meeting documentation is inconsistent and depends on the organizer, rather than following a standardized best-practice approach. Without formal records, valuable ideas risk being lost or overlooked, particularly if they are not frequently repeated or come from less vocal participants. As a result, some meetings are seen as unstructured and ineffective, with unclear value and objectives.

The team lacks a designated facilitator with the necessary problem-solving and moderation skills, which is also valid for the broader context in ad-hoc problem-solving or general meetings. Within the team, this is mitigated by rolling moderation from team members, yielding good results, as the team is relatively small.

Due to the absence of a facilitator in meetings, external to the team, it can happen that no one takes clear control of discussions, leading to dominant voices overshadowing quieter participants. Skilled facilitators are broadly missing. This issue is particularly evident in virtual meetings, where participants often feel interrupted or overwhelmed, while in-person meetings tend to be more balanced. The absence of structured facilitation limits inclusive discussions and effective problem resolution.

The assessment reveals that there are no standardized mentoring programs or structured job rotation processes to facilitate knowledge sharing within the team. While an onboarding program exists at the business unit level, mentoring relies solely on individual initiative rather than a formal system. As a result, knowledge transfer and learning opportunities are inconsistent, limiting the spread of expertise within the team and the business unit.

Further it was said that there are no formal Communities of Practice at the local level, making structured knowledge sharing difficult. However, a cross-location Community of Practice was independently established with Spanish colleagues, demonstrating proactive efforts. Additionally, a global “World Meeting” exists for discussing challenges, problems, and best practices, but due to its large scale and focus on defining global standards, detailed discussions are often lacking. While this setup creates opportunities for best practice exchange, it is not ideal, and knowledge sharing still relies heavily on individual initiative.

Formal practices for information sharing across teams are limited. While updates at the business unit and site level exist, there is little visibility into the activities of other teams, making it difficult to overcome team boundaries and stay informed.

MANAGEMENT OF THE KNOWLEDGE VALUE STREAM

TEAM 1

The assessment indicates that knowledge management systems doesn't fit the needs of the team. A key issue is the lack of descriptive documents, such as glossaries for abbreviations, which poses a challenge for new employees. While high-level processes are available, procurement-specific resources are limited, making it difficult to access relevant knowledge. Additionally, the team's specialized setting means there are no dedicated repositories where essential documents would be readily available.

Although standards are documented (high-level processes), daily business operations are largely missing from the organization's knowledge base. Instead, the team relies on internally documented best practices, highlighting a gap in formalized and accessible knowledge.

Further, accessing domain-specific expertise outside the team is often challenging, when the team is lacking the knowledge internally. Additionally, delays in obtaining necessary information or knowledge further reinforces a sense of isolation within the procurement organization. As a result, the team often resorts to solving issues independently, which, while fostering growth and adaptability, also highlights the need for quicker and more structured access to external knowledge sources.

Employees are rarely encouraged to participate in training and professional development, leading to missed opportunities for acquiring relevant job knowledge. While mandatory training sessions exist, they do not fully address the team's needs.

Internal procurement-related training, such as negotiation courses, is available for new employees, but the overall offering is insufficient, with training opportunities occurring at best once per year. Although the existing internal training is highly valued, the lack of specialized courses limits professional growth.

Additionally, general training programs are often not well-suited to the team's specific needs, and differences in workflow structures across procurement divisions further contribute to inconsistencies in learning opportunities.

Finally, the findings highlights that a lack of time and capacity prevents employees from developing new skills or expanding beyond their formal roles. Without sufficient resources or support, opportunities for professional growth and skill enhancement remain limited, restricting employee's ability to improve their work.

TEAM 2

The assessment pointed out, that knowledge management systems are fragmented and lack standardization, leading to scattered and unreliable knowledge sources. Everyone maintains their own system, but there is no shared repository at the team, department, or site-wide level. As a result, knowledge remains siloed, and local workarounds are used instead of a structured, accessible system for collective knowledge storage and retrieval.

The assessment further indicates that structured reflection on past performance and issues is rarely conducted, as retrospective meetings and similar formats are often skipped. There is little review of completed work packages, limiting opportunities to learn from past experiences and avoid repeating mistakes.

While some methods have been optimized, data on key metrics such as delivery performance, trends, and lead times are not systematically collected or analyzed. This lack of structured reflection and data-driven insights reduces the team's ability to monitor effectiveness and continuously improve their way of working.

Furthermore, new employees and promoted staff receive little to no structured training or preparation for their roles. Employee development is generally lacking, with few opportunities for professional growth or career-specific advancement.

There is minimal support from leadership in fostering technical expertise or career progression, leading to employees remaining in the same roles and tasks for decades without structured skill development. Additionally, individual development plans based on employees interests and abilities do not exist, further limiting opportunities for learning and progression.

TEAM 3

The assessment indicates that knowledge and experience are rarely formalized into structured documentation such as guidelines, manuals, or checklists, limiting the exchange of best practices.

Within the team, knowledge codification is challenging due to high specialization and a lack of cross-functional collaboration. Additionally, time constraints prevent proper documentation, meaning that expertise is primarily shared informally and used as needed rather than systematically recorded.

At the business unit level, for instance, engineering guidelines are missing. Even where guidelines are available, time pressure often leads to shortcuts or non-compliance, reducing their effectiveness in supporting knowledge transfer.

Knowledge repositories such as wikis and databases are fragmented, inconsistently updated, and lack organization-wide standardization, leading to scattered and unreliable information sources.

Different teams and individuals maintain their own wikis, resulting in inconsistent knowledge management. While temporary project-based SharePoint repositories exist, they do not provide long-term accessibility or structured knowledge retention. Additionally, local collections of information exist, but access to wikis relevant to specific professions is limited, making it difficult for employees to find and utilize critical knowledge efficiently.

Structured reflection on work processes and performance is rarely conducted, with retrospectives and similar formats not being adopted. There is little effort to evaluate goals, methods, and practices, leading to missed opportunities for continuous improvement.

The agile approach, including its retrospectives, has not been embraced, and a lack of understanding and engagement has resulted in frustration, reducing enthusiasm for meetings focused on reflection and improvement. Within the team, methods and practices remain static, while at the business unit level, it was said, that adjustments are made reactively rather than proactively.

Additionally, data collection and analysis are lacking, as key metrics like lead times are viewed as monitoring rather than valuable input for process optimization. While planning is in place, the team rarely revisits data for evaluation and long-term improvement.

In this team each member has a high degree of specialization, and it is often difficult to access expertise from other teams, departments, or external sources if internal knowledge is insufficient.

This challenge is largely due to a lack of designated points of contact beyond personal networks, making knowledge acquisition highly dependent on individual connections. Additionally, resource constraints, particularly time limitations, further hinder the ability to seek out and leverage external expertise efficiently.

Moreover, new employees and promoted staff receive minimal training and preparation for their roles. Onboarding and transition support are superficial, leaving individuals without the necessary guidance to fully adapt to their responsibilities. Additionally, there is little structured support, making it difficult for employees to develop the skills needed for their new positions effectively.

Further the assessment reveals, that employees are encouraged to develop new skills, but lack the necessary time and resources to do so. While there is an expectation to engage in skill development, it is left to individuals to find the time and manage it on their own, without structured support. As a result, opportunities for growth remain limited, as daily responsibilities take priority over professional development.

DRIVE PROBLEM-SOLVING METHODOLOGY

TEAM 1

The assessment showed that while the team recognizes the importance of customer value, it does not always fully consider it during problem-solving. The approach tends to be one-dimensional, often focusing on details while losing sight of the bigger picture.

Systemic impacts of decisions on the customer are not thoroughly analyzed, and the question of how changes affect the customer is often overlooked. This suggests a lack of customer focus, with problem-solving occurring in siloed thinking rather than a holistic, customer-centric approach.

Further on, it was indicated that the team tends to jump to solutions without fully understanding or discussing the problem components. Instead of conducting a thorough root cause analysis, the focus is often on treating symptoms rather than addressing underlying issues.

Preventive measures are rarely prioritized, with corrective actions being more common. While this is not always the case, it occurs frequently enough to underscore the need for a structured, data-driven problem-solving methodology. The absence of a standardized approach further contributes to this issue and implementing one could significantly improve problem resolution.

TEAM 2

The results indicate that while the team acknowledges the importance of customer value, it does not always fully consider it during problem-solving. Due to time constraints, solutions are sometimes developed without thoroughly analyzing customer needs, leading to decisions that may not align with customer expectations. A deeper analysis would be beneficial, but time pressure was said to be a main obstacle.

Besides that, the team tends to quickly settle on minor adjustments to existing standard approaches rather than developing comprehensive solutions. Often, the problem is not analyzed in depth, and a quick transition to solutions is observable.

Due to limited expertise within the team, derivatives from existing standards are more common, but across the department, the general approach remains to work with what already exists and make minimal modifications.

Time pressure, cost constraints, and other limitations were said to often prevent in-depth problem analysis, leading to a focus on quick solutions rather than thorough exploration. While ideas are collected, they are frequently discarded due to resource constraints, pushing the team toward the simplest and most immediate option. This reactive approach is more common in customer projects, whereas R&D projects allow for deeper analysis and solution development.

While problem-solving methods like TRIZ are mentioned, they are not consistently applied. Their application is more observable in innovation projects, dedicated to R&D, but in routine, structured methodologies tend to be neglected. This suggests a need for a more systematic approach to problem-solving.

TEAM 3

The assessment indicates that the team tends to focus on minor adjustments to existing standard approaches rather than exploring comprehensive solutions. Ideas are only briefly considered, and in-depth discussions on alternative solutions are rare.

A key reason for this was said to be their limited time resources, which often prevents the team from collecting and thoroughly analyzing relevant data before making decisions. As a result, problem-solving remains surface-level, with solutions being developed based on quick assessments rather than a data-driven approach. This constraint limits innovation and the ability to address issues at their root cause.

4.7.6 SUMMARY AND DISCUSSION

ENSURE HEALTHY TEAM DYNAMICS AND FUNCTIONING

The assessment highlights common challenges across all three teams in collaboration, openness, and engagement in broader organizational settings. Within their immediate teams, no fundamental trust issues were observed, and different opinions are generally considered. However, in broader problem-solving meetings, participation tends to be low, with small groups leading discussions while others remain passive.

In hierarchical or intercultural settings, team dynamics are more complex. Team 2 noted that Indian colleagues, coming from a steeper hierarchy, initially hesitated to share ideas, and within the larger application engineering team, strong technical leadership limits open discussion. Similarly, Team 3 reported that ideas are sometimes dismissed or overly criticized, leading to low motivation for proactive change. The lack of team cohesion in Team 3, where members work more side by side than collaboratively, further reinforces this issue.

While each team operates differently, broader organizational meetings often struggle with engagement, inclusion, and trust in diverse perspectives, pointing to a need for better facilitation and cultural adaptation in collaborative settings.

MANAGEMENT OF THE INFORMATION- AND KNOWLEDGE-FLOW

The assessment uncovered common challenges across all three teams, particularly in meeting discipline, facilitation, and knowledge sharing. Meetings often lack clear agendas, structure, and documentation, making it difficult for participants to prepare and track decisions. Deadlines and follow-ups are inconsistent, leading to low urgency and accountability for meeting outcomes. A standardized best-practice approach is generally absent.

None of the teams have dedicated external facilitators, and meeting moderation often falls to the organizer, which can result in unstructured discussions where dominant voices potentially take over.

Knowledge sharing is another major challenge. Job rotation and mentoring programs are missing or informal, limiting expertise transfer. While some proactive efforts exist, such as independent Communities of Practice, formal knowledge-sharing structures are largely absent or doesn’t fit the needs. Information exchange across teams and business units is weak, leaving teams often unaware of broader organizational activities.

MANAGEMENT OF THE KNOWLEDGE VALUE STREAM

Across all teams, knowledge repositories are fragmented, inconsistently updated, and lack standardization, leading to scattered and unreliable knowledge sources. Teams rely on individual or local workarounds, and formal documentation of best practices is either missing or incomplete.

Additionally, structured reflection on past work and performance is rarely conducted (2/3 Teams), with retrospectives and continuous improvement processes being largely absent.

Access to external expertise is a recurring issue, as teams struggle to tap into knowledge beyond their immediate networks. This is compounded by resource constraints, particularly time limitations, making it difficult to seek out relevant information efficiently.

Training and professional development opportunities are insufficient across all teams. New employees and promoted staff receive little structured onboarding, and career development is largely absent. While there is an expectation for employees to develop new skills, the lack of time and structured resources makes this difficult, leaving skill-building largely up to individual initiative.

Overall, the findings reveal that teams operate in knowledge silos, lack structured learning and reflection processes, and face barriers to accessing expertise and development opportunities.

DRIVE PROBLEM-SOLVING METHODOLOGY

The assessment unhides common challenges across all teams, particularly in problem-solving depth, customer focus (2/3), and time constraints. While all teams acknowledge the importance of customer value, they do not consistently integrate it into their decision-making processes. Problem-solving is often one-dimensional, focusing on immediate details rather than considering broader systemic impacts on the customer. Time pressure further worsens this issue, leading to quick decisions without thorough analysis.

Across all teams, problem-solving tends to rely on minor adjustments to existing approaches rather than exploring comprehensive solutions. Root cause analysis is often overlooked, and solutions are developed based on symptom treatment rather than preventive measures. Limited time and resource constraints further prevent in-depth discussions and systematic data collection, making problem resolution more reactive than proactive.

Additionally, while structured problem-solving methodologies are known (TRIZ, PDSA), their application is inconsistent. This highlights a need for a more standardized, data-driven methodology to enhance problem resolution and innovation across all teams.

CONCLUSION AND DISCUSSION

Overall, the findings reveal a need for structured collaboration, formalized knowledge-sharing mechanisms, improved facilitation, and a systematic approach to problem-solving. Strengthening cross-team communication, mentoring, training, and standardized methodologies will enhance efficiency and long-term OL.

The workshop yielded very satisfactory results, meaning that the format was capable in gathering deep insights to the different teams working reality. Not only team specifics and characteristics were detected, but also structural issues could be identified. Thereby, the results highlight issues on department, business unit, as well as cross-site level, bringing deep insights to the overall organization and related improvement possibilities.

By strengthening the introduced Lean KW Practices, the related Wastes can be attacked in a systematic manner. An overview is presented as follows in Figure 18 - Practices and Wastes:

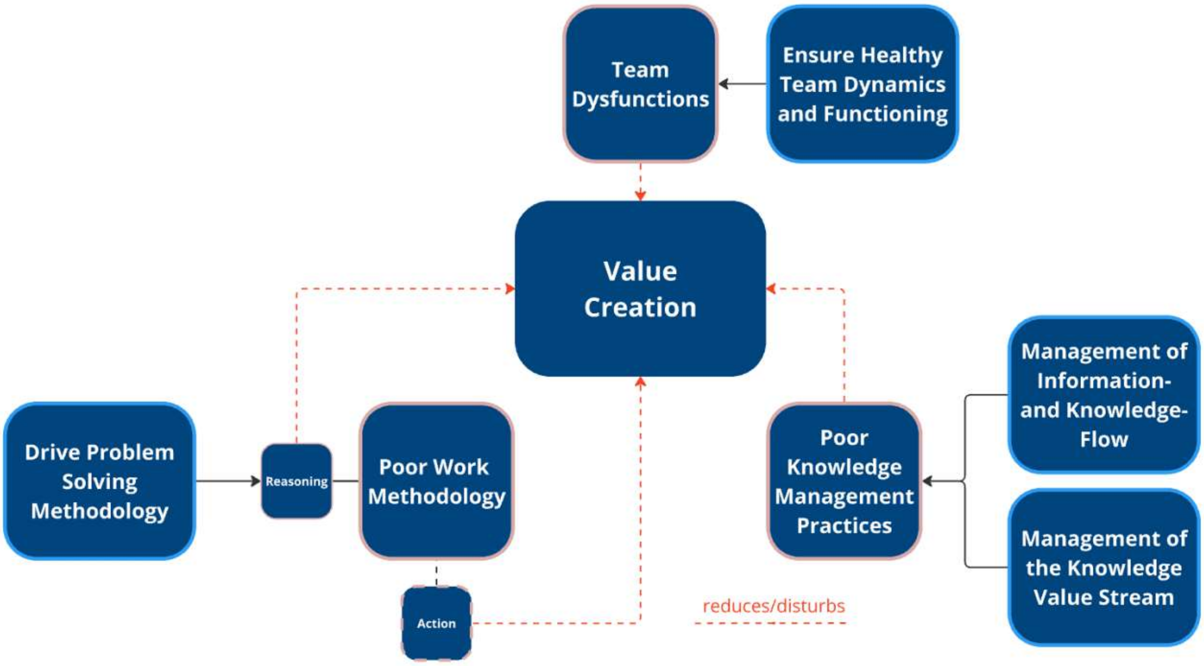


Figure 18 - Practices and Wastes

4.7.7 QUALITY ASSURANCE: FEEDBACK FORM RESULTS

The Likert Scale results (Figure 19) indicate a consistently high average rating of 4.33 across all evaluated aspects, suggesting that participants found the examples comprehensible, relatable, and relevant to their daily work. Additionally, they were able to easily identify similar problems from the provided examples by abstraction.

These results reflect a strong alignment between the workshop content and participants needs, indicating high perceived usefulness and clarity of the format.

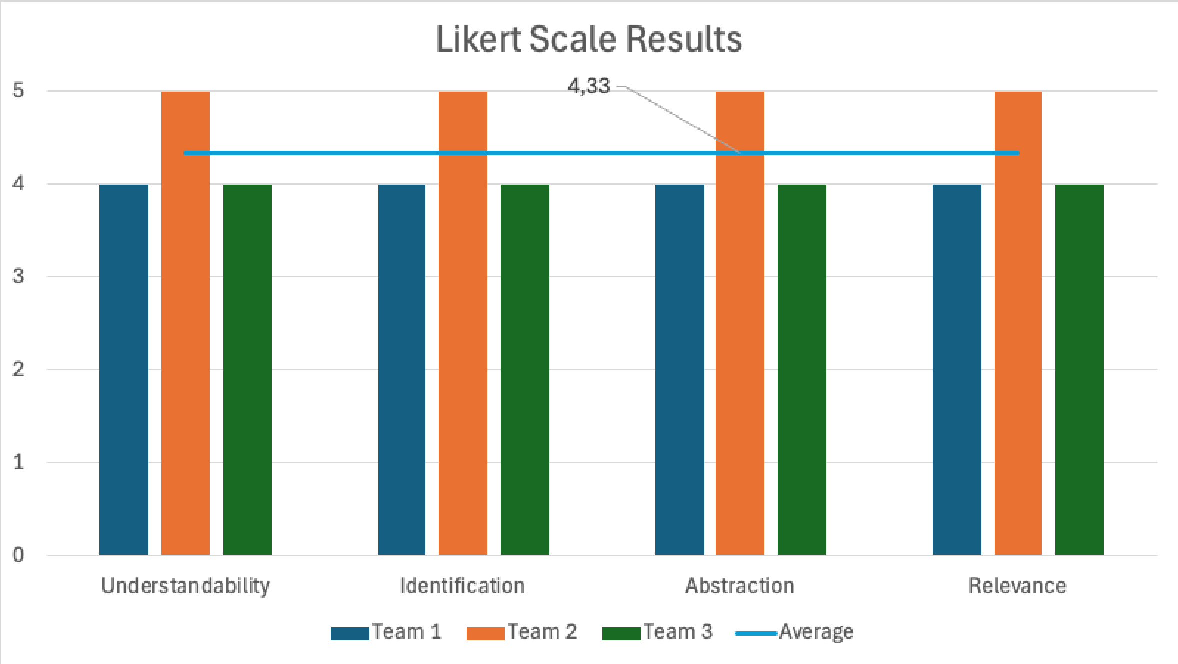


Figure 19 - Likert Scale Feedback Results

The open responses provide valuable insights into individual experiences with the workshop. While one participant initially struggled with comprehensibility, the moderator's guidance helped clarify the content, highlighting the importance of facilitation in ensuring understanding. This potentially opens possibilities for future improvement.

Another participant found the workshop particularly useful for self-reflection, emphasizing that the examples provided a quick and relevant reference to their own work. These responses reinforce the overall positive feedback from the Likert Scale results.

Figure 20 shows the time consumption for each run of the format. Where initially 90 minutes were needed to onboard the participant to the topic and perform the assessment, the last run only consumed 75 minutes. This can be explained by the moderator's learning curve in dealing with the newly introduced format. Overall, the objective to obtain results after a maximum of 2h assessment was therefore achieved with ease.

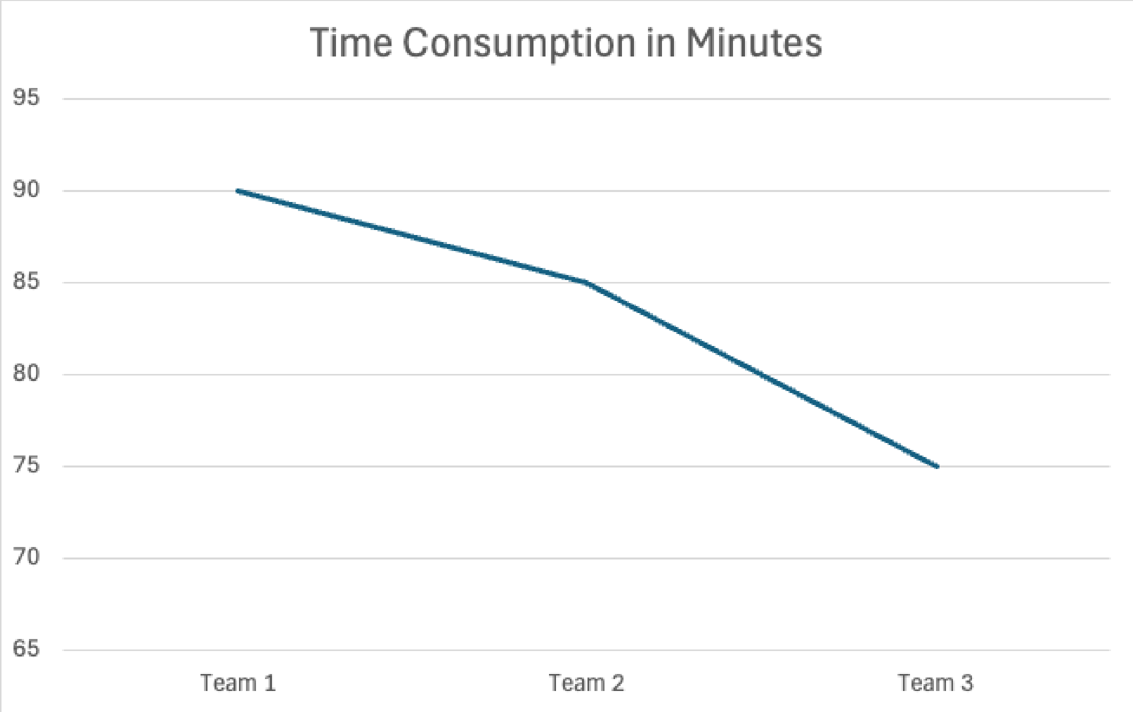


Figure 20 - Time Consumption

5. CONCLUSIO AND OUTLOOK

5.1 CONCLUSIO AND DISCUSSION

RECAP

This research aimed to develop a structured and universally applicable Waste framework for KW (O1) and explores its operationalization and practical application in agile, cross-functional teams (O5–O8). To achieve this, a Variation based view was applied through the Lenses and Principles of Lean, addressing the root causes of Waste (O2). Knowledge processes and information handling as key focal areas were emphasized (O3).

The study was guided by the following research questions:

R1: *How can a holistic and universally applicable Waste Framework be defined for the KW domain to enable structured Waste reduction from the Lean Perspective?*

R2: *How can the framework be operationalized so that the occurrence of Wastes can be detected?*

> *R2a: What are the Dimensions and their Attributes to evaluate the identified Wastes from the Lean Perspective for KW?*
>
> *R2b: Which Indicators serve to assess the occurrence of the Wastes?*
>
> *R2c: What format serves to conduct the assessment and how is it applied and facilitated?*
>
> *R2d: How well does the developed format serve to identify Wastes?*

SUMMARY

The study successfully developed a holistic and structured Waste Framework for KW (O1), allowing for a universally applicable assessment of Wastes (O5).

Based on the development of a model for Value Creation in KW, which was derived from the aspects of OL and the Intellectual Bandwidth Model (O3), three major Waste categories were defined: *Team Dysfunctions, Poor Knowledge Management Practices, and Poor Work Methodologies*.

This model introduces a Variation-based (Flow Lense) perspective on Waste in KW contexts, as it is derived directly from the conditions, conductive to create value and incorporates the attributes, that enable a team or an organization to face uncertainty within KW. Thus, addressing the root causes of Variation based Wastes (O2).

Further, it aligns with the Organization Lens by addressing human behavior and biased thinking, as well as it incorporates a Flow Lense perspective, by incorporating the Knowledge- and Information-Flow Principle within the KM aspects. In advance, the outlined Framework introduced modularity in a way, that is allows for Process Lens Waste categories to be attached to it, which is consistent with existing domain-specific approaches.

Finally, it could be shown that the model broadly aligns with the work of Ellis (2020) and is one abstraction level above the model.

To operationalize the framework (R2), I defined Dimensions and Attributes to evaluate the identified Wastes from the Lean Perspective for KW (R2a). They are found on the Lean Principles for KW and findings related to problem-solving ins teams, as well as OL, and KM. They incorporate ingredients of two established assessment tools.

They serve two key purposes: (1) acting as evaluation dimensions for the assessment tool based on their defined characteristics and (2) providing a Lean KW perspective to guide practitioners in Continuous Improvement through actionable Practices in addressing the Wastes (O5).

Namely they are *Ensure Healthy Team Dynamics, Management of the Information- and Knowledge-Flow, Drive Problem Solving Methodology,* as well as *Drive Work Execution Methodology* (where the latter is not included in the scope of this work (O6)).

Further on, I developed Indicators to assess the Wastes based on established Methods and according to the introduced Dimensions (R2b).

A format was designed as qualitative workshop (R2c) (O7), ensuring that it is fast and lightweight for practical use (O8). Thereby, the solution is a team-specific workshop format designed for team leaders. Facilitated by a Lean Specialist, the workshop is conducted in a one-on-one setting to ensure psychological safety and encourage honest insights from participants. The final workshop is delivered digitally using the online tool MIRO, enabling interactive and engaging sessions.

The evaluation showed that the developed format effectively identifies Wastes (R2d). It successfully identified team-specific characteristics (O6) as well as issues at the department, business unit, and site levels, providing valuable insights for organizational improvement. The findings highlight the need for structured collaboration, formalized knowledge-sharing mechanisms, improved facilitation, and a systematic approach to problem-solving.

Finally, the workshop format successfully met the objective of fast and lightweight application, with assessment durations decreasing from 90 minutes to 75 minutes as the moderator's efficiency improved. This indicates that the format is well-structured and adaptable, allowing facilitators to quickly onboard participants while maintaining quality.

The high Likert Scale ratings (4.33) across all aspects confirm that participants found the examples comprehensible, relevant, and useful for reflection, demonstrating strong alignment with their needs. The open responses further emphasize the importance of facilitation, as moderator guidance played a key role in ensuring participant understanding, and possibilities to abstract to similar situations and settings.

THEORETICAL AND PRACTICAL CONTRIBUTION

This research contributes to the academic discourse by addressing the lack of a structured and universally applicable framework for Waste in KW. Existing studies have primarily focused on domain-specific adaptations of Lean Waste categories, leading to highly context-driven approaches that limit generalizability. By developing a holistic Waste framework, this study provides a theoretically grounded model that extends beyond sector-specific applications and integrates a Lean perspective tailored to KW environments.

Furthermore, this research advances the understanding of Variation (Uncertainty) in the context of Waste in KW, emphasizing its role in Value Creation through overall KM, learning, problem-solving, iterative work execution, and team collaboration. While previous studies have largely focused on observable Wastes, this study shifts the perspective toward underlying drivers, bridging a critical gap in literature.

The framework applies the Lean Lenses (Process, Flow, Network, Organization) to KW, and shifts the focus on knowledge processes and information handling, reinforcing Lean’s applicability beyond manufacturing and service industries.

While Lean has been widely explored in manufacturing and service industries, its application to knowledge-intensive work remains underdeveloped. By linking Lean principles to KW through an operationalized framework, this research extends theoretical models and provides a foundation for future empirical studies.

Lastly, the study introduces an assessment methodology in the form of a structured, qualitative workshop format, enabling empirical exploration of Lean principles in KW contexts. The format allows for practical validation of Lean Waste concepts in (agile), cross-functional teams, offering a scalable and adaptable research tool for future studies.

By addressing these gaps, this research contributes to the evolution of Lean Thinking in KW, providing both a solid theoretical foundation and an actionable framework that supports structured Waste identification and its reduction through continuous improvement in knowledge-intensive environments.

In conclusion, this research bridges the gap between Lean Thinking and KW by providing a structured framework for Waste identification and a practical assessment tool for agile teams. By shifting the focus from symptom reduction to root cause analysis, this study paves the way for more effective and sustainable Lean implementations in KW environments.

5.2 LIMITATIONS AND OUTLOOK

While this study provides a structured and universally applicable Waste framework for KW, several limitations must be acknowledged, along with opportunities for future research.

First, the Lean KW Principles applied in this research were derived from existing literature and adapted for this study's framework. However, a more formalized and standardized description of these principles and their corresponding assessment items remains an area for future refinement and validation. Establishing a consistent theoretical foundation for these principles would strengthen their applicability across various KW contexts.

Second, the Work Methodology dimension, particularly the Agile Work Methodology Assessment, was not included in this study's scope. Future research should expand on this aspect to provide a more comprehensive perspective, ensuring that the framework captures not only KM, team dynamics and problem-solving but also work execution methodologies. This would enable a full-spectrum assessment of Lean in KW environments.

Additionally, while the artefact effectively operationalizes the Waste Framework using problem-solving, team dynamics, and KM-related indicators, it remains partially dependent on existing assessment tools. Future work should focus on developing more independent assessment indicators that span all four dimensions—including a more precise set for team functioning and a complete one for work execution methodology—to create a more balanced and self-contained evaluation model.

In conclusion, this study lays the foundation for structured Waste identification and Lean KW assessment, but further research is needed to formalize Lean KW Principles, integrate work execution methodologies, and develop more independent assessment metrics. These advancements would enhance the framework's robustness, applicability, and completeness, ultimately supporting more effective Lean implementation in KW environments.

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FIGURES

TABLES

APPENDIX A: INDICATOR LIST

A1: ENSURE HEALTHY TEAM DYNAMICS AND FUNCTIONING

Practice / Variable	Indicator / Statement	Description	Measure	Origin	Acronym
Knowledge Sharing	Colleagues seldom proactively provide their knowledge and experience if someone has difficulty in completing their work.	Willingness to share knowledge with other team members.	Mutual Trust Conflict	Knowledge Management (SECI - Socialization)	TDF1
Team Interaction Style	During Team Problem-Solving activities, team members often defend their own ideas, leading to minimal constructive debate and shallow discussions that do not explore the strengths, weaknesses, or reasoning behind different perspectives.	Describes how team members react to opinions and perspectives that differ from their own.	Mutual Trust Conflict	Team Problem-Solving (TPSAT)	TDF2
Team member participation	Not all members are actively involved in the problem-solving process. A minority of the team is running the debate on the problem, where some members don't contribute.	Indicates the degree of involvement of members in the team's problem-solving efforts	Mutual Trust Conflict Individual Commitment	Team Problem-Solving (TPSAT)	TDF3

A2: MANAGEMENT OF INFORMATION- AND KNOWLEDGE-FLOW

Practice / Variable	Indicator / Statement	Description	Measure	Origin	Acronym
Communication Practices & Management of Interactions					
Problem Definition	1) The team does not clearly define the purpose of meetings in advance, meetings are unplanned and lack structure. 2) Background information (e.g., on the problem) is not provided, and there is no indication of what the team should accomplish during each meeting. 3) No agenda has been developed. Members have little or no understanding of what is expected of them or what to expect during the meeting.	Represents how much the team knows about their meetings and what is expected of them during those meetings	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF1
Written logs of Meetings	The team does not keep a written log for the meeting, visible to all members afterwards. Consequently, the rich diversity of ideas is not recorded, leading to ideas being overlooked based on who contributed them or because they are not frequently repeated.	Refers to the team's thinking and deliberations being recorded for all to see during their meetings	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF2
Meeting Facilitation	1) We have no expertized facilitator, skilled in problem solving, from outside the team who runs the meeting. 2) The team has either no member designated to run	Availability of a Facilitator and availability of respective skills	Management of Interactions	Team Problem-Solving (TPSAT)	IKF3

	meetings with the purpose of problem-solving and/or the facilitator is lacking problem-solving and facilitation skills.				
Pressure to solve the problem	The team lacks a clear timetable or fixed deadlines, resulting in no pressure on members regarding the outcome of their meetings and resulting tasks.	Availability of action plans and follow ups to solve the problem after meetings	Meeting Discipline	Team Problem-Solving (TPSAT)	IKF4
Transfer of Knowledge, Information & Knowledge Sharing					
Mentoring Practices	1) We are lacking mentoring programs that would pair experienced workers with new or less experienced colleagues to facilitate knowledge transfer and learning. 2) We don't or barely make use of role and job rotations to spread knowledge and experience within the team.	Knowledge sharing through Mentoring and Job Rotations	Information Redundancy and transfer of knowledge	Knowledge Management (SECI - Socialization)	IKF5
Knowledge Sharing	We don't, or have difficulties, to attend in communities of practice, or other formats, to share knowledge, experience, and best practice with other colleagues from the organization.	Sharing through social networks like Community of Practices	Information Redundancy and transfer of knowledge	Knowledge Management (SECI - Socialization)	IKF6
Organizational Communication	1) We are rarely informed about activities in other teams, business units or the whole organization. 2) Meetings or other formats with the purpose of information sharing. are missing or are irregularly held.	Norms and formal practices to share information and news, keep colleagues updated, and to overcome hierarchical levels, as well as boundaries between	Information Availability	Knowledge Management (SECI - Combination)	IKF7

		units of the organization			
Technical Support	We don't have, or have restricted access, to technologies that allow us to easily share knowledge and information between colleagues, different teams, units, and other parts of the organization.	Knowledge Management Systems (KMS) and tools that increase useful and fast transfer and access to information and knowledge	Information and Knowledge Sharing	Knowledge Management (SECI - Combination)	IKF8

A3: MANAGEMENT OF THE KNOWLEDGE VALUE STREAM

Practice / Variable	Indicator / Statement	Description	Measure	Origin	Acronym
Organizational Memory	We don't or rarely capture knowledge and experience by producing guidelines, manuals, rulesets, tutorials, checklists, or similar artifacts, that support knowledge transfer by best practice.	Practices like producing best practice collections, manuals, reports and other written documentation	Formalization of Knowledge in KMS	Knowledge Management (SECI - Externalization)	KVS1
Technical Support	Knowledge repositories, like Wikis or Databases, are not regularly updated, not standardized across the organization, or doesn't provide the needed functionality. This leads to scattered systems, unreliable resources of knowledge and information, or local workarounds.	Knowledge Management Systems (KMS) (repositories) actuality, standardization, and functionality	Quality of KMS	Knowledge Management (SECI - Combination)	KVS2
Team Reflexivity	1) We seldom or do not reflect on past performance and encountered issues by retrospective meetings or other formats, to avoid future repetition of failures. 2) We do not or barely collect and process data in order to monitor activities and their effectiveness. 3) We barely revise the efficiency of how we work. Meaning we often miss out on reflecting on goals, applied methods, and practices to adjust adequately.	Reflection within the team on own way of working, as well as on encountered issues and gathering of relevant data.	Analysis and Closed Feedback Loops	Knowledge Management (SECI - Externalization)	KVS3
Team member expertise	1) When we encounter problems in our domain we need to solve, we often lack the right expertise within the team. 2) If we are lacking the right expertise within	The amount of available domain-specific knowledge within and to the team	Information and Knowledge Availability	Team Problem-Solving (TPSAT)	KVS4

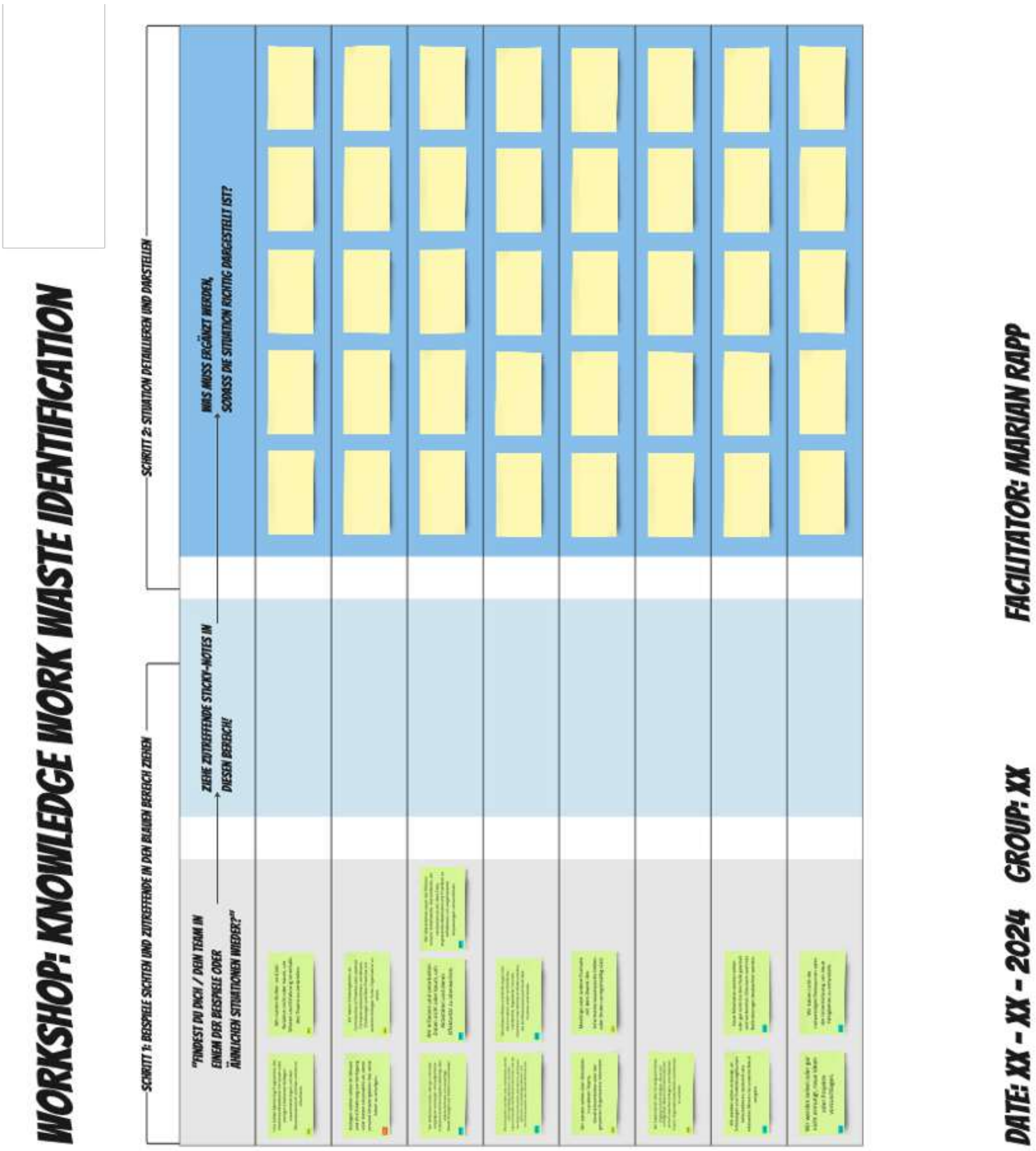
	the team, it is often difficult to access that expertise from other teams, units or external sources.				
HR Training	1) We are seldom encouraged to attend trainings and development courses, thus missing out relevant knowledge to our profession. 2) New employees rarely or do not get trained and prepared for their role. This might also be observable during promotions.	Learning processes designed to help employees assimilate new knowledge and reshape their mental models, whether for decision-making, work procedures, or to support role transitions	Availability of trainings relevant to the profession and role transitions	Knowledge Management (SECI - Internalization)	KVS5
HR Development	1) We are seldom or not encouraged to propose new ideas or projects. 2) We don't have the necessary resources or support for developing new skills.	Enabling people to understand the significance of their work, attribute meaning to their professional experiences, and appreciate their behaviors that go beyond formal role requirements	Opportunities to improve the own work, develop own skills, and to creatively participate beyond their formal role	Knowledge Management (SECI - Internalization)	KVS6

A4: PROBLEM-SOLVING METHODOLOGY

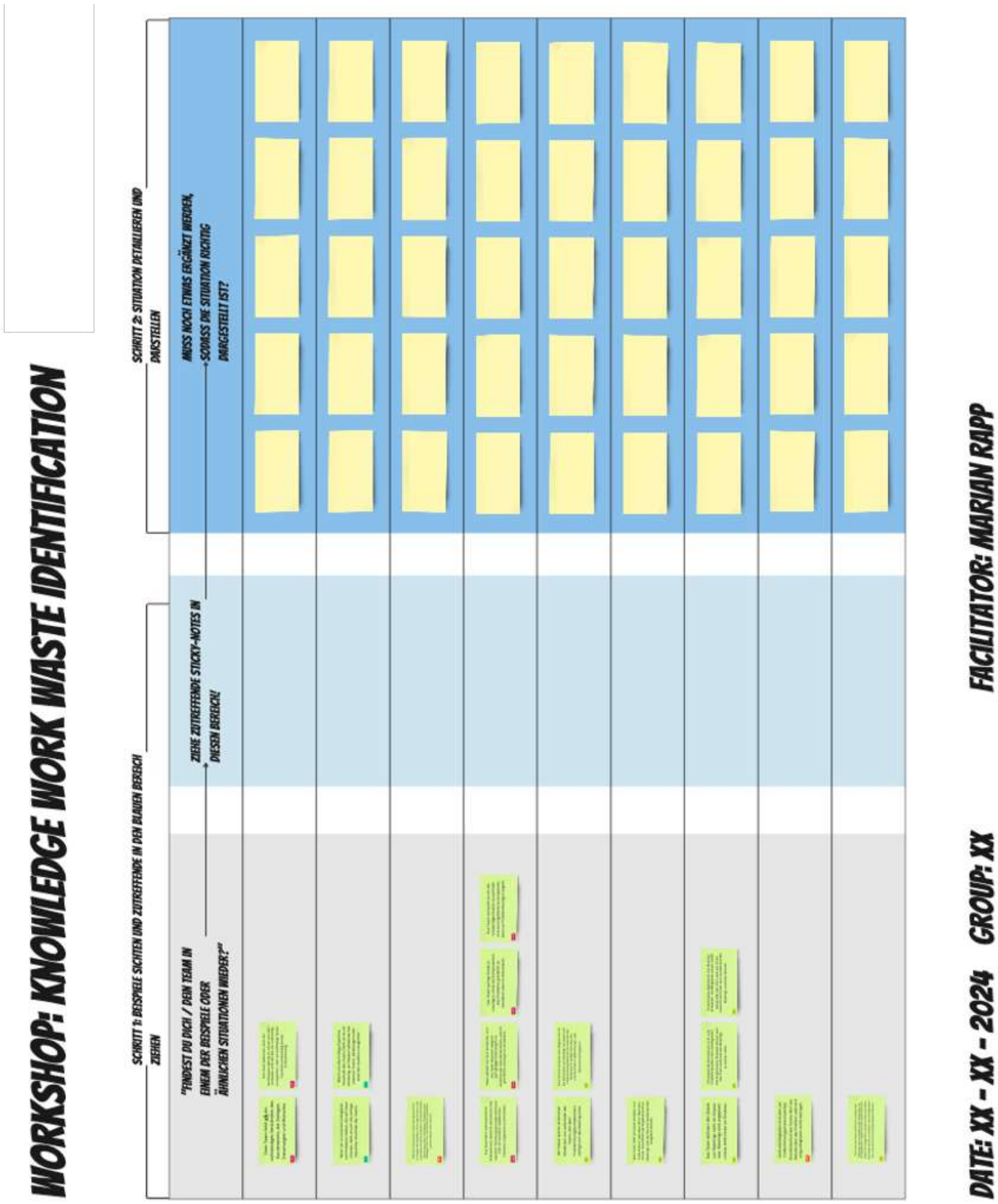
Practice / Variable	Indicator / Statement	Description	Measure	Origin	Acronym
Customer's Value	1) The team often lacks a full understanding of the customer's values—needs, concerns, expectations, and desires. 2) The team knows these values are important but does either not take the time to fully comprehend them or does not consider them when developing solutions during problem solving.	Refers to the extent to which the team understands the customer's needs, concerns, expectations, and desires, and considers them during problem-solving	Consideration of Customer Value	Team Problem-Solving (TPSAT)	PSM1
Systematic problem exploration and solution development	1) The team engages in unfocused discussions that jump between topics without a clear plan, often failing to explore any aspect of the problem in depth. 2) Ideas are only briefly considered, and the team merely debates minor modifications to standard approaches instead of developing thorough solutions. 3) The team jumps straight to solutions without thoroughly understanding or discussing the problem's components. 4) The Team often lacks gathering the necessary data and its in-depth analysis, when approaching problem-solving.	The process the team uses to explore the problem and develop a solution	Problem Solving Methodology	Team Problem-Solving (TPSAT)	PSM2

APPENDIX B: WORKSHOP DESIGN

B1: KNOWLEDGE MANAGEMENT PRACTICES (GERMAN VERSION)



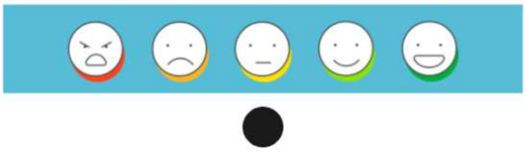
B2: TEAM PROBLEM-SOLVING (GERMAN VERSION)



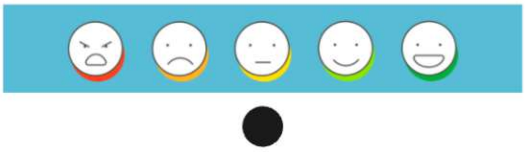
APPENDIX C: FEEDBACK FORM

BITTE NIMM DIR ETWAS ZEIT, UM DAS FOLGENDE FEEDBACKFORMULAR AUSZUFÜLLEN:

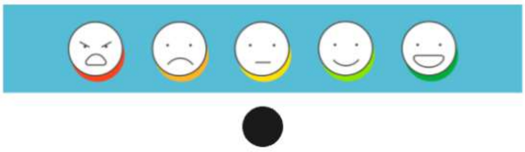
1) WIE VERSTÄNDLICH WAREN DIE BEISPIELE?



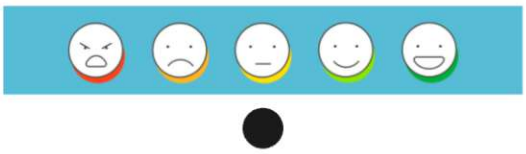
2) KONNTEST DU DICH IN DEN BEISPIELEN WIEDER FINDEN?



3) KONNTEST DU ANHAND DER BEISPIELLISTE ÄHNLICHE PROBLEME LEICHT IDENTIFIZIEREN?



4) FÜR WIE RELEVANT HÄLST DU DIE BEHANDELTEN PROBLEME IN BEZUG AUF DEINE TÄGLICHE ARBEIT?



5) WAS IST OFFEN GEBLIEBEN? WAS MÖCHTEST DU UNS MITTEILEN?