KNOWLEDGE SHARING IN AGILE PROJECTS

Exploring knowledge sharing patterns in agile projects around Philips Research context

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MSc Graduation Project

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by

Jiawen Wang

Defense on 31st Oct

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Project Duration

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PREFACE

This report is the result of an intensive and challengeable seven-month graduation project as the final part of my study on the Master of Science in construction management and engineering at the Delft University of Technology. Conducting this research not only fulfilled my interest in knowledge management but also introduced me to a modern management methodology – agile methods. Being someone who prefers to stay in control and favor of a certain level of predictability, this research offered me an excellent opportunity to learn about a more flexible management style than waterfall project management. Learning by doing, I conducted my research project applying the agile way of working – regular interaction with my "stakeholders" (graduation committee), working documents, and responding to consistent change!

I would like to thank my committee, without their guidance, feedback, and help, I would not succeed. Yan Liu, as my first supervisor, guided me through the graduation process, and he was always available and gave me constructive advice when I was uncertain about how to proceed. Next, I want to thank my company supervisor Patrick van den Heijkant, who provided me with this valuable opportunity in Philips. He always found time to discuss with me despite his enormous workload and provided me with indispensable practical insight on knowledge management. I want to also thank Leonore van den Ende for being part of my committee, as an anthropologist, her constructive feedbacks made my research more human-centered. Last but not least, thanks to Marcel Hertogh, who was very busy but still willing to be my chairman, and made me feel the trust and support.

Also, I'm very grateful to conduct this research in collaboration with Philips Research. Everyone I met and worked with was so friendly and always willing to help. Especially thank the Pepijn Wortelboer, Jan van Nijnatten, Rob in 't Groen, and Allard Breet in Research Knowledge Flow Team, who are passionate experts on knowledge management and worked dedicated to promoting knowledge flow within Philips Research. Their opinions and intensive involvement inspired me with diverse thoughts and insights. Also conducting interviews with Philip researchers and project managers as a part of the research that I enjoyed so much. The cooperation, openness, and enthusiasm of all interviewees were inspiring, and their valuable input made this research as it is.

Finally, I am grateful to have my family and friends who supported me throughout the process of the graduation project. They provided me with the energy and positivity I needed to overcome challenges along the way. Special thanks go to my best "investors" - my mom and dad, who never gave me pressure even I delayed graduating for two months :))

Jiawen Wang
Eindhoven, Oct 2019

EXECUTIVE SUMMARY

Introduction

The background of this study is that Philips Research organization introduced the agile project management method as a new project management method since 2016. It was concerned by Philips Research organization that there might be a decrease on the codified knowledge in the corporate knowledge base, as the Agile manifesto emphasizes "*working product or service* over *comprehensive documentation*" and "*individuals and interactions* over *processes and tools*."

Though agile methods were promoted to effectively empower knowledge sharing in software development, and continually spreading beyond software development projects to non-IT projects. Little was known on whether agile methods truly contribute to knowledge sharing in other types of projects in non-software development industries. The existing researches were limited by industry.

Above all, this research responds to the opportunity for knowledge sharing improvement under Research organization agile way of working. This graduation project aims to explore how Philips Research agile way of working influence knowledge sharing behavior and its efficiency. The outcomes of this explorative research contribute to an improved understanding on how people work in agile research projects share knowledge within projects and outside the projects, and what are the factors that influence the effectiveness of knowledge sharing in agile projects. The main research question is formulated as:

> ***Research question**: How can effective knowledge sharing be achieved under Philips Research agile way of working?*

Research Methods

This research can be described as practice-oriented qualitative research, semi-structured interviews as the primary research approach are chosen. Explorative studies, including literature study, explorative interviews, and desk research are conducted to give a better understanding of the research parameters: agile methods, knowledge sharing, and R&D context, and the relations between parameters. Also, this results in the conceptual framework with the identification of critical elements (people, process, tool) that are relevant to examine the agile-induced knowledge sharing characteristics and patterns in Philips Research.

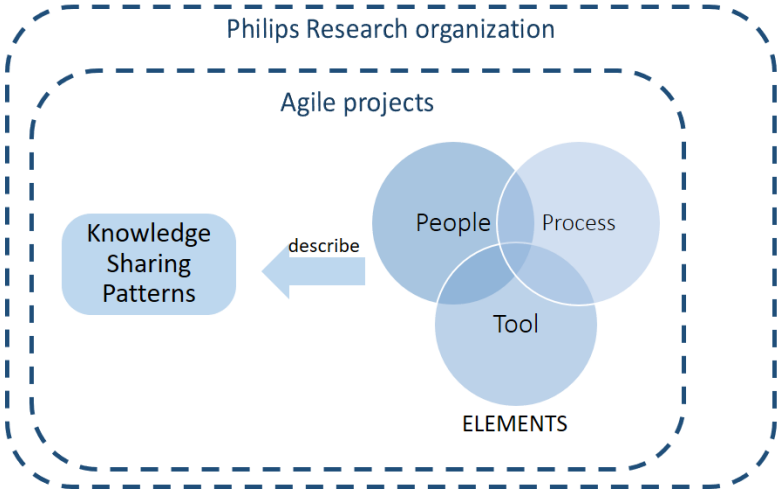

Figure 1 Conceptual framework of this study

The core of the research is the semi-structured interview. Detailed data on knowledge sharing characteristics of knowledge sharing situations in agile projects, the agile-induced inhibitors of knowledge sharing patterns, and possible solutions to stimulate better knowledge sharing are collected during the interviews. In total, thirteen interviewees, including project managers and researchers who are working in or used to work in agile research projects, are interviewed.

Research Findings

The summarized interviews are quantified by distinguishing agile-induced knowledge sharing situations and coding each one according to its characteristics in terms of agile-induced knowledge sharing tools, process, and actors and the relations between these three components.

Repetitive knowledge sharing situations enable the identification and prioritization of knowledge sharing patterns, based on the frequency of the occurrence of the codes during the interviews. The primary knowledge sharing patterns in agile projects in Philips Research are:

- **Imbalanced personalization and codification (tool perspective)**
- **Process misalignment (process perspective)**
- **Ignorance on the value of knowledge sharing (people perspective)**

Linking the identified agile-induced knowledge sharing patterns with qualitative interview findings enables the interpretation of what are agile-induced factors to inhibit knowledge sharing patterns in Philips Research. Causes of agile-induced knowledge sharing patterns are clustered and interpreted based on Wang's knowledge sharing behavior framework (shown in figure 2).

There are three **Environmental factors** identified as 1) *Agile team characteristics*: Agile cadence meetings and non-aligned knowledge sharing tools used in different projects created too much overhead for researchers. 2) *Agile process adoption*: No formal knowledge sharing process embedded in the agile project management process. 3) *Management support*: No responsibility for the agile management team to support knowledge sharing. Two **Individual factors** as 1) *Agile*

experience: Some people considered 'agile' as 'no documentation,' because of their limited experience of agile methodology. 2) *Perceptions*: Knowledge is considered as the value delivered to customers in agile projects. Moreover, two **Motivational factors**: 1) *Perceived benefits and cost:* Researchers perceived no adding value of existing complex documentations compared with personal interaction. 2) *Trust:* the Distributed agile team could inhibit knowledge sharing, and the agile project runs in a short period while building trust needs time.

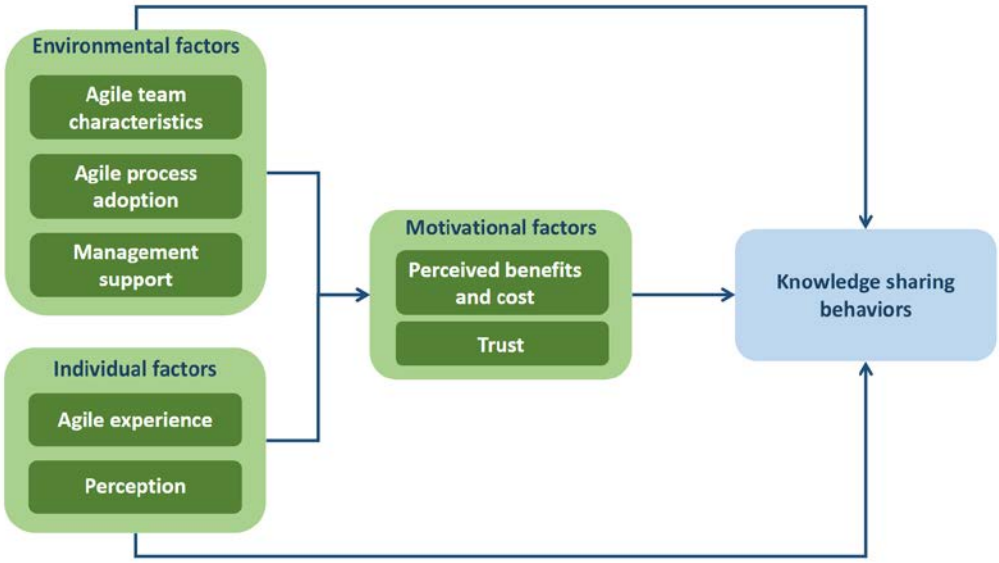

Figure 2 Framework on factors of knowledge sharing behaviors in agile projects in Philips Research

Proposed Solutions

Expert meetings are held after the completion of the interpretation of knowledge sharing patterns to identify the leading cause of ineffective agile-induced knowledge sharing in Philips Research. To cope with the prioritized cause, a solution of "Embedding codification in agile project process" is proposed. By allocating the primary KS elements knowledge sender & receiver and appropriate tools along the agile project process, a user-driven codification-focused knowledge sharing agile project process is obtained.

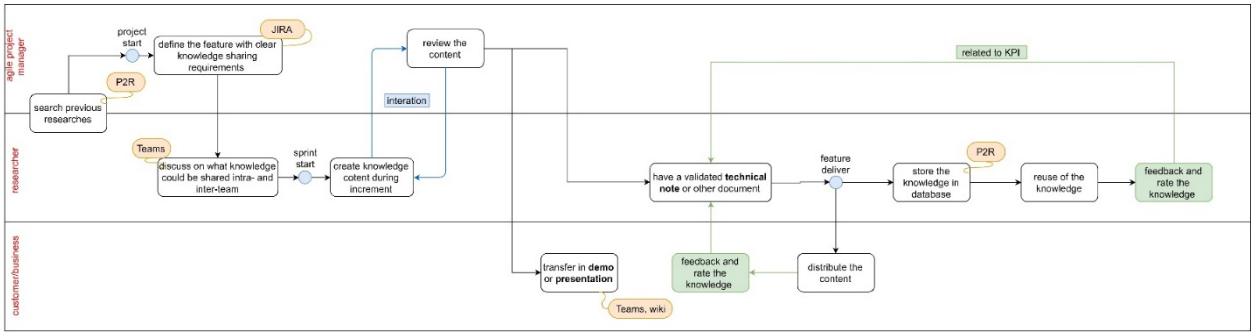

Figure 3 Proposed process to cope with imbalanced codification and personalization

Conclusion and Recommendations

Agile methods as knowledge sharing enablers reinforce personal interaction by emphasizing the value of individual interaction over process and comprehensive documentation. The paradox could be recognized that with the overemphasis on the intra-team knowledge sharing in agile projects, there is the potential of sacrificing long-term learning and organizational level knowledge sharing. The enablers could transform into agile-induced **inhibitor** on knowledge sharing to some extent. To achieve effective knowledge sharing in Philips agile research projects, the organization needs to **balance codification and personalization strategy** to leverage both intra-team and organizational knowledge sharing and **adjust agile methods to fit the rapid learning organization characteristics** rather than "do by the book."

CONTENT

LIST OF FIGURE

LIST OF TABLE

ABBREVIATION

COI: Community of interest

COP: Community of practice

CTO: Chief Technology Office

KM: Knowledge management

KMS: Knowledge management system

KS: Knowledge sharing

QMS: Quality management system

P2R: Portal to Research

PEPF: Philips Excellence Process Framework

PM: Project managers

PO: Product Owner

R&D: Research & Development

RTE: Release Training Engineer

SaiR: Scaled Agile practice

SM: Scrum masters

VSO: Value Stream Owner

PRAT I

RESEARCH INTRODUCTION

1. INTRODUCTION

The graduation research explores the knowledge sharing patterns and factors that inhibit knowledge sharing in agile projects within the research environment. This chapter presents a detailed introduction to the research topic. Section 1.1 introduces the research background, and sections 1.2 presents the motivation of conducting this research. Research scope, objective, and questions are explained in section 1.3 to 1.5.

1.1 Background

1.1.1 Knowledge sharing in R&D organizations

Knowledge is recognized as the most valuable organizational resource, which provides a sustainable competitive advantage in a competitive and dynamic economy environment (Wang & Noe, 2010). Research & Development (R&D) organization as the most knowledge-intensive part in a company, fosters high level of intellectual work, sufficient knowledge sharing, therefore, as the key to leverage knowledge assets in company's business performance and innovation (Cabrera & Cabrera, 2002; Jackson, Chuang, Harden, & Jiang, 2006). Besides, how to share and reuse knowledge has for long been a central issue for organizations in order to avoid reinventing the wheel (Santos, Goldman, & de Souza, 2015).

1.1.2 Fitting agile methodology within Philips Research organizations

Agile methods have initially been developed by software developers as an alternative to waterfall software development in 2001 before it broadly spreads to non-IT projects in multiple industries. The traditional waterfall approach is rigid and made it difficult for teams to adapt to changing requirements and evolving circumstances, while agile contributes to solving the problems (APQC, 2019; Serrador & Pinto, 2015).

The study was conducted in collaboration with Philips Research [1]. As a technology-based healthcare company, Philips subjects to constant change. Philips Research is the core to drive rapid change by fostering a high level of innovation and intelligent work in Professional Healthcare and Personal Health with 4,500 researchers globally (Leest, 2019).

In response to the rapid change and flexibility requirement of research projects, agile project management methods – *Scaled Agile* was introduced to Philips Research in 2016. Both traditional *Stage Gating Project Management* (PMSG, waterfall) and agile methods are used in Philips Research for delivering a regular project now (see the figure below).

[1] Philips Research: a global organization in the Philips Chief Technology Office (CTO) with research departments in Europe, North America, Africa and Asia. Both research and development projects are conducted with Philips Research. The Research organization structure can be found in appendix D.

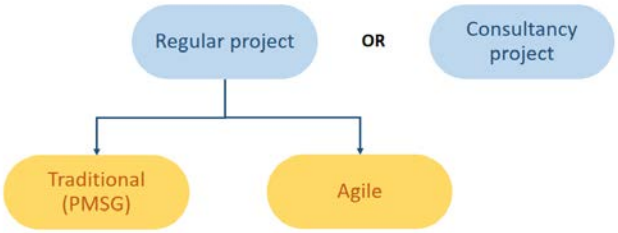

Figure 4 Project types in Philips Research organization

1.2 Motivation

1.2.1 Research gap

The paring of knowledge sharing and agile methodology has been addressed by some researchers (Dissanayake, Dantu, & Nerur, 2013), and most of the researches was conducted in the context of software development. As agile methodology has been continuing spreading beyond software development projects to non-IT projects (Dybå & Dingsøyr, 2008; Serrador & Pinto, 2015), little was known on whether the agile methodology is genuinely contributing to knowledge sharing in non-IT industries. The existing researches were limited by industry.

In addition, most researches emphasized the knowledge sharing enablers that were embedded in the agile approach (Dissanayake et al., 2013), only a few explained knowledge sharing barriers in agile teams. Further research on how agile inhibit knowledge sharing in non-IT organizations will help inform both practitioners and researchers to the real value of agile methodology.

1.2.2 Relevance of practice

In response to the agile way of working, people have more interaction and communication within agile project teams, which contributes to the improved quality on project deliverables, but have no emphasis on sharing project knowledge and insights on the organization-wide repository system. Philips has a concern that there might have a decrease on the codified knowledge in the corporate knowledge base, thus has adverse effects on knowledge reusing and reinventing the wheel.

1.3 Research Scoping

This study examines the knowledge sharing patterns and causes of patterns in agile projects within Philips Research organization. Therefore, the **unit of analysis** of this study is agile research project.

Definition of specific words used in this study:

- "**Knowledge**" mentioned in this study indicates that technical knowledge resulted from research project results, including both tacit and explicit knowledge.

- "**Agile methods**" used in the study indicate an iterative project management methodology, which is based on the same vision and core values.

1.4 Research Objective

This research aims to explore how Philips Research agile way of working influence knowledge sharing behavior and its effectiveness. The outcomes of this explorative research contribute to an improved understanding of how people work in agile projects share knowledge, and what are the factors that inhibit knowledge sharing in agile projects. From a practical point of view, a customized solution is proposed to solve the prioritized ineffective knowledge sharing pattern in Philips Research.

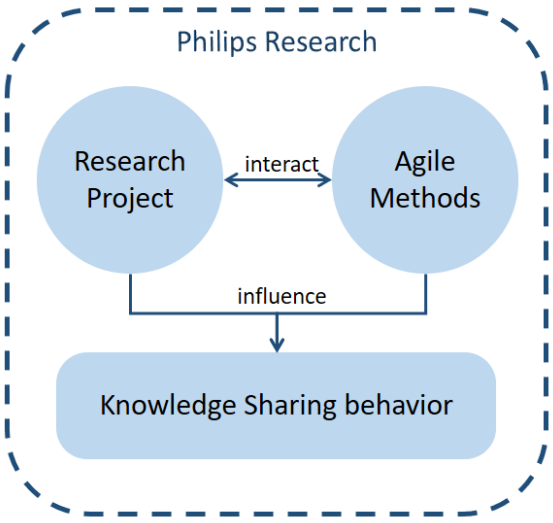

Figure 5 Relation between key parameters of research question (own illustration)

1.5 Research Question

"***How can effective knowledge sharing be achieved under Philips Research agile way of working?***"

To answer the main research question, sub-questions are answered in the following sequence:

SQ1: What are the implications of agile methodology on knowledge sharing in research projects?

SQ2: What are the knowledge sharing patterns in agile projects in Philips Research?

SQ3: What are the agile-induced factors that hinder knowledge sharing in agile projects in Philips Research?

SQ4: What measures can be proposed for the address the main knowledge sharing patterns in agile projects in Philips Research?

2. RESEARCH DESIGN

This chapter explains the research phases and methods used to collect and analyze relevant data needed to provide a valid answer to the research questions.

2.1 Research Phases

With the **practical-oriented** characteristics responding to practical challenges, this research study could be divided into five steps: 1) Problem analysis, 2) diagnosis, 3) design, 4) intervention and 5) evaluation (Verschuren & Doorewaard, 2010). As the main aim of this study is to explore how Philips Research agile way of working influence knowledge sharing behavior and its effectiveness, the focus of this study would be the diagnosis part, including analyze the knowledge sharing patterns and the factors inhibit knowledge sharing under Philips Research organization agile way of working. The evaluation (step 5) of the scheme in practice could be considered; however, exceeds the capacity of the graduation project, wherefore will not be performed.

These four steps create guidance through the thesis project. They can be linked to the project phases in terms of data collection and analysis methods presented in the next section. The formulated sub-questions will be answered through the research process, and contribute to the main research question. Figure 6 shows a schematic overview of the research approach.

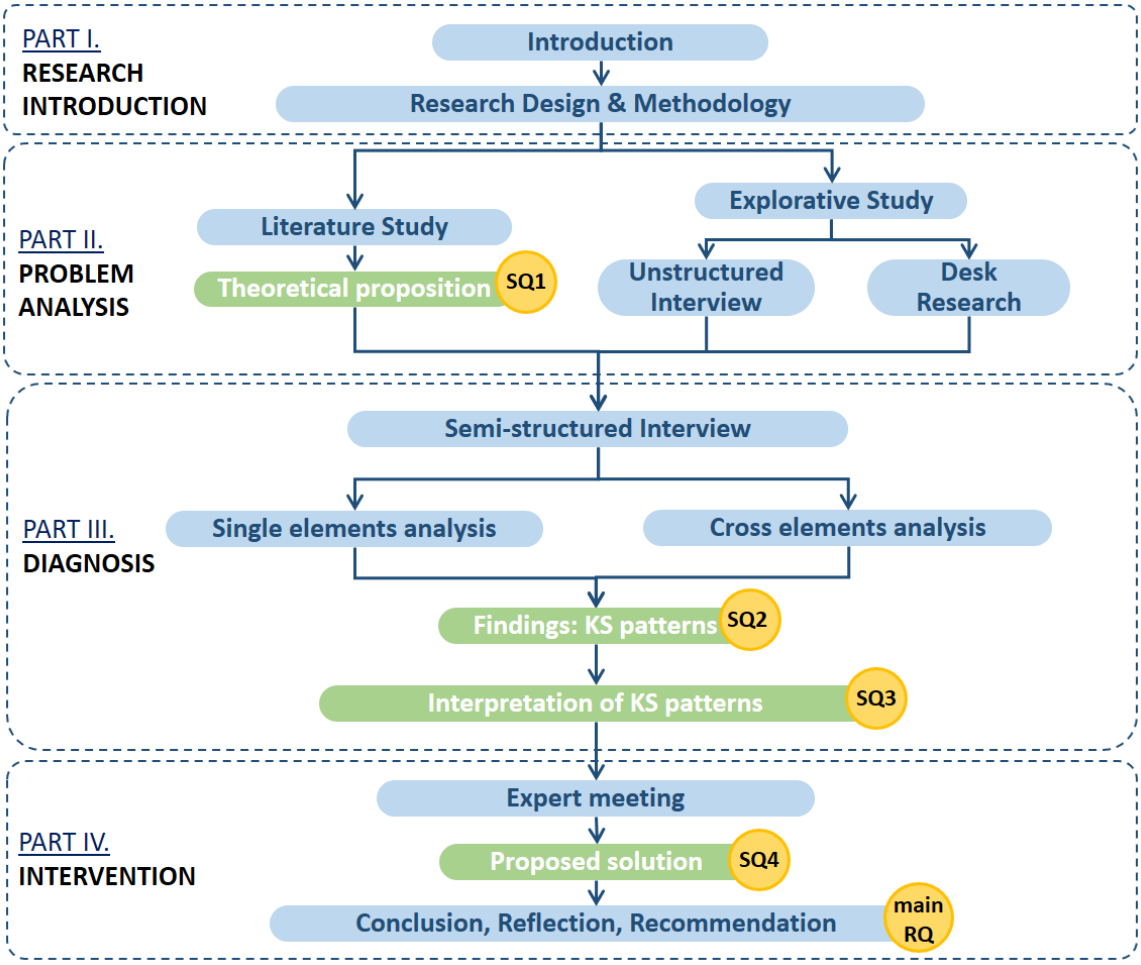

Figure 6 Schematic overview of research method (own illustration)

2.2 Research Methods

As practice-oriented **explorative** research responds to explore what are the knowledge sharing patterns in agile projects and what agile-induced factors inhibit knowledge sharing. The main research method applied is **semi-structured interviews** in order to collect in-depth data to elaborate this gap (Verschuren & Doorewaard, 2010). Besides, literature study, desk research, and unstructured interviews are conducted to gain a better understanding of existing theory and current knowledge sharing situation in agile projects in Philips Research organization.

2.2.1 Data collection

Desk research

Available documents, websites are reviewed to receive an understanding of the agile project practice and knowledge sharing processes. The choice of documents based on their relevance to the research in terms of agile methodology and knowledge management in Philips Research.

Unstructured Interview

Next to the desk research, unstructured interviews are conducted with practitioners in Philips Research organization involved in agile projects, to establish a link between theory and practice. This enabled a demarcation of the research scope in terms of specific inter- and intra-team project knowledge sharing within agile projects. The exploratory interview candidates are selected as senior managers or subject matter experts who have knowledge on the history and development of agile projects in Philips Research organization, and are experienced in agile project management. As unstructured interviews, there is no specific set of predetermined questions, but the scope of the topic reflects the main purpose of this study was prepared and kept in mind during the interview. Open-ended questions are developed to follow the flow of the unstructured interviews, based on the interviewees' responses (Qu & Dumay, 2011).

Semi-structure Interview

The primary method for data collection in the study is qualitative interviewing. Thirteen interviews are conducted as a sufficient set for research to understand the commonalities within a homogeneous group (Saunders, 2009). Interviews are performed in a semi-structured way, which assured some degree of predetermined order and comparability, while still granting flexibility in the way issues were addressed by the interview candidates. Before the interviews start, the researcher will discuss the overall goal of this research to the interviewee. The interview questions are descriptive and with the base questions. Follow up questions are asked based on the discussion. The implications of knowledge sharing in agile projects identified in the theoretical framework create the basis for the semi-structured interview outline (see Appendix A).

The interview sampling and selection criteria are explained in detail in Chapter 4.

2.2.2 Data analysis

The collected data from the literature study, explorative interviews, and desk research are coded into elements and categories. *Thematic analysis* is used to identify knowledge sharing situations and analyze patterns within qualitative data based on three agile-induced knowledge-sharing components (Virginia & Victoria, 2006). After transcribing all collected data into written forms, the central part of thematic analysis is coding the qualitative data into preliminary defined coding categories. As many potential elements as possible are *open coded* and developed during the interviews iteratively, which enabled *cross-validation* that initially, some elements seem insignificant may be necessary for later analysis process (Virginia & Victoria, 2006; Corbin & Strauss, 1990; Rubin & Rubin, 2011). Lastly, *theoretical integration* is made by comparing the resulting model to existing theories in the literature (Santos et al., 2015).

Single elements (tool, people, process) and cross-elements analysis after semi-structured interviews are conducted. After the data are thematically coded, Pivot Table in Excel was also used to enable the quantification of the qualitative data. The amount of codes per interview quantifies the data.

PART II

PROBLEM ANALYSIS

3. THEORETICAL FRAMEWORK

In order to gain an overview understanding of the context of how agile methods influence knowledge sharing activities, a theoretical framework covered a systematic literature study on the three critical parameters of this study: knowledge sharing, agile methodology, and research environment are built in this phase. By looking at the main elements of knowledge sharing in agile projects under the Research environment can be distinguished.

The theoretical framework can hold or support a theory of a research study and introduces and describes the theory that explains why the research problem under study exists. Translated the abstractly defined core concepts into observable indicators, the formulation of the theoretical framework will be used to design semi-structured interviews in next phase (Verschuren & Doorewaard, 2010).

3.1 Knowledge Sharing in R&D

Knowledge sharing is one of the cornerstones of many organizations' knowledge-management strategies (Riege, 2005). R&D is transforming to become more innovative in recent years. The challenge of managing and sharing a variety of knowledge is introduced (Paraponaris, 2003).

For knowledge-intensive organizations, knowledge is embedded in people, systems, procedures, and products. It is always hard to find where the right knowledge resides (Levy & Hazzan, 2009). If R&D can manage their knowledge efficiently, they can highly decrease the time and development cost and increase project quality. To improve the research performance, it is important to manage knowledge in a structured way, which will help to identify the right knowledge to the right people at the right time.

3.1.1 R&D Introduction

Research and development (R&D), refers to innovative activities undertaken by corporations in developing new services or products or improving existing services or products. Companies across all industries undergo R&D activities to stay top of their sustainable competitive advantage (Liao, Wang, Chuang, Shih, & Liu, 2010). Separate from most operational activities, the research and development activities are not performed with the expectation of immediate payoff. Instead, it is expected to contribute to a future-oriented, long-term gain in science and technology. R&D activities may lead to the creation of patents, copyrights, products and services (Paraponaris, 2003; Ruostela et al., 2015). With a knowledge-based culture within an organization encourages people to create and share knowledge (Holsapple & Joshi, 2001; Liao et al., 2010).

R&D projects are perceived as high complexity and with a high level of uncertainty or risk. Complexity can be observed that varied interrelated elements, tasks, and specialists are contained in complicated, intricate research work (Serrador & Pinto, 2015). Uncertainty derives

from non-standard and non-tailored output calculates realized benefits hard to estimate. More money invested in R&D contributes to a higher level of capital risk (Ruostela et al., 2015).

One of the critical principles of defining Knowledge Intensive Companies is their operating expense on R&D and innovation. However, more input does not always produce more output; it is hard to put "knowledge-intensive" in a measurable form. The level of knowledge-intensity may vary, but the essential tasks include knowledge-related activities such as acquiring knowledge, processing it, and creating new knowledge are performed mostly in R&D departments by knowledge workers (Davenport & Prusak, 1998; Ruostela et al. 2015). Knowledge work is a combination of high-level cognitive work, with mundane tasks such as storing and retrieving information (Suchman, 2000; Bosch-sijtsema, Ruohomäki, & Vartiainen, 2009).

"Research" and "Development" activities are often performed separately in corporations, as "research" denotes long-term exploratory activities more abstract than products and services, whereas the term "development" denotes activities that create plans for specific new products and services (Motohashi, 2015; Paraponaris, 2003).

3.1.1 Knowledge and knowledge sharing

From the organizational perspective, knowledge is the combination of information and human context of framed experience, values, skills, and expert insights that provides a framework for enhancing the capacity for action (Davenport & Prusak, 1998; Nonaka & Takeuchi, 1995). The two most used dimensions of knowledge are individual & team & organizational level and tacit & explicit knowledge. Lam (2000) defined individual knowledge as part of an organization's knowledge, which resides in the brains and physical skills of the knowledge workers (Lam, 2000).

According to Davenport and Prusak, knowledge can be defined as "a set of experiences, values, skills, and information related to experts' viewpoints that provides a frame for combination and evaluation of information and new experiences."

Knowledge sharing in R&D is essential because it provides a link between the individual and the organization by moving knowledge that resides with individual researchers to the organizational level (Hendriks, 1999). These kinds of transformations of explicit project knowledge help researchers to learn from the previous studies, so it is essential to store the knowledge for future reuse. Explicit knowledge can be codified in documents, repositories and shared in formal, systematic languages or objects. While tacit knowledge embeds in action, process, routines, cultures and personal experience, which makes it difficult to formalize and communicate (Davenport & Prusak, 1998; Smith, 2001).

Knowledge sharing behavior is defined as a set of individual behaviors involving sharing one's work-related knowledge and expertise with other members within one's organization (Yi, 2009)

3.1.2 Knowledge sharing components

Critical factors can be categorized to assess the potential of facilitating knowledge sharing capability for R&D and innovation. Based on several studies, the main knowledge sharing factors are identified as Technology, Process, and People. A detailed explanation of each factor is provided below.

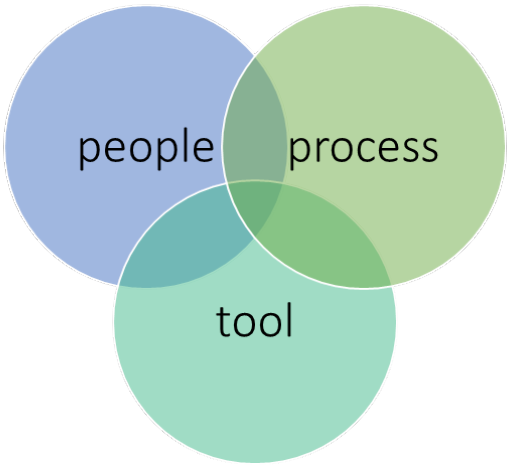

Figure 7 Knowledge sharing factors

Tool/technique

The first component of knowledge sharing is Tool. In practice, knowledge is shared using a mixture of knowledge management tools and techniques that contribute to both interactions between people and codification of explicit knowledge by documenting and sharing (*PMBOK® Guide-Sixth Edition*, 2017).

Managing knowledge means more than just introducing powerful databases or intranets but adding or creating value by actively leveraging 'know-how' within the organization (Tiwana, 2000). The tool component was always emphasized on hardware and software knowledge management tools (Argote, Ingram, Levine, & Moreland, 2000). IT facilitates rapid knowledge collection, storage, and exchange (Liao et al., 2010). This component is the easiest one to implement therefore in many organizations the only component to be implemented (Bhatt, 2000). Only 10% of the issues related to implementing knowledge management in an organization relate to the technology component (Bhatt, 2000). A holistic approach is needed for the implementation of all knowledge management elements.

Appropriate knowledge sharing tools and techniques could connect people so they can work together to create new knowledge, share tacit knowledge, and integrate the knowledge of diverse team members (*PMBOK® Guide-Sixth Edition*, 2017). Tool and techniques include:

- *Networking*, including informal social interaction and online social networking. Online forums where people can ask open questions which are useful for starting knowledge-sharing conversations with knowledge experts;
- *Communities of practice* (or called communities of interest, communities) and special interest groups;
- *Meetings,* including virtual meetings via communications technology;
- *Discussion forums* such as focus groups;
- *Knowledge-sharing events* such as seminars and conferences, or knowledge fairs and cafés;
- *Workshops*, including problem-solving sessions and learning reviews designed to identify lessons learned;
- *Storytelling*;
- *Training* that involves interaction between learners.

People

The People component indicates how the organization manages, develops and releases the knowledge and full potential of its people at an individual, team-based and organization-wide level, and plans these activities in order to support its policy and strategy and the effective operation of its processes (Bhatt, 2000). The people are the human components of an organization (Argote et al., 2000). The development issues related to this people component will probably require the most effort when developing knowledge sharing strategies in an organization. However, this element is necessary to develop for only then actual benefits will be realized (Bhatt, 2000). Some sub-elements of this knowledge-sharing component are attitude, motivation, and communities.

It is worth noticing that knowledge sharing is an unnatural act; it is human nature to hoard knowledge and suspects upon others' knowledge. People tend not to collaborate in uncertain conditions, such as when collaborative behavior is not guaranteed, and sharing knowledge is time- and effort-consuming (Levy & Hazzan, 2009). Installing the new system and making the information available will not lead to widespread knowledge sharing. Knowledge sharing is the cornerstone of KM initiatives (Riege, 2005). Motivation needs to be enhanced through time-honored techniques like performance evaluation, compensation, etc. (Davenport & Prusak, 1998).

The asymmetric and incomplete information between parties could influence the efficiency of knowledge sharing and transferring. Researchers seek knowledge may not be able to find the qualified provider, proper expert may be less motivated to share their knowledge. Before sharing the knowledge, it is hard for sender or receiver to measure how much value could be realized. The natural of knowledge, senders' knowledge ability, the context which the knowledge is put to use, fit between knowledge and receiver, and tie between sender and receiver constitute the expectation on the value of knowledge shared (Lin, Geng, & Whinston, 2005).

Process

The last knowledge-sharing component determines how the organization designs, manages and improves its processes in order to support its policy and strategy and fully satisfy, and generate increasing value for, its customers and other stakeholders (Bhatt, 2000). Processes reflect the organization's goals, intentions, and purposes (Argote et al., 2000). Processes should follow standard practices and procedures. For knowledge sharing to be successful, it is essential to determine what practices and procedures are standard and how eager employees are to follow standardized practices and procedures. The processes in an organization help the people to make optimum use of the available technologies (Nonaka & Takeuchi, 1995). The knowledge sharing in R&D should be embedded in managerial policies and practices. Thus, to perceive knowledge sharing as an integral part of general project management processes, not only in a specialist function role (Bosch-sijtsema et al., 2009).

3.1.3 Knowledge sharing approach

Organizations who are able to select fit-for-purpose knowledge management strategies will ensure the knowledge is transferred from its source to where it is needed (Alavi & Leidner, 2001; Liu, Ray, & Whinston, 2010)

Managing and sharing knowledge means more than just introducing powerful databases or intranets of "know-what" knowledge, but adding or creating value by actively leveraging 'know-how' within the organization (Tiwana, 2000). The main characteristics of knowledge management distinguish it from information management is that knowledge involves human actions, whereas information is an object that can be filed, stored, and moved around (McDermott, 1999). It focuses on value as a function of user satisfaction. In this context, most studies formulate knowledge sharing strategies into two approaches: codification and personalization (Gammelgaard, 2007; M. T. Hansen, Nohria, & Tierney, 1999; Liu, Ray, and Whinston 2010). Often companies implement some aspects of both approaches but emphasize one. (M. T. Hansen, Nohria, & Tierney, 1999).

A better understanding of the concept and implications of knowledge sharing approaches were achieved through a review of the main contributions (Choi & Lee, 2003; Garavelli, Gorgoglione, & Scozzi, 2004; López-Nicolás & Meroño-Cerdán, 2011; Martini & Pellegrini, 2005; Mom, Van Den Bosch, & Volberda, 2007; Zack, 1999).

Table 1 A review of knowledge sharing approaches

Author	System-oriented	Human-oriented
Hansen et al. (1999)	**Codification**	**Personalization**
Zack (1999)	Conservative	Aggressive
Choi and Lee (2003)	Systems-oriented	Dynamic, human-oriented
Garavelli et al. (2004)	Market	Community
Martini and Pellegrini (2005)	Codification	Network-based
Mom, Van Den Bosch, and Volberda (2007)	Exploitation	Exploration
López-Nicolás and Meroño-Cerdán (2011).	Codification	Personalization

Personalization

The personalization approach or network approach centers on facilitating interpersonal knowledge sharing through networks. In companies' knowledge closely tied to the dialogue between individuals, technology helps to communicate rather than store knowledge. When reviewing the three knowledge management components, this strategy puts more emphasis on the people component. The focus on knowledge transfer through personal contacts, human behavior, and the cultural context are elements of the people component. The process and technology component in the personalization industry help to support the people component (Paraponaris 2003; Gammelgaard, 2007; Liu, Ray, and Whinston 2010).

An increase in codification may damage existing network-sharing ties. Individuals may hoard their knowledge to protect their network ties, even when there are rewards for codification (M. T. Hansen, Nohria, & Tierney, 1999; Liu, Ray, and Whinston 2010).

Codification

Focusing on *codification* approaches, explicit knowledge is codified and documented in electronic repositories, where it can be accessed and used easily by knowledge workers in the company (Gammelgaard, 2007; Prencipe & Tell, 2001). Such technical databases facilitate codification of organizational knowledge, collection, storage, verification, and dissemination are called Knowledge Management Systems (KMS) (Alavi & Leidner, 2001). In this strategy, knowledge is regarded as a production factor that can be analyzed independently of the current carriers of knowledge. The emphasis of the codification strategy is on the technology component. The people and process components support the technology component. The incentive for codification comes from rewards and recognition. Companies can encourage codification by rewarding contributors. These rewards may include bonuses, salary increases, or promotions. Siemens provides points and shares for codification (MacCormack, Volpel, & Herman, 2002).

3.2 Agile Methodology in R&D

3.2.1 Agile and waterfall project management methods

Agile management has revealed itself as a new way of thinking that copes with unclear product scope and fast-changing circumstances in the late 1990s (Owen, Koskela, Henrich, & Codinhoto, 2006; Wysocki, 2011). It was first introduced in software development, which follows an iterative process and divides projects into sprints of the shorter span. In close to two decades of its existence, agile methods have adopted by almost all industries and gained a growing interest by research communities.

Waterfall project management, as a plan-driven method, is developed to provide team members with guidance for most or all foreseeable situations. The experts, therefore, make them very comprehensive but tailored down for less critical or less complicated situations (Boehm & Turner, 2003).

Agile methodology was designed based on actual requirements of the actions needed in corporations (Ruostela et al., 2015). It has been proposed to increase communication in companies as they suggest that business people and developers must work together daily and project information should be shared through informal, face-to-face conversation rather than through documentation (Pikkarainen, Haikara, Salo, Abrahamsson, & Still, 2008).

Starting in the late 1990s and evolved through the current decade, agile management has revealed itself as a way-of-thinking and a philosophy that anticipates changes. In focusing on flexibility, efficiency and speed, agile development practices have led to a paradigm shift first in software development. In 2001, a group of seventeen renowned software developers came together to discuss the variety of agile approaches and to seek common ground, resulting in the Agile Manifesto (Beck et al., 2001). Although many different agile methodologies do exist, its core lies in the adaptive and people-oriented methods, which can all be related to four values described in the Agile Manifesto:

Individuals and interaction over *processes and tools*

Customer collaboration over *contract negotiation*

Working software over *comprehensive documentation*

Responding to change over *following a plan*

The values represent the expectations of a new way of working, which value better communication, creativity, innovation, knowledge sharing, knowledge workers' autonomy. As Bontis (2011) says: it is about finding ways to *work smarter, not harder* (Bontis, 2011; Ruostela et al., 2015).

The main reason why a **value-driven** approach (agile) is better suited than a **plan-driven** approach (waterfall) can be found by considering an essential characteristic of research projects, which is we learn at least some of what it takes as we go about exploring or development process (Narayan, 2015). Any research team has to deal with the so-named 'unknown unknowns'; during exploration and development, the team encounters unanticipated challenges. In general, it is not possible to do upfront work to eliminate unknown unknowns.

Agility

Different kinds of methods were being practiced in different industries and projects. Since this research aims to investigate knowledge sharing in the context of Philips Research agile way of working, it is desired to determine the agility of the research project. The obtained aspects can be used to classify the level of agility qualitatively. The aspects were categorized into four levels that were repeatedly found in the literature (Nerur, Mahapatra, & George, 2005; Vinekar, Slinkman, & Nerur, 2006), resulting in culture, principle, project management, and practice in table 2. This study mainly focuses on agile projects, more specifically on the projects which applied Scaled Agile methods.

Table 2 agility level

AGILITY LEVEL	INDICATORS
CULTURE/ENVIRONMENT/MANNER/WAY OF WORKING	Iterative, adaptive, change
PRINCIPLE/MINDSET/PHILOSOPHY/VALUE	Individuals and interaction
	Customer collaboration
	Working product or service
	Responding to change
PROJECT MANAGEMENT	Traditional (project-based) or agile (value-driven)
PRACTICE/PARADIGM	Scrum, XP, Scaled agile….

3.2.2 The implications of knowledge sharing in agile projects

Codification

One of the values debated in the Agile Manifesto is working software over comprehensive documentation. (Beck et al., 2001). Although this does not imply that documentation should be fully abandoned, it seems to be an aspect to take into account when implementing agile approaches in an organization. Much of the knowledge in agile development is tacit and resides in the heads of the development teams (Nerur et al., 2005) or was captured in informal documents. Although these informal documents often contain much of the information required, it is not always realized by the business (Karlström & Runeson, 2006). As a result, the documentation that the business requires is not a natural output of agile methods (Turner & Boehm, 2005; Van Waardenburg & Van Vliet, 2013)

Personalization

In the agile R&D project, most knowledge sharing happens through the interaction. Researchers share knowledge by working together through pair programming, extreme programming, daily scrum, and sprint retrospectives in Scrum. In the traditional research project, knowledge sharing primarily focus on explicit knowledge, which can be stored explicitly documented in repositories and database. However, managing knowledge in the agile project relies on tacit knowledge. *Extracting tacit knowledge* to explicit knowledge is one of the biggest challenges for knowledge-intensive organizations. Due to the absence of explicit knowledge in the agile project, researchers need to spend much time in repeatedly working on the same topic and answering the same questions. Less contribution to organizational knowledge, and hence less support for reusing the project knowledge. According to Michael Earl's study, the technocratic aspect is closely related to traditional project management and those who are conducting research projects through traditional approaches are probably getting benefit from technocratic elements. On the other hand, the behavioral aspect is more related to the agile approaches and agile teams are more benefiting from it. A survey in traditional and agile companies shows, agile companies seem to be more satisfied with their knowledge management approaches compared to traditional companies.

The following practices are discussed to explore how the agile approach enhances the people's awareness of the situations which lead to tacit knowledge extraction and reuse (Levy & Hazzan, 2009).

- *Agile project team:* In agile project teams, all members communicate as much as possible. Agile teams normally collocated in collaborative workspaces, which facilitates face-to-face communication. Team members with different roles used to belong to separate teams are now integrated into one agile team;
- *Daily stand-up meeting*: Usually, the meeting takes place every morning for 15 minutes. In this meeting, each team member concisely presents the status of their development tasks and what they plan to accomplish during the next day, both concerning the development tasks and the personal role. When needed, one sentence can be added by each team member at his or her turn concerning anticipated problems.

3.1Theoretical proposition

> ***Sub-question 1****: What are the implications of agile methods on knowledge sharing in research projects?*

Based on the literature study and the exploratory research performed, a conceptual framework for the research is established and an answer to the first sub-question, concerning the implications of agile methods on knowledge sharing can be given.

Three components are identified as crucial for effective knowledge sharing in agile research teams, including knowledge sharing tools, knowledge sharing process in agile projects, and people involved in agile-induced knowledge sharing.

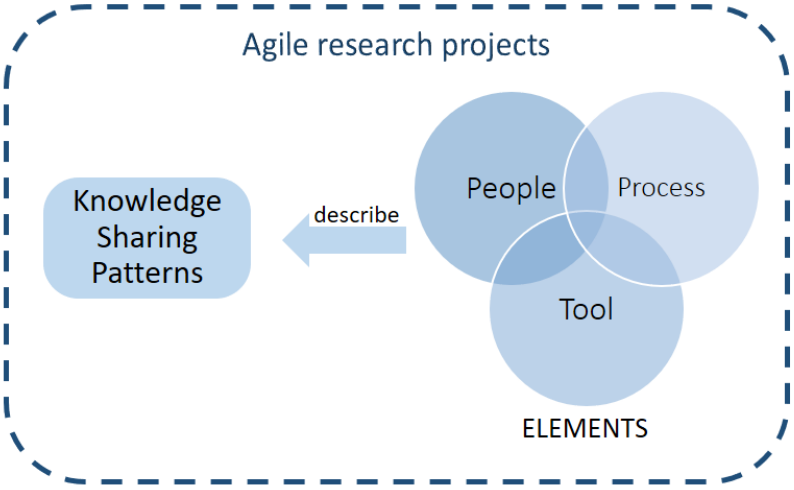

Figure 8 Conceptual framework of this study

The distinguished three components that are impacted by the use of agile methods in research projects, and at the same time influence the effectiveness of knowledge sharing, create a crucial part of the theoretical framework for this research study. Their interconnection characterizes different knowledge sharing patterns in an agile research project and influences the overall effectiveness knowledge management. Each of the components is studied in detail based on literature and practical situation in Philips Research in terms of their characteristics in agile projects.

The three components link together can collectively describe different knowledge sharing situations in agile projects and help with the interpretation of why agile influences efficient or inefficient knowledge sharing (Rubin & Rubin, 2011).

4. EXPLORATIVE STUDY

Field study is conducted aims to explore the knowledge sharing and agile working way in Philips Research, desk research of existing resources within Philips, and explorative interviews with senior project managers who work in Philips Research are conducted based on the theoretical proposition. A link between theory and practice is established based on preliminary research in terms of desk research and explorative interview. The outcome of exploratory interviews with practitioners in Philips Research organization enables the customized characteristics of theoretical components affecting knowledge sharing.

4.1 Knowledge sharing tool

Different platforms are used in Philips to motivate efficient knowledge sharing activities, the graph below positioning the inner and outer loop of knowledge sharing activities and tools to illustrate their interrelationship. For example, the output of the stories is stored and archived in Sharepoint as a result, stories could be transferred in other formats to business.

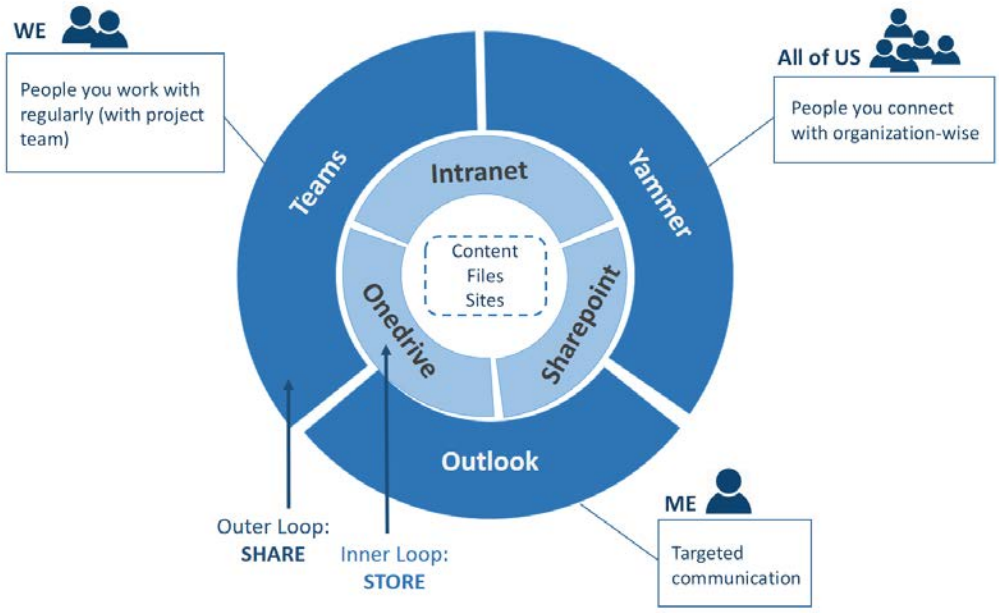

Figure 9 Knowledge sharing platforms in Philips

Research results are documented in different databases, different document standards and templates for different research subjects. *Manuscripts (Publications), Technical Notes, Reports, Project Proposals, Progress Reports, Project minutes, legal documents* were formally stored in *Portal2Research*.

In 2016, the agile method as a new project management practice was introduced in Philips Research, a sharp decrease on the amount of technical note in Portal2Research (P2R) could be observed (in figure 10 below). In agile projects compared to traditional project, the Philips Research agile manifesto emphasizes "*working product or service* over *comprehensive documentation*" and "*individuals and interactions* over *processes and tools*" ("Philips Research Quality Management System (QMS) - Scaled Agile," 2019).

As Philips Research is still a traditional project-based organization that runs with the yearly budget on projects, a sharp increase on the amount of Technical note at the end of each year could be seen in figure 11.

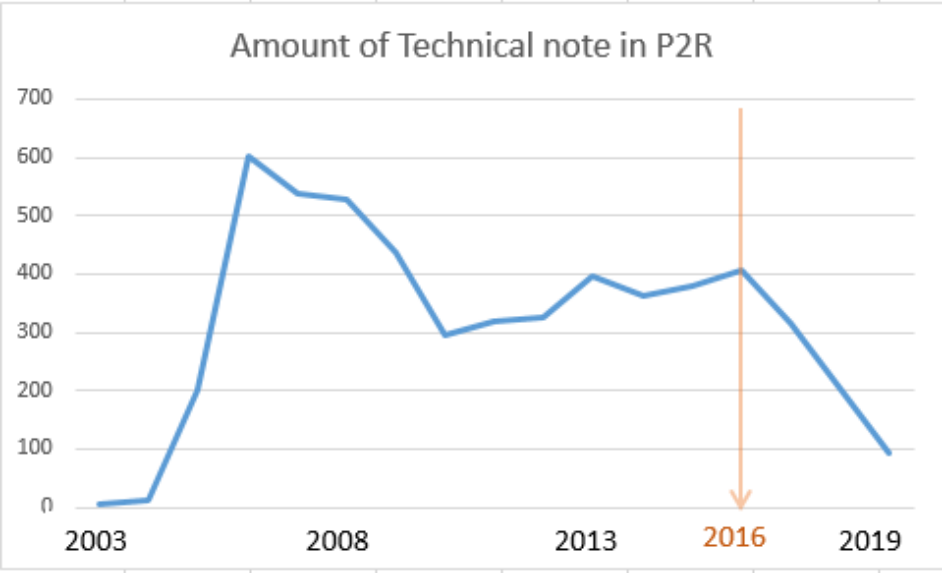

Figure 10 Yearly amount of Technical note from 2003 to 2019

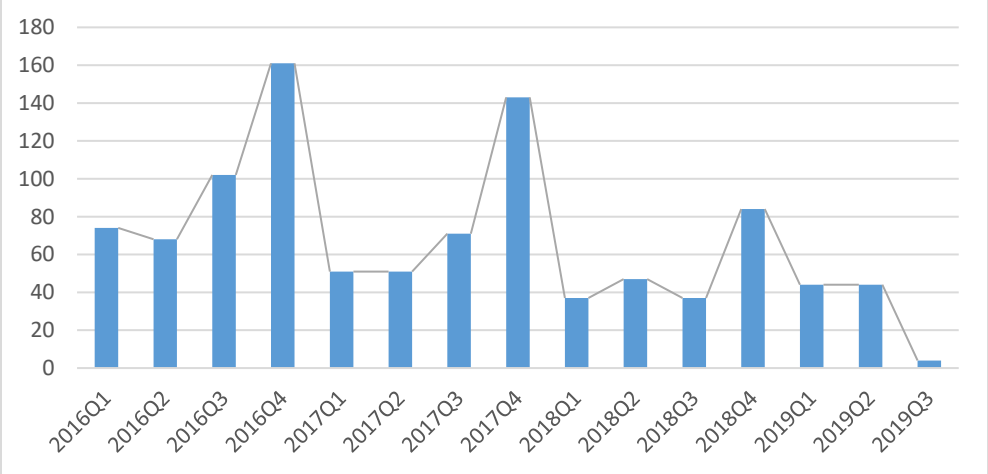

Figure 11 Quarterly Amount of Technical note from 2016 to 2019

In waterfall projects, with a fixed sequence of initiation, planning, execution, monitoring, and closure, researchers were accountable for professional documentation of knowledge and insights as well as critical data collected at the project closure. However, in agile projects, the knowledge should be documented in the form of procedure documents including Retrospective Report and Increment Review ("Philips Research Quality Management System (QMS) - Scaled Agile," 2019), which turned out that less mature and less structured knowledge is documented in different database, with different standards and templates for different research subjects. Confirmed by another project manager that "… *if someone is interested and requires knowledge sharing, the demo is done during the project and presentation is done while finish the work*".

The P2R database expert also mentioned that the number of documents in the system increased from 2010 until 2013 could be *"related to the effort of one CTO department head made, he mentioned the importance of knowledge sharing each year in the annual meeting with the whole department."*

In addition, researchers' contribution to P2R used to be part of Personal Performance Management (PPM). Management support and incentive system could encourage knowledge sharing behavior. One senior manager mentioned that *"senior researchers who are experienced and knowledgeable are willing to share, but prefer recognized way such as a presentation or public speech, in which way their contribution is broadly recognized."*

4.2 Knowledge sharing process in agile projects

In traditional projects, the lifecycle consists of four phases: initiation, definition, realization, closure. There is no specific procedure on knowledge management or knowledge sharing stored in Quality Management System. In the "Procedure Project Closure" document, some relevant topics are addressed: Lessons learned, project deliverables, and documentation need to be archived at the end of the project. Two activities are mentioned related to the idea of sharing the project knowledge: *"Document / Summarise knowledge captured during Project (e.g., in Exploration Note or Technology Recommendation"; "Archive project results according to Work Instruction Archiving of Project Documents."* These are all focus on the codification of explicit knowledge.

Agile methods cannot be used by the book in complex organizational environments. This means that the adoption of agile methods in practice involves customization and tailoring to some extent. (Pikkarainen, Haikara, Salo, Abrahamsson, & Still, 2008) Agile methods introduced to R&D namely *Scaled Agile (SAiR*) to suit the flexibility and interaction needs of research projects; the changes can be quickly coped compared to the traditional way.

Knowledge sharing activities happened mostly at the finish point of each scale cadence in the form of meetings. The setup of scaled agile includes four backlog cadences: The first one is '*Epic*,' which indicates the long-term goal of the research project. The next one is *Product Backlog*

Artifact - '*Feature*,' it is the work package for thirteen weeks, including three sprints and one extra week. The third one is four-weeks *Sprint Backlog Artefact* – '*Story,'* with the Feature together indicate what has been achieved in the research project already. The last one is '*Task,'* which indicates whether an activity is started or even finished. Within each scale, there are different cadences. The following figure will show the overview of the scaled agile cadence.

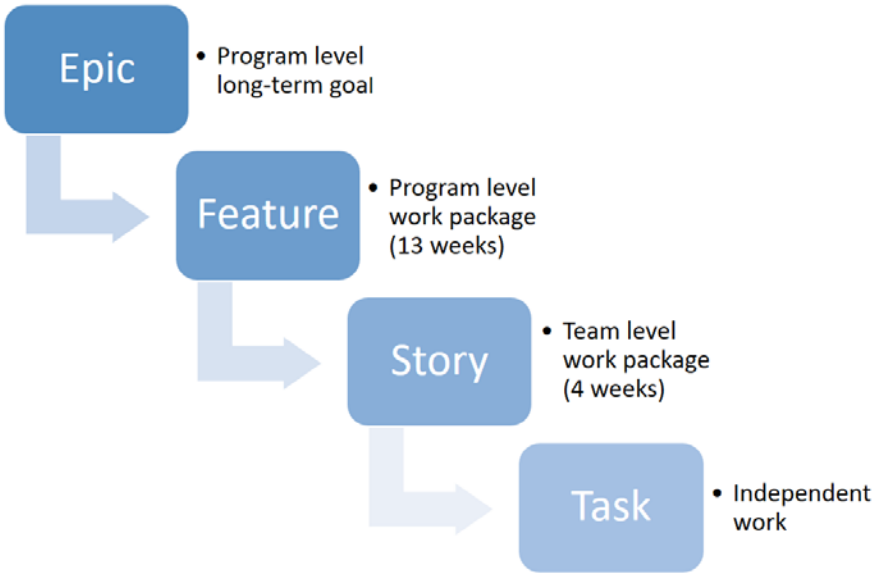

Figure 12 Philips Scaled Agile backlog artefacts

4.3 People involved in knowledge sharing

More roles are involved in agile projects compared with traditional projects. Value stream owner, scrum master, release train engineer, etc. are the standard roles in scale agile practice, while in traditional projects, there are only project leaders and researchers.

Researchers work in same agile projects are mainly work on the same domain. A traditional research project is a group of people with different expertise, who are not always overlapping in capabilities and work on the sub parts. However, in agile teams, one should be able to pick up the other's task, this means people in one agile team shared same expertise. Value stream supported by value stream owner enabled more interaction between knowledgeable people from different domains, more efficient knowledge sharing and higher quality research result could be expected. The knowledge sharing situations between different actors can be illustrated as shown in the below figure:

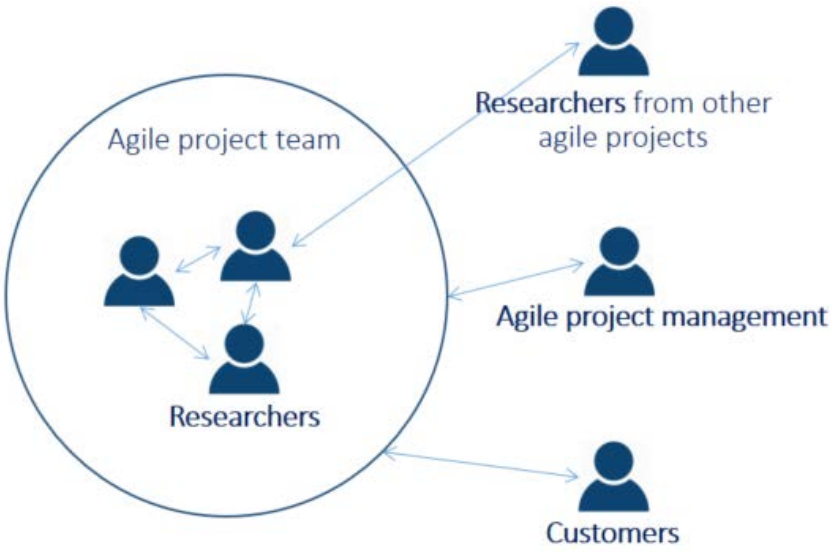

Figure 13 knowledge sharing situations between different actors in agile projects

Between project team members who are working on the same project share a lot; between teams less sharing could be observed. Structured knowledge sharing moments were organized within the department. One project lead mentioned that *"in traditional projects, teams worked separately. Agile stimulated more interaction between disciplines, researchers shared knowledge and opinion within Value stream, and learned from each other, and being able to correct mistakes as soon as possible"*.

PART III

DIAGNOSIS

5. INTERVIEW DESIGN

In order to collect detailed data on knowledge sharing characteristics in agile research teams, fourteen qualitative interviews are conducted, thirteen of them were valid. All interviews are recorded, while parallel manual notes per question are taken by the researcher. Subsequently, all interviews are summarized based on the interview records. Each interview summary is verified by the respective interview candidate to assure that the interview content has been understood correctly and no false information is collected. The interview summaries create the input for the subsequent data analysis. The following sub-chapters provide the interview candidates, and the interview structure applied.

5.1 Sampling

The interview candidates are project members from Philips Research who had experience in both agile and traditional research projects. To avoid the elite bias of only interviewing certain people of high status. Interviewees include not only project managers who are critical informants. Conversely, lower status informants are also interviewed to represent various “voices” and gain a broader situation of how are the knowledge sharing patterns in agile research project teams (Myers & Newman, 2007; Rubin & Rubin, 2011). A minimum of twelve interviewees is considered sufficient for research that aims to understand the commonalities within a homogenous group.

To gain a rounded perspective, interview candidates derived from different roles involved in the agile research projects, including:

1. Researchers
2. Project managers
3. Scrum masters
4. Value Stream Owner
5. Product Owner
6. Release Training Engineer

Thirteen candidates were selected who took the roles as stated above, and they can be generically divided into three groups: project manager, researcher, and researcher with software development backgrounds. PM and researcher with software backgrounds are more experienced in agile methodology. Most researchers have less than three years of experience in agile.

Table 3 Demographics including roles and agile experience of interviewees

No.	Researcher	RTE	SM	PO	PM	VSO	SE	Year of experience in agile
1		✓	✓		✓			7
2		✓	✓	✓	✓			9
3		✓			✓	□	□	10
4	✓						✓	8
5	✓						✓	9
6	✓			✓			✓	6
7	✓						✓	4
8	✓							2
9	✓		✓					3
10	✓	✓						0.5
11	✓					✓		2.5
12	✓		✓		✓			5
13	✓					✓		3
total	10	4	4	2	5	2	4	

5.2 Interview protocol

The interviews involve mainly four parts:

- Opening
- Introduction
- Key questions
- Close

The interview started with the introducing of the background of the interviewer, followed by explaining the purpose of the interview. The script of the critical questions is prepared. In order to achieve flexibility, improvisation, and openness of the interview, the script are incomplete. At the close point, the interviewer asks for a follow-up and points that feedback is provided. The snowballing technique is used to ask the interviewees to refer to other potential participants.

See the interview structure in Appendix A.

6. INTERVIEW ANALYSIS

This chapter response to the analysis of the collected interview data. The following subsections provide the introduction of the way to analyze the collected data and description of the critical findings.

6.1 Introduction of Data Analysis

The collected interview data in the form of interview summaries are first analyzed with the help of PivotTable in Excel, which quantifies the qualitative data by the number of responses per code. The codes derived from interview analysis refer to the elements identified after the literature study and field study. In the open coding process, different terms are used by interviewees, various codes are recognized, but combined and summarized into the several representative ones. Table 4 below provides an overview of the codes used in the data analysis phase of this study, followed by a detailed explanation of specific codes.

Table 4 Components per element characterizing agile-induced knowledge sharing situations in Philips Research

Knowledge sharing tool		**Knowledge sharing process**	**Actors involved**	
Structured	***Personalization means***	Beginning of the project	***Senders***	***Receivers***
Standup meeting	Email	During the project	Researcher	Researcher
Sprint meeting	Dialogue	End of project	Agile team	Agile team
Program increment meeting	Call	Out of project		Management team Customer
Cluster meeting	Meeting	Daily		Organization
Documentation		2/3 times a week		vague
	Codification means	Weekly		
Unstructured	Backlog	Bi-weekly		
COI/COP	DEMO	Every 2/3 weeks		
"One room approach"	Technical note	Monthly		
Coffee corner talk	Presentation	Tri-monthly		
vague	Report	Quarterly		
	Other documents	Once a few months		
	vague	Ad-hoc		
		n/a		
		vague		

Knowledge sharing tool

Knowledge Sharing Tool is defined from two perspectives to specified different knowledge sharing characteristics. The manners and means could have overlaps but have a different emphasis. The researchers used *"structured & unstructured* manner" very often. It is more related to whether the knowledge sharing technical was initiated by organization or

spontaneously initiated by researchers themselves. *"personalization & codification means*" was related to different carriers of knowledge sharing strategy (M. T. Hansen, Nohria, & Tierney, 1999; Liu, Ray, and Whinston 2010; Gammelgaard, 2007). For example, during the sprint meeting (structured manner), knowledge could be shared in the means of demo presentation (personalization means) or dialogue (codification means).

Added explanations on specific codes:

- "One room approach" stands for unplanned meetings, one-room approach, technical meeting, not necessary co-located in the same place, could via call/skype.
- "Coffee corner talk" stands for lunch learning events, coffee corner talk, share the same coffee machine.

Knowledge sharing process

The coding family Knowledge Sharing Process is described not only by specific project phase, such as beginning, during, at the end; but also more general terms are used to describe the sharing frequency, such as very specific time indication such as 2/3 times a week, weekly, monthly are used.

Knowledge sender and receiver

Knowledge Sender and Receiver is categorized into different coding families. Because as this study focused on how agile project shares the technical knowledge created during the project, so the senders could be either an individual researcher or an agile project team. When coming to receivers, it could be individual researchers, agile project team, and also management team, customers (group), and whole Philips organization.

Added explanations on specific codes:

- "Customer" includes business, business partner, external stakeholders, external customers, and internal customers
- "Management team" includes team lead, project manager, scrum master, value stream owner, product owner, and release training engineer. Though they have different roles when referring to knowledge sharing activities in agile projects, they can be assumed have similar functions.

6.2 Interview Results

In total, 89 knowledge sharing situations are identified and coded from the 13 semi-structured interviews. Repetitive knowledge sharing situations enable the identification and prioritization of knowledge sharing patterns, based on the frequency of the occurrence of the codes during the interviews. Appendix B provides an overview of all codified knowledge sharing situations.

The following subsections describe the interview findings per coding family, in terms of tool, process, and people perspectives and the relations between these three components. The knowledge sharing situations described are the results of a quantitative analysis of the codes.

6.2.1 Knowledge sharing tool

Structured & unstructured manners

The most common knowledge sharing technique mentioned was structured knowledge sharing (see table 5). Within structured sharing manners, documentation was mentioned frequently, as often as scaled agile cadence meetings (standup, sprint, and program increment meetings); both accounted for around 50% of total structured knowledge sharing manners. Seldom interviewees mentioned the cluster meeting. “One room approach” and COI/COP appeared more often than coffee corner talk, which were all related to the means of dialogue.

Though the structured sharing ways were coded almost twice times as many as unstructured sharing, most researchers expressed the preference for unstructured and interactive sharing ways. Half interviewees mentioned words like “coffee corner talk or coffee machine,” which indicate the preference for unstructured and informal knowledge sharing.

> One interviewee said, *“Instead of organizing a meeting, I prefer grabbing a coffee with people*,” another one also stressed, “*…coffee corner talk inspires people at the right moment to have the right idea!”*

Table 5 Overview of interview findings with respect to knowledge sharing tools - manner (structured & unstructured)

Row Labels	Total
structured	**52**
Standup meeting	8
Sprint meeting	12
Program increment meeting	6
Documentation	23
Cluster meeting	3
unstructured	**29**
"One room approach"	12
Coffee corner talk	6
COI/COP	11
vague	**8**
vague	8
Total	**89**

Codification & personalization means

The proportion of codified knowledge sharing means and personalized means are similar, and personalization means were mentioned a bit more (see table 6). Within codification means,

Demo was the most used documentation means, followed by Technical note, report and other documents. The main personalization means mentioned was meeting, which accounted for 50%. Dialogue is the second popular knowledge sharing means highlighted. Both calls and emails were hardly mentioned. The call was only mentioned once, and email was mentioned slightly more.

Technical note as the formal and main codification knowledge sharing way was seldom used in agile projects. Half of the interviewees even did not mention technical note as a knowledge-sharing way, and only one of whom appreciated and advocated for writing down the technical knowledge as the interviewee was benefited from an ancient technical note once. On the contrary, connecting with people by initiating conversations was preferred.

> Interviewees mentioned that *"We do not usually write technical reports." "You can write it (knowledge) down, but talking to people is always better than documentation."*

Table 6 Overview of interview findings with respect to knowledge sharing tools - means (codification & personalization)

Row Labels	Total
Codification means	**35**
Backlog	3
Demo	12
Other documents	6
Presentation	2
Report	5
Technical note	7
Personalization means	**45**
Call	1
Dialogue	12
Email	3
Meeting	29
vague	**9**
vague	9
Total	**89**

The juxtaposition of manners and means

Based on the juxtaposition of knowledge sharing manners and means (see table 7), the occurrence of codification means was twice as often as personalization means in structured knowledge sharing. Within unstructured knowledge sharing, personalization means constituted the vast majority. Personalization means was captured in both structured and unstructured knowledge sharing situations, while codification means was not always related to structured or unstructured sharing.

Table 7 Overview of interview findings with respect to relations between manner and means

Row Labels	structured	unstructured	vague	Total
codification means	31	2	2	35
personalization means	18	25	2	45
vague	3	2	4	9
Total	**52**	**29**	**8**	**89**

To get a closer look at the detailed manners and detailed means listed in table 8. Demo and meeting were highlighted as both codification & personalization means in the agile cadence meeting. “One room approach” and coffee corner talk were often conducted in the means of dialogue and meeting. COI/COP was found in either documentation means or interaction means.

Table 8 Overview of interview findings with respect to relations between manner and means (in detail)

				structured Total				unstructured Total		vague Total	Total
	Cluster	Docu	Agile cadence		"ORA"	CCT	COI/COP		vague		
codification means		**20**	**11**	**31**			**2**	**2**	**2**	**2**	**35**
Backlog		3		3							3
Demo		2	9	11					1	1	12
Other document		3	2	5					1	1	6
Presentation							2	2			2
Report		5		5							5
Technical note		7		7							7
personalization means	**3**	**3**	**12**	**18**	**12**	**6**	**7**	**25**	**2**	**2**	**45**
Call					1			1			1
Dialogue					5	5	2	12			12
Email		3		3							3
Meeting	3		12	15	6	1	5	12	2	2	29
vague			3	**3**			**2**	**2**	**4**	**4**	**9**
vague			3	3			2	2	4	4	9
Total	**3**	**23**	**26**	**52**	**12**	**6**	**11**	**29**	**8**	**8**	**89**

6.2.2 Knowledge sharing process

Knowledge sharing situations were seldom mentioned at the beginning of the project. Knowledge sharing out of the project was mentioned frequently, but not even half as often as knowledge sharing during the project. More than half number of knowledge sharing patterns identified happened during the project (see table 9).

Only one interviewee mentioned that *"If you start a new topic or new project, it always makes sense to look into technical notes, see whether people worked on similar topics before, and what existing knowledge could be leveraged"*.

Table 9 Overview of interview findings with respect to knowledge sharing process

Row Labels	Total
Beginning of the project	2
During the project	56
End of project	9
Out of project	21
vague	1
Total	**89**

Ad-hoc knowledge sharing activity was stated the most often, which accounted for half of the planned ones. Followed by weekly occurrence. There was no clear pattern of sharing frequency. Ad-hoc sharing frequency was highlighted most during and out of the project (see table 10).

One interviewee mentioned that *"Agile cadence meetings were often planned well at the beginning, (but not followed)."*

Table 10 Overview of interview findings with respect to knowledge sharing process & frequency

Row Labels	Beginning of the project	During the project	End of project	Out of project	vague	Total
Planned ones		2		1		32
2/3 times a week		7		2		3
Weekly		1		2		9
Bi-weekly		5		2		3
Monthly		7				7
Tri-monthly		3				7
Quarterly	1	11		4	1	3
Ad-hoc		9		8		17
vague	1	11	9	2		17
n/a	**2**	**56**	**9**	**21**	**1**	23
Total						**89**

6.2.3 Knowledge sender and receiver

The most frequently mentioned interaction in agile research teams is recognized as individual sharing between researchers, which accounted for almost half of the knowledge sharing patterns.

Researchers as individual senders also shared within organizations, but much less than individual sharing (see table 11).

Knowledge sharing from an agile project team to the customer was recognized as the most often used group-level sharing pattern, followed by inter-group knowledge sharing between different agile project teams.

Table 11 Overview of interview findings with respect to knowledge sharing sender and receiver

Row Labels	Researcher	Agile team	Customer	Management team	Organization	vague	**Total**
Researcher	41				11		52
Agile team		8	12	6	7	1	34
vague						3	3
Grand Total	**41**	**8**	**12**	**6**	**18**	**4**	**89**

6.2.4 Interrelations between different elements

Tool & process

When positioning knowledge sharing tools and processes together (see table 12), hardly any sharing means was mentioned at the beginning of the project, the technical note was only mentioned once to be used as the knowledge sharing means. In contrast, most knowledge sharing means were related to project on-going phase. Both codification and personalization means were equally critical during the project. The meeting was the most frequently mentioned means during the project, followed by Demo. At the end of the project, the technical note was the most often used sharing means. Out of project, personalization sharing means was highlighted five times more than documentation means; the meeting was the most frequently used means.

Table 12 Overview of interview findings with respect to relations between knowledge sharing tool (means) and process

Row Labels	Beginning of project	During project	End of project	Out of project	vague	Total
codification means	**1**	**22**	**9**	**3**		**35**
Backlog		3				3
Demo		11	1			12
Other document		5	1			6
Presentation				2		2
Report		3	1	1		5
Technical note	1		6			7
personalization means		**28**		**16**	**1**	**45**
Call		1				1
Dialogue		5		6	1	12
Email		3				3
Meeting		19		10		29
vague	**1**	**6**		**2**		**9**
vague	1	6		2		9
Total	**2**	**56**	**9**	**21**	**1**	**89**

Taking a closer look at meeting and Demo in different project phases in table 13, meeting during or out of the project was highlighted equally in unstructured knowledge sharing manners, while in structured manners, the occurrence of meetings took place during the project was four times as many as out of the project.

Table 13 Overview of interview findings with respect to relations between knowledge sharing tool (DEMO & MEETING) and process

Row Labels	During the project	End of project	Out of project	Total
Demo	**11**	**1**		**12**
structured	10	1		11
vague	1			1
Meeting	**19**		**10**	**29**
structured	12		3	15
unstructured	6		6	12
vague	1		1	2
Total	**30**	**1**	**10**	**41**

Tool & people

Taking individual research as the knowledge sender, sharing happened mainly by personalized sharing manner, while codification was the main sharing manner from a group perspective; Meeting and dialogue were the first and second frequently used sharing ways between individual

researchers. Knowledge sharing from researchers to a broad audience in the organization was primarily recognized during meetings.

Taking the agile project team as the knowledge sender, knowledge was shared most with organization and customer. The demo was primarily used from agile teams to management teams, and Technical note was the primary means to share knowledge from agile team to organization (see in table 14).

Table 14 Overview of interview findings with respect to relations between knowledge sharing tool (manner) and people

Row Labels	Agile team	Customer	Mgmt	Org	vague	Agile team Total	Org	Researcher	Researcher Total	vague	vague Total	Total
codification means	**3**	**6**	**3**	**7**	**1**	**20**	**2**	**11**	**13**	**2**	**2**	**35**
Backlog								3	3			3
Demo	3	4	2			9		1	1	2	2	12
Other document		1		1		2		4	4			6
Presentation							2		2			2
Report			1	1	1	3		2	2			5
Technical note		1		5		6		1	1			7
personalization means	**3**	**4**	**1**			**8**	**7**	**28**	**35**	**1**	**1**	**44**
Call								1	1			1
Dialogue	1					1	1	10	11			12
Email		1	1			2		1	1			3
Meeting	2	3				5	6	16	22	1	1	28
vague	**1**	**2**	**2**			**5**	**2**	**2**	**4**			**9**
vague	1	2	2			5	2	2	4			9
Total	**7**	**12**	**6**	**7**	**1**	**33**	**11**	**41**	**52**	**3**	**3**	**88**

Standup meeting was mentioned that "*could be the tool for scrum masters or product owners to open up the team*" and increase the possibility of taking over others' work by transferring project information.

6.3 Interview Findings

The specific characteristics of knowledge sharing situations described in the last chapter enable a general definition of knowledge sharing patterns in Philips Research. This section summarizes the distinguished knowledge sharing patterns in agile research projects, responding to the second sub-question:

> ***Sub-question 2**: What are the knowledge sharing patterns in agile projects in Philips Research?*

6.3.1 Imbalanced codification and personalization

More unstructured the sharing situation is more preferred by researchers. Though structured knowledge sharing situations were recognized almost twice as often as unstructured ones, most researchers expressed the preference for unstructured and interactive sharing ways. If it was not required according to structured agile cadence meetings, **coffee corner talk** was preferred by most researchers as the tool to share knowledge and inspire new ideas. Another evidence is that though **cluster meetings** shared the same function as **COI/COP** which focused on sharing experience and information on the specific research topics, it was much less applied than COI/COP. Both cluster meetings and COP, while coffee corner talk can be more casual and has no specific intention, knowledge flows beyond the agile project and within the organization.

When it comes to personalization and codification sharing means, it can be concluded that agile contributes to defining new knowledge-sharing manners, while the legacy knowledge sharing way was still applied. **Technical note** as the formal and central codification knowledge sharing way was seldom used in agile projects compared with other personalization means. Still, within codification means, knowledge-sharing activities were conducted mostly utilizing **Technical note** in documents, and **Demo** was the most used means in agile cadence meetings.

6.3.2 Process misalignment

The knowledge-sharing process was not aligned with the agile project process. Most researchers search on external resources rather than internal codified knowledge at the **beginning of the project**. Only one interviewee did internal searching on corporate knowledge base on existing technical knowledge at the beginning of the project, which was unexpected, as the technical note was initially designed for knowledge reusing in Philips Research organization.

Most sharing happened **during the project** in balanced codification and personalization means. Due to the different characteristics of individual research projects, different meeting rhythms were applied. Ad-hoc or unplanned knowledge sharing activities happened often, and mainly during the project. Also, because research projects always have less clear and vague defined objects, it would be challenging to set boundaries to make tasks that are so specific. Most projects do not apply the Scaled Agile method strictly according to the Philips Research procedure.

The knowledge sharing at the **end of the project** mainly refers to the codification of the project result in the means of the technical note. Sharing **out of project** could be recognized, but not so much, and most cases were personalized sharing including COI/COP and coffee corner talks. There was no clear pattern of sharing frequency for planned sharing, as agile cadence meetings were often planned well at the beginning, but not followed.

6.3.3 Ignorance on the value of knowledge sharing

Individual sharing between researchers happened a lot, no matter the researchers work on the same projects or not. They often shared knowledge via meeting or dialogue. Knowledge transferring from individual researchers to the organization was much less than individual sharing. It can be observed that sharing from researcher to broader audience most frequently happened during meetings, rather than in technical note.

Taking the **agile project team** as the sender, organizational knowledge sharing was not well applied. Within the small amount of mentioned sharing situation from agile team to the organization, the technical note was the primary means; the Agile project team as the knowledge sender shared most often with the **customers**, e.g. business, or patients in the hospital. The demo was primarily used during the projects, and the research result was presented at the end of projects. Demos and presentation as research results were achieved in Sharepoint within an agile team and could be transferred to business.

Compared with project managers and researchers who had software development backgrounds, most researchers were in less favor of codification sharing techniques but preferred personalized knowledge-sharing techniques.

7. DISCUSSION

In order to find underlying causes of ineffective knowledge sharing patterns, and propose a solution to improve effective knowledge sharing in agile projects, this discussion is structured in three parts. The first section selection of the framework to cluster the causes of three main sharing patterns. The second part is clustered and visualized the interpretation on the causes of knowledge sharing patterns based on Wang's knowledge sharing factor framework (Wang & Noe, 2010). The outcome of this chapter responds to the third sub-question:

> ***Sub-question 3:*** *What are the agile-induced factors that hinder knowledge sharing in agile projects in Philips Research?*

7.1 Methods of gathering causes

A framework is selected to cluster the causes of knowledge sharing patterns. Therefore, multiple frameworks are considered that are utilized to portray the factors of ineffective knowledge sharing.

The framework selected in this study to analyze the causes of ineffective knowledge sharing chose Wang's framework (details see figure 14) integrating the disciplines on investigating how organizational and individual characteristics influence knowledge sharing within a project team. Prior studies of knowledge sharing factors have been conducted on technological issues, organizational tools, strategic management, social and organizational behavior, and psychology. (e.g., Alavi & Leidner, 2001; Martini & Pellegrini, 2005; McDermott, 1999; Santos et al., 2015; Wang & Noe, 2010). As mentioned in theoretical study part, an important reason for the failure of knowledge management tools to facilitate knowledge sharing is in lacking of consideration on how the organizational and interpersonal context influence knowledge sharing (Wang & Noe, 2010).

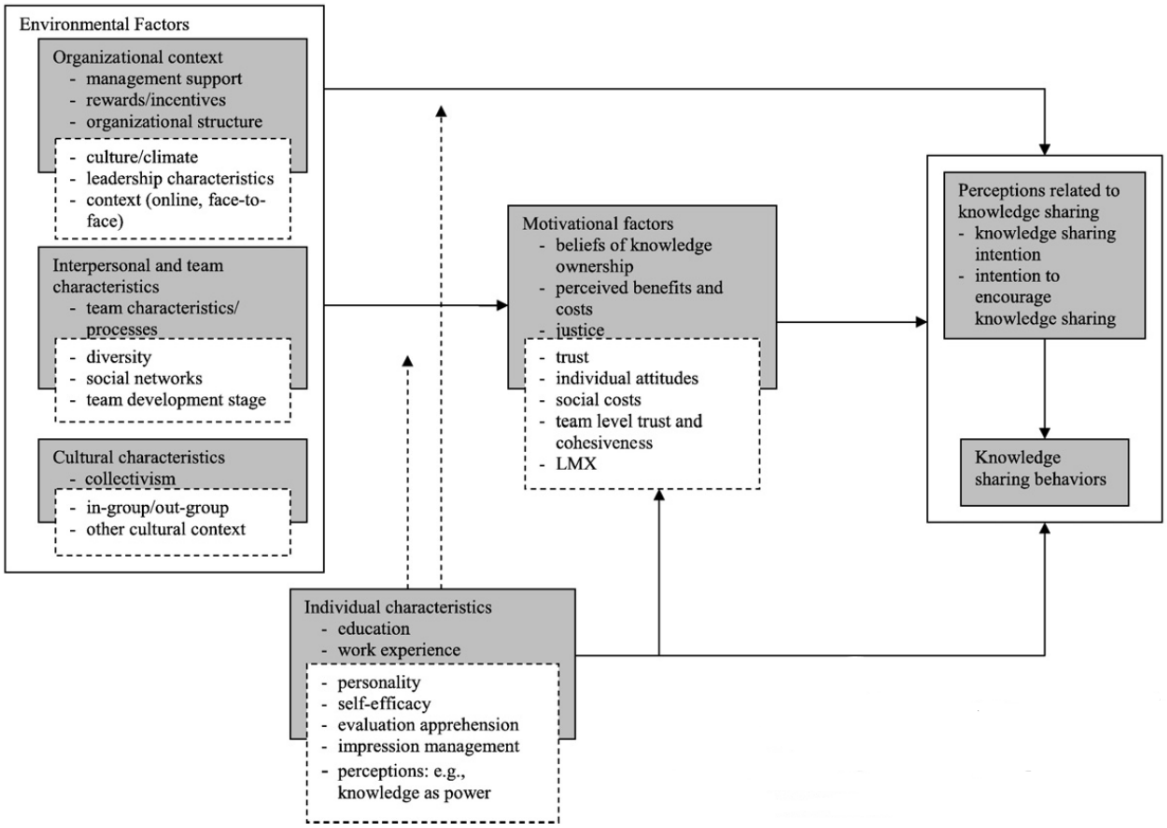

Figure 14 Framework on factors of knowledge sharing behaviors (Wang & Noe, 2010)

7.2 Interpretation of current knowledge sharing patterns

The characteristics of identified knowledge sharing patterns in the previous section and their link to interview findings enable the interpretation of the factors which hinder effective knowledge sharing in agile projects. The obtained causes from empirical research findings were further explained by linking the findings back to literature and interview findings.

The main factors are clustered based on Wang's framework into environmental factors, individual factors, and motivational factors (see figure 15 below) which are detailed explained in three sub chapters.

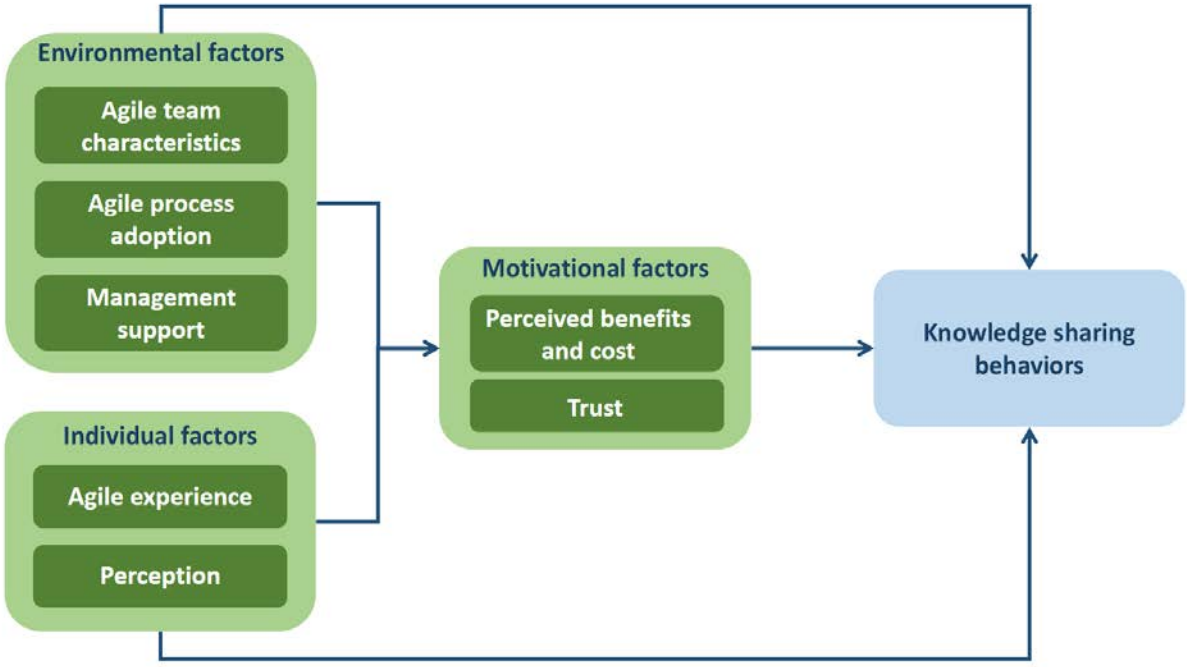

Figure 15 Framework on factors inhibit knowledge sharing behaviors in agile projects in Philips Research

7.2.1 Environmental factors

Agile team characteristics

First, **agile cadence meetings created too much "overhead".** Researchers who are occupied in attending agile cadence meetings have no time in other knowledge sharing activities like initiating unstructured knowledge sharing activities or document the technical knowledge from projects. Project managers are all positive about agile cadence meetings because Agile increment meetings including *standups and sprint meetings* enable better personal interaction, which contributes to better sharing of tacit knowledge and accelerates innovation process (Gloet & Terziovski, 2004). *Program Increment meeting*, designed in scaled agile methods, try to mitigate the drawbacks of only empowering intra-team knowledge sharing in agile methods, and improve organizational level knowledge sharing, which was perceived less efficient by most researchers. With too big a group and too diverse topics, this kind of sharing is not useful for everyone. Not all stakeholders are interested in all topics. Could divide one Increment meeting into several meetings with the interested stakeholders (Santos et al., 2015).

Second, **non-aligned knowledge sharing tools used in different projects** not only increases the effort researchers need to devote to the projects but also inhibit alignment on the sharing tools used and organizational knowledge sharing possibility. As researchers changed from one project (feature) to another. Projects in Research organization involve many unknowns; strictly planned agile cadence is not applicable. Therefore, different projects do agile in their way, as one of the project managers said: "*we do cherry-picking* (on agile practice elements)." For instance, some

only use JIRA (a project management tool) to monitor the project progress; some apply only sprint meetings with agile project members once every 2-3 weeks, etc.

Agile process adoption

No formal knowledge sharing process embedded in the agile project management process. *"Technical note was not always done in agile research projects, most of the time Demo is done, and then people are happy.*" There is no formal process on knowledge management in agile research projects in Philips Research. A department head is more or less free to organize and manage this aspect. Regarding ways to secure knowledge, on the department level most is being done within competency teams (with people who work on the same topics). Pepijn proposed in Philips Research in 2016 that the differentiation of roles within a department is needed to create sustainable knowledge sharing and this may require a process description with clear responsibilities (Wortelboer, 2016).

Documenting technical knowledge created during the research project is less important nowadays, just "*comes nicely with agile*". **There has no project closure in agile projects,** and no requirements on documentation of the whole research output*, "need to move on next feature soon".* In tradition year of research, used to be very common to write a technical note as one main deliveries. In traditional projects, product is presented and reviewed by customers only at the end of the project (could be two years) in a document.

Management support

No responsibility for agile management team to support knowledge sharing. There are scrum masters, agile project managers, value stream owners, product owners, and release train engineers taking management roles in agile projects, but none of them have the specific responsibilities on supporting technical knowledge sharing and learning. Project managers could assume technical experts do internal communication and sharing, only intervene when things went wrong. Some effort could seem from project managers when they considered knowledge sharing as a tool to stimulate better "communication" and "collaboration" in their team.

7.2.2 Individual factors

Agile experience

Some researcher (individual) **consider 'agile' as 'no documentation', because of their limited experience on agile methodology**, which contributes to the decrease of codified technical knowledge in the corporate knowledge base. Project managers mentioned that misunderstanding of agile also contributed to less codification. "*In research, people say we are all going to work in agile, but what it is and what you should do is not clear for researchers*." Actually, in agile, knowledge is broken down to share, there are more reporting in agile. Value achieved in 10 min reports. Most knowledge sharing actives were happening in Backlog – epics, features, stories, tasks (a list of things want to achieve) which are defined at the beginning of the project. Researchers' specific work is defined there and shared in Demo.

Inbuilt characteristics of agile methods hold the promise for improving knowledge sharing but could overemphasize tacit knowledge sharing on the intra-team level. Tacit knowledge could be spread more effectively through face to face communication than by documentation (Kavitha & Ahmed, 2011).

Perceptions

Knowledge is considered as the value delivered to customers in agile projects. Both project managers and agile project members could focus on short-term accomplishments and thus ignore long-term learning goals. Agile project managers consider the value created and shared with customers is of the highest importance. They are always result-driven and focus on the deliverables for customers rather than the learning within the projects. Knowledge sharing within teams is the tool to achieve better collaboration or communication (Gostick & Elton, 2018) and to make sure the job can be transferred from one to another within the team. One interviewee mentioned that "*It is important to have it (knowledge) in more than one head."* For some researchers who recognize the idea behind the deliverables is the actual value for organization are willing to capture it in the documentation for long-term use. While some are in lack of the mindset of knowledge transfer, only focus on their assigned projects. They always say, "*I have no time, always busy with customers' change*."

7.2.3 Motivational factors

Perceived benefits and cost

Researchers perceived **no adding value of existing complex documentations compared with personal interaction**. Perceived benefits or costs have been one of the most studied antecedents of knowledge sharing (Wang & Noe, 2010). Perceived benefits such as rewards, respect, and reputation have a positive influence on knowledge sharing while perceived costs negatively associated with knowledge sharing (Wasko & Faraj, 2005).

Only half of the interviewees mentioned technical note as a knowledge-sharing way, and only one of them appreciated and advocated writing down the knowledge for internal knowledge base based on his experience of benefiting from an ancient technical note.

Most researchers, as knowledge senders mentioned that the primary reason they do not write a technical note is that writing a technical paper *"…took me much time, and no one will read i*t." Researchers as knowledge receivers prefer personal interaction instead of reading the knowledge report; one said, "*It is always difficult to judge how the technical note is going to be useful for you. So if I find a technical note, I reach out to the writer and have a meeting.*" Technical note, used to be the main internal project knowledge report accountable for archiving and reusing research results, was seldom written by researchers nowadays.

Trust

Distributed agile teams could inhibit knowledge sharing. If people are not co-located, it will be difficult for informal sharing and building interpersonal relationship. Sit closer increase trust, and contribute to team bounding. One project manager mentioned that "*Social interaction is the core of sharing, and interpersonal relationship, bound between people makes people willing to share*." Another one mentioned that "*In practice, if people do not get along or not open, collaboration will not happen."*

The agile project runs in a short period while building trust needs time. Researchers work on the same projects or work in the same departments shared more frequently. The tie between members in one project or one department is strong, as they worked together for a long time, and know each other well. By using agile methods, researchers are organized to work on short-term (e.g., 3 months) features rather than on long-term (e.g., 2 years) projects, people could be selected from different departments, they get little opportunity to know more people in a short time. So most time they could communicate with the members, only if necessary.

PART IV

INTERVENTION

8. SOLUTION

This part answered the fourth sub question by proposing solutions on how to address the main ineffective knowledge sharing pattern under Philips Research agile way of working. Expert meeting organized to help with identifying the main cause for ineffective knowledge sharing in agile projects, the solution proposed was focused on the main cause. More recommendations on improving knowledge sharing in agile projects could be found in chapter 9.

> ***Sub-question 4**: What measures can be proposed for the address the main knowledge sharing patterns in agile projects in Philips Research?*

8.1.1 Expert Meeting to Identify the Main Cause

Expert meetings were held after the completion of the interpretation of knowledge sharing patterns and prioritizing the main cause of inefficient knowledge sharing in Philips Research. In total four experts from Philips CTO have been consulted. The meeting took about one hour and were initiated by a presentation, most of the time was spend on discussion with the experts. All participants are considered as experts in the field of R&D. The observations that were derived from the interviews were recognizable to the experts. New insights that were obtained during the discussions in relation to the interpretation of the findings.

A user-centered process on embedding codification in the agile project process was proposed in the following chapter to cope with the prioritized ineffective agile-induced knowledge sharing pattern: imbalanced personalization and codification.

8.1.2 Proposed Solutions: Embedding codification in agile project process

In this sub chapter, a codification approach embedded in agile working process for effective inter-team knowledge sharing is designed. The comparison of interview findings and theory enables the explanation on the process proposed to address the identified main cause of inefficient agile-induced knowledge sharing in Philips Research. The process proposed referred to Philips Excellence Process Framework (PEPF), which defines the standard knowledge management process in Philip (Visschers, 2016) (see in appendix C). By allocating the main KS elements knowledge sender & receiver and appropriate tools along agile project process, a codification-driven agile-induced knowledge sharing project process is obtained.

Detailed explanation on the elements in the process proposed:

Senders and receivers

Actors (written in red) involved in knowledge sharing activities in agile projects were grouped into three categories: agile project managers, researchers, and customers. Researchers who work on the agile project are the senders of project knowledge, researchers who work on others projects but have potential to reuse the knowledge and customers are all receivers.

More actors are involved in reviewing and evaluating the codified project knowledge. In previous process, publishing a technical note was in need of the consultation with project leader, and subject to review and approval by the department head. Learned from Fujitsu's user driven process, ***"Feedback and rate the knowledge"*** (in green boxes) as a vital people element was added to enable researchers and customers to rate the knowledge report from zero to five stars through the knowledge database (P2R). Rating by users ensures the quality of knowledge shared; thereby make sure people could benefit from the codified technical knowledge in corporate knowledge base. This can help fellow members determine which reports are most worthy of use (Jones, 2017)

Tool

Tools and platforms (in yellow boxes) suggested in orange boxes were specifically selected in the context of Philips Research way of working.

The one-entrance organizational-wise knowledge base should be accessible to all researchers and be aligned within the organization, to make sure researchers is able to find the right technical notes at the beginning of the project. Project managers are responsible for supporting agile team member with using different tools to share different kinds of knowledge intra-team and inter-team.

Process

The circle and box in blue indicate the agile project ***process*** (in blue boxes). Codifying the project knowledge in each sprint rather than at the end of the project could mitigate the huge time investment at the end of project. Product Owners could define the requirements of documentation in Features. Product owner need to discuss with the agile team on what kind of knowledge is valuable to be shared by documentation. If nothing needed to be shared on organizational level, a Demo or presentation with customers would fulfill the knowledge sharing requirements between agile team and customers. If other researchers could reuse the knowledge acquired from the project, then write down the requirements in the Feature. For example, if the requirement of having a technical note was written down in the feature, then in the every increment once researchers create knowledge, need to be reviewed and will be added to technical note.

To increase quality of codified knowledge, Key Performance Indicator (KPI) measuring is added as part of the process. One expert mentioned that KPI used to only linked the quantity of knowledge report researchers completed per year. In the proposed process, peer/expert review link the quality with KPI.

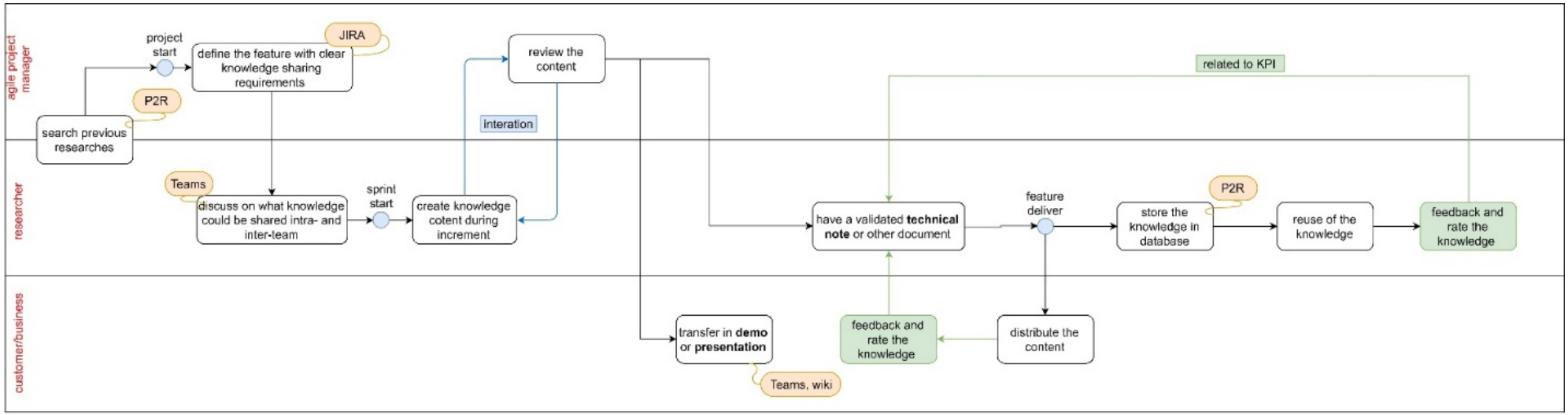

Figure 16 Proposed process embedded codification in agile project

9. CONCLUSION AND RECOMMENDATION

This chapter starts by presenting an answer to the main research question. Recommendations for future research are discussed in Section 9.2. Lastly, Section 9.3 presents a personal reflection on the graduation project.

9.1 Answering the Main Research Question

This research aims to explore how Philips Research agile way of working influence knowledge sharing behavior and its efficiency. The outcomes of this explorative research contribute to an improved understanding of how to achieve intra-team and inter-team agile-induced knowledge sharing efficiency in Philips Research. In this way, an answer can be given to the research question:

> ***Research question**: How can effective knowledge sharing be achieved under Philips Research agile way of working?*

This research brings the obtained knowledge sharing patterns back to three elements and various sub-components that explain the influence of agile methods on knowledge sharing behaviors. The main patterns are identified as 1) imbalanced codification and personalization, 2) process misalignment and 3) ignorance on the value of knowledge sharing according to tools, process, and people. Relating these to the research question suggests that organizations could consider these elements and components to gain a better understanding of knowledge sharing behaviors in agile projects.

Agile methods as knowledge sharing **enablers** could reinforce personal interaction by emphasizing the value of *individual interaction* over *process and comprehensive documentation*. Agile cadence meetings provide opportunities for an agile team to collaborate and communicate in which way contributing to intra-team knowledge sharing. Agile principles - *customer collaboration* influence knowledge sharing behaviors by stimulating more short-term knowledge sharing session with customers during review meetings. The Scaled agile as the agile practice used by Philips Research provides researchers more chances on organizational level knowledge sharing in the way of having cluster meetings or program increment meetings.

As argued earlier, the paradox could be recognized that with the overemphasis on the intra-team knowledge sharing in agile projects, there is the potential of sacrificing long-term learning and organizational level knowledge sharing. The enablers could transform into agile-induced **inhibitor** on knowledge sharing to some extent. Various agile cadence meetings conducted are mainly focused on project result, and deliverables for customers; result-riven mindset and neglecting on the organizational level learning could harm research organization with more innovation and intelligent work happening. As researchers are occupied in attending meetings or responding to customers' changes, there is not much time for them to write down project

knowledge at the end of the agile project or attending community activities or cluster meetings for people who work on the same topics to share their experience and knowledge. Also, misunderstanding of agile because of researchers' limited experience of agile methodology could influence decreasing in documenting project technical knowledge, thus inhibit long-term learning in the organization.

Above all, to achieve effective knowledge sharing in Philips agile research projects, the organization needs to **balance codification and personalization strategy** to have leveraged both intra-team and organizational knowledge sharing and **adjust agile methods to fit the rapid learning organization characteristics** rather than "do by the book."

9.2 Recommendations

This explorative research gained several new insights about how agile methods influence knowledge sharing behaviors and their efficiency. Besides the solution proposed in chapter 8, there are more practical recommendations obtained for research organizations that are facing challenges fostering effective knowledge sharing. Next, many questions remain unanswered, and therefore, some suggestions are made for future research.

9.2.1 Recommendation for practice

Steering personalization approach

Researchers are strongly in favor of promoting "share the same coffee machine." Unstructured and unplanned knowledge sharing or information exchanging inspire people at the right moment has the right idea. Structured knowledge sharing is needed if it is needed by other people or in the future.

Personal interaction could be achieved online too. No interviewees mentioned they used Teams or other online collaboration and communication tools for sharing knowledge or information. Instead of having endless meetings, online collaboration tool could be used for time-saving and real-time knowledge sharing, while safeguarding the knowledge. The collaboration tool could support the community of practice or other communities to share knowledge with people who have the same interest or work on the same topics. "*It is all about connecting with people, that is essential here."* One project manager said the Artificial Intelligent community meeting was regarded as *"the best meeting during the week*" by community members. Based on several studies, participating in knowledge sharing in an online community of practice contributes to increasing internal satisfaction, enhancing professional reputations, and helping advance the community (Lin, 2007c; Hew& Hara, 2007; Wasko & Faraj, 2005).

Avoiding heavy agile structure, fostering "rapid learning cycle."

Applying agile methods in non-IT industries should not be done by the book. Admittedly, inbuilt agile methods empower the agile team in achieving its goals and facilitating the transmission of

knowledge and experience, mostly within the agile teams (Kavitha & Ahmed, 2011; Santos et al., 2015). There is still a challenge to overcome inefficient organizational level knowledge sharing. The Scaled agile as the primary agile practice used by Philips provided researchers more chances on inter-team level knowledge sharing in the way of cluster meetings or program increment meetings.

However, based on interview findings, there are not many benefits researchers recognized from inter-team meetings. To utilize the organizational level knowledge sharing opportunity and achieve long-term knowledge sharing goals, an agile & learning environment needs to be created.

Agility in organizations should not be seen as a goal or a strategy, but rather as a fundamental existence necessity. Organizations have always had to be sufficiently agile to adjust to their changing environment. Agility is being discussed in recent years is because nowadays the environment is changing fast, especially in a research environment where direction gets set for a company's future competitive advantage, projects always have high uncertainty and high cost of change. That is the reason why only agile methods are not enough, but a rapid learning cycle is promoted (Radeka, 2017).

Figure 17 Rapid learning cycle framework (Radeka, 2017)

Above all, instead of complying with strict agile methods with the result-driven mindset in research environment, a rapid learning cycle should be considered since learning should be one of the primary purposes of the group. By combines traditional project management's awareness of the impact of change on Agile methods to address uncertainty. Rapid learning cycle makes agile research teams aware of the drivers of uncertainty and cost of change; they are better prepared to use their time effectively to lower the uncertainty and risk of costly changes.

9.2.2 Recommendation for further research

Recommendation on further study referring to the limitation of this study are addressed in this section.

The first recommendation is to extend the research field. This study is focused on research organizations; same explorative study can be conducted within other industries where agile is practiced to explore if agile adds value to other industries in terms of knowledge sharing.

Secondly, further study could be conducted based on this explorative study. For example, as the interviewees participated were either researchers or project managers, further study could be conducted in exploring how different perceptions influence knowledge sharing effectiveness, or focus on only intra-team or inter-team knowledge sharing. It could also be interesting to refer more to knowledge sharing in the traditional way of working and make a comparison between knowledge sharing patterns in agile and traditional methods.

Thirdly, the answer to the research question suggests making some adjustments to balance codification and personalization and adjust agile methods to fit the organization's characteristics. But this should be measured in practice to investigate how particular adjustments could affect the effectiveness of knowledge sharing, and how to measure effectiveness. One study suggested that effectiveness could be evaluated by the level of purpose achievement, frequency, level of formalization and reassessment of the practices in the organization (Santos et al., 2015).

Fourthly, this study focused on exploring the factors that inhibit knowledge sharing without emphasizing the interrelations between the factors; further study could be done.

The last recommendation for further study is to investigate more best practices on how to address ineffective organizational level knowledge sharing in agile projects.

9.3 Reflection

Doing this research was something totally new and challengable for me. The research was conducted in an area with a high level of uncertain compared with the construction industry. Philips Research where initiates game-changing innovation across businesses and markets, offered me an excellent opportunity to see how projects are managed by using modern project management methods. Everything was new and exciting, which means I need to conduct a thorough literature study on not only knowledge management and agile methods, but also how research organizations construct and run.

Besides, since this study started with too many unknowns and uncertainties, it was conducted followed agile methods, with consistent discussion with committees and experts, and continuously learning, making sure the main deliverables are well defined with consistent improvement and changes along with whole project phase.

By using mixed research methods, I learned both quantitative and qualitative analysis methods. And found myself have enormous interests and talents in conducting interviews, I enjoy listening to people's opinions and exacting patterns from analyzing "big data" (no real big data in this study, but still, thirteen cases enable some extent pattern identification) while obtaining specialty from observing details of "small data" per case. It was a pity that no data was found available on the number of technical notes per traditional projects and agile projects. Otherwise, it might be strong evidence to support the hypothesis that agile methods compared to waterfall methods influence knowledge sharing effectiveness.

Finally yet importantly, one of the most challenging parts during the graduation process was to mitigate and balance different expectations and opinions surrounding the research. This was because committee members had different backgrounds and had diverging perspectives on my work. Next to that, many people showed their interests in the research and shared their expectations with me. The interesting discussions and diverging opinions were highly appreciated since it provided me with various new insights, but also a big challenge for me was to filter the feedback, prevent wandering back and forth, and stick to my own way of conducting this research.

10. REFERENCE

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APPENDIX

Appendix A. Semi-structured Interview Outline

This appendix describes the process of the interview and serve as a guide in the implementation of interviews.

Step 1 – Preparation

Research:

- In the context of a graduation thesis in TUDelft in collaboration with Philips research
- Keywords: Agile Methods, Knowledge Sharing, Research Project
- Main question: How agile methods influence the project knowledge sharing way in Philips research projects compared to the traditional way of working? (patterns)
- What adjustments can be made to stimulate efficient knowledge sharing in agile research projects? (improvements)

Practical:

- The interview will take approximately 1 hour
- The sound recording will be made during the interview and will be deleted after the investigation is done
- A summary will be sent to the interviewees for review and validate
- The outcome of the interview will be treated confidentially and anonymously, and only be used in this research study

GENERAL INFORMATION

- Date:
- Name:
- Role in the agile project:
- Year of experience in agile:

KEY QUESTIONS	EXPECTED OUTCOME
KNOWLEDGE SHARING MOMENT **(WHEN)**	
1. Can you briefly take me through the agile process from project initiation until the delivery of a sprint/feature?	- Get an overview of the agile process
2. Which phases involve KS activities? o *Standup meeting;* o *Sprint review meeting;* o *Team Retrospective meeting;*	- Gain the insight of the structured knowledge sharing moments (patterns)

3. What other KS activities did you participate? o *Collaboration;* o *Coffee corner talk;* o *Online community;*	- Gain the insight of other unstructured knowledge sharing moments (patterns)
ACTORS INVOLVED **(WHO)**	
4. How much experience do the team members have with agile way of working?	- Understand the current agile ability of research project team (adjustments)
5. How is the overall knowledge sharing mindset of all project participants involved in the research project?	- Understand the current knowledge sharing situation within the agile research team (adjustments)
6. Which roles you corporate and share knowledge with during the agile project? *Individual:* o *Scrum Master;* o *Researcher;* o *Project Manager;* o *Department Head;* o *Business Partner;* o *Value Stream Owner;* o *Product Owner;* o *Release Training Engineer;* o *Division Head* *Group* o *Agile team;* o *Management team;* o *Customer;*	- Gain the insight of actors involved in knowledge sharing activities (patterns)
KNOWLEDGE SHARING MANNER **(HOW)**	
7. What is the interaction level of the knowledge sharing? o *Individual;* o *Team;* o *Organizational level;*	- Get the insight of what is the knowledge interaction level of agile research team
8. Which tools are used to share knowledge? o *Document - Technical Note, Publication;* o *Dialogue;*	- Get the insight of the usage of knowledge sharing tools

o *Email;* o *Database - P2R, Philips Wiki;* o *Platform - Yammer, Teams*	
9. Is there any knowledge sharing requirements within the project?	- Gain the idea of the process-wise knowledge sharing importance (adjustments)
10. What management strategies were taken to determine or stimulate knowledge sharing?	- Gain the idea of the management support on knowledge sharing (adjustments)
OTHERS	
11. What kind of knowledge are shared? *Explicit* o *Project lessons learned;* o *Intellectual Property;* o *Working product;* o *Services;* o *Project result;* *Tacit* o *Experience;* o *Value;*	- Gain the insight of what knowledge are shared within the research team (patterns)
12. Which kind of knowledge shared you find is more valuable for you?	- Gain the insight of what knowledge are most valuable for the research team members (adjustment)
13. What you expect could be shared within agile research project team?	- Understand which kind of knowledge is missing but needed (adjustment)
14. Which kind of knowledge sharing way you find is more efficient?	- Gain human-centered perspective on efficient knowledge sharing - Better techniques, process or culture elements could be addressed (adjustments)
15. What is the biggest barrier for efficient knowledge sharing?	- Gain human-centered perspective on efficient knowledge sharing (why)
16. What is the difference of knowledge sharing between agile and traditional projects in knowledge sharing activities?	- Gain the insight of why agile or traditional way of working works well in knowledge sharing (why)

Appendix B. Quantitative interview coding on knowledge sharing elements

	KS tool - manner	manner	Sharing tool - means	means	Process	Project Phase	Sender	Receiver
1	Standup meeting	structured	Meeting	interaction means	2/3 times a week	During the project	Researcher	Researcher
3	Sprint meeting	structured	Demo	documentation means	Tri-monthly	During the project	Researcher	Researcher
9	"One room approach"	unstructured	Meeting	interaction means	Ad-hoc	During the project	Researcher	Researcher
10	"One room approach"	unstructured	Dialogue	interaction means	Ad-hoc	During the project	Researcher	Researcher
13	COI/COP	unstructured	Dialogue	interaction means	Ad-hoc	Out of project	Researcher	Researcher
14	COI/COP	unstructured	Meeting	interaction means	vague	Out of project	Researcher	Researcher
15	COI/COP	unstructured	Meeting	interaction means	vague	Out of project	Researcher	Organization
16	Coffee corner talk	unstructured	Dialogue	interaction means	Ad-hoc	vague	Researcher	Researcher
19	Coffee corner talk	unstructured	Dialogue	interaction means	Ad-hoc	Out of project	Researcher	Researcher
20	Coffee corner talk	unstructured	Meeting	interaction means	Ad-hoc	Out of project	Researcher	Researcher
21	Standup meeting	structured	Meeting	interaction means	Weekly	During the project	Researcher	Researcher
22	Documentation	structured	Email	interaction means	n/a	During the project	Researcher	Researcher
24	"One room approach"	unstructured	Call	interaction means	Ad-hoc	During the project	Researcher	Researcher
25	Documentation	structured	Backlog	documentation means	n/a	During the project	Researcher	Researcher
26	Sprint meeting	structured	Other document	documentation means	Monthly	During the project	Researcher	Researcher
27	Program increment meeting	structured	Other document	documentation means	Tri-monthly	During the project	Researcher	Researcher
30	"One room approach"	unstructured	Meeting	interaction means	Ad-hoc	During the project	Researcher	Researcher
34	"One room approach"	unstructured	Dialogue	interaction means	Ad-hoc	During the project	Researcher	Researcher
36	Coffee corner talk	unstructured	Dialogue	interaction means	Ad-hoc	Out of project	Researcher	Researcher

37	COI/COP	unstructured	Meeting	interaction means	vague	Out of project	Researcher	Organization
44	COI/COP	unstructured	Dialogue	interaction means	vague	Out of project	Researcher	Organization
45	Standup meeting	structured	Meeting	interaction means	Weekly	During the project	Researcher	Researcher
46	Documentation	structured	Backlog	documentation means	n/a	During the project	Researcher	Researcher
48	COI/COP	unstructured	Presentation	documentation means	Monthly	Out of project	Researcher	Organization
49	vague	vague	vague	vague	vague	During the project	Researcher	Researcher
50	vague	vague	vague	vague	Ad-hoc	Beginning of the project	Researcher	Researcher
51	Cluster meeting	structured	Meeting	interaction means	Weekly	Out of project	Researcher	Researcher
52	Cluster meeting	structured	Meeting	interaction means	Monthly	Out of project	Researcher	Organization
55	Standup meeting	structured	Meeting	interaction means	2/3 times a week	During the project	Researcher	Researcher
56	"One room approach"	unstructured	Dialogue	interaction means	Ad-hoc	During the project	Researcher	Researcher
57	Documentation	structured	Other document	documentation means	n/a	During the project	Researcher	Researcher
59	Documentation	structured	Other document	documentation means	n/a	During the project	Researcher	Researcher
60	COI/COP	unstructured	vague	vague	vague	Out of project	Researcher	Organization
61	COI/COP	unstructured	Presentation	documentation means	Bi-weekly	Out of project	Researcher	Organization
62	"One room approach"	unstructured	Dialogue	interaction means	Ad-hoc	During the project	Researcher	Researcher
63	Documentation	structured	Backlog	documentation means	n/a	During the project	Researcher	Researcher
64	Program increment meeting	structured	Meeting	interaction means	Monthly	During the project	Researcher	Organization
65	Coffee corner talk	unstructured	Dialogue	interaction means	Weekly	Out of project	Researcher	Researcher
66	vague	vague	Meeting	interaction means	Bi-weekly	Out of project	Researcher	Researcher
67	Documentation	structured	Report	documentation means	n/a	During the project	Researcher	Researcher

69	Documentation	structured	Report	documentation means	n/a	During the project	Researcher	Researcher
71	Documentation	structured	Technical note	documentation means	n/a	Beginning of the project	Researcher	Agile team
74	COI/COP	unstructured	vague	vague	n/a	Out of project	Researcher	Organization
75	Coffee corner talk	unstructured	Dialogue	interaction means	2/3 times a week	Out of project	Researcher	Researcher
76	Cluster meeting	structured	Meeting	interaction means	n/a	During the project	Researcher	Researcher
77	"One room approach"	unstructured	Meeting	interaction means	n/a	During the project	Researcher	Researcher
78	"One room approach"	unstructured	Meeting	interaction means	Weekly	During the project	Researcher	Researcher
79	Standup meeting	structured	Meeting	interaction means	Weekly	During the project	Researcher	Researcher
80	"One room approach"	unstructured	Meeting	interaction means	Ad-hoc	During the project	Researcher	Researcher
81	COI/COP	unstructured	Meeting	interaction means	vague	Out of project	Researcher	Organization
85	COI/COP	unstructured	Meeting	interaction means	vague	Out of project	Researcher	Organization
88	Standup meeting	structured	Meeting	interaction means	Weekly	During the project	Researcher	Researcher

Appendix C. Philips enterprise knowledge management process in PEPF

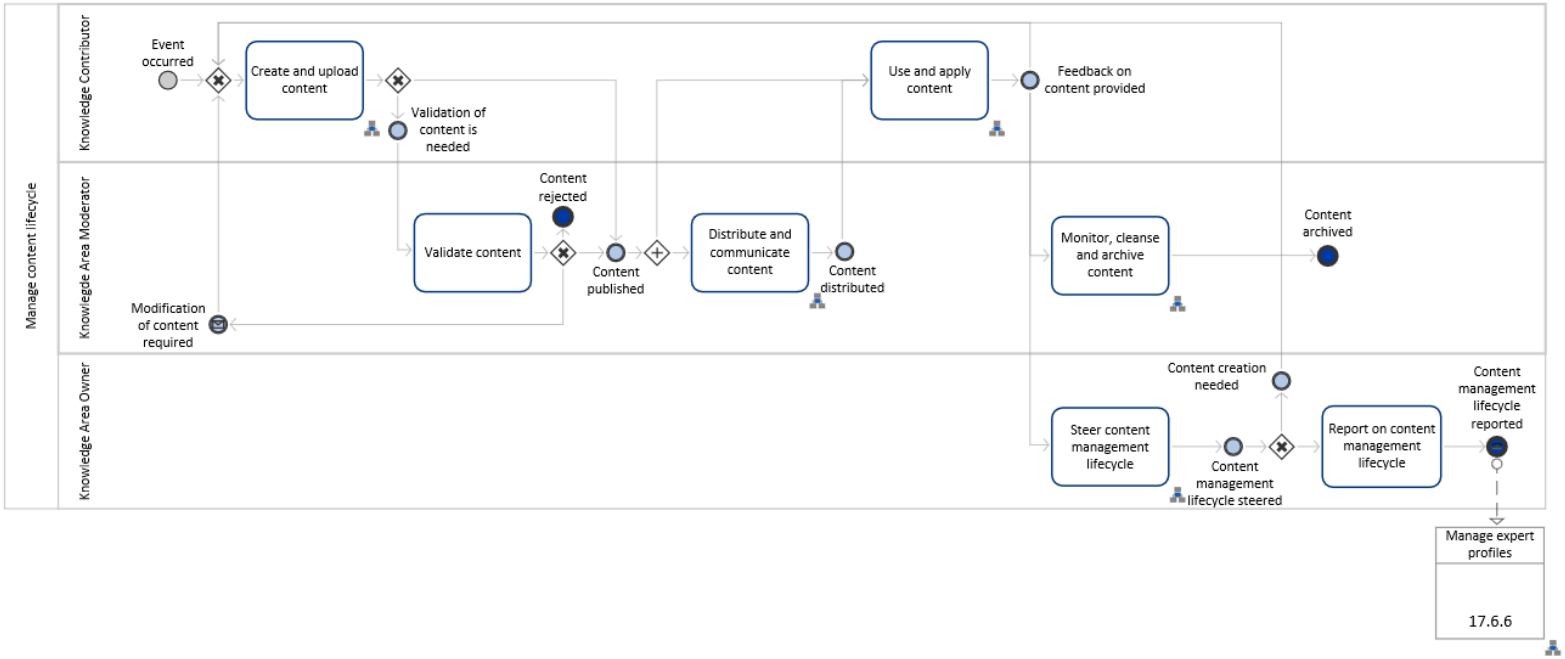

Figure 18 Philips Enterprise knowledge management process

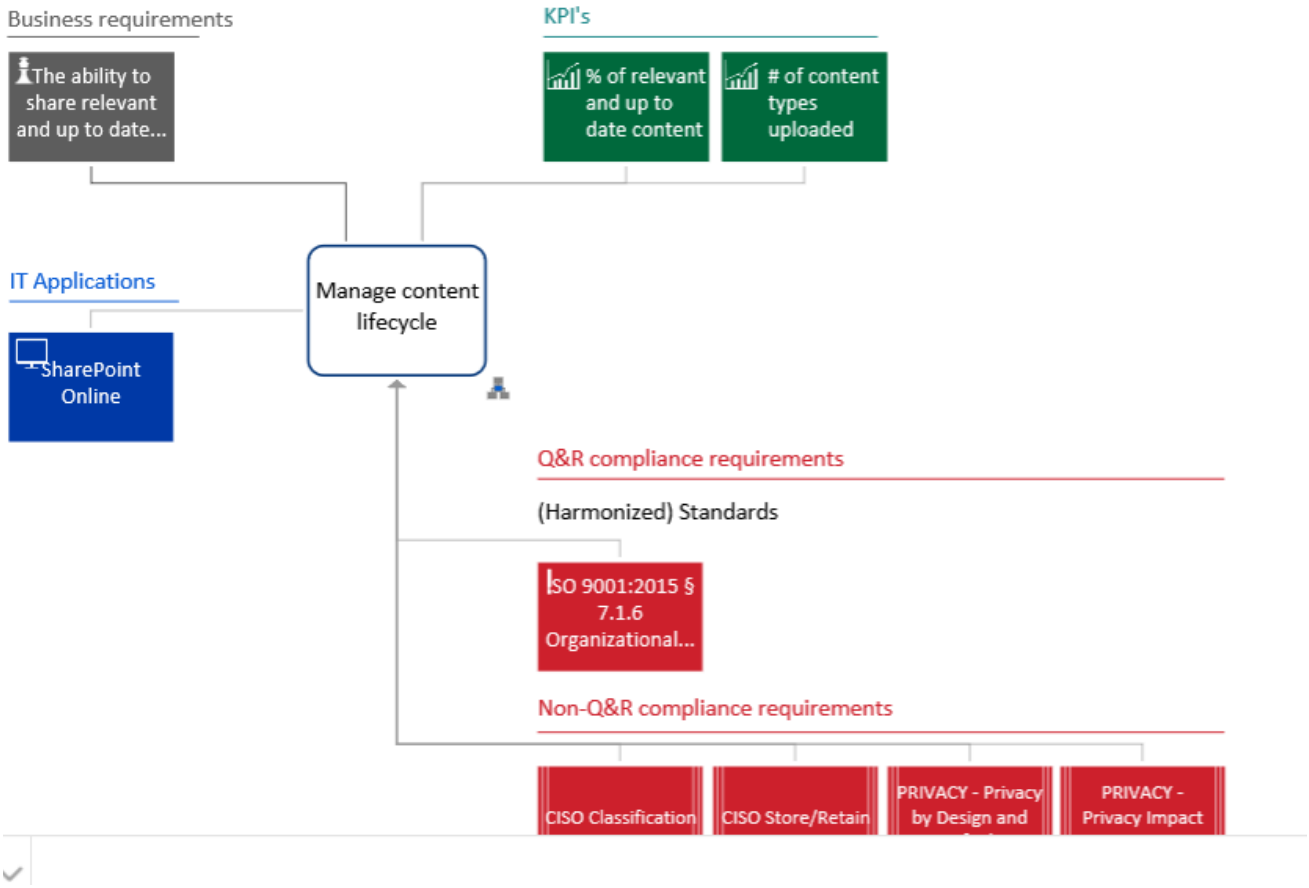

Figure 19 Additional information relevant to the process

Appendix D. Explanation on Specific Words

CTO organization: is part of Innovation & Strategy, a strong initiating role in innovation across businesses and markets and leads game-changing innovation that disrupts and crosses boundaries in health technology.

Philips Research: is a global organization in the CTO organization with research departments in Europe, North America, Africa, and Asia. (Philips Research organization structure is shown in figure 20 below, T: agile teams; D: departments; VS: value stream)

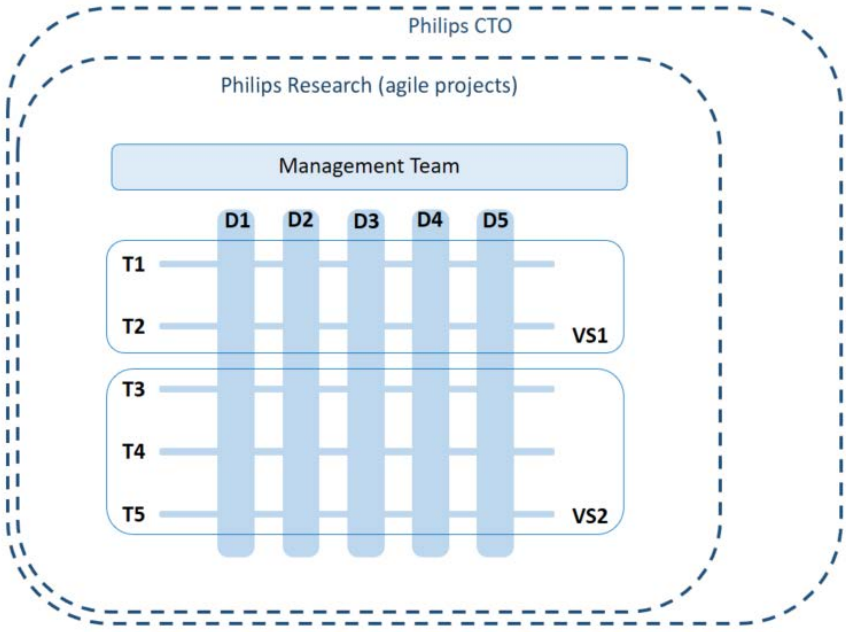

Figure 20 Philips Research organization structure (agile projects)

Technical note: A Technical Note is an internal report, intended for rapid dissemination and archiving of research results within Philips. Researchers are accountable for professional documentation of knowledge and insights as well as critical data collected in the projects or others (e.g., during conference or benchmark visit).

Feature (in agile methodology): A feature is a set of logically related requirements that allows the user to satisfy an objective. A feature tends to be a higher-level objective than a requirement.